SKANSKA COSTAIN STRABAG Working on behalf of HS2

1MC03 Main Works - Contract Lot S1

Groundwater Monitoring Plan S1 and S2

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	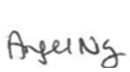					

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1 Definitions and abbreviations

1.1 Definitions

1.1.1 The project terminology used in this document can be found in the High Speed 2 (HS2) Project Dictionary [R1].

1.2 Abbreviations

1.2.1 Table 1 below outlines abbreviations and technical terms used within this monitoring plan.

Table 1: List of Abbreviations

Abbreviation	Definition
AfW	Affinity Water Limited
ALV	Alluvium
APA	Asset Protection and Monitoring Agreement between Affinity Water and HS2
ARLT	Atlas Road Logistics Tunnel
ARSC	Atlas Road Satellite Compound
ATS	Auto Transformer Station
BS	British Standards
CA	Community Area
CFA	Community Forum Area
CoCP	Code of Construction Practice
CP	Cross Passages
DMP	Designer Monitoring Plan
DQRA	Detailed Quantitative Risk Assessment
EPIE	Electronic Piezometer
EMR	Environmental Minimum Requirements
EMS	Environmental Management System
ES	Environmental Statement
EST	Euston Station Throat
EU	European Union
FWRA	Foundation Risk Assessment
GI	Ground Investigation
GPW	Greenpark Way
GRA	Groundwater Risk Assessment

Abbreviation	Definition
GTB	Granby Terrace Bridge
GW	Groundwater
GW1	Groundwater Monitoring Advisory Sheet 1
GW2	Groundwater Monitoring Advisory Sheet 2
GWMP	Groundwater Monitoring Point
HAR	Harwich Formation
HS2	High Speed 2 Ltd
LEMP	Local Environmental Management Plan
LMG	Lambeth Group
LC	London Clay
mbgl	Meter below existing ground level
MDR	Mandeville Road
MWCC	Main Works Civils Contract
MG	Made Ground
mAOD	Meters above Ordnance Datum
N/A	Not Applicable
NTC	Northolt Tunnels Central
NTE	Northolt Tunnels East
NWR	Northwest Ruislip
PMI	Project Manager's Instruction
PVE	Park Village East
RNSP	Ruislip Northern Sustainable Placement
RSSP	Ruislip Southern Sustainable Placement
SCSJV	Skanska Costain STRABAG Joint Venture
S1	Lot S1 for Phase 1 of the HS2 scheme
S2	Lot S2 for Phase 1 of the HS2 scheme
SP	Standpipe
SPB	South Package B
SPG	Gas Standpipe
SPG/GW	Gas / Groundwater Monitor Standpipe
SPIE	Standpipe Piezometer
SPZs	Source Protection Zones

Abbreviation	Definition
SR	South Ruislip
SSECP	Site Specific Environmental Control Plans
SSI	Site Scale Impact
SUPD	Superficial Deposits
SuRF	Survey Request Form
TBC	To be confirmed
TS	Thanet Sand
U&As	Undertakings and Assurances
UPR	Upnor Formation
VWP	Vibrating Wire Piezometer
WFD	Water Framework Directive
WRP	West Ruislip Portal

2 Introduction

2.1 Purpose

2.1.1 This Groundwater Monitoring Plan has been prepared based on the current information made available regarding the permanent works design (Scheme Design) of assets in the MWCC Lots S1 and S2 of the HS2 Phase One project managed by Skanska-Costain-STRABAG Joint Venture (SCSJV). The content of this plan should be reviewed and updated as appropriate when there is a change in design and construction assumptions.

2.1.2 The overall purpose of this plan is to set out groundwater monitoring requirements for groundwater protection purposes and monitor construction activities relevant to groundwater protection. Thus, this plan does not include an exhaustive proposal for all groundwater monitoring relating to construction compounds, temporary works design, construction methodologies and transports routes.

2.1.3 This monitoring plan has been prepared based on the current information available regarding design and construction methodology, sequencing and programme provided at the time of writing. The specification should be reviewed should these assumptions change.

2.1.4 Appendix A of this plan includes monitoring requirements and testing schedules for each identified asset. The requirements of this document take precedence over existing Ground Investigation Specifications [R2, R3], referenced as follows:

- HS2-HS2-GT-SPE-000-000001 P02 - HS2 Specification for Ground Investigation
- 1MC03-SCJ-GL-SPE-S001-000001_FINAL - SCS Specification for Additional Ground Investigation Works -S1

2.1.5 This revision of the plan sets out the general plan for monitoring and reporting criteria. Note that the selection of trigger and control are documented separately within a specific asset's baseline monitoring report. The details for these plans will be agreed following consultation with HS2 and the relevant regulator or stakeholder.

3 Legislation, policy & guidance

3.1 Legislation and policy

High Speed Rail (London - West Midlands) Act 2017

3.1.1 On 23 February 2017, Royal Assent was granted for Phase One of HS2. The High Speed Two Bill is now an Act of Parliament (law) i.e. High-Speed Rail (London - West Midlands) Act 2017 [R4] including its Environmental Minimum Requirements (EMRs).

3.1.2 The EMRs set out the high level environmental and sustainability commitments and are contained in the EMR General Principles document supported by a series of papers:

- Annex 1: Code of Construction Practice (see below) [R5]
- Annex 2: Planning Memorandum [R6]
- Annex 3: Heritage Memorandum [R7]
- Annex 4: Environmental Memorandum [R8]
- Register of Undertakings and Assurances [R9]

Environmental Minimum Requirements - General principles

3.1.3 The Environmental Minimum Requirements (EMRs) - General Principles require that the controls to be implemented in delivering the scheme (including the EMRs, powers contained in the Act and Undertakings and Assurances (U&As)) will ensure that the impacts assessed in the Environmental Statement (ES) (as amended) will not be exceeded. If the significant adverse impacts identified in the ES (as amended) are likely to be exceeded, all reasonable steps will be taken to minimise or eliminate those additional impacts.

3.1.4 Annex 1 to the EMRs comprises a Code of Construction Practice (CoCP), which shall be adopted and implemented by SCSJV and its contractors in delivering the works, the high-level requirements of which are set out below.

3.1.5 In developing the scheme through the Parliamentary process and beyond into the detailed design stage, site-specific control measures are being developed in conjunction with local authorities. Such measures are to be set out in each of the Local Environmental Management Plans (LEMPs) and shall be implemented in delivering the works.

Code of Construction Practice (CoCP)

3.1.6 The Code of Construction Practice (CoCP) sets out the general control measures to be implemented and the standards to which the nominated undertaker and its contractors will comply in delivering the scheme. Its aim is to ensure that likely significant construction effects that are reported in the ES (as amended) will either be avoided or mitigated. Notwithstanding this, SCSJV and its contractors will adopt appropriate measures to design and construct the

scheme so that influence from and/or impact to groundwater does not give rise to adverse effects, as identified in the ES (as amended). Where reasonably practicable, environmental mitigation will be integrated within the design and implemented by the contractors within the works.

3.1.7 The general control measures and monitoring arrangements for water bodies identified in the CoCP have been considered in the development of this plan and, where appropriate, are incorporated.

3.1.8 Site-specific controls are to be developed in conjunction with local communities, local authorities and other stakeholders. These controls will be captured in Site Specific Environmental Control Plans (SSECP).

Local Environmental Management Plans

3.1.9 Local Environmental Management Plans (LEMPs) have been published on the gov.uk website for all applicable local authorities. These will be updated on a six-monthly basis or in the event of a significant change to the works.

3.1.10 LEMPs focus on area specific topics as relevant to construction works within the relevant local authority area. The measures described in LEMPs will be applied by SCSJV for the duration of the MWCC to minimise the potential environmental and community impacts of the works.

3.2 Technical standards and requirements

3.2.1 Various Technical Standards and guidance documents have been developed by HS2. These prescribe the methodologies, processes and/or specifications that SCSJV and its contractors shall comply with when carrying out the works and implementing the various control measures. The Technical Standards relating to groundwater are as follows:

- Groundwater Protection (HS2-HS2-EV-STD-000-000010) [R10];
- Water Framework Directive (WFD) Compliance Process (HS2-HS2-EV-STD-000-000012) [R11];
- Water Resources and Flood Risk Consenting Strategy (HS2-HS2-EV-STD-000-000015) [R12];
- Water Resources Strategy (HS2-HS2-EV-STD-000-000016) [R13];
- Land Quality (HS2-HS2-EV-STD-000-000027) [R14]; and
- Water Resources and Flood Risk Monitoring Technical Standard (HS2-HS2-EV-STD-000-000029) [R15]; and
- Asset Protection and Monitoring Agreement between Affinity Water Limited (AfW) and High Speed Two (HS2) Limited, dated 2017 [R31].

3.3 Relevant legislation

3.3.1 Relevant legislation is described in detail in the Technical Standard - Groundwater Protection (HS2-HS2-EV-STD-000-000010) [R10] and therefore has not been restated here.

3.4 Undertakings and assurances

3.4.1 Undertakings and Assurances in relation to groundwater exist route wide and within the MWCC Lots S1 and S2. A summary of those relevant to this Groundwater Monitoring Plan is included in Table 2.

3.4.2 Requirements or mitigations needed to meet applicable U&As will be set out in the site-specific environmental control plans and briefed to site teams to ensure they are met (Table 2). Evidence of compliance against U&As will be submitted by SCSJV to HS2 Ltd through commitment compliance plans [R16]. Groundwater management plans related to U&As will be documented in a separate document [R17].

Table 2: Extract of relevant Undertakings and Assurances

U&A Reference	Extracted text
49	"Impacts of the Proposed Scheme on groundwater flows, levels and quality, have been analysed. Where the assessment predicts that a likely significant adverse effect may occur, a strategy to manage the risk will be agreed with the Environment Agency. Potential significant adverse effects on groundwater, due to construction, (such as excavations to form cuttings or tunnels, including green tunnels), will be mitigated locally wherever reasonably practicable. The tunnels will be designed so that the ingress of groundwater is not significant. The assessment has demonstrated that the passage of groundwater past the tunnels is not significantly reduced. The drainage within the Proposed Scheme will be designed, where reasonably practicable, to encourage the recharge of groundwater bodies."
51	Engagement has been, and will continue to be, undertaken with the Environment Agency, Lead Local Flood Authorities, Internal Drainage Boards, the Canal and River Trust and water companies, to ensure that likely residual significant adverse effects are managed and mitigated appropriately.
1664	"8.4.2 The SoS will require HS2 Ltd to at all times use best endeavours and best practice to avoid causing any flooding of the Crossrail Depot from the Grand Union Canal arising from the carrying out of the HS2 Works."
2220_13	"12.1 The Promoter shall not deposit or discharge directly or indirectly any polluting material on, in or over the Canal and shall not without the consent of the Trust: 12.1.1 deposit or discharge any other materials directly or indirectly into the Canal (other than materials comprised in an Authorised Work authorised by the Act and detailed in the Technical Appendices); or 12.1.2 notwithstanding anything in Schedule 2 paragraph 8 of the Act, discharge any water directly or indirectly into the Canal. 12.2 Any consent of the Trust required under clause 12.1 of this Agreement shall not be unreasonably withheld and: 12.2.1 shall be deemed to have been given if it is neither given nor refused within 28 days of the submission of the request for it or where the Trust reasonably requests further particulars of the deposit or discharge, within 28 days of the submission of those particulars; and 12.2.2 may be given subject to reasonable requirements as the Trust may make including but not limited to those requirements in paragraph 1.6 of Appendix 1 of the Technical Appendices.

U&A Reference	Extracted text
2220_24	Relating to discharge of water into Canal & River Trust waterways: " 1.6.1. When seeking the Trust's consent for the discharge of water directly or indirectly into the Canal under clause 12 of the Agreement, the Promoter shall follow the process set out in Part 2, Section 3 of the Code of Practice. 1.6.2. When assessing possible discharges, the Trust will not use the Environment Agency's "Greenfield Attenuation" levels or be bound by any other industry standard but will make its own reasonable assessment of the impact of new or increased discharges. 1.6.3. Any consent given by the Trust may require oil and silt traps, pollution cut-off valves and other reasonable measures specified by the Trust, to be installed at all discharge points into the Canals and the maintenance of these facilities shall be agreed with the Trust and undertaken/funded by the Promoter"
2220_27	"1.9.1. No excavations, surface water or groundwater may be discharged onto the Trusts property until it can be demonstrated to the reasonable satisfaction of the Trust that it is not contaminated. 1.9.2. Where such material or water is contaminated, any proposed remediation prior to discharge should be approved by the Trust."
2220_29	"Any Authorised Works that may adversely impact on the Trust's water supplies (short term or long term) from surface water feeders or groundwater pumps will be mitigated by the Promoter to the reasonable satisfaction of the Trust prior to commencement of such Authorised Works."
2508	Relates to a Ground Source Cooling System at Westmark Investment Properties Limited, near Westgate vent shaft: "3.7 Prior to commencing the construction of any part of the Authorised Works in the vicinity of the Ground Source Cooling System the Promoter will require the Nominated Undertaker to assess the potential for the construction of such works to:- 3.7.1 disrupt the operation of the Ground Source Cooling System; and 3.7.2 contaminate the Ground Source Cooling System, together being the 'GSCS Risks', and to identify such monitoring measures as may need to be employed by the Nominated Undertaker during the construction of such Authorised Works for the purposes of minimising in so far as is reasonably practicable the GSCS Risks. 3.8 In the event that notwithstanding the measures taken pursuant to clause 3.7 above the Ground Source Cooling System is contaminated in consequence of the construction of the Authorised Works then the Promoter shall require the Nominated Undertaker to undertake such mitigation measures as is deemed reasonably necessary by the Nominated Undertaker so as to remedy any contamination damage caused to the Ground Source Cooling System.
2783	"Monitoring will be undertaken in consultation with the Environment Agency prior to and during construction, and if required post construction, to establish baseline conditions for surface water and groundwater and to confirm the effectiveness of temporary and permanent mitigation measures together with any remedial works deemed necessary."

3.5 Consents and licensing

3.5.1 All proposed groundwater monitoring locations will be submitted to HS2 for acceptance so that consent and agreements can be obtained from the relevant regulatory authorities and any private asset holders.

3.5.2 The installation of proposed monitoring locations will not be undertaken until written consents and agreements are in place and communicated accordingly.

3.5.3 Baseline groundwater monitoring is required for the bespoke waste permit application for Ruislip Northern Sustainable Placement (RNSP) Area and Ruislip Southern Sustainable Placement (RSSP) Area. Baseline monitoring is also required for Schedule 33 consents from the Environment Agency where any permanent structure works have the potential to interact in Source Protection Zones (SPZ) and/or within Principal/Secondary A Aquifers.

4 Selection of monitoring locations

4.1 Background to previous monitoring

Monitoring as part of the HS2 Ground Investigation

4.1.1 Sites along S1 & S2 alignment had previously been investigated as part of the HS2 commissioned ground investigation. The field work was completed in March 2018.

4.1.2 Historic baseline groundwater monitoring has been undertaken by HS2 appointed ground investigation contractors at several locations spanning the HS2 S1 and S2 alignment under different GI packages: SPB, NWR, NTC and NTE. For NWR, this has also included groundwater quality sampling at selected locations.

- South Package B (SPB) covers HS2 railway route in S2 from Camden to Kensal Green;
- Northwest Ruislip (NWR) covers the HS2 railway route in S2 between Breakspear Road South (eastern extent of the site) to Harvil Road to the west in West Ruislip, including Copthall tunnel and the Ruislip Northern and Southern Sustainable Placement areas;
- Northolt Tunnels Central (NTC) covers S2 tunnels from Westgate to Northolt through Perivale and Greenford; and
- Northolt Tunnels East (NTE) covers HS2 railway route in S2 from North Acton and Hanger Lane Underground Stations on the Central Line;

4.1.3 Two GI packages, HS2 Euston Station Throat (EST) and South Package A, covering the tunnelled section of the S1 route from Euston station to Old Oak Common reported no groundwater monitoring data since the end of the field work period.

4.1.4 For those GI packages with groundwater monitoring, groundwater level readings were to be taken unless otherwise instructed, in all standpipes, standpipe piezometers and combined groundwater/soil gas standpipes; except for those containing loggers, during return visits to site at monthly intervals for 12 months following the end of field work.

4.1.5 Groundwater quality sampling was to be taken in accordance with "Water quality. Sampling. Guidance on Sampling of Groundwaters" (BS ISO 5667-11: 2009) [R27] in standpipes during the field work period after development and purging/micro-purging. Samples were also taken following completion of the field work.

4.1.6 Data loggers were set to measure groundwater pressures / levels at daily intervals unless otherwise instructed and the data downloaded at a minimum frequency of one every three months.

4.1.7 Following the direction of the EA, and in discussion with HS2, additional groundwater level and quality monitoring was undertaken as part of the NWR GI package.

4.1.8 *EA Priority Monitoring*

4.1.9 As part of early investigations, the EA identified locations to be monitored groundwater level and quality for a period at least 12 months. These locations are indicated in Appendix E. As part of the groundwater monitoring plan, these priority monitoring locations have been incorporated as appropriate. However, in some instances, installations have been removed where they conflict with construction requirements (i.e. they are or will be in the way of construction). Appendix E also notes installations which will be retained or to be / have been decommissioned due to construction conflicts.

4.2 Background to ongoing monitoring

SCS additional ground investigation

4.2.1 An additional ground investigation sanctioned by SCS and undertaken by Concept Engineering Consultants (referred as 'SCS additional ground investigation') from August 2018 was required along parts of the route to inform the detailed design and fill in the gaps of the main investigation works. In particular the ground investigation focused on obtaining information about the foundations of the structures likely to be affected by the tunnelling works and pumping tests to establish hydrogeological properties of the underlying Chalk aquifer and groundwater conditions at various S2 sites. In addition to the main SCS GI, further supplementary works were sanctioned by SCS at Cross-Passage locations, Euston Scissor Box, River Pinn Flood Compensation Area, PVE Wall and other key assets to inform design and fill in any data gaps.

4.2.2 Boreholes installed as part of the SCS Additional Ground Investigation including supplementary GI works starting from August 2018 (ongoing) require groundwater level monitoring for 12 months following installation, as set out in the Ground Investigation Specification [R18 & R19].

4.2.3 Although SCS investigation locations have been incorporated into the monitoring, some of the specific details of these installations are awaiting to be confirmed and will be updated once AGS data becomes available. The availability of existing baseline data at the time of the report delivery is described below.

Other additional monitoring - Survey Request Forms (SuRF)

4.2.4 In addition to the monitoring undertaken as part of the GI Specification, SCS provides instructions to the groundwater monitoring subcontractor in the form of Survey Request Forms (SuRFs). A variety of SuRFs have been generated across the S1 and S2 alignments. Note that this plan is intended to supersede all previous groundwater monitoring related SuRFs. However, future SuRFs may be generated as interim documents as needed prior to the next iteration of this monitoring plan. Thus, care should be applied to ensure that the current groundwater monitoring requirement are being implemented by the subcontractor. SCS and

Design House should be consulted as needed to ensure that the monitoring plan is being correctly implemented as needed.

4.2.5 SuRFs available at the time of this issue have been included in the references section of this plan.

Designer Monitoring Plans (DMPs) for Geotechnical Monitoring During Constructions

4.2.6 This groundwater monitoring plan is intended to cover monitoring to establish baseline conditions for both compliance to environmental requirements and to support geotechnical design. Construction and post-construction monitoring for environmental compliance are also within the scope of this monitoring plan. However, **groundwater monitoring to support geotechnical design during construction is excluded from this plan. Details on groundwater monitoring requirements to support geotechnical design during construction are documented in asset specific Designer Monitoring Plans (DMPs).**[1]

Project Manager's Instruction PMI- 104

4.2.7 In addition to the above, SCS received a Project Manager's Instruction which transfers scope from the Area South GI Framework Package to the MWCC Contractor (until December 2019) to close out the outstanding monitoring which was not completed within the (EST and South Package A packages of GI).

4.2.8 The Post-field work Monitoring scope includes the following elements:

- Return visit to site following completion of field work to take readings in or recover samples from installations.
- Subsequent monthly visits when locations on Hampstead Road (ML000-RC014 & ML000-RC036) are not monitored.
- Subsequent 3 monthly visits when locations on Hampstead Road (ML000-RC014 & ML000-RC036) are monitored.
- Traffic safety and Management- all works associated with future Post-field work monitoring- Visits only.

4.2.9 Note that at this time, given the start or impending start of construction, PMI-104 is assumed to no longer be relevant and has been superseded by this groundwater monitoring plan.

[1] Note that for geotechnical specific construction monitoring please refer to asset specific DMPs which are not referenced in this plan, since this plan is primarily related to compliance with regulatory requirements.

4.3 Basis for selection

4.3.1 In this latest groundwater monitoring plan, monitoring for both groundwater level and/or groundwater quality monitoring are proposed and will be performed in accordance with HS2 Water Resources and Flood Risk Monitoring Technical Standard [R15], and consultations with HS2, EA and Affinity Water. Note that geotechnical monitoring during construction is addressed separately in asset specific Designer Monitoring Plan (DMPs) as noted above.

4.3.2 Lot S1 and S2 areas which require ongoing groundwater monitoring have been selected based on the following criteria:

- Construction of S1 & S2 assets which require groundwater control due to intersection with the Lower Aquifer (i.e. the Upnor and/or Chalk Formations) or vicinity to the Lower Aquifer;
- Construction of S1 & S2 assets which require groundwater control due to the presence of sand channels within the Lambeth Group;
- The asset is located overlying a Source Protection Zone 1 or 2 (SPZ 1 or SPZ 2). Note that the West Ruislip Area is located within SPZ1 associated with an Affinity Water abstraction well (referred to by Affinity Water as the 'Ickenham Well'). The Ickenham Well it is considered an indirect receptor, where the direct receptor is the Lower Aquifer within the Chalk Formation. Note that requests for information have been sent to the Local Authorities if there are licensed private abstraction wells that may also affect the HS2 alignment. At the time of this document, no response has been received.
- To maintain baseline compliance with EA regulations for consent purposes - Ruislip Northern and Southern Sustainable Placement areas or at locations where piling/cutting into the Chalk Formation occurs;
- To provide further insight and help inform design in certain areas, such as at Euston Park Village East (PVE) wall and Granby Terrace Bridge (GTB); and

4.3.3 In several locations, groundwater quality samples have been requested to establish groundwater chemistry for discharge or other purposes.

4.3.4 As noted in the Water Resources and Flood Risk Monitoring Technical Standard [R15], monitoring shall be considered during the following phases:

- Pre-baseline (assumed to be completed at this stage of the project),
- Pre-construction/baseline (which is nearly completed or has been completed),
- Construction, and
- Post-construction.

4.3.5 This monitoring plan has been updated from earlier revisions which dealt only with the pre-construction/baseline phases for the assets indicated above. **This current iteration primarily deals construction phase. Whilst the specified monitoring is considered to be appropriate for post-construction monitoring, the plan should be reviewed following commissioning**. In particular, a plan to conclude groundwater monitoring should be developed. For the purpose of this document, groundwater monitoring is assumed to continue for two years following post construction in line with HS2 guidance. Where practicable, reduction of this monitoring period will be agreed with the EA and its stakeholders. For portions of the alignment which fall within the Asset Protection and Monitoring Agreement (APA) between Affinity Water Limited (AfW) and HS2 Limited [R43], post construction monitoring will continue until its conclusion is agreed with AfW and HS2.

4.3.6 As part of the evolution of this project, there may be a variety of reasons where this monitoring plan needs to be adjusted including during construction and post-construction. Where appropriate, future monitoring plans (whether site-specific or as a revision to this total alignment plan) shall take precedence and supersede the proposed groundwater monitoring plan provided in this document.

4.4 Compliance with HS2 Technical Standards

Water Framework Directive (WFD) Assessments

4.4.1 The Water Framework Directive (WFD) aims to protect and enhance the quality of the water environment across all European Union (EU) member states.

4.4.2 In the WFD assessments, the potential impacts from the Scheme elements have been colour coded according to their potential effect on the WFD status class, as indicated in Table 3. This colour coding is used in the Decision Trees to indicate the likely need for monitoring for each scheme element [R15].

Table 3: Colour coding used in WFD stats risk screening tables

Impact Type	
Dark blue	Impacts when taken on their own have the potential to lead to significant improvement
Light blue	Impacts when taken on their own have the potential to lead to minor localised or temporary improvement
Green	No measurable change to any quality elements
Yellow	Impacts when taken on their own have the potential to lead to minor localised or temporary effect
Amber	Impacts when taken on their own have the potential to lead to widespread or prolonged effect

Impact Type	
Red	Impacts when taken on their own have the potential to lead to widespread or prolonged effect even with mitigation in place

4.4.3 Part 1 of the 'Groundwater Decision Tree' was used to evaluate whether groundwater level and/or groundwater quality monitoring is needed, with reference to the route wide WFD risk assessments and the Community Forum Area (CFA) Community Area (CA) site-specific water resource assessments. Details of the decision tree phase is documented in the Water Resources and Flood Risk Monitoring Technical Standard [R15].

4.4.4 WFD scale impacts are evaluated by the following questions:

- Q1: Which WFD Groundwater (GW) bodies are affected by the scheme element(s)?
- Q2: Identify the most up to date assessments for each scheme element which affects a groundwater body. Are more detailed assessments required for one for more of the following reasons?
- Q3: For each scheme element, what impact type / effect type combinations have been identified in the most up to date WFD status risk screening tables?

4.4.5 Based on the Groundwater Decision Tree, only assets with permanent potential impacts are considered relevant for compliance with the WFD. These assets are the Northern and Southern Sustainable Placement Areas (RNSP, RSSP) where landfills will be generated, and the Lower Aquifer lies underneath.

4.4.6 Table 4 summarises the recommended monitoring requirements for the assets along S1 and S2 based on impact / effect type combinations, adopted from the HS2 Water Resources and Flood Risk Monitoring Technical Standard [R29]. The monitoring sheets requirements are presented in Table 6.

Table 4: WFD Scale Impact Assessment for S1 and S2 Assets

Site / Asset	Q1: Affected groundwater Body	Q2: Why is assessment needed?	Q3: Identified impact / effect type combinations			
			De-watering	Damming	Pathway	Contamination
Ruislip Northern Sustainable Placement	Lower Aquifer	Consenting				
Ruislip Southern Sustainable Placement	Lower Aquifer	Consenting				
Copthall Tunnel	Lower Aquifer	No need				
West Ruislip Area Structures	Lower Aquifer	No need				
West Ruislip Portal (WRP)	Lower Aquifer	No need				
WRP to South Ruislip (SR) Ventilation Shaft	Lower Aquifer	No need				

Site / Asset	Q1: Affected groundwater Body	Q2: Why is assessment needed?	Q3: Identified impact / effect type combinations			
			De-watering	Damming	Pathway	Contamination
SR	Lower Aquifer	No need				
SR to Mandeville Road (MDR) Ventilation Shaft	Lower Aquifer	No need				
MDR	Lower Aquifer	No need				
MDR to Greenpark Way (GPW) Ventilation Shaft	Lower Aquifer	No need				
GPW	Lower Aquifer	No need				
GPW to Westgate Ventilation Shaft	Lower Aquifer	No need				
Westgate Ventilation Shaft	Lower Aquifer	No need				
Victoria Road Crossover Box	Upper Aquifer	No need				
Atlas Road Logistics Tunnel	Upper Aquifer	No need				
Old Oak Common to Canterbury Works Ventilation Shaft	Upper Aquifer	No need				
Canterbury Works Ventilation Shaft	Upper Aquifer	No need				
Adelaide Road Ventilation Shaft	Upper Aquifer	No need				
Euston Approach	Upper Aquifer / Lower Aquifer	No need				

Note: Refer to Table 6 for colour coding definitions.

Site-specific water resources assessments

4.4.7 Similarly, Part 2 of the 'Groundwater Decision Tree' was also used to identify monitoring requirements based on site scale impacts (SSI).

4.4.8 Site scale impacts (SSI) are evaluated by the following questions:

- Q4: For each scheme element, does it have a magnitude of impact with no mitigation for any groundwater receptor of greater than 'Negligible' in the appropriate ES CFA potential impact summary table and/or greater than 'very low' in any subsequent assessment?
- Q5: What type of impact on the groundwater receptor(s) has been identified?

4.4.9 Table 5 summarises the recommended monitoring requirements for scheme element based on impact type, adopted from HS2 Water Resources and Flood Risk Monitoring Technical Standard [R29]. The monitoring advisory sheets requirements are presented in Table 6.

Table 5: Site Scale Impact Assessment for S1 and S2 Assets

Site / Asset	Q4: CFA impact > 'Negligible'?	Q5: Identified Impact Type			
		Dewatering	Damming	Pathway	Contamination
Ruislip Northern Sustainable Placement	Yes			GW2	GW2
Ruislip Southern Sustainable Placement	Yes			GW2	GW2
Copthall Tunnel	Yes			GW2	GW2
West Ruislip Area Structures	Yes			GW2	GW2
West Ruislip Portal (WRP)	Yes	GW1		GW2	GW2
WRP to South Ruislip (SR) Ventilation Shaft	Yes	GW1		GW2	GW2
SR	Yes	GW1		GW2	GW2
SR to Mandeville Road (MDR) Ventilation Shaft	Yes	GW1		GW2	GW2
MDR	Yes	GW1		GW2	GW2
MDR to Greenpark Way (GPW) Ventilation Shaft	Yes	GW1		GW2	GW2
GPW	Yes	GW1		GW2	GW2
GPW to Westgate Ventilation Shaft	Yes	GW1		GW2	GW2
Westgate Ventilation Shaft	Yes				
Victoria Road Crossover Box	Yes				
Atlas Road Logistics Tunnel	Yes				
Canterbury Works Ventilation Shaft to Old Oak Common	Yes				
Canterbury Works Ventilation Shaft	Yes				
Adelaide Road Ventilation Shaft	Yes				
Euston Approach	Yes	GW1	GW1	GW2	GW2

Notes:
1. Refer to Table 6 for colour coding definitions.
2. Whilst there is an identified guidance for monitoring at Westgate Ventilation Shaft, as indicated in the groundwater risk assessment, no groundwater monitoring is required for environmental compliance purposes.

Monitoring advisory sheets

4.4.10 Following the 'Groundwater Decision Tree', the relevant Groundwater Monitoring Advisory Sheets were identified with reference to Table 6.

Table 6: Monitoring advisory sheet requirements

WFD classification element category	Impact type	Effect type			
		GREEN	YELLOW	AMBER	RED
Quantitative	Dewatering	No specific WFD GW Monitoring required. Adhere to CoCP	Advisory Sheet GW3	Advisory Sheet GW1	Consult with EA directly
	Damming				

WFD classification element category	Impact type	Effect type			
		GREEN	YELLOW	AMBER	RED
Chemical	Pathways			Advisory Sheet GW2	
	Contamination				

4.4.11 The recommendations in the Advisory Sheets were used to help compile the Groundwater Monitoring Plan for the assets along S1 and S2. The relevant Advisory Sheet(s) for each asset is presented in Table 7.

Table 7: Advisory Sheet relevant to assets along S1 and S2

Site / Asset	Groundwater Advisory Sheets			
	GW1	GW2	GW3	EA
Ruislip Northern Sustainable Placement		✓		Consulted
Ruislip Southern Sustainable Placement		✓		Consulted
Copthall Tunnel		✓		
West Ruislip Area Structures		✓		
West Ruislip Portal (WRP)	✓	✓		
WRP to South Ruislip (SR) Ventilation Shaft	✓	✓		
SR	✓	✓		
SR to Mandeville Road (MDR) Ventilation Shaft	✓	✓		
MDR	✓	✓		
MDR to Greenpark Way (GPW) Ventilation Shaft	✓	✓		
GPW	✓	✓		
GPW to Westgate Ventilation Shaft	✓	✓		
Westgate Ventilation Shaft				
Victoria Road Crossover Box				
Atlas Road Logistics Tunnel				
Canterbury Works Ventilation Shaft to Old Oak Common				
Canterbury Works Ventilation Shaft				
Adelaide Road Ventilation Shaft				
Euston Approach	✓	✓		
Note: Whilst there is an identified guidance for monitoring at Westgate Ventilation Shaft, as indicated in the groundwater risk assessment [R74], no groundwater monitoring is required for environmental compliance purposes.				

Application of methodology and deviations from Advisory Sheets

4.4.12 An extract of the relevant Groundwater Advisory Sheets GW1 and GW2 from the HS2 Water Resources and Flood Risk Monitoring Technical Standard [R15] is presented in Table 8 and Table 9 respectively. The application of the Advisory Sheets to S1 and S2 assets is summarised in Table 10. Details of the monitoring locations and requirements are presented in Appendix C.

4.4.13 The details of the risk evaluation are described below. The following sections also identify monitoring requirements and provide the basis for monitoring.

4.4.14 To the extent practicable, a minimum of one upgradient and two downgradient monitoring locations have been selected. However, where groundwater gradients are slight to negligible, there will be a minimum of one monitoring point between the asset and each nearby identified receptor (as laid out in the associated site-specific groundwater risk assessment).

4.4.15 As part of the evolution of this project, there may be a variety of reasons where this monitoring plan needs to be adjusted including during construction and post-construction. Where appropriate, future monitoring plans (whether site-specific or as a revision to this total alignment plan) shall take precedence and supersede the proposed groundwater monitoring plan provided in this document.

4.4.16 There will be specific activities which will require deviations from this plan such as when dewatering and groundwater control measures are detailed. When these activities are developed, the site-specific monitoring plans will be developed in line with HS2 guidance as well as once a dewatering contractor has been procured by SCS.

Table 8: Advisory Sheet GW1 [Extract from R15]

RECEPTOR	WHAT?	PHASE	Baseline (Pre-construction)			Construction			Operational (post-construction)			Agreed Monitoring with EA
		HOW?	WHERE?	WHEN?	Duration	WHERE?	WHEN?	Duration	WHERE?	WHEN?	Duration	
		Method	Locations	Frequency		Locations	Frequency		Locations	Frequency		
Disturbed aquifer(s) (i.e. dewatered, dammed, connected to other aquifers)	GW level	*Standard monitoring*										
		Logger measurements *Dips*	*Minimum of 3x monitoring boreholes in each disturbed aquifer - one up and two down hydraulic gradient of the disturbance including at least one between disturbed zone and each flagged receptor in the ES*	*Hourly* *Monthly*	*Minimum 12 months*	*As baseline*	*Hourly* *Weekly during any active construction operations*	*Throughout construction phase*	*As baseline*	*Hourly* *Monthly*	*2 years post construction unless agreed otherwise with EA*	
		Additional monitoring if dewatering operations taking place										
		Logger measurements *Dips*	*At least 3x monitoring boreholes per pumping well where dewatering taking place - one up and two down (background) hydraulic gradient of the pumping well at different radial distances*	*Hourly* *Monthly*	*Minimum 12 months*	*As baseline*	*Hourly* *Weekly during any dewatering operations*	*Throughout construction phase*	*As baseline*	*Hourly* *Monthly*	*2 years post construction unless agreed otherwise with EA*	
	Abstraction rate	*Flow meter*	*pumping well*	*Hourly*			*Hourly*			*Hourly*		

Table 9: Advisory Sheet GW2 [Extract from R15]

RECEPTOR	WHAT?	PHASE	Baseline (Pre-construction)			Construction			Operational (post-construction)			Agreed Monitoring with EA
		HOW?	WHERE?	WHEN?	Duration	WHERE? Locations	WHEN?	Duration	WHERE? Locations	WHEN? Frequency	Duration[7]	
		Method	Locations	Frequency			Frequency					
Disturbed aquifer(s) (i.e. dewatered, dammed, connected to other aquifers, exposed to potential contaminants)	*Standard monitoring where exposure to potential contaminants during construction*											
	GW level	*Dips*	*Minimum of 3x monitoring boreholes in each disturbed aquifer - one up and two down hydraulic gradient of the disturbance including at least one between disturbed zone and each flagged receptor in the ES*	*Monthly*	*Minimum 12 months*	*As baseline*	*Weekly*	*Throughout construction phase*	*As baseline*	*Monthly*	*2 years post construction unless agreed otherwise with EA*	
	GW quality	*Field measurements*										
		Samples (purged)		*Monthly (core suite), quarterly (full suite)*			*Weekly (core suite), monthly (full suite)*			*Monthly (core suite), quarterly (full suite)*		
		Visual (post purge)		*Monthly*			*Weekly*			*Monthly*		
	Additional monitoring if there are known sources of pre-existing poor quality or contaminated groundwater (e.g. landfill site, or elevated nitrate concentrations) in the disturbed aquifer(s)											
	GW level	*Dips*	*At least 1 x monitoring borehole between poor quality/contaminated GW and disturbance. At least 1 x monitoring borehole between poor quality / contaminated GW and each receptor*	*Monthly*	*Minimum 12 months*	*As baseline*	*Weekly*	*Throughout construction phase*	*As baseline*	*Monthly*	*2 years post construction unless agreed otherwise with EA*	
	GW quality	*Field measurements*										
		Samples (purged)		*Monthly (core suite), quarterly (full suite)*			*Weekly (core suite), monthly (full suite)*			*Monthly (core suite), quarterly (full suite)*		
		Visual (post purge)		*Monthly*			*Weekly*			*Monthly*		

Table 10: Application of the Advisory Sheets GW1 and GW2 relevant assets along S1 and S2

Advisory Sheet		Additional Baseline Monitoring		Borehole Status		Construction Monitoring		Post Construction Monitoring		Assets
GW1	GW2	Decommission	Retain	Decommission	Retain	Level	Quality	Level	Quality	
✓	✓	Monthly (Dip)	Monthly (core suite) & Monthly (full suite) *	✓		Not applicable	Not applicable	Not applicable	Not applicable	WRP, SR, MDR, GPW, CPs (III/IV), Euston Approach
✓	✓	Hourly (Logger) & Monthly (Dip)	Monthly (core suite) & Monthly (full suite) *		✓	Hourly (Logger) & Weekly (Dip) #	Weekly (core suite) & Monthly (full suite)	Hourly (Logger) & Monthly (Dip) #	Monthly (core suite) & Quarterly (full suite)	
✓		Hourly (Logger) & Monthly (Dip)	Not applicable	✓		Not applicable	Not applicable	Not applicable	Not applicable	Not applicable **
✓		Hourly (Logger) & Monthly (Dip)	Not applicable		✓	Hourly (Logger) & Weekly (Dip) #	Not applicable	Hourly (Logger) & Monthly (Dip) #	Not applicable	Not applicable **
	✓	Monthly (Dip)	Monthly (core suite) & Monthly (full suite) *	✓		Not applicable	Not applicable	Not applicable	Not applicable	RNSP, RSSP, Copthall Tunnel
	✓	Monthly (Dip)	Monthly (core suite) & Monthly (full suite) *		✓	Weekly (Dip)	Weekly (core suite) & Monthly (full suite)	Monthly (Dip)	Monthly (core suite) & Quarterly (full suite)	

Notes:
*For baseline monitoring, Advisory Sheet GW2 calls for monthly monitoring of the core suite and quarterly monitoring of full suite. The monthly (core suite and full suite) has been selected given the relatively short time period remaining prior to construction.
** As discussed in Section 4.19, while Westgate Ventilation Shaft has the potential to impact the shallow aquifer River Terrace Deposits, the construction methodology will use other measures rather than groundwater monitoring wells to manage impacts.
# Monthly (data collection) is recommended where hourly (logger) is specified.
CP - Cross-passages
GPW - Greenpark Way
MDR - Mandeville Road
RNSP - Ruislip Northern Sustainable Placement
SSSP - Ruislip Southern Sustainable Placement
SR - South Ruislip
WRA - West Ruislip Area
WRP - West Ruislip Portal

4.5 Compliance with the AfW/HS2 APA

4.5.1 The Asset Protection and Monitoring Agreement (APA) between Affinity Water (AfW) and High Speed 2 Limited (HS2) sets out requirements for the contractor regarding construction monitoring for Phase 1. Note that it is SCS's understanding that the APA is relevant from the northwestern edge of Lot S2 until around chainage 10+750 (i.e. around 750 m west of the Victoria road Crossover Box).

4.5.2 Specific requirements relevant to Groundwater Sources are summarised below. Further details on the specific language use to define these requirements are in Section 2 and Schedule 3 of the APA [R43]. In addition to the requirements described below, AfW requires a schedule of construction activities to be provided to allow AfW to manage its own resourcing and response. SCS will provide a construction schedule (i.e. a 'look-ahead') under separate cover.

Groundwater Monitoring Compliance Requirements

Baseline Monitoring: The APA requires baseline monitoring information to be based on 2 years of data prior to construction; and that baseline data is provided 6 months prior to construction.

- **SCS Plan**: The baseline monitoring reports are provided separately [R42 provides an example baseline report reference]. Baseline monitoring began in December 2016 providing nearly three years of groundwater levels and quality data. The report will define control and trigger levels for both groundwater levels and quality based on baseline conditions. The report will document any identified data gaps and propose measures to fill identified gaps.

Construction Monitoring Plan: The APA requires the construction monitoring plan to include the following components:

- Monitoring the quality of AW's Sources by reference to a list of determinants;

  SCS Plan: Groundwater quality monitoring is defined in Section 4, the monitoring specification is provided in Section 5, and the analytical suite is provided in Appendix A;

- Monitoring of any reduction in water levels and/or the quantity of water available for abstraction by AW at the Sources;

  SCS Plan: Groundwater level monitoring is defined in Section 4.

- Monitoring of any release (accidental and otherwise) of any Hazardous Substance including but not limited to any contaminative fluids;

  SCS Plan: An environmental management plan during construction is documented

separately which details methods for protection against releases of Hazardous Substances as well as monitoring [R44].

- Monitoring of any release of chalk particles as a result of excavation or any other activities during the construction of Phase 1 (including the Works) which may affect the turbidity of any Sources;

  SCS Plan: Groundwater quality monitoring during construction (as proposed in Section 5) is intended to monitor to identify local scale impacts to groundwater, including increases in turbidity.

- Monitoring of any mobilisation of any existing poor-quality water from any pre-existing sources of contamination;

  SCS Plan: Groundwater quality monitoring during construction (as proposed in Section 5) is intended to monitor to identify changes in groundwater quality due to mobilisation of any pre-existing sources of contamination;

- Monitoring of the creation of any new or enhanced pathways;

  SCS Plan: Groundwater level monitoring is defined in Section 4 and is intended to identify changes in local groundwater flow conditions.

- Addressing the number and location of proposed Monitoring Boreholes

  SCS Plan: Appendix B presents the proposed locations of monitoring boreholes and Appendix C provides a table of all proposed monitoring boreholes.

- Addressing the testing frequency and duration of monitoring of the proposed Monitoring Boreholes;

  SCS Plan: Appendix C provides a table of all proposed monitoring boreholes and identifies testing frequency during baseline, construction, and post-construction periods.

- Monitoring any change to the hydraulic flow regime around Monitoring Boreholes;

  SCS Plan: Groundwater level monitoring is defined in Section 4 and is intended to identify changes in local groundwater flow conditions.

- Addressing any other issues that AfW may notify to HS2 as an issue that should be included in the Draft Construction Monitoring Plan;

  SCS Plan: SCS intends to address issues identified by AfW, when comments are provided by AfW;

- Reporting the results of Monitoring to AW including format and frequency of reporting.

SCS Plan: Reporting is addressed in Section 5.4. A mechanism of data transmittal will be agreed with AfW (namely a method to electronically transfer data).

- Monthly Meetings: The APA requires monthly meetings with AfW and HS2 and its contractors.

  SCS Plan: SCS will arrange groundwater coordination meetings at a minimum of once per month with Affinity Water. SCS will ensure appropriate team members will attend the coordination meeting as needed and will identify a primary point of contact.

Exceedance Notification: Notification of control / trigger level exceedances and/or emerging trends leading to exceedances is required.

- **SCS Plan**: Control and trigger levels (selected in the Baseline Monitoring Reports [R42] provides an example) will be monitored in accordance with the monitoring frequency proposed in this Plan. Upon receipt of data indicating an exceedance, AfW will be notified within 5 working days via email and by any other method requested by AfW. Where trends are identified which indicate a control or trigger level will likely be exceeded, AfW will be notified of the measures intended to reverse the trend and stabilise conditions.

Mitigation Measures: Mitigation measures are required following control and trigger level exceedances.

- **SCS Plan**: As part of SCS's notification procedures following an exceedance, the proposed mitigation measure and implementation schedule will be included in the notification. As part of any mitigation measure, a reporting and communication plan will be included to ensure AfW is made aware of the outcome of the mitigation.

Risk Assessment: The APA requires that potential sources of Hazardous Substances are identified and assessed. The APA also requires that risks are assessed on an on-going basis.

- **SCS Plan**: Risk assessments are prepared during each design stage. The results of these risk assessments will form part of the asset construction plan. SCS has defined an internal requirement to assess risks on an on-going basis and to document any identified project risks during construction [R44]. Where identified risks result in a change to the findings of the asset risk assessment, AfW shall be notified as part of the SCS communication plan [R44]. As above, AfW will be notified via email and by any other method requested by AfW.

Other APA Compliance Requirements

4.5.3 Other APA compliance requirements relate to the following:

- **Ground movement and interruption to supply**: SCS has developed a register which defines construction related to existing assets and how issues will be managed and

mitigated. This is a living document which is updated regularly as SCS evolves its design and as well as through conversation with AfW [R45], [R46];

- **Leakage of AfW assets**: Leakage is also addressed separately in the same document register noted above and ongoing consultation with AfW [R45], [R46];
- **General legal compliance**: legal compliance will be as required in Schedule 3 of the APA [R43]; and
- **Post-Construction monitoring**: Post-construction monitoring compliance requirement to the APA will essentially be identical to the Construction-monitoring compliance requirements documented in this section.

4.6 Assets requiring monitoring along S1 and S2

4.6.1 Based on the selection criteria identified above, the following assets have been identified which require groundwater monitoring needs to be addressed (Figure 1 in Appendix B):

- Area West Assets (Sections 4.7 to 4.12):
  - Ruislip Northern Sustainable Placement (Figure 2 in Appendix B);
  - Ruislip Southern Sustainable Placement (Figure 2 in Appendix B);
  - Copthall Tunnel (Figure 2 in Appendix B);
  - West Ruislip Area Structures (including River Pinn Underbridge, Breakspear Road Underbridge, Great Crested New Pond, and West Ruislip Retained Embankment) (Figure 2 in Appendix B);
  - West Ruislip Portal (Figure 3 Figure 6in Appendix B);
  - Cross-passages and tunnels between West Ruislip Portal and South Ruislip Ventilation Shaft which will intersect or potentially impact the Lower Aquifer (Figure 4 in Appendix B);
- Area Central Assets (Sections 4.13 to 4.18):
  - South Ruislip Ventilation Shaft (Figure 5 in Appendix B);
  - Cross-passages and tunnels between South Ruislip Ventilation Shaft and Mandeville Road Ventilation Shaft which will intersect or potentially impact the Lower Aquifer (Figure 6Figure 9 in Appendix B);
  - Mandeville Road Ventilation Shaft (Figure 7 in Appendix B);
  - Cross-passages and tunnels between Mandeville Road Ventilation Shaft and Greenpark Way Ventilation Shaft which will intersect or potentially impact the Lower Aquifer (Figure 8 in Appendix B);

- Greenpark Way Ventilation Shaft (Figure 9 in Appendix B);
- Cross-passages and tunnels between Greenpark Way Ventilation Shaft and Westgate Ventilation Shaft (Figure 10 in Appendix B); and

- Area East Assets (Section 4.19):
  - Euston Approach (Figure 11 in Appendix B).

4.7 Ruislip Northern Sustainable Placement

Site Description

4.7.1 The Ruislip Northern Sustainable Placement (RNSP) area is located approximately 2.4km to the west of Ruislip with the centre of the area at an approximate location of 507104.4, 188401,5 (See Figure 2 in Appendix B).

4.7.2 The Ruislip Northern Sustainable Placement will be a permitted landfill which minimises the off-haul of excavated naturally occurring soil and potentially some tunnelling waste materials. The sustainable placements (shown in Figure 2 in Appendix B) are the onsite location for disposal of surplus excavated material to avoid causing environmental effects that would otherwise be associated with the offsite disposal of that material. Inert soils excavated from the nearby Copthall Tunnel area (shown in Figure 2 in Appendix B) will be placed onto this dedicated site.

4.7.3 More details are provided in the hydrogeological risk assessment (HRA) reports for the Ruislip Northern Sustainable Placement:

- Western Mound - Ruislip Northern Sustainable Placement S2 (HRA report document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL07-000035) [R47]
- Eastern Mound - Ruislip Northern Sustainable Placement S2 (HRA report document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL07-000036) [R48]

Summary of Identified Groundwater Risks

4.7.4 Potential WFD impacts have been identified at the Ruislip Northern Sustainable Placement due to the creation of potential pathways, and the potential migration of contaminants association with the Ruislip Northern Sustainable Placement. These potential impacts have also been carried forward as Site Scale Impact (SSI).

4.7.5 The potentially affected groundwater body is the Lower Aquifer, including an area overlying a SPZ-1. Assessment is required for consenting purposes with the EA.

4.7.6 For the Ruislip Northern Sustainable Placement, HS2 has agreed with the EA that the groundwater quality of the Lambeth Group / Sand Unit / Upnor Formation can be monitored as a surrogate for groundwater quality in the Lower Aquifer.

Summary of Baseline Monitoring

4.7.7 The HRAs [R47] [R48] covered the baseline monitoring details in the Ruislip Northern Sustainable Placement. As indicated in Table 10 and the conditions above, groundwater monitoring requirements from the GW2 Advisory Sheet are generally appropriate. Baseline monitoring is now largely complete with the impending start of construction.

Additional Proposed Baseline Monitoring

4.7.8 The completion of baseline monitoring is documented in the HRAs for the asset [R47] [R48].

Proposed Construction Monitoring

4.7.9 The number of proposed monitoring locations are based on the following factors:

- Nature of the identified risk (relatively low potential impacts given the placement of low permeability materials on top of existing naturally occurring low permeability materials),
- Current groundwater conditions (i.e. within a relatively low groundwater gradient), and
- Site constraints for the location of monitoring wells.

4.7.10 As indicated in Table 10, groundwater monitoring requirements from the GW2 Advisory Sheet are appropriate.

4.7.11 The proposed locations for groundwater level and quality monitoring during the construction stage are presented in Figure 2 in Appendix B and Appendix C.

Proposed Post Construction Monitoring

4.7.12 As indicated in Table 10, groundwater monitoring requirements from the GW2 Advisory Sheet are appropriate.

4.7.13 The proposed locations for groundwater level and quality monitoring during the post construction stage are presented in Figure 2 in Appendix B and Appendix C.

4.7.14 These recommendations should be reviewed as necessary and following commissioning. A plan to conclude groundwater monitoring (i.e. terminate the monitoring programme) should be developed and agreed with relevant stakeholders. For the purpose of this document, groundwater monitoring is assumed to continue for two years following construction of a structure or completion of land-filling, as in the case of the Sustainable Placements.

4.8 Ruislip Southern Sustainable Placement

Site Description

4.8.1 The Ruislip Southern Sustainable Placement (RSSP) will be a permitted landfill which minimises the off-haul of excavated naturally occurring soil and potentially some tunnelling waste materials (See Figure 2 in Appendix B).

4.8.2 A hydrogeological risk assessment (HRA) has been performed separately as part of the landfill permit application which provides additional details:

- Hydrogeological Risk Assessment (HRA) - Ruislip Southern Sustainable Placement S2 (Document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL07-000034) [R49]

Summary of Identified Groundwater Risks

4.8.3 Potential WFD impacts have been identified at the Ruislip Southern Sustainable Placement due to the creation of potential pathways, and the potential migration of contaminants association with the area. These potential impacts have also been carried forward as Site Scale Impact (SSI).

4.8.4 The potentially affected groundwater body is the Lower Aquifer. Assessment is required for consenting purposes with the EA.

4.8.5 For the Ruislip Southern Sustainable Placement, HS2 has agreed with the EA that the groundwater quality of Lambeth Group / Sand Unit / Upnor Formation can be monitored as a surrogate for groundwater quality in the Lower Aquifer.

Summary of Baseline Monitoring

4.8.6 The HRA [R49] covers the baseline monitoring details in the Ruislip Southern Sustainable Placement.

Proposed Additional Baseline Monitoring

4.8.7 As indicated in Table 10 and the conditions above, monitoring requirements from the GW2 advisory sheet are generally appropriate.

4.8.8 In addition to monitoring for compliance with HS2 technical standards for groundwater protection [R15], for consistency with the Ruislip Northern Sustainable Placement, the baseline groundwater monitoring requirements have been previously agreed with the EA.

4.8.9 The proposed locations and frequency for additional groundwater level and quality baseline monitoring are presented in Figure 2 in Appendix B and Appendix C.

Proposed Construction Monitoring

4.8.10 The number of proposed monitoring locations are based on the following factors:

- Nature of the identified risk (relatively low potential impacts given the relatively short duration of placement of low permeability materials on top of existing naturally occurring low permeability materials),
- Current groundwater conditions (i.e. within a relatively low groundwater gradient), and
- Site constraints for the location of monitoring wells.

4.8.11 As indicated in Table 10 and the conditions above, groundwater monitoring requirements from the GW2 Advisory Sheet are appropriate.

4.8.12 The proposed locations for groundwater level and quality monitoring during the construction stage are presented in Figure 2 in Appendix B and Appendix C.

Proposed Post Construction Monitoring

4.8.13 As indicated in Table 10, groundwater monitoring requirements from the GW2 Advisory Sheet are appropriate.

4.8.14 The proposed locations for groundwater level and quality monitoring during the post construction stage are presented in Figure 2 in Appendix B and Appendix C.

4.8.15 These recommendations should be reviewed as necessary and following commissioning. A plan to conclude groundwater monitoring (i.e. terminate the monitoring programme) should be developed and agreed with relevant stakeholders. For the purpose of this document, groundwater monitoring is assumed to continue for two years following project commissioning.

4.8.16 Note that as indicated in Figure 2Figure 3 in Appendix B, an SPZ-1 underlies the northern portion of the Ruislip Southern Sustainable Placement, but no mounds are planned to overlie the SPZ-1.

4.9 Copthall Tunnel

Site Description

4.9.1 The site is located in Ickenham, London Borough of Hillingdon, and extends from the cut/fill line at the west end of Gatemead Embankment (around Ch. 24+905) westwards to the re-aligned Harvil Road (around Ch 25+738 to 25+762) and the end of Lot S2 (around Ch. 25+805), which is the cut / fill line with the Colne Viaduct Embankment [R50] (See Figure 4 in Appendix B).

4.9.2 A detailed quantitative risk assessment (DQRA) has been performed for Copthall Tunnel which focuses on the impact of the tunnel construction method [R53]. A more general site-specific groundwater risk assessment has also been conducted (Document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL07-000025) [R51].

4.9.3 In the wider Copthall Tunnel area, a site-specific groundwater risk assessment has been conducted for Harvil Road Overbridge (over Chiltern Lines) [R52], Harvil Road Stream Underbridge [R103], Harvil Road General Highway Works [R106] and Gatemead Embankment [R105].

Relevant Construction Methods

4.9.4 Proposed construction methods which can potentially impact the Lower Aquifer are:

- The cut and cover methodology for tunnel construction; and
- Piling at Harvil Road Overbridge (Over Chiltern Lines) located at chainage around 25+610m to the southwest of Copthall Tunnel (see Figure 2 in Appendix B).

4.9.5 Separate risk assessments have been performed for each of these methods. A detailed quantitative risk assessment (DQRA) has been prepared for the tunnel [R107] and piling is addressed a Foundation Risk Assessment (FWRA) report [R53].

4.9.6 All piles associated with the Harvil Road OCL are currently planned to be constructed using continuous flight auger (CFA) methodology. For the Harvil Road OCL north abutment, there will be a total of 35 piles across the two wingwalls and further 19 piles for the abutment, all 1200mm in diameter, extending to 20 to 22m bgl. For the south abutment, the current design includes a total of 70, all 750mm diameter, extending to a depth of 25 to 30m bgl. Only the lower circa 5m of the piles will be within the Chalk Formation. The pile toe level is around +21.3 mOD. The majority will be in the overlying strata (predominantly London Clay and Lambeth Group). The current design does not include any grouting associated with piling, if grouting is included at a later stage this report will be reviewed and updated as required [R53].

4.9.7 HS2 have stated that in areas of higher groundwater sensitivity, the curing time of the concrete should take precedent over other considerations such as carbon savings, so as to ensure the minimisation of any potential temporary effects on groundwater quality [R53].

Summary of Identified Groundwater Risks

4.9.8 The Copthall Tunnel is a cut and cover tunnel, where material will be placed to construct the tunnel. However, as indicated in the DQRA [R107], no significant long-term impacts are considered to be present, thus no WFD related monitoring is required.

4.9.9 Short-term impacts may exist related to temporary works, thus only SSIs have been considered. Identified SSIs are related to the potential migration of contaminants during construction.

4.9.10 The potentially affected groundwater body is the Lower Aquifer, which is mostly within a SPZ-1. Monitoring is required to demonstrate no degradation to hydrogeological systems due to construction.

Summary of Baseline Monitoring

4.9.11 A groundwater baseline monitoring report for Copthall Tunnel is provided separately [Document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL07-000025] [R51].

Basis of Selected Groundwater Monitoring Installations

4.9.12 As indicated in the DQRA [R107] and the nearby West Ruislip Area baseline monitoring report [R42], the regional groundwater flow direction of the Chalk Aquifer is to the south / southeast. However, the local groundwater flow direction is west / northwest. This local contradiction to the regional flow direction may be a combination of local features such as a potential fault to the east of the tunnel. Further groundwater monitoring (as indicated below) will be used to confirm the local groundwater flow direction at the tunnel.

Proposed Additional Baseline Monitoring

4.9.13 No additional baseline monitoring is required.

Proposed Construction Monitoring

4.9.14 The number of proposed monitoring locations are based on the following factors:

- Nature of the identified risk (relatively low potential impacts given the limited nature of the piling works - relatively short duration),
- Current groundwater conditions (i.e., within a relatively low groundwater gradient), and
- Site constraints for the location of monitoring wells.

4.9.15 As indicated in Table 10 and the conditions above, groundwater monitoring requirements from the GW2 Advisory Sheet are appropriate.

4.9.16 The proposed locations for groundwater level and quality monitoring during the construction stage are presented in Figure 2 in Appendix B and Appendix C.

Proposed Post Construction Monitoring

4.9.17 As indicated in Table 10, groundwater monitoring requirements from the GW2 Advisory Sheet are appropriate. At the completion of construction and evaluation of monitoring results, the need for additional post-construction monitoring will be assessed.

4.9.18 The proposed locations for groundwater level and quality monitoring during the post construction stage are presented in Figure 2 in Appendix B and Appendix C.

4.9.19 These recommendations should be reviewed as necessary and following commissioning. A plan to conclude groundwater monitoring (i.e. terminate the monitoring programme) should be developed and agreed with relevant stakeholders. For the purpose of this document, groundwater monitoring is assumed to continue for two years following project commissioning.

4.10 West Ruislip Area Structures

Description of Structures

4.10.1 The West Ruislip Area contains several structures which overlie a SPZ-1 (See Figure 2 in Appendix B), including:

- Flood Compensation Area;
- River Pinn Underbridge;
- Breakspear Road Underbridge;
- Great Crested Newt Pond; and
- West Ruislip Retained Embankment.

4.10.2 A site-specific Groundwater Risk Assessment (GRA) has also been performed for the corresponding design element in the West Ruislip Area within Lot S2 of the 1MC04 Main Works project:

- 024-S1 River Pinn Underbridge S2 (GRA report document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL07-000019) [R55]
- 024-S2 Breakspear Road South Underbridge S2 (GRA report document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL07-000020) [R56]
- 024-L1 West Ruislip Retained Embankment S2 (GRA report document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL07-000021) [R34]

4.10.3 The only construction activity which may interact with the Lower Aquifer is related to piling works. As such, no long-term potential impacts are considered to be present, thus no WFD impacts have been identified.

Relevant Construction Methods

4.10.4 The only proposed relevant construction method which can potentially impact the Lower Aquifer will be piling at the identified structures. Details are documented in the Foundation Risk Assessment (FWRA) report [R40]. A summary is provided in Table 11 below:

4.10.5 At this design stage, piling generally includes the following:

- Drilling to the full depth of the pile using a support fluid (as identified in below);
- Installation of any reinforcement; and
- Displacement of the support fluid and completion of the pile with a cement-based grout.

4.10.6 In addition, limited groundwater depressurisation will be performed at the Great Crested Newt Pond. Groundwater monitoring will be performed at this location to characterise groundwater quality prior to discharge to the River Pinn.

Table 11: A summary of the proposed construction method involving piling [R40]

Site / Asset	Proposed Piling Descriptions			
	No. of piles	Pile toe level (MOD)	Support fluid	Terminating Geology
River Pinn Underbridge	43 24	+21.0 +18.5	None	More than 5 m into Chalk More than 5 m into Chalk
Breakspear Road South Underbridge	50	+23.3	None	More than 5 m into Chalk
West Ruislip Retained Embankment	41	+26.5	None	Around 1 to 2 m into Chalk
Note: There are two groups of piles being designed for the River Pinn Underbridge site (at the East Abutment and West Abutment areas)				

Summary of Identified Groundwater Risks

4.10.7 Short-term impacts may exist related to temporary works, thus only Site Scale Impacts SSIs have been considered. Identified SSIs are related to the potential migration of contaminants during piling as no depressurisation is expected in this area.

4.10.8 The potentially affected groundwater body is the Lower Aquifer, which is mostly within a SPZ-1. Monitoring is required to demonstrate no degradation to hydrogeological systems due to construction activities.

Summary of Baseline Monitoring

4.10.9 A groundwater monitoring report for West Ruislip Area is provided separately [Document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL07-000032] [R42]. Identified risks are related to subsurface construction (piling) that will interact with the Lower Aquifer.

Basis of Selected Groundwater Monitoring Installations

4.10.10 As indicated in the West Ruislip Area baseline monitoring report, the regional groundwater flow direction of the Chalk Aquifer is to the south / southeast. However, the local groundwater flow direction is west / northwest. This local contradiction to the regional flow direction may be a combination of local features such as a potential fault to the east of the tunnel. Further groundwater monitoring (as indicated below) will be used to confirm the local groundwater flow direction at in the area.

Proposed Additional Baseline Monitoring

4.10.11 No additional baseline monitoring is required.

Proposed Construction Monitoring

4.10.12 As indicated in the Foundation Works Risk Assessment [R40], the principal groundwater related risks are associated with piling works.

4.10.13 The number of proposed monitoring locations are based on the following factors:

- Nature of the identified risk (relatively low potential impacts given the limited nature of the piling works - relatively short duration),
- Current groundwater conditions (i.e. within a relatively low groundwater gradient), and
- Site constraints for the location of monitoring wells.

4.10.14 As indicated in Table 10, groundwater monitoring requirements from the GW2 Advisory Sheet are appropriate.

4.10.15 The proposed locations for groundwater level and quality monitoring during the construction stage are presented in Figure 2 in Appendix B and Appendix C.

Proposed Post Construction Monitoring

4.10.16 As indicated in Table 10, groundwater monitoring requirements from the GW2 Advisory Sheet are appropriate. At the completion of construction and evaluation of monitoring results, the need for additional post-construction monitoring will be assessed.

4.10.17 The proposed locations for groundwater level and quality monitoring during the post construction stage are presented in Figure 2 in Appendix B and Appendix C.

4.10.18 These recommendations should be reviewed as necessary and following commissioning. A plan to conclude groundwater monitoring (i.e. terminate the monitoring programme) should be developed and agreed with relevant stakeholders. For the purpose of this document, groundwater monitoring is assumed to continue for two years following project commissioning.

4.11 West Ruislip Portal

Site Description

4.11.1 The site is located in West Ruislip, London, at Grid Reference TQ081869 between HS2 chainage Ch. 023+500 and Ch. 023+980. The site is located on land which is currently occupied by a golf course in the north and railway land (the Marylebone to Aylesbury Line) in the south. The site location is shown in Figure 3 in Appendix B.

4.11.2 A detailed initial groundwater risk assessment has been conducted for West Ruislip Portal (Document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL07-000023) [R35].

Relevant Construction Methods

4.11.3 The only proposed relevant construction methods which can potentially impact the Lower Aquifer will be piling at the identified structures and dewatering to support portal construction. Details related to piling risk are documented in the Foundation Risk Assessment (FWRA) report [R41]. A summary is provided in Table 12 below. At this design stage, piling generally includes the following:

- Drilling to the full depth of the pile using a support fluid (as identified in Table 12); and
- Installation of any reinforcement; and
- Displacement of the support fluid and completion of the pile with a cement-based grout.

Table 12: A summary of the proposed construction method involving piling [R41]

Site / Asset	Proposed Piling Descriptions			
	No. of piles	Pile toe level (MOD)	Support fluid	Terminating Geology
West Ruislip Portal Retaining wall (contiguous piles)	226	Deepest +16.0	Bentonite	Around 1.5 m into Chalk
West Ruislip Portal piles (base slab piles)	42	Deepest +4.0	Bentonite	More than 5.0 m into Chalk

4.11.4 The dewatering requirements and design are ongoing and will be addressed separately, including monitoring requirements related to identified risks.

Summary of Identified Groundwater Risks

4.11.5 The West Ruislip Portal contains an excavation which extends into the Lambeth Group and is expected to have piling into the Lower Aquifer. As such, no long-term potential impacts are considered to be present, thus no WFD impacts have been identified.

4.11.1 Short-term impacts may exist related to temporary works, thus only SSIs have been considered. Temporary work that may affected groundwater includes piling works, depressurisation of London Clay and Lambeth Group, and dewatering of the Chalk aquifer. The identified SSIs are related to the potential migration of contaminants during piling and geotechnical impacts during limited depressurisation of sandier lenses within the Lambeth Group. Requirements from discharge are documented in the Surface Water Monitoring Plan S1 & S2 [Document No. 1MC03-SCJ-EV-PLN-S001-000029] [R102].

4.11.2 The potentially affected groundwater bodies are the Lower Aquifer and sandier lenses within the Lambeth Group. Monitoring is required to demonstrate no degradation to hydrogeological systems due to construction and no potential geotechnical impacts from depressurisation.

Summary of Baseline Monitoring

4.11.3 Groundwater baseline monitoring report for West Ruislip Area is provided separately (Document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL07-000032) [R42].

Basis of Selected Groundwater Monitoring Installations

4.11.4 As indicated in the West Ruislip Area baseline monitoring report, the regional groundwater flow direction of the Chalk Aquifer is to the south / southeast. However, the local groundwater flow direction is west / northwest. This local contradiction to the regional flow direction may be a combination of local features such as a potential fault to the east of the portal. Further groundwater monitoring (as indicated below) will be used to confirm the local groundwater flow direction at the tunnel. During portal construction limited depressurisation is expected within the Chalk formation resulting in a temporary change in flow direction towards the portal.

Proposed Additional Baseline Monitoring

4.11.5 No additional baseline monitoring is required.

Proposed Construction Monitoring

4.11.6 As indicated in the Foundation Works Risk Assessment [R40], the principal groundwater related risks are associated with piling works and groundwater control during construction (i.e. depressurisation). In line with Table 10, a minimum of three monitoring installations have been selected to be monitored during construction activities. In addition, groundwater monitoring during construction will be reviewed and revised as needed once a specialist dewatering contractor has been procured by SCS.

4.11.7 The number of proposed monitoring locations are based on the following factors:

- Nature of the identified risk (relatively low potential impacts given the limited nature of the piling works - relatively short duration),
- Current groundwater conditions (i.e. within a relatively low groundwater gradient), and
- Site constraints for the location of monitoring wells.

4.11.8 As indicated in Table 10, groundwater monitoring requirements from GW1 and GW2 Advisory Sheet are appropriate.

4.11.9 Thames Water and Affinity Water have monitoring installations within the Lambeth Group which typically include sand lenses towards the bottom of the Lambeth Group. Since these installations are not targeting the Lower Aquifer or are at the base of the Lambeth Group, they are not considered appropriate for monitoring of the Lower Aquifer.

4.11.10 Specific dewatering related monitoring has not yet been developed given that the dewatering design is still underway. Dewatering monitoring will need to be added to monitoring

requirements once the dewatering design has been developed. This dewatering related monitoring may also need to include groundwater quality monitoring, depending on the construction methods. For these reasons, monitoring related to dewatering activities will be addressed separately after a dewatering subcontractor has been procured.

4.11.11 The proposed locations and frequency for groundwater level and quality monitoring during the construction stage are presented in Figure 3 in Appendix B and Appendix C.

Proposed Post Construction Monitoring

4.11.12 As indicated in Table 10, groundwater monitoring requirements from the GW1 and GW2 Advisory Sheet are appropriate. At the completion of construction and evaluation of monitoring results, the need for additional post construction monitoring will be assessed.

4.11.13 The proposed locations for groundwater level and quality monitoring during the post construction stage are presented in Figure 3 in Appendix B and Appendix C.

4.11.14 These recommendations should be reviewed as necessary and following commissioning. A plan to conclude groundwater monitoring (i.e. terminate the monitoring programme) should be developed and agreed with relevant stakeholders. For the purpose of this document, groundwater monitoring is assumed to continue for two years following project commissioning.

4.12 Cross Passage Monitoring between West Ruislip Portal to South Ruislip Ventilation Shaft

Site Description

4.12.1 Along this portion of the alignment, two subsurface tunnels will be constructed using tunnel boring machines (TBMs). Cross passages (CPs) will connect the two tunnels and will be constructed using mining techniques.

4.12.2 Six cross passages (CP29 to CP34) are planned between the West Ruislip Portal and South Ruislip Ventilation Shaft which are likely to be require groundwater control (see Figure 4 in Appendix B). The cross-passage classification is defined in detail with respect to groundwater control requirements in 'Review of Hydrogeology Relevant to Shafts and Cross-Passages at S2. Document No. 1MC04-SCJ-GT-REP-SS05_SL06-000009' [R24].

4.12.3 A detailed groundwater risk assessment for the cross-passages of Northolt Tunnels West (Document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL06-000030) [R57] is provided separately.

Relevant Construction Methods

4.12.4 Distribution of the cross passages (CP) has been proposed based solely on spacing requirements. The constructability review of the cross passages at these locations will be undertaken during TBM Part 2 design phase [R58]. These cross passages will require

depressurisation in the Lambeth Group and dewatering of the Lower Aquifer to enable construction.

Summary of Identified Groundwater Risks

4.12.5 Although minor damming of the Lower Aquifer can occur because of the cross-passage construction, the overall impact is not any greater than the presence of the tunnels. Therefore, no long-term potential impacts are considered to be present, thus no WFD impacts have been identified.

4.12.6 Short-term impacts may exist related to temporary works, thus only SSIs have been considered. Identified SSIs are related geotechnical impacts during limited depressurisation of sandier lenses within the Lambeth Group and depressurisation of the Lower Aquifer.

4.12.7 The potentially affected groundwater bodies are the Lower Aquifer and sandier lenses within the Lambeth Group. Groundwater monitoring is required to demonstrate no potential geotechnical impacts from depressurisation/dewatering. Note that pathways and contamination have been excluded from consideration as no additional impacts have been identified above normal tunnelling activities.

Summary of Baseline Monitoring

4.12.8 Groundwater baseline monitoring Report for the cross passages of Northolt Tunnels West is provided separately [Document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL06-000050] [R59].

Proposed Additional Baseline Monitoring

4.12.9 As indicated in Table 10 and the conditions above, groundwater monitoring requirements from the GW1 and GW2 Advisory Sheets are generally appropriate.

4.12.10 Specific dewatering related monitoring has not yet been developed given that the dewatering design is still underway. Dewatering monitoring will need to be added to monitoring requirements once the dewatering design has been defined. This dewatering related monitoring may also need to include groundwater quality monitoring, depending on the construction methods. For these reasons, monitoring related to dewatering activities will be addressed separately after a dewatering subcontractor has been procured.

4.12.11 The proposed locations and frequency for additional groundwater level and quality baseline monitoring locations are presented in Figure 4 in Appendix B and Appendix C.

Proposed Construction Monitoring

4.12.12 The number of proposed monitoring locations are based on the following factors:

- Nature of the identified risk (relatively low potential impacts given the limited nature of the piling works - relatively short duration),
- Current groundwater conditions (i.e., within a relatively low groundwater gradient), and

- Site constraints for the location of monitoring wells.

4.12.13 As indicated in Table 10, groundwater monitoring requirements from GW1 and GW2 Advisory Sheet are appropriate.

4.12.14 The proposed locations and frequency for groundwater level and quality monitoring during the construction stage are presented in Figure 4 in Appendix B and Appendix C.

Proposed Post Construction Monitoring

4.12.15 As indicated in Table 10, groundwater monitoring requirements from the GW1 and GW2 Advisory Sheets are appropriate.

4.12.16 The proposed locations for groundwater level and quality monitoring during the post construction stage are presented in Figure 4Figure 7 in Appendix B and Appendix C.

4.12.17 These recommendations should be reviewed as necessary and following commissioning. A plan to conclude groundwater monitoring (i.e. terminate the monitoring programme) should be developed and agreed with relevant stakeholders. For the purpose of this document, groundwater monitoring is assumed to continue for two years following project commissioning.

4.13 South Ruislip Ventilation Shaft

Site Description

4.13.1 The South Ruislip Vent shaft is located in the London Borough of Hillingdon, at Northolt tunnels, around Ch 20+771.2 to 20+783.5 (upline) and Ch 20+744.2 (downline) in Lot S2. The centre of satellite shaft is around 20+726.2 (downline chainage) [R61] (See Figure 5 in Appendix B). It comprises the following elements:

- South Ruislip Vent Shaft; and
- South Ruislip Vent Shaft Headhouse

4.13.2 A detailed initial groundwater risk assessment has been conducted for South Ruislip Ventilation Shaft (Document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL06-000027) [R62].

Relevant Construction Methods

4.13.3 Two ventilation shafts are planned at the South Ruislip site. These shafts will require depressurisation in the Lambeth Group and limited dewatering of Lower Aquifer to enable construction. A diaphragm wall will be used to reduce inflows and impacts outside of the shafts. The groundwater risk assessment (GRA) for South Ruislip [R62] provides more details on the construction sequence.

Summary of Identified Groundwater Risks

4.13.4 Grout treatments will also form part of the groundwater control solution for the Lower Aquifer. No long-term potential impacts are considered to be present, thus no WFD impacts have been identified.

4.13.5 Short-term impacts may exist related to temporary works, thus only SSIs have been considered. Identified SSIs are related geotechnical impacts during limited depressurisation of sandier lenses within the Lambeth Group and dewatering of the Lower Aquifer.

4.13.6 The potentially affected groundwater bodies are the Lower Aquifer and sandier lenses within the Lambeth Group. Monitoring is required to demonstrate no potential geotechnical impacts from depressurisation. Given the use of grouting treatments and the top down method of shaft construction, pathways and contamination impacts are considered to be relevant.

Summary of Baseline Monitoring

4.13.7 Groundwater baseline monitoring Report for South Ruislip Vent Shaft has been provided separately [Document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL06-000047] [R63].

Basis of Selected Groundwater Monitoring Installations

4.13.8 During temporary works, the local groundwater regime of the Lower Aquifer will be dominated by the dewatering to facilitate shaft construction. Thus, the local gradient will shift during temporary works towards the shafts. For the duration of construction, two chalk formation monitoring wells will be used to evaluate upgradient conditions, and dewatering wells will be used to evaluate downgradient conditions, in terms of water quality. Groundwater levels will similarly be monitored at these installations. Additional monitoring will also be performed prior to construction as indicated below.

4.13.9 Prior to dewatering, and during construction of the diaphragm wall (D-wall), bentonite and grouting will occur, which may potentially be released into the Chalk formation. During this period, the prevailing groundwater flow direction is to the southeast [R120], where ML020-RC401 and ML020-RC004 will act as upgradient monitoring installations and ML020-RC403 and ML020-RC108 will act as downgradient monitoring installations. In addition, and similar to the piling works at West Ruislip portal, the construction monitoring will be based on the use of support fluids and grout and monitoring the volumes added. This monitoring of support fluids /grout will be the principal method to evaluate whether construction methods will impact groundwater quality during D-wall construction.

Proposed Additional Baseline Monitoring

4.13.10 No additional baseline monitoring is required. Any replacement wells will adopt control and trigger levels associated with the former monitoring installation being replaced.

Proposed Construction Monitoring

4.13.11 The number of proposed monitoring locations are based on the following factors:

- Nature of the identified risk (relatively low potential impacts given the limited nature of the piling works - relatively short duration),
- Current groundwater conditions (i.e. within a relatively low groundwater gradient), and
- Site constraints for the location of monitoring wells.

4.13.12 As indicated in Table 10, groundwater monitoring requirements from GW1 and GW2 Advisory Sheets are appropriate.

4.13.13 The proposed locations and frequency for groundwater level and quality monitoring during the construction stage are presented in Figure 5 in Appendix B and Appendix C.

Proposed Post Construction Monitoring

4.13.14 As indicated in Table 10, groundwater monitoring requirements from the GW1 and GW2 Advisory Sheets are appropriate. At the completion of construction and evaluation of monitoring results, the need for additional post construction monitoring will be assessed.

4.13.15 The proposed locations for groundwater level and quality monitoring during the post construction stage are presented in Figure 5 in Appendix B and Appendix C.

4.13.16 These recommendations should be reviewed as necessary and following commissioning. A plan to conclude groundwater monitoring (i.e. terminate the monitoring programme) should be developed and agreed with relevant stakeholders. For the purpose of this document, groundwater monitoring is assumed to continue for two years following project commissioning.

4.14 Cross Passage Monitoring between South Ruislip Ventilation Shaft to Mandeville Road Ventilation Shaft

Site Description

4.14.1 Along this portion of the alignment, two subsurface tunnels will be constructed using tunnel boring machines (TBMs). Cross passages (CPs) will connect the two tunnels and will be constructed using mining techniques.

4.14.2 Eight cross passages (CP21 to CP28) are planned between the South Ruislip and Mandeville Road Ventilation Shafts which will require groundwater control [R24] (See Figure 5 to Figure 7 in Appendix B). The cross-passage classification is defined in detail with respect to groundwater control requirements in 'Review of Hydrogeology Relevant to Shafts and Cross-Passages at S2. Document No. 1MC04-SCJ-GT-REP-SS05_SL06-000009' [R24].

4.14.3 A detailed groundwater risk assessment for the cross passages of Northolt Tunnels West (Document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL06-000030) [R57] is provided separately.

Relevant Construction Methods

4.14.4 Distribution of the CPs has been proposed based solely on spacing requirements. The constructability review of the cross passages at these locations will be undertaken during TBM Part 2 design phase [R58]. These cross passages will likely require depressurisation in the Lambeth Group and dewatering of the Lower Aquifer to enable construction.

Summary of Identified Groundwater Risks

4.14.5 Although minor damming of the Lower Aquifer can occur because of the cross-passage construction, the overall impact is not any greater than the presence of the tunnels. Therefore, no long-term potential impacts are considered to be present, thus no WFD impacts have been identified.

4.14.6 Short-term impacts may exist related to temporary works, thus only SSIs have been considered. Identified SSIs are related geotechnical impacts during limited depressurisation of sandier lenses within the Lambeth Group and depressurisation of the Lower Aquifer.

4.14.7 The potentially affected groundwater bodies are the Lower Aquifer and sandier lenses within the Lambeth Group. Monitoring is required to demonstrate no potential geotechnical impacts from depressurisation/dewatering. Note that pathways and contamination have been excluded from consideration as no additional impacts have been identified above normal tunnelling activities.

Summary of Baseline Monitoring

4.14.8 Groundwater baseline monitoring Report for the cross passages of Northolt Tunnels West is provided separately [Document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL06-000050] [R59].

Proposed Additional Baseline Monitoring

4.14.9 As indicated in Table 10 and the conditions above, monitoring requirements from the GW1 and GW2 Advisory Sheets are generally appropriate.

4.14.10 Specific dewatering related monitoring has not yet been developed given that the dewatering design is still underway. Dewatering monitoring will need to be added to monitoring requirements once the dewatering design has been defined. This dewatering related monitoring may also need to include groundwater quality monitoring, depending on the construction methods. For these reasons, monitoring related to dewatering activities will be addressed separately after a dewatering subcontractor has been procured.

4.14.11 The proposed locations and monitoring frequency for additional groundwater level and quality baseline monitoring locations are presented in Figure 5 to Figure 7 in Appendix B and Appendix C.

Proposed Construction Monitoring

4.14.12 The number of proposed monitoring locations are based on the following factors:

- Nature of the identified risk (relatively low potential impacts given the limited nature of the piling works - relatively short duration),
- Current groundwater conditions (i.e. within a relatively low groundwater gradient), and
- Site constraints for the location of monitoring wells.

4.14.13 As indicated in Table 10, groundwater monitoring requirements from GW1 and GW2 Advisory Sheets are appropriate.

4.14.14 The proposed locations and frequency for groundwater level and quality monitoring during the construction stage are presented in Figure 5 to Figure 7 in Appendix B and Appendix C.

Proposed Post Construction Monitoring

4.14.15 As indicated in Table 10, groundwater monitoring requirements from the GW1 and GW2 Advisory Sheets are appropriate.

4.14.16 The proposed locations for groundwater level and quality monitoring during the post construction stage are presented in Figure 5 to Figure 7 in Appendix B and Appendix C.

4.14.17 These recommendations should be reviewed as necessary and following commissioning. A plan to conclude groundwater monitoring (i.e. terminate the monitoring programme) should be developed and agreed with relevant stakeholders. For the purpose of this document, groundwater monitoring is assumed to continue for two years following project commissioning.

4.15 Mandeville Road Ventilation Shaft

Site Description

4.15.1 The Mandeville Road Vent shaft is located in the London Borough of Ealing, at Northolt tunnels around 17+823.4 to 17+835.7 (upline) and Ch 17+798.1 (downline) in Lot S2. The centre of satellite shaft is around 17+817.60 (downline chainage) (See Figure 7 in Appendix B). It comprises the following elements [R64]:

- Mandeville Road Ventilation Shaft; and
- Mandeville Road Ventilation Shaft Headhouse

4.15.2 A detailed initial groundwater risk assessment has been conducted for Mandeville Road Ventilation Shaft (Document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL06-000028) [R65].

Relevant Construction Methods

4.15.3 Two ventilation shafts are planned at the Mandeville Road site. These shafts will require depressurisation in the Lambeth Group and limited dewatering of Lower Aquifer to enable construction. A grout curtain will be used to reduce inflows and impacts outside of the shafts.

The groundwater risk assessment (GRA) for Mandeville Road provides more details on the construction sequence.

Summary of Identified Groundwater Risks

4.15.4 Grout treatments will also form part of the groundwater control solution for the Lower Aquifer. No long-term potential impacts are considered to be present, thus no WFD impacts have been identified.

4.15.5 Short-term impacts may exist related to temporary works, thus only SSIs have been considered. Identified SSIs are related geotechnical impacts during limited depressurisation of sandier lenses within the Lambeth Group and dewatering of the Lower Aquifer.

4.15.6 The potentially affected groundwater bodies are the Lower Aquifer and sandier lenses within the Lambeth Group. Monitoring is required to demonstrate no potential geotechnical impacts from depressurisation. Given the use of grouting treatments and the top down method of shaft construction, pathways and contamination impacts are considered to be relevant.

4.15.7 The initial detailed groundwater risk assessment [R65] identifies the following risks:

- Groundwater discharge exceeds an acceptable rate;
- The scheme design grout curtain depth may not terminate deep enough into the Chalk formation;
- Constructing a sufficiently low permeability grout curtain may be difficult to achieve, particularly in areas where angled boreholes are required; and
- Developing a sufficiently robust depressurisation specific monitoring network will be challenging.

Summary of Baseline Monitoring

4.15.8 Groundwater baseline monitoring Report for Mandeville Road Ventilation Shaft has been provided separately [Document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL06-000048] [R66].

Basis of Selected Groundwater Monitoring Installations

4.15.9 During temporary works, the local groundwater regime of the Lower Aquifer will be dominated by the dewatering to facilitate shaft construction. Thus, the local gradient will shift during temporary works towards the shafts. For the duration of construction, two chalk formation monitoring wells will be used to evaluate upgradient conditions, and dewatering wells will be used to evaluate downgradient conditions, in terms of water quality. Groundwater levels will similarly be monitored at these installations. Additional monitoring will also be performed prior to construction as indicated below.

Proposed Additional Baseline Monitoring

4.15.10 No additional baseline monitoring is required. Any replacement wells will adopt control and trigger levels associated with the former monitoring installation being replaced.

Proposed Construction Monitoring

4.15.11 The number of proposed monitoring locations are based on the following factors:

- Nature of the identified risk (relatively low potential impacts given the limited nature of the piling works - relatively short duration),
- Current groundwater conditions (i.e. within a relatively low groundwater gradient), and
- Site constraints for the location of monitoring wells.

4.15.12 As indicated in Table 10, groundwater monitoring requirements from GW1 and GW2 Advisory Sheets are appropriate.

4.15.13 The proposed locations and frequency for groundwater level and quality monitoring during the construction stage are presented in Figure 7 in Appendix B and Appendix C.

Proposed Post Construction Monitoring

4.15.14 As indicated in Table 10, groundwater monitoring requirements from the GW1 and GW2 Advisory Sheets are appropriate. At the completion of construction and evaluation of monitoring results, the need for additional post-construction monitoring will be assessed.

4.15.15 The proposed locations for groundwater level and quality monitoring during the post construction stage are presented in Figure 7 in Appendix B and Appendix C.

4.15.16 These recommendations should be reviewed as necessary and following commissioning. A plan to conclude groundwater monitoring (i.e. terminate the monitoring programme) should be developed and agreed with relevant stakeholders. For the purpose of this document, groundwater monitoring is assumed to continue for two years following project commissioning.

4.16 Cross Passage Monitoring between Mandeville Road to Greenpark Way Ventilation Shaft

Site Description

4.16.1 Along this portion of the alignment, two subsurface tunnels will be constructed using tunnel boring machines (TBMs). Cross passages (CPs) will connect the two tunnels and will be constructed using mining techniques.

4.16.1 Five cross passages (CP16 to CP20) are planned between the Mandeville Road and Greenpark Way Ventilation Shafts which will require groundwater control [R24] (See Figure 8 in

Appendix B). The cross-passage classification is defined in detail with respect to groundwater control requirements in 'Review of Hydrogeology Relevant to Shafts and Cross-Passages at S2. Document No. 1MC04-SCJ-GT-REP-SS05_SL06-000009' [R24].

4.16.2 A detailed groundwater risk assessment has been conducted for the cross passages of Northolt Tunnels West (Document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL06-000030) [R57].

Relevant Construction Methods

4.16.3 Distribution of the CPs has been proposed based solely on spacing requirements. The constructability review of the cross passages at these locations will be undertaken during TBM Part 2 design phase [R58]. These cross passages will likely require depressurisation in both the Lambeth Group and Lower Aquifer to enable construction.

Summary of Identified Groundwater Risks

4.16.4 Although minor damming of the Lower Aquifer can occur because of the cross-passage construction, the overall impact is not any greater than the presence of the tunnels. Therefore, no long-term potential impacts are considered to be present, thus no WFD impacts have been identified.

4.16.5 Short-term impacts may exist related to temporary works, thus only SSIs have been considered. Identified SSIs are related geotechnical impacts during limited depressurisation of sandier lenses within the Lambeth Group and depressurisation of the Lower Aquifer.

4.16.6 The potentially affected groundwater bodies are the Lower Aquifer and sandier lenses within the Lambeth Group. Monitoring is required to demonstrate no potential geotechnical impacts from depressurisation. Note that pathways and contamination have been excluded from consideration as no additional impacts have been identified above normal tunnelling activities.

Summary of Baseline Monitoring

4.16.7 Groundwater baseline monitoring Report for the cross passages of Northolt Tunnels West is provided separately [Document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL06-000050] [R59].

Proposed Additional Baseline Monitoring

4.16.8 As indicated in Table 10 and the conditions above, monitoring requirements from the GW1 and GW2 Advisory Sheets are appropriate.

4.16.9 Specific dewatering related monitoring has not yet been developed given that the dewatering design is still underway. Dewatering monitoring will need to be added to monitoring requirements once the dewatering design has been defined. This dewatering related monitoring may also need to include groundwater quality monitoring, depending on the construction methods. For these reasons, monitoring related to dewatering activities will be addressed separately after a dewatering subcontractor has been procured.

4.16.10 The proposed locations and monitoring frequency for additional groundwater level and quality baseline monitoring locations are presented in Figure 8 in Appendix B and Appendix C.

Proposed Construction Monitoring

4.16.11 The number of proposed monitoring locations are based on the following factors:

- Nature of the identified risk (relatively low potential impacts given the limited nature of the piling works - relatively short duration),
- Current groundwater conditions (i.e. within a relatively low groundwater gradient), and
- Site constraints for the location of monitoring wells.

4.16.12 As indicated in Table 10, groundwater monitoring requirements from GW1 and GW2 Advisory Sheets are appropriate.

4.16.13 The proposed locations and frequency for groundwater level and quality monitoring during the construction stage are presented in Figure 8 in Appendix B and Appendix C.

Proposed Post Construction Monitoring

4.16.14 As indicated in Table 10, groundwater monitoring requirements from the GW1 and GW2 Advisory Sheets are appropriate.

4.16.15 The proposed locations for groundwater level and quality monitoring during the post construction stage are presented in Figure 8 in Appendix B and Appendix C.

4.16.16 These recommendations should be reviewed as necessary and following commissioning. A plan to conclude groundwater monitoring (i.e. terminate the monitoring programme) should be developed and agreed with relevant stakeholders. For the purpose of this document, groundwater monitoring is assumed to continue for two years following project commissioning.

4.17 Greenpark Way Ventilation Shaft

Site Description

4.17.1 The Greenpark Way (GPW) Ventilation Shaft is within the Greenpark Way Industrial area in the Borough of Ealing in west London, at Northolt tunnels around Ch. 15+635.00 to 15+647.30 (upline) and Ch. 15+622.35 to 15+633.85 (downline) in Lot S2. It comprises the following elements [R67] (See Figure 9 in Appendix B):

- Greenpark Way Ventilation Shaft; and
- Greenpark Way Ventilation Shaft Headhouse

4.17.2 A detailed initial groundwater risk assessment has been conducted for Greenpark Way Ventilation Shaft (Document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL06-000029) [R67].

Relevant Construction Methods

4.17.3 Two ventilation shafts are planned at the Greenpark Way site. These shafts will require depressurisation in the Lambeth Group and limited dewatering of Lower Aquifer to enable construction. A diaphragm wall will be used to reduce inflows and impacts outside of the shafts. The groundwater risk assessment (GRA) for Greenpark Way [R68] provides more details on the construction sequence.

Summary of Identified Groundwater Risks

4.17.4 Grout treatments will also form part of the groundwater control solution for the Lower Aquifer. No long-term potential impacts are considered to be present, thus no WFD impacts have been identified.

4.17.5 Short-term impacts may exist related to temporary works, thus only SSIs have been considered. Identified SSIs are related geotechnical impacts during limited depressurisation of sandier lenses within the Lambeth Group and dewatering of the Lower Aquifer.

4.17.6 The potentially affected groundwater bodies are the Lower Aquifer and sandier lenses within the Lambeth Group. Monitoring is required to demonstrate no potential geotechnical impacts from depressurisation. Given the use of grouting treatments and the top down method of shaft construction, pathways and contamination impacts are considered to be relevant.

4.17.7 The initial detailed groundwater risk assessment [R68] identifies the following risks:

- Groundwater discharge exceeds an acceptable rate;
- The scheme design grout curtain depth may not terminate deep enough into the Chalk Formation, and existing data may not be sufficient to select a reliable termination depth;
- Grout loss may occur into the Lower Aquifer;
- Constructing a sufficiently low permeability grout curtain may be difficult to achieve, particularly in areas where angled boreholes are required; and
- Developing a sufficiently robust dewatering specific monitoring network will be challenging.

Summary of Baseline Monitoring

4.17.8 Groundwater baseline monitoring Report for Greenpark Way Ventilation Shaft has been provided separately [Document No. 1MC04-SCJ_SDH-GT-REP-SS05_SL06-000049] [R69].

Basis of Selected Groundwater Monitoring Installations

4.17.9 During temporary works, the local groundwater regime of the Lower Aquifer will be dominated by the dewatering to facilitate shaft construction. Thus, the local gradient will shift during temporary works towards the shafts. For the duration of construction, one chalk

formation monitoring well will be used to evaluate upgradient conditions, and dewatering wells will be used to evaluate downgradient conditions, in terms of water quality. Groundwater levels will similarly be monitored at these installations.

4.17.10 Prior to dewatering, and during construction of the grout curtain, grouting will occur which may potentially be released into the Chalk formation. Similar to the piling works at West Ruislip portal, the construction monitoring will be based on the use of grout and monitoring of the volumes added. This monitoring of grout use will be the principal method to evaluate whether construction methods will impact groundwater quality during grout curtain construction. In addition, monitoring will continue at all available boreholes to evaluate changes in water quality / level. While the transmissivity is greater at Greenpark Way than other locations, the construction monitoring plan is considered to be appropriate for the following reasons:

- Monitoring of grout use is a direct method to evaluate loss of grout to the aquifer; and
- Existing monitoring locations provide two locations downgradient of the natural groundwater flow direction (to the Southeast).

4.17.11 Additional monitoring will also be performed prior to construction as indicated below.

Proposed Additional Baseline Monitoring

4.17.12 No additional baseline monitoring is required. Any replacement wells will adopt control and trigger levels associated with the former monitoring installation being replaced.

Proposed Construction Monitoring

4.17.13 The number of proposed monitoring locations are based on the following factors:

- Nature of the identified risk (relatively low potential impacts given the limited nature of the piling works - relatively short duration),
- Current groundwater conditions (i.e. within a relatively low groundwater gradient), and
- Site constraints for the location of monitoring wells.

4.17.14 As indicated in Table 10, groundwater monitoring requirements from GW1 and GW2 Advisory Sheets are appropriate.

4.17.15 The proposed locations and frequency for groundwater level and quality monitoring during the construction stage are presented in Figure 9 in Appendix B and Appendix C.

Proposed Post Construction Monitoring

4.17.16 As indicated in Table 10, groundwater monitoring requirements from the GW1 and GW2 Advisory Sheets are appropriate. At the completion of construction and evaluation of monitoring results, the need for additional post-construction monitoring will be assessed.

4.17.17 The proposed locations for groundwater level and quality monitoring during the post construction stage are presented in Figure 9 in Appendix B and Appendix C.

4.17.18 These recommendations should be reviewed as necessary and following commissioning. A plan to conclude groundwater monitoring (i.e. terminate the monitoring programme) should be developed and agreed with relevant stakeholders. For the purpose of this document, groundwater monitoring is assumed to continue for two years following project commissioning.

4.18 Cross Passage Monitoring between Greenpark Way Ventilation Shaft to Westgate Ventilation Shaft

Site Description

4.18.1 Along this portion of the alignment, two subsurface tunnels will be constructed using tunnel boring machines (TBMs). Cross passages (CPs) will connect the two tunnels and will be constructed using mining techniques.

4.18.2 With the exception of cross passage CP14 which may require depressurisation of the Lower Aquifer, Northolt Tunnels East cross passages between the Greenpark Way and Westgate Ventilation Shaft will not require depressurisation [R24] (See Figure 10 in Appendix B). The cross-passage classification is defined in detail with respect to groundwater control requirements in 'Review of Hydrogeology Relevant to Shafts and Cross-Passages at S2. Document No. 1MC04-SCJ-GT-REP-SS05_SL06-000009' [R24].

4.18.3 A groundwater risk assessment for the cross passages of Northolt Tunnels East is provided separately (Document No. 1MC04-SCJ_SDH-GT-REP-SS03_SL05-000017) [R70].

Relevant Construction Methods

4.18.4 Distribution of the CPs has been proposed based solely on spacing requirements. The constructability review of the cross passages at these locations will be undertaken during TBM Part 2 design phase [R71]. Cross passage CP14 will require depressurisation in both the Lambeth Group and Lower Aquifer to enable construction [R57].

Summary of Identified Groundwater Risks

4.18.5 Although minor damming of the Lower Aquifer can occur because of the cross-passage construction, the overall impact is not any greater than the presence of the tunnels. Therefore, no long-term potential impacts are considered to be present, thus no WFD impacts have been identified.

4.18.6 Short-term impacts may exist related to temporary works, thus only SSIs have been considered. Identified SSIs are related geotechnical impacts during limited depressurisation of sandier lenses within the Lambeth Group and depressurisation of the Lower Aquifer.

4.18.7 The potentially affected groundwater bodies are the Lower Aquifer and sandier lenses within the Lambeth Group. Monitoring is required to demonstrate no potential geotechnical impacts from depressurisation. Note that pathways and contamination have been excluded from consideration as no additional impacts have been identified above normal tunnelling activities.

Summary of Baseline Monitoring

4.18.8 Groundwater baseline monitoring Report for the cross passages of Northolt Tunnels East is provided separately [Document No. 1MC04-SCJ_SDH-GT-REP-SS03_SL05-000031] [R72].

Proposed Additional Baseline Monitoring

4.18.9 As indicated in Table 10 and the conditions above, monitoring requirements from the GW1 and GW2 Advisory Sheets are appropriate.

4.18.10 Specific dewatering related monitoring has not yet been developed given that the dewatering design is still underway. Dewatering monitoring will need to be added to monitoring requirements once the dewatering design has been defined. This dewatering related monitoring may also need to include groundwater quality monitoring, depending on the construction methods. For these reasons, monitoring related to dewatering activities will be addressed separately after a dewatering subcontractor has been procured.

4.18.11 The proposed locations and monitoring frequency for additional groundwater level and quality baseline monitoring locations are presented in Figure 10 in Appendix B and Appendix C.

Proposed Construction Monitoring

4.18.12 The number of proposed monitoring locations are based on the following factors:

- Nature of the identified risk (relatively low potential impacts given the limited nature of the piling works - relatively short duration),
- Current groundwater conditions (i.e. within a relatively low groundwater gradient), and
- Site constraints for the location of monitoring wells.

4.18.13 As indicated in Table 10, groundwater monitoring requirements from GW1 and GW2 Advisory Sheets are appropriate.

4.18.14 The proposed locations and frequency for groundwater level and quality monitoring during the construction stage are presented in Figure 10 in Appendix B and Appendix C.

Proposed Post Construction Monitoring

4.18.15 As indicated in Table 10, groundwater monitoring requirements from the GW1 and GW2 Advisory Sheets are appropriate.

4.18.16 The proposed locations for groundwater level and quality monitoring during the post construction stage are presented in Figure 10 in Appendix B and Appendix C.

4.18.17 These recommendations should be reviewed as necessary and following commissioning. A plan to conclude groundwater monitoring (i.e. terminate the monitoring programme) should be developed and agreed with relevant stakeholders. For the purpose of this document, groundwater monitoring is assumed to continue for two years following project commissioning.

4.19 Euston Approach

Site Description

4.19.1 The Euston Approach is located to the west of Euston Station, comprising a number of asset types as shown in Figure 11 in Appendix B, including cavern shaft, retaining wall, tunnels, headhouse, bridges and cuttings.

4.19.2 Site-specific groundwater risk assessment (GRAs) has been performed for the corresponding design elements in the Euston Approach area within Lot S1 of the 1MC03 Main Works project:

- Euston Throat Retained Cut S1 (GRA report document No. 1MC03-SCJ_SDH-GT-REP-SS01_SL12-000013) [R91]
- Hampstead Road Bridge S1 (GRA report document No. 1MC03-SCJ_SDH-GT-REP-SS01_SL12-000014) [R92]
- Euston Scissor Cut S1 (GRA report document No. 1MC03-SCJ_SDH-GT-REP-SS01_SL12-000015) [R93]
- Euston Cavern Shaft S1 (GRA report document No. 1MC03-SCJ_SDH-GT-REP-SS01_SL03-000011) [R94]
- Granby Terrace Bridge S1 (GRA report document No. 1MC03-SCJ_SDH-GT-REP-SS01_SL12-000016) [R97]
- Park Village East Wall (Detailed GRA report document No. 1MC03-SCJ_SDH-GT-REP-SS01_SL03-000014) [R104]
- Euston Cavern S1 (GRA report document No. 1MC03-SCJ_SDH-GT-REP-SS01_SL03-000015) [R95]
- Euston Crossover Tunnels S1 (GRA report document No. 1MC03-SCJ_SDH-GT-REP-SS01_SL03-000016) [R96]
- Euston Tunnels S1 (GRA report document No. 1MC03-SCJ_SDH-GT-REP-SS02_SL01-000026) [R98]

Relevant Construction Methods

4.19.3 The Euston Approach will be constructed within the London Clay, may require excavation of Made Ground and is expected to have piling into the Lower Aquifer (specifically into the Thanet Sands).

Summary of Identified Groundwater Risks

4.19.4 Once the piles have been constructed, no additional pathways to the Lower Aquifer will be present. As such, no long-term potential impacts are considered to be present, and thus no WFD impacts have been identified. The final construction will not generate any new potential pathways to groundwater bodies. Therefore, no long-term potential impacts are considered to be present, thus no WFD impacts have been identified.

4.19.5 Short-term impacts may exist related to temporary works, thus only SSIs have been considered. Identified SSIs are related to the potential migration of contaminants during piling and geotechnical impacts during limited depressurisation of sandier lenses within the Lambeth Group.

4.19.6 The potentially affected groundwater body is the Lower Aquifer. Groundwater monitoring is required to demonstrate no degradation to hydrogeological systems due to construction.

Summary of Baseline Monitoring

4.19.7 Groundwater baseline monitoring report for Euston Approach has been provided separately (Document No. 1MC03-SCJ_SDH-GT-REP-SS01-000004) [R99].

Basis of Selected Groundwater Monitoring Installations

4.19.8 The Lower Aquifer groundwater flow direction is to the southeast of the Euston area toward the base of the groundwater depression in the London Basin. In addition, the groundwater is table is relatively depressed leading to unconfined conditions at the Euston Approach area. Opportunities for groundwater installations are challenging given the dense urban area and highly constrained construction space. Nevertheless, long term monitoring locations have been identified within the Chalk formation as discussed below. In addition, monitoring will continue for as long as practical for other locations which will eventually need to be decommissioned to facilitate construction.

Proposed Additional Baseline Monitoring

4.19.9 As indicated in Table 10 and the conditions above, monitoring requirements from the GW1 and GW2 Advisory Sheets are appropriate.

4.19.10 The proposed locations and monitoring frequency for additional groundwater level and quality baseline monitoring locations are presented in in Appendix B and Appendix C.

Proposed Construction Monitoring

4.19.11 The number of proposed monitoring locations are based on the following factors:

- Nature of the identified risk (relatively low potential impacts given the limited nature of the piling works - relatively short duration),
- Current groundwater conditions (i.e. within a relatively low groundwater gradient), and
- Site constraints for the location of monitoring wells.

4.19.12 As indicated in Table 10, groundwater monitoring requirements from GW1 and GW2 Advisory Sheets are appropriate. The identified Chalk formation monitoring locations are presented in .

4.19.13 The proposed locations and frequency for groundwater level and quality monitoring during the construction stage are presented in Figure 11 in Appendix B and Appendix C.

Proposed Post Construction Monitoring

4.19.14 As indicated in Table 10, groundwater monitoring requirements from the GW1 and GW2 Advisory Sheets are appropriate.

4.19.15 The proposed locations for groundwater level and quality monitoring during the post construction stage are presented in Figure 11 in Appendix B and Appendix C.

4.19.16 These recommendations should be reviewed as necessary and following commissioning. A plan to conclude groundwater monitoring (i.e. terminate the monitoring programme) should be developed and agreed with relevant stakeholders. For the purpose of this document, groundwater monitoring is assumed to continue for two years following project commissioning.

4.20 Dewatering Monitoring

4.20.1 GW1 Advisory Sheet suggests additional monitoring requirements where dewatering is planned. Groundwater level monitoring related to depressurisation will comply with consent requirements. For example, groundwater level monitoring is included at West Ruislip Portal (Figure 3).

4.20.2 Discharge monitoring will also be performed in accordance with consent requirements. Requirements for monitoring of any groundwater to be discharged will be documented in a revised version of the Surface Water Monitoring Plan S1 & S2 [Document No. 1MC03-SCJ-EV-PLN-S001-000029] [R102]. For convenience, groundwater discharge at West Ruislip Portal laboratory analyses requirements are included in Appendix A.

4.21 Monitoring during Tunnelling

4.21.1 As the TBMs advance to construct the tunnels, the frequency of groundwater level and quality monitoring will be increased to weekly for all monitoring installations indicated in this plan which are located within the Chainage where the TBMs are advancing (for example

monitoring locations associated with West Ruislip Portal, Crosspassages, or the three ventilation shafts).

4.21.2 During the weekly monitoring, the core suite will be amended to include additional laboratory analytes as indicated in Appendix A.

4.21.3 Once a TBM has crossed to the next chainage, the monitoring will revert to monthly monitoring for both the core and full monitoring suites.

5 Groundwater monitoring specifications

5.1 Introduction

5.1.1 Groundwater monitoring, including both groundwater level monitoring and groundwater quality monitoring, shall be carried out according to requirements specified in this report. It should be noted that some locations only require groundwater level monitoring whereas others require both groundwater level and groundwater quality monitoring.

5.1.2 The groundwater monitoring shall be performed as a supplemental scope of work to the ongoing ground investigation as specified in the "SCS Specification for Additional Geotechnical Investigation Works - S1" [R18] and the "SCS Specification for Additional Geotechnical Investigation Works - S2" [R19].

5.1.3 Where referenced in the following sections, the Investigation Supervisor is deemed to be the SCSJV nominated Site Engineer with support from a technical adviser within the SCS Design House, as defined in the Specification [R18 & R19].

5.1.4 Reference should be made to the contract conditions and particulars from SCSJV for definition of payment, measurement, requirements related to health and safety and environmental compliance, site access and related matters, and all other commercial matters relating to the specified testing, and cost/schedule impacts to the existing contract for ground investigation.

5.1.5 This monitoring specification has been prepared based on the current information made available regarding temporary works designs and construction methodology, sequencing and programme provided by SCSJV at the time of writing. The specification should be reviewed should these assumptions change.

5.2 Specification of groundwater level monitoring

Groundwater level monitoring locations

5.2.1 The groundwater monitoring stations are presented in Section 4 (see Figure 1 to Figure 11 in Appendix B, Appendix C). Readings shall be taken in all instruments at the frequency and duration specified. Monitoring results shall be issued to the Investigation Supervisor in AGS and excel format within a week of being undertaken.

5.2.2 Groundwater level monitoring shall be performed that conform to the following requirements:

- monitoring at the correct location shall be confirmed, this can be done by measuring the total depth of the installation and recording this depth on a field monitoring form;
- the inside of the borehole should have the well ID labelled using a sharpie, when it starts to fade, the sampler should re-write it.

Monitoring schedule

5.2.3 Groundwater monitoring shall be performed on an hourly, weekly, monthly to quarterly basis in Section 4 (see Figure 1 to Figure 11 in Appendix B, Appendix C) commencing upon instruction by SCS.

5.2.4 It is a Specification requirement that all standpipes and piezometers installed as part of the SCS ground investigation are monitored monthly for a period consistent with this monitoring plan. Refer to Clause 1.17.1 of the Specification [R18 & R19].

5.3 Specification of groundwater quality monitoring

Groundwater quality - sampling method

5.3.1 Details of standpipe installations are presented in Section 4.

5.3.2 Groundwater monitoring shall be performed using micro-purge techniques that conform to the following requirements:

- depth to groundwater should be measured before any purging is undertaken.
- drawdown shall be monitored and shall not exceed 0.1 m or 25 % of the distance from the top of the well screen to the pump intake;
- the groundwater sampling rate shall not exceed 500 Ml/min;
- physico-chemical parameters shall be monitored in the field using a flow cell which must be decontaminated between monitoring locations;
- physico-chemical parameter measurement for pH, temperature, conductivity, oxidation/reduction, and turbidity shall be performed at a rate equivalent to one flow cell volume (including associated tubing and pump volume); and
- any in-hole equipment shall be inserted and removed carefully to minimize disturbances within the well.

5.3.3 Purging shall occur through use of a peristaltic pump from the approximate mid-point of the water column of the response zone (adjacent to the borehole screen). Where a peristaltic pump is not feasible, the purging method shall be pre-approved by SCS. Purging shall continue until all physico-chemical parameters have stabilised within recommended stabilisation thresholds. **Unless otherwise specified by the Investigation Supervisor, the degree of stabilisation should be determined during purging as follows: Maximum - Minimum of 3 readings taken 3-5 mins apart / Last reading x 100. Stabilisation typically occurs in the following order (with percentage stabilisation thresholds given in brackets): pH (0.1 pH units), temperature (3%), electrical conductivity (3%), dissolved oxygen (10%).** At this point, physico-chemical measurements should be stored electronically for later download and recorded on the Monitoring Record Sheet for the monitoring point. Should the well be purged dry, the Investigation Supervisor shall be contacted for additional instruction.

5.3.4 At each monitoring point, all field observations and measurements will be recorded on a Monitoring Record Sheet. The Monitoring Record Sheet will record the monitoring point, date and time the monitoring was undertaken, description of the appearance of the sample (covering colour, opaqueness/transparency, any cloudiness, presence of suspended sediment or other material, smell if there is a smell, and weather conditions. The Monitoring Record Sheet need to be collated and provided as a project deliverable together with the spreadsheet.

5.3.5 Sufficient water samples (as determined by the laboratory) shall be taken to allow laboratory testing of the parameters and to the detection limits detailed in schedules specified for that location (see Appendix A). Note that there are separate sampling requirements for the 'Core Suite' and 'Full Suite' of field and laboratory analyses. Appendix A lists the core and full suites.

5.3.6 Care shall be taken to ensure that no cross-contamination occurs either during extraction of the water sample from the sampling well (or water body) or whilst the sample is stored and handled prior to analysis, including the use of nitrile sampling gloves replaced for each new sample. If practical, photos shall be collected documenting appearance and visual evidence of turbidity in the collected groundwater samples.

5.3.7 The groundwater sample will be clearly labelled with sample number, date and time, and required analyses using the bottle types provided in accordance with the parameters being sampled, following all procedures with respect to pre-treatment (e.g. filtration) and sample preservation (in dedicated bottles prepared by the accredited laboratory) in accordance with BS EN ISO 5667-3: 2018[2], and taking all measures to prevent sample contamination (e.g. wearing sampling gloves whenever a sample is being collected and replacing gloves between samples).

5.3.8 Groundwater collected for dissolved metal / dissolved heavy metal analysis shall be filtered in the field using a fresh syringe and 0.45-micron filter tip into a dissolved metal bottle containing nitric acid preservative. Dissolved iron and manganese will require field filtration and preservation in dedicated bottles containing hydrochloric acid preservative. Ammonium subsamples should also be filtered in the field into an Ammonium bottle containing sulphuric acid preservative.

5.3.9 Another subsample that requires preservation but does not require filtration in the field is cyanide, which requires preservation with sodium hydroxide.

5.3.10 A sufficient unfiltered groundwater sample (as determined by the laboratory) shall be collected from each location, which will be used to calculate total suspended solids. In addition, water samples for volatile hydrocarbon analysis shall not be filtered.

[2] BS EN ISO 5667-3:2018 Water quality – Sampling Part 3: Preservation and handling of water samples

5.3.11 Groundwater sampling should be carried out in accordance with British Standard (BS) ISO 5667-3 and 5667-11.

Quality Control Procedures for Monitoring

5.3.12 Best practice monitoring should include provisions for quality control procedures to be built into the monitoring design.[3] The purpose of these procedures is to provide confidence that the monitoring has delivered high quality data that is suitable as baseline data against which any future environmental impact can be adequately assessed.

5.3.13 Quality control procedures are designed to check the effectiveness and reproducibility of the monitoring, sampling process and laboratory analytical procedures. Such procedures also help to demonstrate that correct sampling techniques have excluded the possibility of sample contamination occurring. Any exceptional results from the quality control sampling will be investigated and repeat analysis undertaken where necessary.

5.3.14 For the purposes of the groundwater quality sampling to be undertaken under the Survey Work Package, three main quality control procedures will be undertaken in addition to those described for physico-chemical parameters:

- Ionic balance - for every sample, an ionic balance should be calculated to assess the level of precision and confidence in the major ion analyses. The sum of the chemical activities for the cation should equal those of the anions to within 10% (as a minimum requirement).
- Field blanks - these are samples prepared in the field using laboratory grade de-ionised water, which are analysed in the laboratory to demonstrate that no sampling contamination occurs on the monitoring round.
- Split duplicate samples - these are groundwater samples that are prepared in the field by splitting one well mixed sample into two sample bottles for analysis. The purpose of this is to demonstrate the degree of precision delivered by the laboratory analysis for all parameters monitored at a given location.

5.3.15 The monitoring will include 10% quality assurance samples to be collected as part of the best practice approach in water sampling (i.e. field duplicates) at a minimum frequency of one sample per monitoring event. Analytical results from these quality assurance samples will be checked by the appointed monitoring contractor. The quality assurance and quality control of these samples shall be reported separately to demonstrate they have been undertaken, and that the results are valid.

[3] Note that improved QA/QC measures are specified in this plan will be as required for future monitoring as part of this plan.

5.3.16 Field measurements of pH and Electrical Conductivity require validation in the laboratory. If there is a marked difference between the field and laboratory measurements of pH and conductivity, this will be investigated for the source of the difference.

5.3.17 The contractor shall notify SCS immediately when monitoring installations cannot be accessed and/or sampled and shall notify SCS within 24 hours of any other deviations to this specification. Following the completion of each monitoring event, a field monitoring record shall be provided within 5 days confirming which samples have been collected.

Handling, storage and laboratory analyses of groundwater samples

5.3.18 All samples shall be immediately chilled and stored at between 1 °C and 5 °C. Temperature of the samples will be checked upon receipt at the laboratory and recorded to demonstrate that the samples had been transferred in refrigerated conditions (cool boxes containing ice blocks).

5.3.19 Whilst the sampling methodology has been described above, the selected analytical laboratory shall be consulted to confirm filtration, preservation, and storage requirements in accordance with BS EN ISO 5667-3: 2018. Where the laboratory requirements differ from the detail provided above, the Investigation Supervisor shall be consulted.

5.3.20 The sample shall be dispatched to the laboratory on the same day. Laboratory analyses shall be carried out within the holding time for all determinants. Specific requirements are provided in Appendix A.

5.4 Reporting

5.4.1 Reporting will be undertaken and shall be submitted by the end of the second calendar week of the month following the relevant monitoring period as agreed between SCSJV and the Contractor. Data shall be reviewed upon receipt of factual reports by SCSJV. The use and selection of control and trigger levels is described below.

5.4.2 The reports will be in a standalone format suitable for submission to the relevant authority on an ongoing basis. All reports will be completed by a competent and suitably qualified groundwater consultant. The format will be pre-agreed with the EA and AfW.

5.4.3 All reports will be submitted in a pre-agreed format, to be developed during the initial monitoring event for each asset.

5.4.4 Each report will include a description of the works and any activities being undertaken that could generate changes to the groundwater regime (to either levels or quality). Each report will also include field monitoring records as an appendix to the report.

5.4.5 Presented data will include a summary of measured groundwater levels and a summary table of groundwater quality requirements. The Contractor will need to provide the data in AGS and excel (xlsx/csv) format in addition to PDF.

5.4.6 Each report will include the details of any monitoring related issues (including damage to monitoring installations).

5.5 Groundwater Control and Trigger Levels

5.5.1 Groundwater baseline monitoring reports are provided separately. The selection (and basis for selection) of relevant groundwater control and trigger levels will be documented in either the relevant hydrogeologic risk assessment (for RNSP and RSSP), groundwater management plan during construction (for West Ruislip, South Ruislip, Mandeville Road, and Greenpark Way), or baseline monitoring reports for other assets.

5.6 Amendments to monitoring plan during construction and post construction phase

5.6.1 The frequency and duration of groundwater level and quality monitoring during the construction and post construction phase shall refer to Advisory Sheets GW1 and/or GW2 as appropriate.

5.6.2 Once baseline data has been collected, trigger levels will be defined for each site indicated above. Trigger levels will be used as indicated above. Where changes in groundwater levels are expected (i.e. during dewatering), site specific trigger levels will be defined based on expected changes in groundwater levels.

5.6.3 In the future, further monitoring points may be required to be installed where required to gain consent (e.g. EA). These additions would be covered in any update to the Plan.

6 References

6.1.1 The following documents are client and industry related documents from which the above information is drawn or to be referred to Table 13.

Table 13: Reference documents

Reference	Title	Document Number
R1	High Speed 2 (HS2) Project Dictionary	HS2-HS2-PM-GDE-000-000002, P08
R2	HS2 Specification for Ground Investigation	HS2-HS2-GT-SPE-000-000001 P02
R3	SCS Specification for Additional Ground Investigation Works -S1	1MC03-SCJ-GL-SPE-S001-000001_FINAL
R4	High Speed Rail (London - West Midlands) Act 2017	http://www.legislation.gov.uk/ukpga/2017/7/contents/enacted
R5	HS2 Environmental Minimum Requirements Annex 1: Code of Construction Practice	LWM-HS2-EV-STA-000-000107
R6	HS2 Environmental Minimum Requirements Annex 2: Planning Memorandum	HS2-HS2-EV-STD-000-000003
R7	HS2 Environmental Minimum Requirements Annex 3: Heritage Memorandum	HS2-HS2-EV-STD-000-000001
R8	HS2 Environmental Minimum Requirements Annex 4: Environmental Memorandum	HS2-HS2-EV-STD-000-000004
R9	Register of Undertakings and Assurances	1MC03-SCJ-IN-REG-S001-000006
R10	Groundwater Protection	HS2-HS2-EV-STD-000-000010
R11	Water Framework Directive Compliance Process	HS2-HS2-EV-STD-000-000012
R12	Water Resources and Flood Risk Consenting Strategy	HS2-HS2-EV-STD-000-000015
R13	Water Resources Strategy	HS2-HS2-EV-STD-000-000016
R14	Land Quality	HS2-HS2-EV-STD-000-000027
R15	Water Resources and Flood Risk Monitoring Technical Standard	HS2-HS2-EV-STD-000-000029

Reference	Title	Document Number
R16	Interface Management: Commitment Compliance Plans for Lots S1 and S2	1MC03-SCJ-IN-REG-S001-000006
R17	Water Resource and Flood Risk Management Plan S1 and S2	1MC03-SCJ-EV-PLN-S001-000015
R18	SCS Specification for Additional Geotechnical Investigation Works - S1	1MC04-SCJ-GL-SPE-S002-000001
R19	SCS Specification for Additional Geotechnical Investigation Works - S2	1MC03-SCJ-GL-SPE-S001-000001
R20	Survey Request Form for Groundwater Monitoring - Around Granby Terrace Bridge - Euston Scissor Cut S1	1MC03-SCJ-GT-FRM-SS01_SL12-000001
R21	Survey Request Form for Groundwater Monitoring - Ruislip Northern SPA S2	1MC04-SCJ-EV-FRM-SS05_SL07-000007
R22	Survey Request for Groundwater Monitoring at Southern SPA S2	1MC04-SCJ-EV-FRM-SS05_SL07-000008
R23	Northern SPA - Hydrogeological Risk Assessment (HRA) S2	1MC04-SCJ-EV-RIA-SS05_SL07-000001
R24	Review of Hydrogeology Relevant to Shafts and Cross-Passages at S2	1MC04-SCJ-GT-REP-SS05_SL06-000009
R25	Geoenvironmental Report: Atlas Road Logistics Tunnel and Shaft S1	1MC03-SCJ-GT-REP-SS02_SL02-000004
R26	Hydrogeological Risk Assessment for Landfills and the Derivation of Control and Trigger Levels	Not applicable
R27	BS ISO 5667-11:2009 Water quality. Sampling. Guidance on sampling of groundwaters	https://shop.bsigroup.com/ProductDetail/?pid=000000000030152313
R28	EA Guidance - Groundwater Protection Technical Guidance	https://www.gov.uk/government/publications/groundwater-protection-technical-guidance/groundwater-protection-technical-guidance
R29	HS2 Water Resources and Flood Risk Monitoring Technical Standard	HS2-HS2-EV-STD-000-000029
R30	Groundwater Risk Assessment S1	1MC03-SCJ-GT-REP-S001-000030
R31	Groundwater Risk Assessment S2	1MC04-SCJ-GT-REP-S002-000037
R32	Groundwater Risk Assessment Report - River Pinn Underbridge S2	1MC04-SCJ_SDH-GT-REP-SS05_SL07-000019
R33	Groundwater Risk Assessment Report - Breakspear Road South Underbridge S2	1MC04-SCJ_SDH-GT-REP-SS05_SL07-000020

Reference	Title	Document Number
R34	Groundwater Risk Assessment Report - West Ruislip Retained Embankment S2	1MC04-SCJ_SDH-GT-REP-SS05_SL07-000021
R35	Detailed Groundwater Risk Assessment Report - West Ruislip Portal S2	1MC04-SCJ_SDH-GT-REP-SS05_SL07-000023
R36	Design Element Statement (DES) - 024-S1 River Pinn Underbridge S2	1MC04-SCJ-DS-STA-SS05_SL07-000003
R37	Design Element Statement (DES) - 024-S2 Breakspear Road South Underbridge S2	1MC04-SCJ-DS-STA-SS05_SL07-000004
R38	Design Element Statement (DES) - 024-L1 West Ruislip Retained Embankment S2	1MC04-SCJ-DS-STA-SS05_SL07-000002
R39	Design Element Statement (DES) - 023-L1 West Ruislip Portal	1MC04-SCJ-DS-STA-SS05_SL07-000001
R40	Foundation Works Risk Assessment (FWRA) - West Ruislip Retained Embankment and Bridges - West Ruislip Area Structures S2	1MC04-SCJ_SDH-EV-ASM-SS05_SL07-000004
R41	Foundation Works Risk Assessment (FWRA) - West Ruislip Portal S2	1MC04-SCJ_SDH-EV-ASM-SS05_SL07-000001
R42	Groundwater Baseline Monitoring Report - West Ruislip Area S2	1MC04-SCJ_SDH-GT-REP-SS05_SL07-000032
R43	Asset Protection and Monitoring Agreement between Affinity Water Limited and High Speed Two (HS2) Limited, dated 2017.	Not applicable (no document number)
R44	Environmental Management Plan (Stage 2 Construction and Detailed Design) S1 and S2	1MC03-SCJ-EV-PLN-S001-000003
R45	Affinity Water Mitigation Approval In principle - LON-01-46022, LON-01-46023 and LON-01-46033	1MC04-SCJ-UT-AGR-SS05_SL06-000067
R46	Affinity Water Mitigation Approval In principle - LON-01-46043	1MC04-SCJ-UT-AGR-SS05_SL06-000069
R47	Hydrogeological Risk Assessment (HRA) - Western Mound - Ruislip Northern Sustainable Placement S2	1MC04-SCJ_SDH-GT-REP-SS05_SL07-000035
R48	Hydrogeological Risk Assessment (HRA) - Eastern Mound - Ruislip Northern Sustainable Placement S2 (In preparation)	1MC04-SCJ_SDH-GT-REP-SS05_SL07-000036
R49	Hydrogeological Risk Assessment (HRA) - Ruislip Southern Sustainable Placement S2	1MC04-SCJ_SDH-GT-REP-SS05_SL07-000034
R50	Design Element Statement (DES) - Copthall Tunnel S2	1MC04-SCJ-DS-STA-SS05_SL07-000008

Reference	Title	Document Number
R51	Groundwater Baseline Monitoring Report - Copthall Tunnel S2 (In preparation)	1MC04-SCJ_SDH-GT-REP-SS05_SL07-000033
R52	Groundwater Risk Assessment Report - Harvil Road Overbridge (Over Chiltern Lines) S2	1MC04-SCJ_SDH-GT-REP-SS05_SL08-000001
R53	Foundation Works Risk Assessment (FWRA) - Harvil Road Overbridge (Over Chiltern Lines) S2	1MC04-SCJ_SDH-EV-ASM-SS05_SL08-000001
R54	Groundwater Risk Assessment Report - Copthall Tunnel S2 (In preparation)	1MC04-SCJ_SDH-GT-REP-SS05_SL07-000025
R55	Groundwater Risk Assessment Report - River Pinn Underbridge S2	1MC04-SCJ_SDH-GT-REP-SS05_SL07-000019
R56	Groundwater Risk Assessment Report - West Ruislip Retained Embankment S2	1MC04-SCJ_SDH-GT-REP-SS05_SL07-000021
R57	Detailed Groundwater Risk Assessment Report - Crosspassages - Northolt Tunnels West S2 (In preparation)	1MC04-SCJ_SDH-GT-REP-SS05_SL06-000030
R58	Design Element Statement (DES) - Northolt Tunnels West S2	1MC04-SCJ-DS-STA-SS05_SL06-000002
R59	Groundwater Baseline Monitoring Report - Crosspassages - Northolt Tunnels West S2 (In preparation)	1MC04-SCJ_SDH-GT-REP-SS05_SL06-000050
R60	Groundwater Risk Assessment Report - Copthall Tunnel S2 (In preparation)	1MC04-SCJ_SDH-GT-REP-SS05_SL07-000025
R61	Design Element Statement (DES) - 020- South Ruislip Vent Shaft with Auto Transformer Station (ATS) S2	1MC04-SCJ-DS-STA-SS05_SL07-000007
R62	Detailed Groundwater Risk Assessment Report - South Ruislip Vent Shaft S2	1MC04-SCJ_SDH-GT-REP-SS05_SL06-000027
R63	Groundwater Baseline Monitoring Report - South Ruislip Vent Shaft S2 (In preparation)	1MC04-SCJ_SDH-GT-REP-SS05_SL06-000047
R64	Design Element Statement (DES) - 017- Mandeville Road Vent Shaft S2	1MC04-SCJ-DS-STA-SS05_SL06-000001
R65	Detailed Groundwater Risk Assessment Report - Mandeville Road Vent Shaft S2	1MC04-SCJ_SDH-GT-REP-SS05_SL06-000028
R66	Groundwater Baseline Monitoring Report - Mandeville Road Vent Shaft S2 (In preparation)	1MC04-SCJ_SDH-GT-REP-SS05_SL06-000048
R67	Design Element Statement (DES)-015-Greenpark Way Vent Shaft with Express Feeder Auto Transformer Station (EFATS) S2	1MC04-SCJ-DS-STA-SS03_SL05-000002

Reference	Title	Document Number
R68	Detailed Groundwater Risk Assessment Report - Greenpark Way Vent Shaft S2	1MC04-SCJ_SDH-GT-REP-SS05_SL06-000029
R69	Groundwater Baseline Monitoring Report - Greenpark Way Vent Shaft S2 (In preparation)	1MC04-SCJ_SDH-GT-REP-SS05_SL06-000049
R70	Detailed Groundwater Risk Assessment Report - Crosspassages - Northolt Tunnels East S2 (In preparation)	1MC04-SCJ_SDH-GT-REP-SS03_SL05-000017
R71	Design Element Statement (DES) - Northolt Tunnels East S2	1MC04-SCJ_SDH-DS-STA-SS03_SL05-000001
R72	Groundwater Baseline Monitoring Report - Crosspassages - Northolt Tunnels East S2 (In preparation)	1MC04-SCJ_SDH-GT-REP-SS03_SL05-000031
R73	Design Element Statement (DES) - 012-S4 Westgate Vent Shaft S2	1MC04-SCJ-DS-STA-SS03_SL05-000001
R74	Groundwater Risk Assessment Report - Westgate Vent Shaft S2	1MC04-SCJ_SDH-GT-REP-SS03_SL05-000016
R75	Groundwater Baseline Monitoring Report - Westgate Vent Shaft S2 (In preparation)	1MC04-SCJ_SDH-GT-REP-SS03_SL05-000030
R76	Design Element Statement (DES) 009-L2 Victoria Rd Crossover Box with ATS S2	1MC04-SCJ-DS-STA-SS04-000001
R77	Groundwater Risk Assessment Report - Victoria Road Crossover Box S2	1MC04-SCJ_SDH-GT-REP-SS04-000019
R78	Groundwater Risk Assessment Report - Victoria Road Ancillary Shaft S2	1MC04-SCJ_SDH-GT-REP-SS04-000024
R79	Groundwater Baseline Monitoring Report - Victoria Road Crossover Box and Ancillary Shaft - Victoria Road Crossover Box S2 (In preparation)	1MC04-SCJ_SDH-GT-REP-SS04-000028
R80	Design Element Statement (DES) - 008-S1 Atlas Road Logistics Tunnel S1	1MC03-SCJ-DS-STA-SS02_SL02-000002
R81	Groundwater Risk Assessment Report - Atlas Road Logistics S1 (In preparation)	1MC03-SCJ_SDH-GT-REP-SS02_SL02-000005
R82	Groundwater Baseline Monitoring Report - Atlas Road Logistics S1 (In preparation)	1MC03-SCJ_SDH-GT-REP-SS02_SL02-000005
R83	Groundwater Risk Assessment Report - Old Oak Common Tunnels S2 (In preparation)	1MC04-SCJ_SDH-GT-REP-SS03_SL04-000010
R84	Groundwater Risk Assessment Report - Canterbury Works Vent Shaft S1 (In preparation)	1MC03-SCJ_SDH-GT-REP-SS02_SL01-000024
R85	Groundwater Baseline Monitoring Report - Old Oak Common Tunnels S2 (In preparation)	1MC04-SCJ_SDH-GT-REP-SS03_SL04-000010

Reference	Title	Document Number
R86	Groundwater Baseline Monitoring Report - Canterbury Works Vent Shaft S1 (In preparation)	1MC03-SCJ_SDH-GT-REP-SS02_SL01-000029
R87	Design Element Statement (DES) - 005-Canterbury Works Vent Shaft with Auto Transformer Station (ATS) S1	1MC03-SCJ-DS-STA-SS02_SL01-000002
R88	Design Element Statement (DES) - 0002 Adelaide Road Vent Shaft S1	1MC03-SCJ-DS-STA-SS02_SL01-000001
R89	Groundwater Risk Assessment Report - Adelaide Road Vent Shaft S1	1MC03-SCJ_SDH-GT-REP-SS02_SL01-000023
R90	Groundwater Baseline Monitoring Report - Adelaide Road Vent Shaft S1	1MC03-SCJ_SDH-GT-REP-SS02_SL01-000030
R91	Groundwater Risk Assessment Report - Euston Throat Retained Cut S1	1MC03-SCJ_SDH-GT-REP-SS01_SL12-000013
R92	Groundwater Risk Assessment Report - Hampstead Road Bridge S1	1MC03-SCJ_SDH-GT-REP-SS01_SL12-000014
R93	Groundwater Risk Assessment Report - Euston Scissor Cut S1	1MC03-SCJ_SDH-GT-REP-SS01_SL12-000015
R94	Groundwater Risk Assessment Report - Euston Cavern Shaft S1	1MC03-SCJ_SDH-GT-REP-SS01_SL03-000011
R95	Groundwater Risk Assessment Report - Euston Cavern S1	1MC03-SCJ_SDH-GT-REP-SS01_SL03-000015
R96	Groundwater Risk Assessment Report - Euston Crossover Tunnels S1	1MC03-SCJ_SDH-GT-REP-SS01_SL03-000016
R97	Groundwater Risk Assessment Report - Granby Terrace Bridge S1	1MC03-SCJ_SDH-GT-REP-SS01_SL12-000016
R98	Groundwater Risk Assessment Report - Crosspassages - Euston Tunnels S1	1MC03-SCJ_SDH-GT-REP-SS02_SL01-000026
R99	Groundwater Baseline Monitoring Report - Euston Approach S1	1MC03-SCJ_SDH-GT-REP-SS01-000004
R100	Survey Request Form - Groundwater Monitoring for West Ruislip Area Structures S2	1MC04-SCJ_SDH-GT-FRM-SS05_SL07-000001
R101	Survey Request Form - Continued Groundwater Level and Quality Monitoring - West Ruislip Area Structures S2	1MC04-SCJ-EV-FRM-SS05_SL07-000009
R102	Surface Water Monitoring Plan S1 & S2	1MC03-SCJ-EV-PLN-S001-000029
R103	Groundwater Risk Assessment Report - Harvil Road Stream Underbridge S2	1MC04-SCJ_SDH-GT-REP-SS05_SL08-000002

Reference	Title	Document Number
R104	Detailed Groundwater Risk Assessment Report - Park Village East Wall S1	1MC03-SCJ_SDH-GT-REP-SS01_SL03-000014
R105	Groundwater Risk Assessment Report - Gatemead Embankment S2	1MC04-SCJ_SDH-GT-REP-SS05_SL07-000024
R106	Groundwater Risk Assessment Report - Harvil Road General Highway Works S2	1MC04-SCJ_SDH-GT-REP-SS05_SL08-000003
R107	Excavated Material Management Study and Groundwater Risk Assessment - Copthall Tunnel S2	1MC04-SCJ_SDH-EV-NOT-SS05_SL07-000003
R108	Survey Request Form -Temporary Groundwater Monitoring - Select Shafts and Portal S2	1MC04-SCJ-EV-FRM-S002-000006
R109	Survey Request Form - Additional Monitoring Well Installation and Groundwater Monitoring - Euston Throat Retained Cut S1	1MC03-SCJ_SDH-GT-FRM-SS01_SL03-000002
R110	Specification - Additional Monitoring Well Installation for Water Level and Water Quality Groundwater Monitoring - Euston Throat Retained Cut S1	1MC03-SCJ_SDH-GT-SPE-SS01_SL03-000004
R111	Survey Request Form - Well Decommissioning - Copthall Tunnel S2	1MC04-SCJ_SDH-GT-FRM-SS05_SL07-000004
R112	Survey Request Form (SuRF) and Specification - Additional Monitoring Well Installations for Groundwater Level and Quality Monitoring - West Ruislip Retained Embankment S2	1MC04-SCJ_SDH-GT-SPE-SS05_SL07-000002
R113	Survey Request Form - Specification for Additional Well Installation for Groundwater Level and Quality Monitoring - South Ruislip Vent Shaft S2	1MC04-SDH-GT-FRM-SS05_SL06-000001
R114	Survey Request Form - Specification for Borehole Decommissioning - S1	1MC03-SCJ_SDH-GT-FRM-S001-000002
R115	Survey Request Form - Specification for Borehole Decommissioning - S2 (Area West)	1MC04-SCJ_SDH-GT-FRM-S002-000002
R116	Survey Request Form - Specification for Borehole Decommissioning - S2 (Area Central)	1MC04-SCJ_SDWESH-GT-FRM-S002-000003
R117	Survey Request Form - Temporary Groundwater Monitoring at Euston Test Piles - Euston Scissor Cut S1	1MC03-SCJ_SDH-EV-FRM-SS01_SL03-000001
R118	Survey Request Form - Specification for Additional Groundwater Monitoring Installations - Park Village East Wall S1	1MC03-SDH-GT-FRM-SS01_SL03-000004
R119	Survey Request Form - Groundwater Monitoring at West Ruislip Area Specification - S2	1MC04-SCJ_SDH-GT-FRM-SS05_SL07-000001

Reference	Title	Document Number
R120	Groundwater Baseline Monitoring Report - South Ruislip Vent Shaft S2	1MC04-SCJ_SDH-GT-REP-SS05_SL06-000047

Appendix A: Groundwater monitoring schedules

1 Core Suite

1.1 Field Water Quality Parameters

1.1.1 The field water quality parameters for all locations are provided in Table 14.

Table 14: Water quality parameters for all groundwater quality monitoring locations (Core Suite)

Parameter	Units	Detection Limit	Degree of Accuracy
pH	pH units	0.1	±0.1
Temperature	°C	0.1	±0.1
Dissolved oxygen	mgO2/l and %	0.1	±0.1
Electrical conductivity	µS/cm	10	±2.0
Redox potential	mV	±1	±0.1
Turbidity	NTU	0.1	±0.1
Core Laboratory Analytical Suite (as defined in asset specific laboratory testing schedules)			

1.2 Core Laboratory Analyses Suite (Core Suite A)

1.2.1 Core suite laboratory analyses are presented in Table 18 for all other locations (West Ruislip, Copthall Tunnell, RSSP, South Ruislip, Mandeville Road, and Crosspassage locations).

Table 15: Core Suite Laboratory Analyses

Analyte	Detection Limits	Analyte	Detection Limits
Ammoniacal nitrogen	0.2 mg/L	**Chlorobenzene**	1 µg/L
Calcium	0.2 mg/L	**1,1-Dichlorobenzene**	1 µg/L
Iron	0.019 mg/L	**TPH as >C6 to C40**	10 mg/L
Magnesium	0.036 mg/L	**Pentachlorobenzene**	Per laboratory method
Sulphate	2 mg/L	**Toluene**	0.2 µg/L
Benzene	0.2 µg/L		

1.3 RNSP Specific Lab Analytes (Core Suite B)

1.3.1 Core suite laboratory analyses for RNSP are presented in Table 16.

Table 16: Core Suite Laboratory Analyses specific to RNSP

Analyte	Detection Limits	Analyte	Detection Limits
Ammoniacal Nitrogen	0.2 mg/L	**1,1-Dichloroethane**	1 µg/L
Calcium	0.2 mg/L	**TPH (>C6 to C40)**	10 mg/L
Iron	0.019 mg/L	**Pentachlorobenzene**	Per laboratory method
Magnesium	0.036 mg/L	**Toluene**	0.2 µg/L
Potassium	0.2 mg/L	**Arsenic**	0.5 µg/L
Sulphate	2 mg/L	**Chloride**	2 mg/L
Benzene	0.2 µg/L	**Selenium**	1 µg/L
Chlorobenzene	1 µg/L		

1.4 Greenpark Way (Core Suite C)

1.4.1 Core suite laboratory analyses are presented in Table 17 for Greenpark Way.

Table 17: Core Suite Laboratory Analyses specific to Greenpark Way

Analyte	Detection Limits	Analyte	Detection Limits
Ammoniacal nitrogen	0.2 mg/L	**Manganese**	3 µg/L
Chloride	2 mg/L	**Nickel**	0.4 µg/L
Copper	0.3 µg/L	**Nitrite (as Nitrogen)**	0.02 mg/L
Fluoride	0.5 mg/L	**Sulphate**	2 mg/L
Iron	0.019 mg/L	**Total Phenols**	0.5 µg/L
Lead	0.2 µg/L		

1.5 During Tunnelling (Additional Analytes)

1.5.1 During tunnelling, there will be a temporary requirement to include the *additional* analytes to the above Core Suite listed in Table 18.

Table 18: Tunnelling related analytes

Analyte	Detection Limits
pH	NA
Total TPH	10 mg/L
Alcohols, C12-14, ethoxylated <2.5 EO, sulphates, sodium salts (CAS No. 68891-38-3)	Per laboratory method
Alcohols, C12-14 (CAS No. 80206-82-2)	Per laboratory method
Poly(oxy-1,2-ethanediyl),a-tridecyl-w-hydroxy-,branched (CAS No. 69011-36-5)	Per laboratory method

2 Full Suite

Table 19. Full Suite Laboratory Analytes

Analyte	Detection Limits	Analyte	Detection Limits
General Water Quality Parameters			
Alkalinity as $CaCO_3$	2 mg/l	Sulphates as SO_4	2000 µg SO_4/l
Bicarbonate alkalinity (as $CaCO_3$)	2 mg/l	pH value	0.1 pH units
Carbonate alkalinity (as $CaCO_3$)	2 mg/l	Total Suspended Solids	TBC
Hardness	2 mg/l	Total Dissolved Solids	TBC
Ammoniacal nitrogen as N	0.02 mg/l	Cyanide - total	10 µg/l
Nitrate as N	0.3 mg/l	Cyanide - free	30 µg/l
Nitrite as N	0.01 mg/l	Ortho phosphate as P	10 µg /l
Total Nitrogen	TBC	Dissolved organic carbon (DOC)	TBC
Calcium	10 µg/l	Electronic Conductivity at 20°C	TBC
Chloride	1 mg/l	Ionic Balance (sum of cations, sum of anions, and % difference)	TBC
Metals			
Arsenic (dissolved)	1 µg/l	Iron (dissolved)	10 µg/l
Antimony (dissolved)	1 µg/l	Iron (total)	10 µg/l
Arsenic (dissolved)	1 µg/l	Lead (dissolved)	1 µg/l
Beryllium (dissolved)	1 µg/l	Magnesium	30 µg/l
Barium (dissolved)	100 µg/l	Manganese (dissolved)	1 µg/l
Boron (dissolved)	1000 µg/l	Manganese (total)	1 µg/l
Cadmium (dissolved)	0.5 µg/l	Mercury (dissolved)	0.1 µg/l
Calcium	1 µg/l	Nickel (dissolved)	1 µg/l
Chloride	1 µg/l	Potassium	10 µg/l
Chromium (total) (dissolved)	1 µg/l	Selenium (dissolved)	1 µg/l
Chromium (III) (dissolved)	3 µg/l	Sodium (dissolved)	10 µg/l
Chromium (VI) (dissolved)	3 µg/l	Vanadium (dissolved)	1 µg/l
Copper (dissolved)	0.5 µg/l	Zinc (dissolved)	1 µg/l
Fluoride	1 µg/l		
Organics			
Alcohols and Acetates in Waters	10 to 100 mg/l	Polyaromatic Hydrocarbons (PAHs)	0.005 to 0.082 µg/l

Analyte	Detection Limits	Analyte	Detection Limits
Acrylamide	0.05 mg/l	Semi-volatile organic compounds (SVOCs)	0.1 µg/l
Benzene, Toluene, Ethylbenzene, Xylenes (BTEX)	0.2 to 1 µg/l	Total Petroleum Hydrocarbons (TPH)	10 mg/L
Total Phenols	0.5 µg/L	Volatile organic compounds	0.2 to 1 µg/l
TBC – to be confirmed			

3 Discharge Monitoring

3.1 West Ruislip Portal

3.1.1 Discharge monitoring requirements are provided in XXX.

Table 20. West Ruislip Portal Discharge Monitoring Requirements.

Parameter	Limit
Total Suspended Solids	50 mg/l
pH	6 to 9 (unitless)
Visible oil or grease	No trace present
Discharge rate	4,104 m^3/d 47.5 l/s as instantaneous discharge with the following formation specific limits: • 7 l/s from the Lambeth Group, • 10 l/s from the Harwich Formation, • 32 l/s from the Chalk Formation.

Appendix B: Figures - Groundwater monitoring location plans

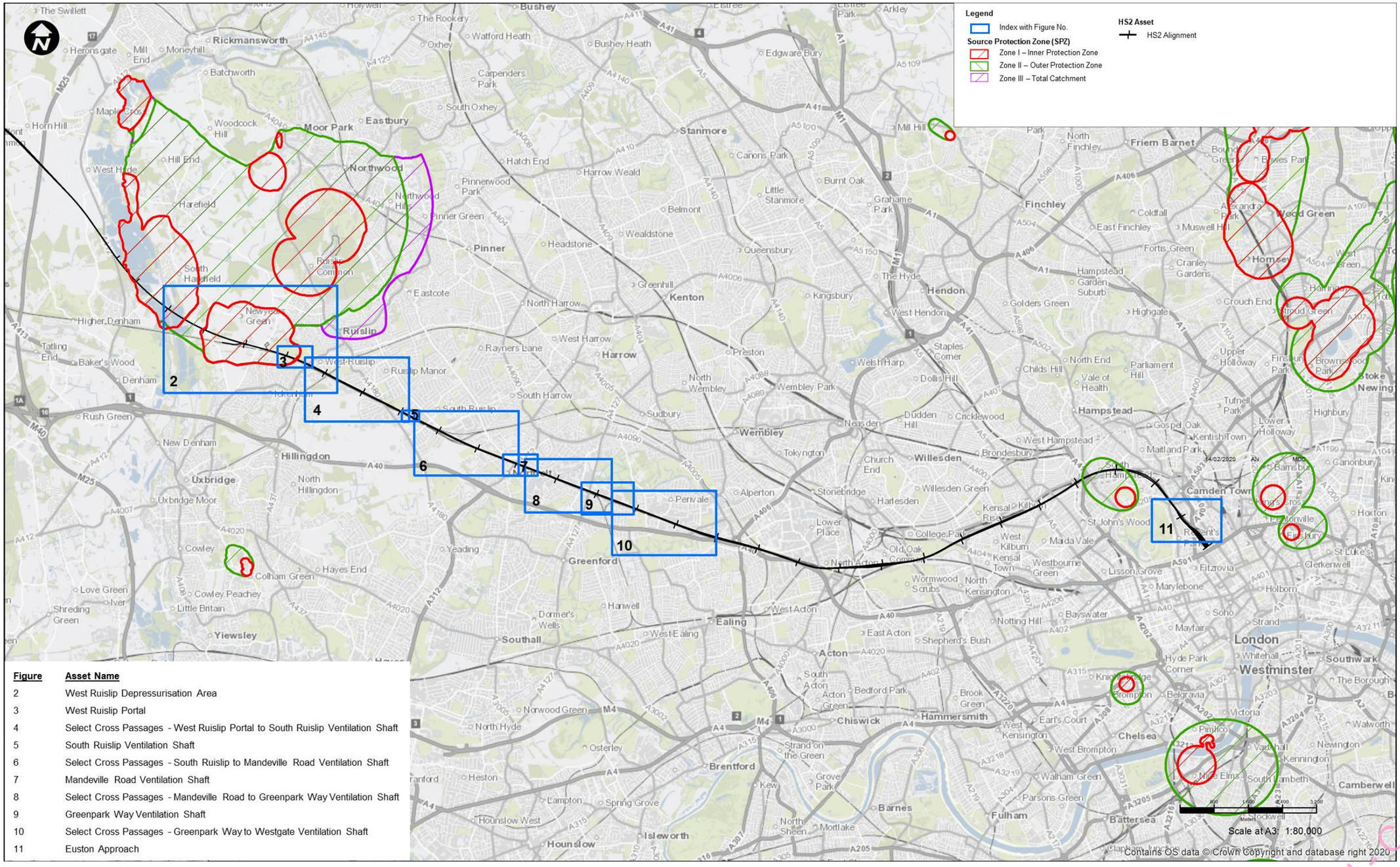

Figure	Asset Name
2	West Ruislip Depressurisation Area
3	West Ruislip Portal
4	Select Cross Passages - West Ruislip Portal to South Ruislip Ventilation Shaft
5	South Ruislip Ventilation Shaft
6	Select Cross Passages - South Ruislip to Mandeville Road Ventilation Shaft
7	Mandeville Road Ventilation Shaft
8	Select Cross Passages - Mandeville Road to Greenpark Way Ventilation Shaft
9	Greenpark Way Ventilation Shaft
10	Select Cross Passages - Greenpark Way to Westgate Ventilation Shaft
11	Euston Approach

Figure 1 Groundwater Monitoring Plan - Index Map

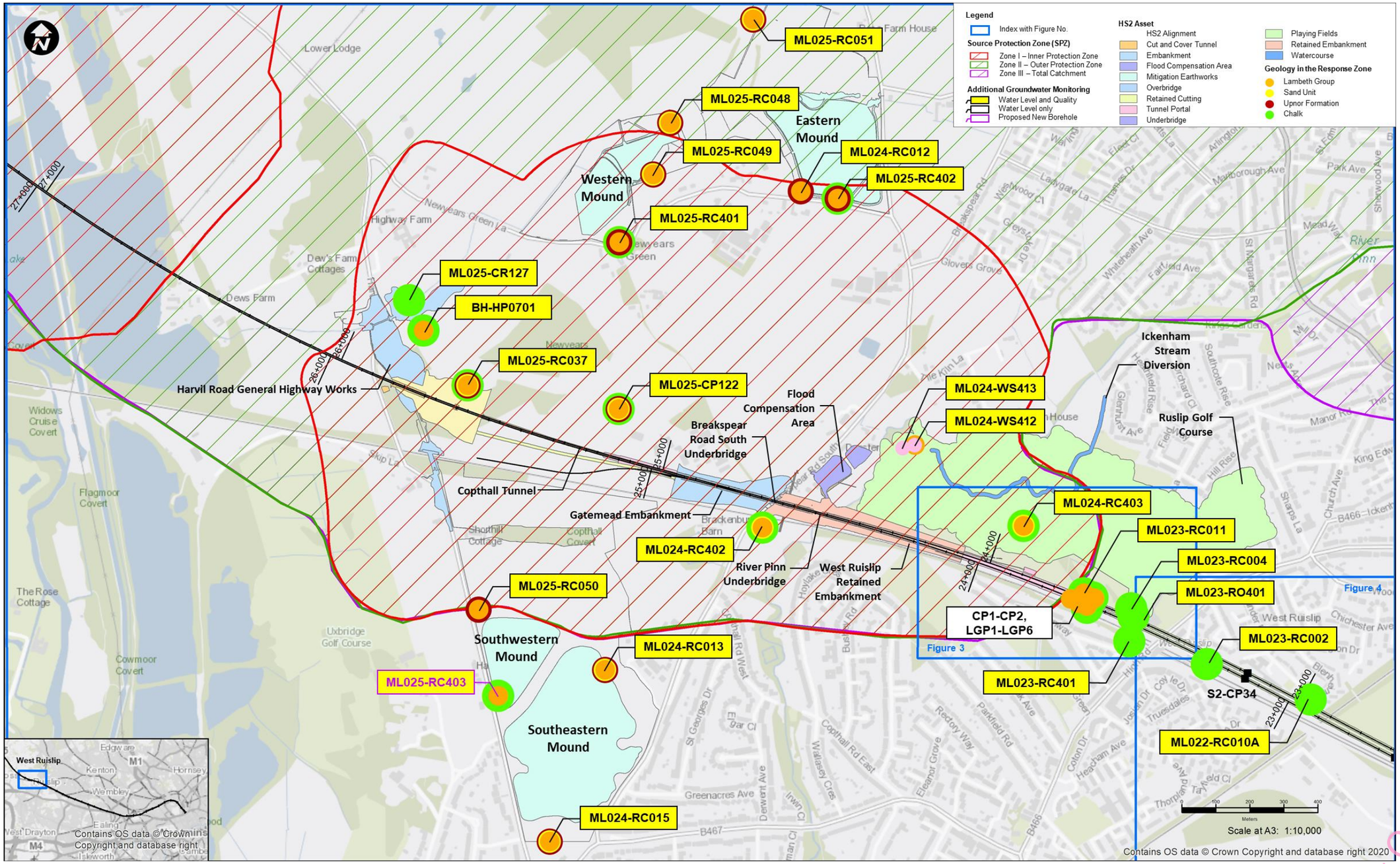

Figure 2 Groundwater Monitoring Plan – West Ruislip Depressurisation Area

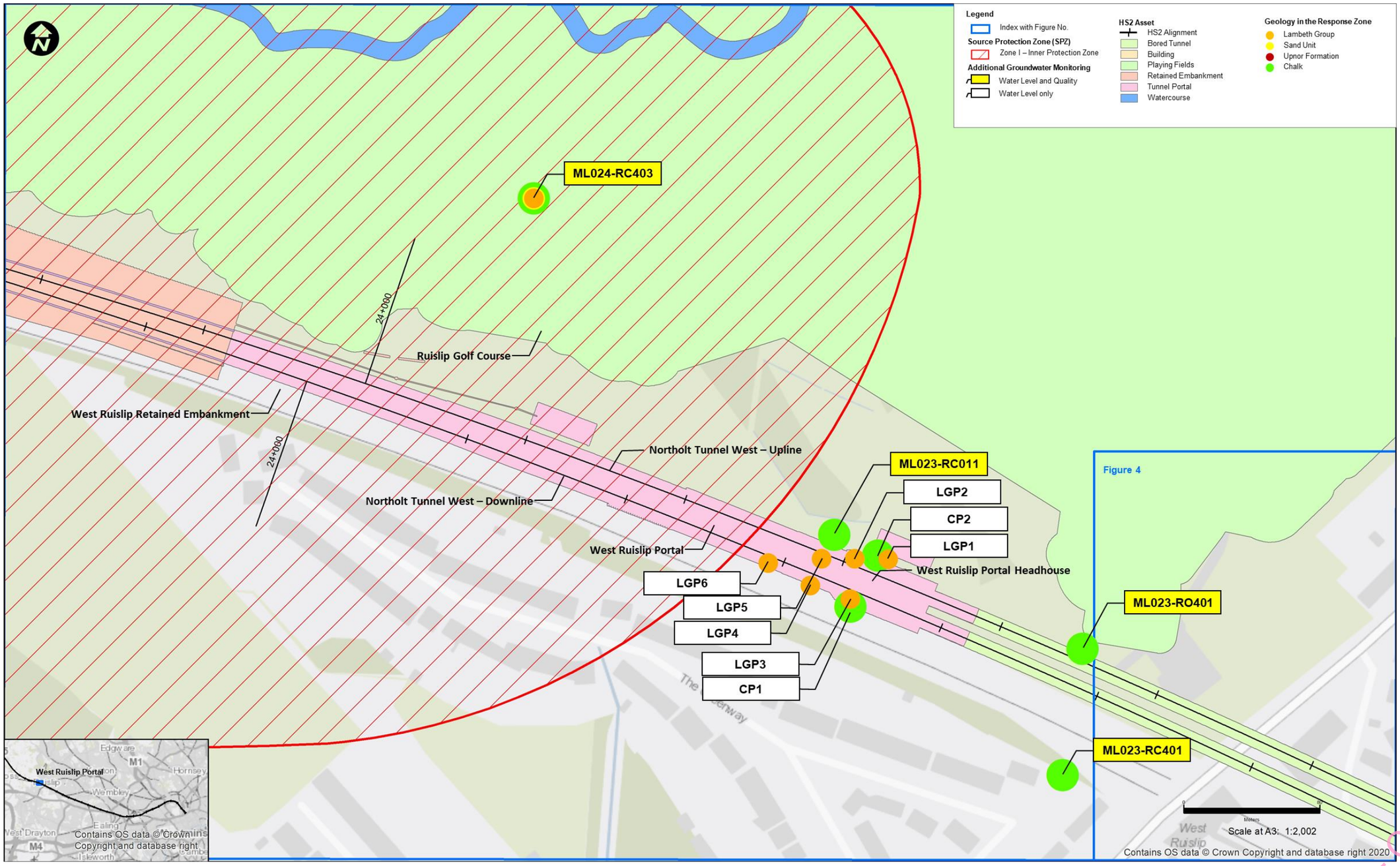

Figure 3 Groundwater Monitoring Plan – West Ruislip Portal

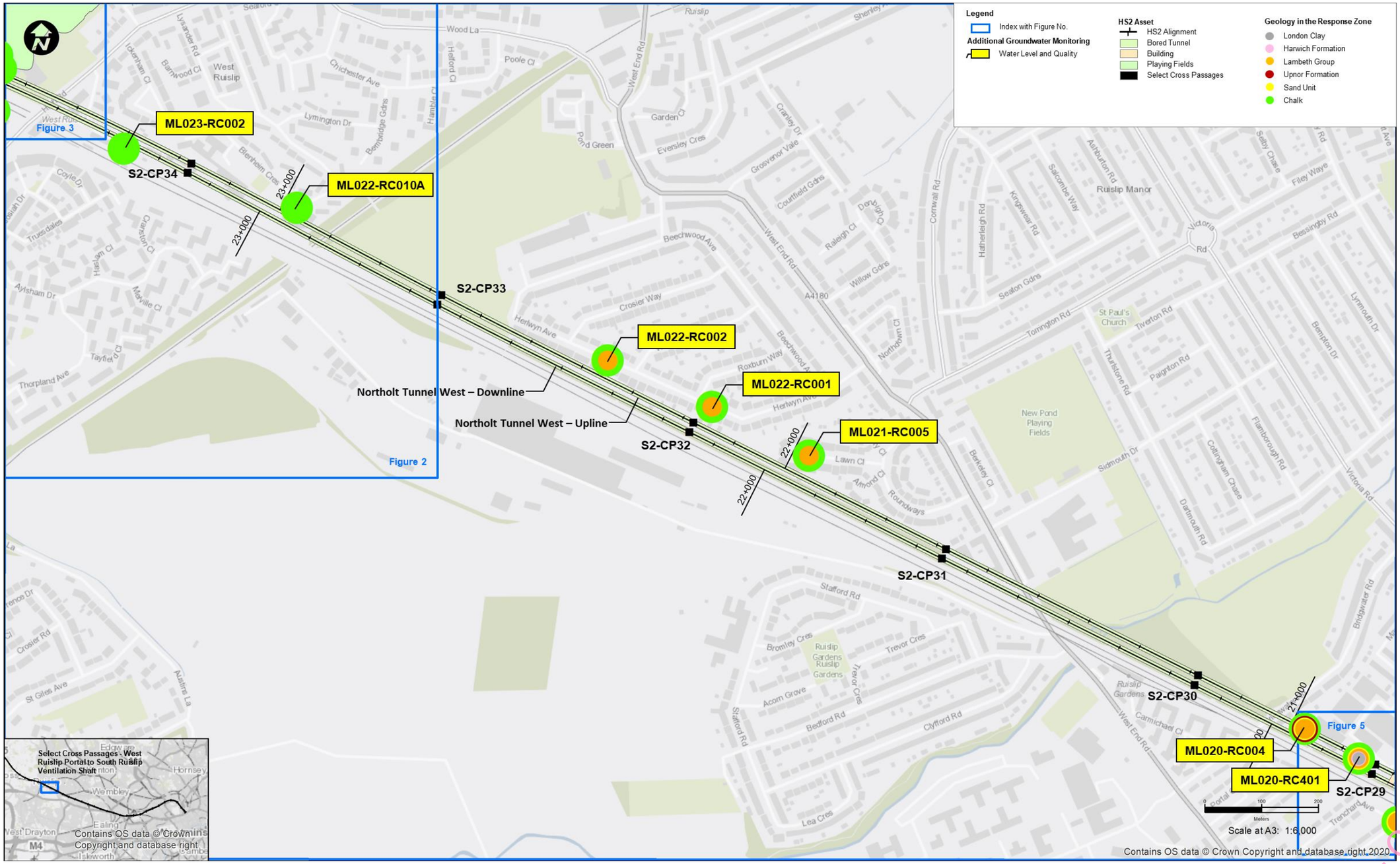

Figure 4 Groundwater Monitoring Plan – Cross Passages and Tunnels – West Ruislip Portal to South Ruislip Ventilation Shaft

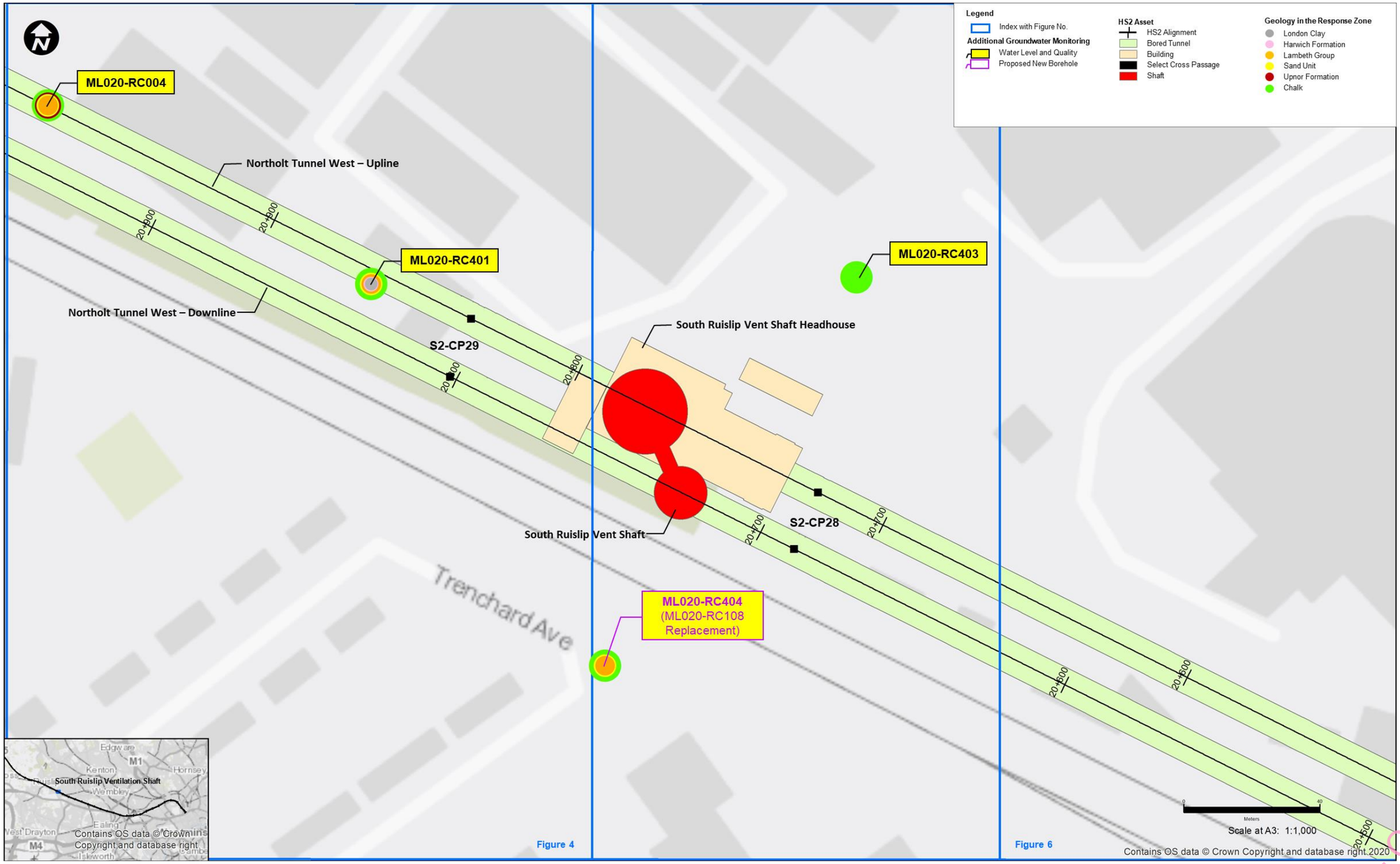

Figure 5 Groundwater Monitoring Plan – South Ruislip Ventilation Shaft

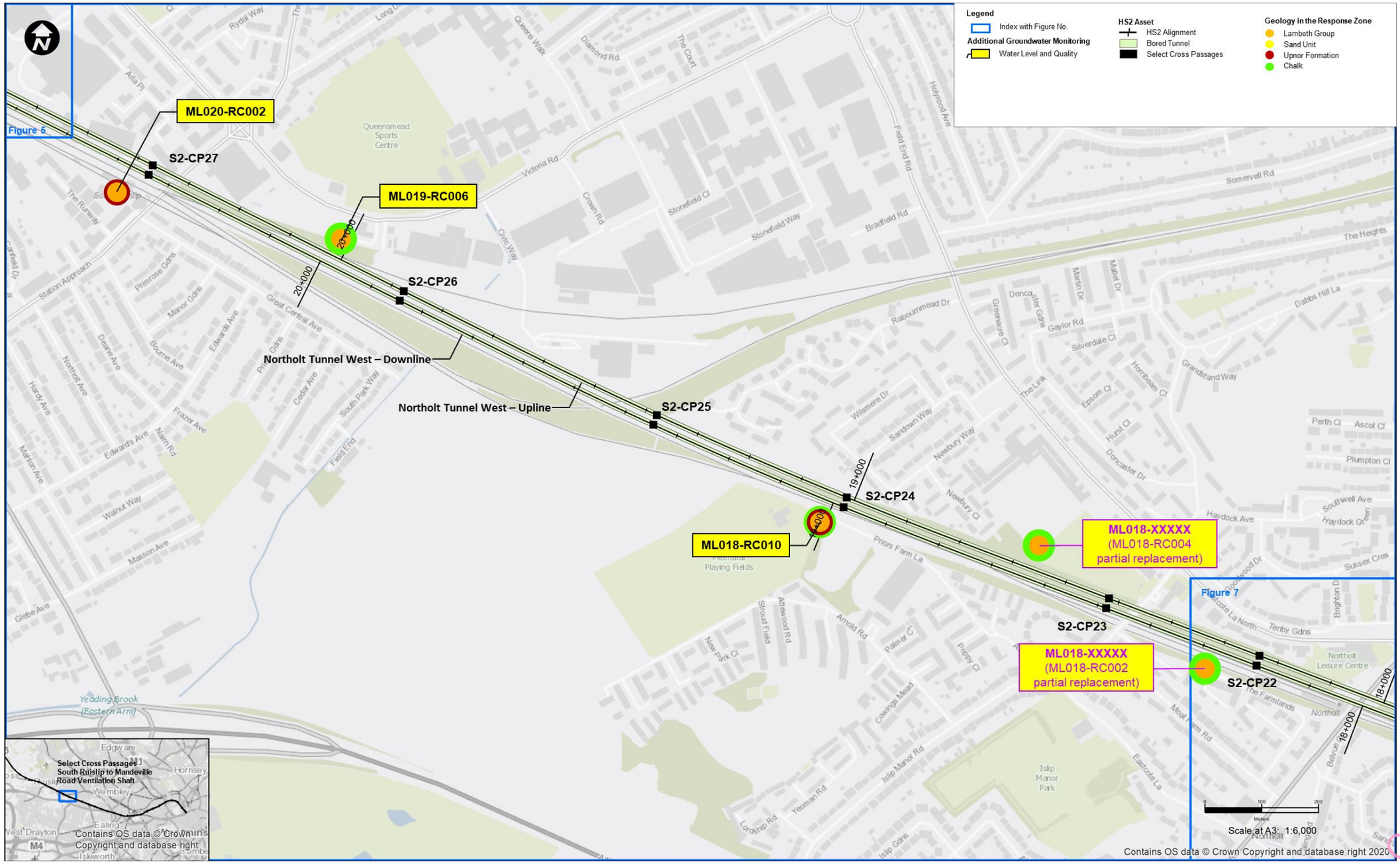

Figure 6 Groundwater Monitoring Plan - Cross Passages and Tunnels - South Ruislip to Mandeville Road Ventilation Shaft

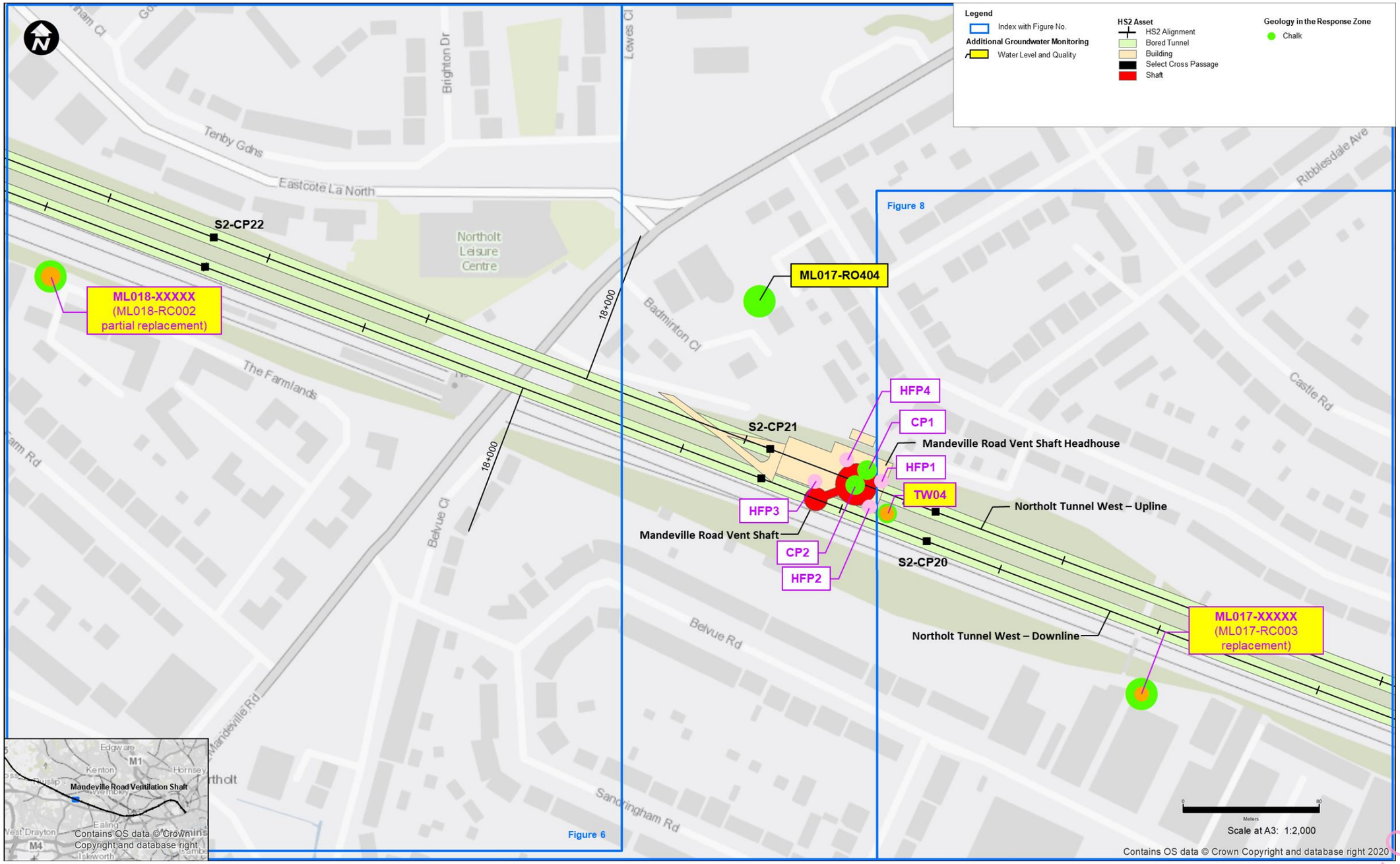

Figure 7 Groundwater Monitoring Plan - Mandeville Road Ventilation Shaft

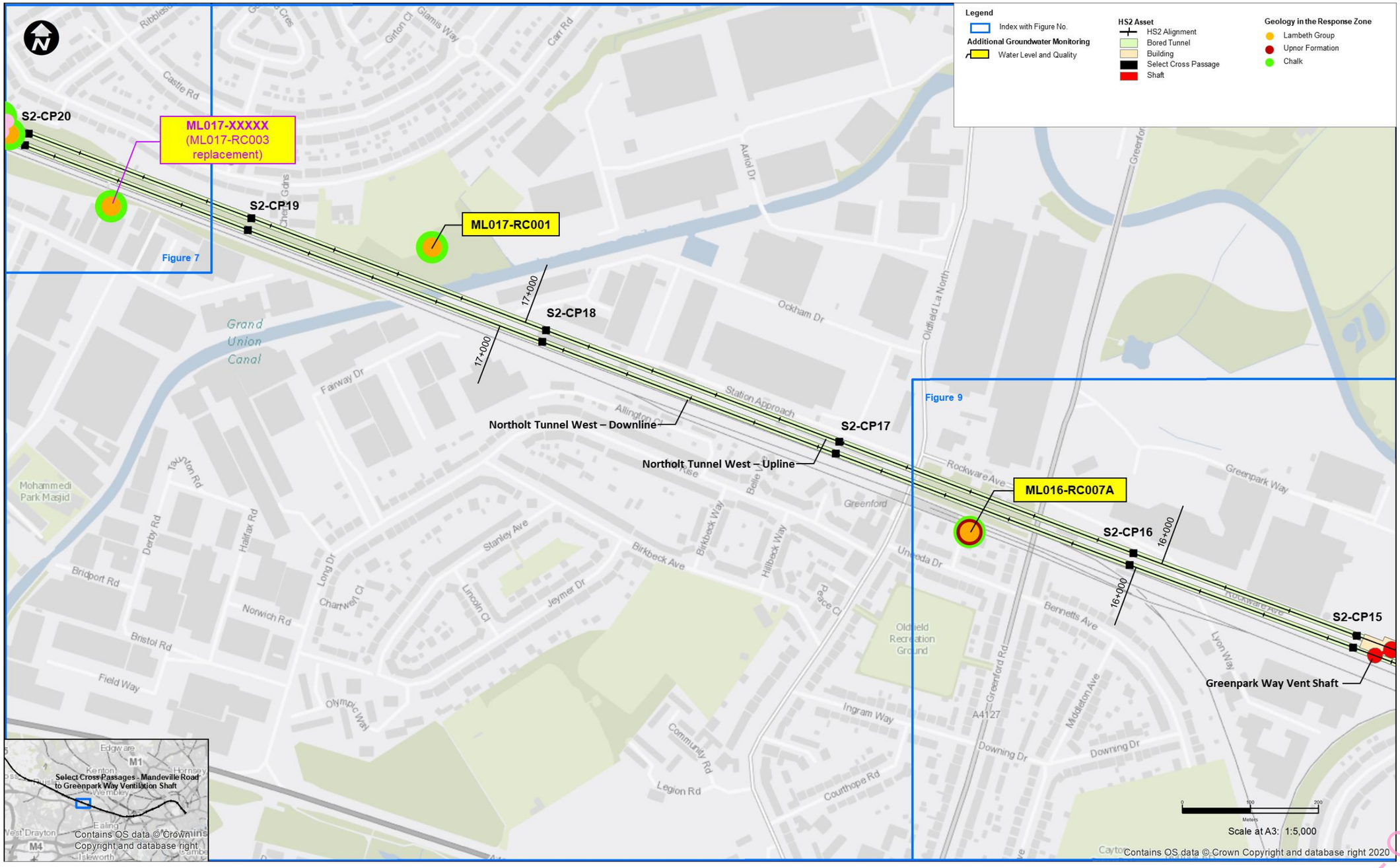

Figure 8 Groundwater Monitoring Plan - Cross Passages and Tunnels - Mandeville Road to Greenpark Way Ventilation Shaft

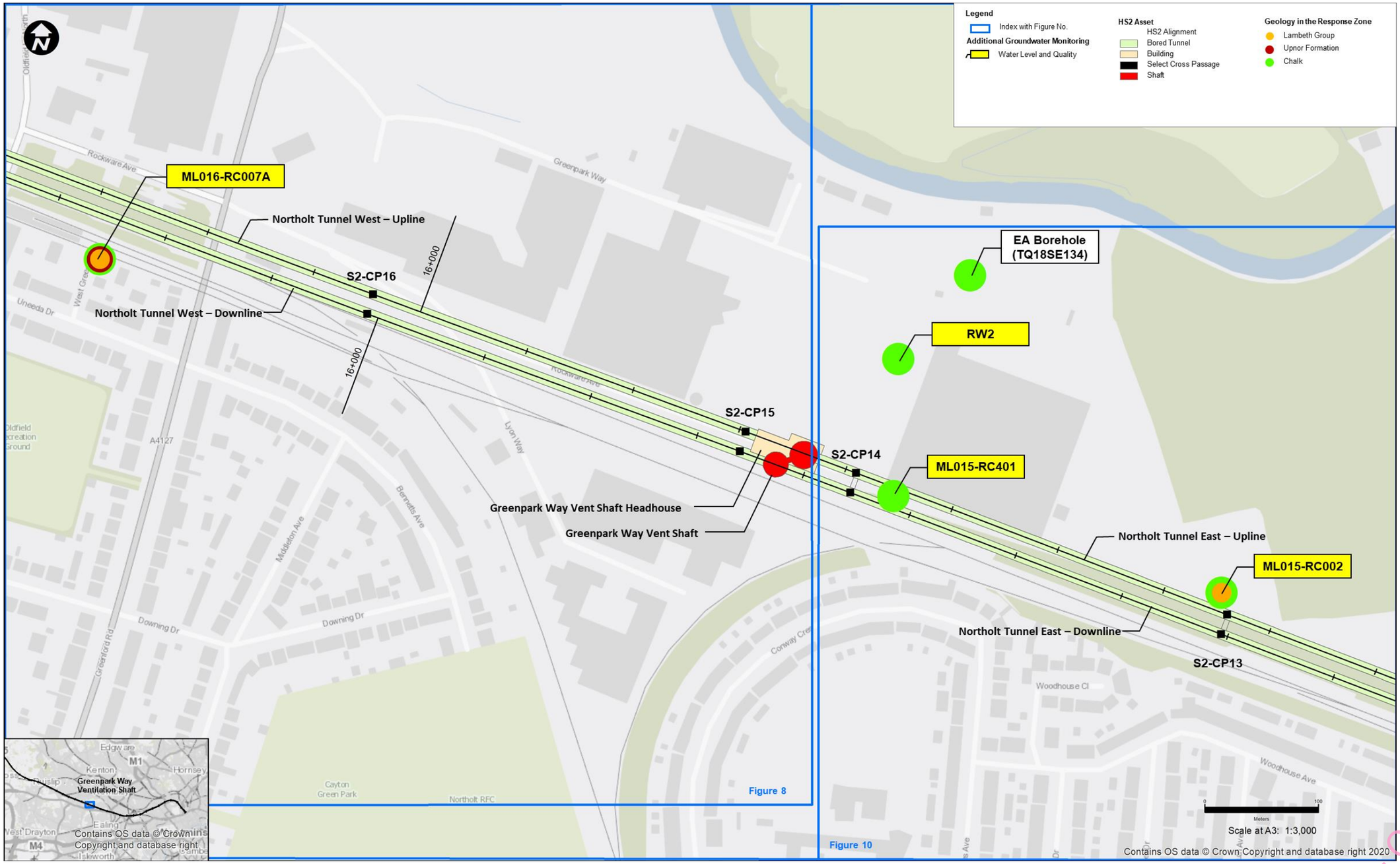

Figure 9 Groundwater Monitoring Plan - Greenpark Way Ventilation Shaft

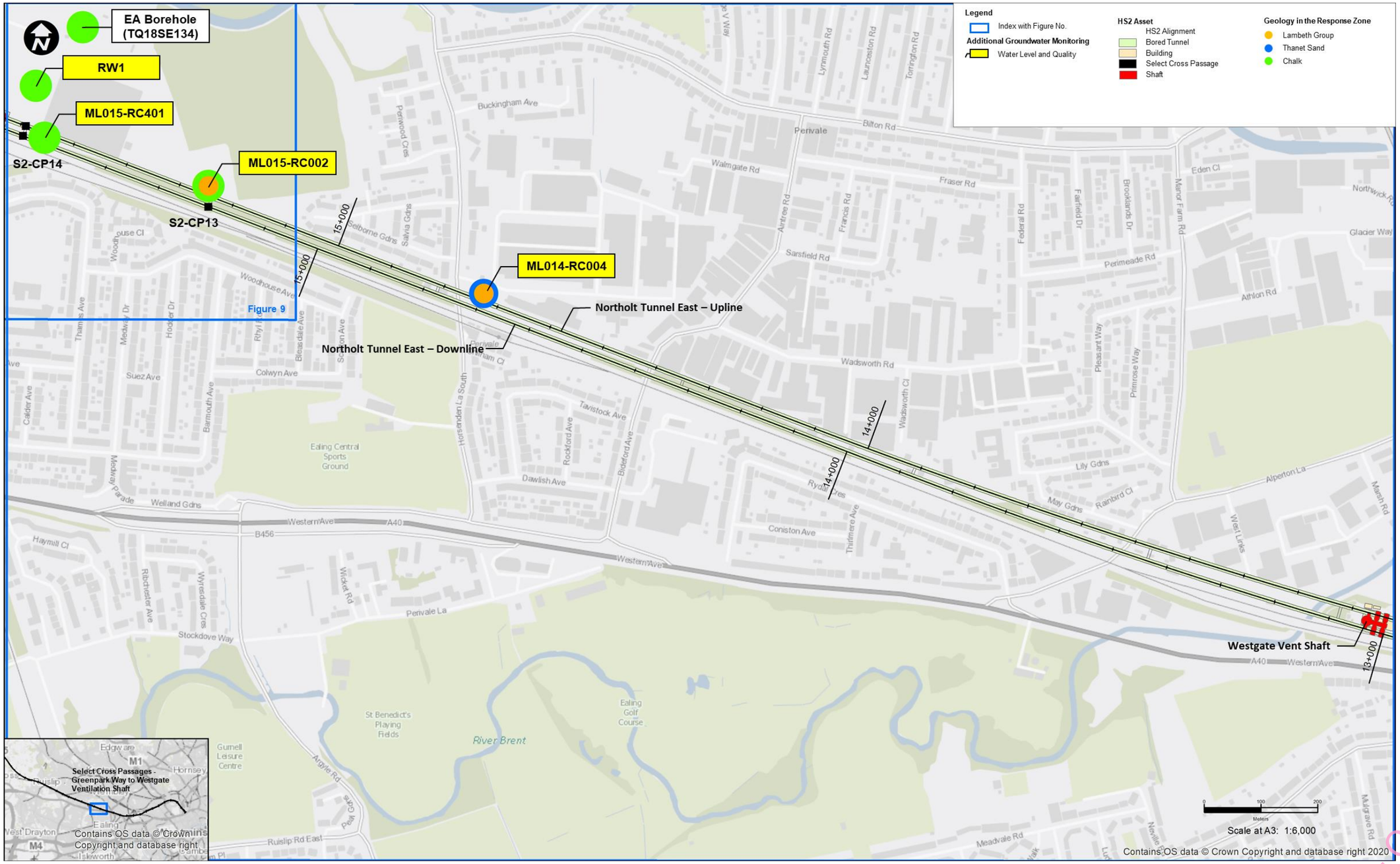

Figure 10 Groundwater Monitoring Plan - Cross Passages and Tunnels - Greenpark Way to Westgate Ventilation Shaft

Figure 11 Groundwater Monitoring Plan - Euston Approach

Appendix C: Groundwater monitoring locations and requirements

		Coordinates						Response Zone (mbgl)		Response Zone (mOD)		Installation Details		Geology									Construction GW Monitoring		Post-Construction GW Monitoring				
Asset ID	Borehole ID	BNG	BNG	SG	SG	Depth (mbgl)	Ground Elevation (mOD)	Top	Bottom	Top	Bottom	Type	Pipe Diameter (mm)	MG	SUPD	LC	HAR	LMG	SU	UPR	TS	CHK	Level	Quality	Level	Quality	Purpose	Core Suite	Contractor
	Harvil Road																												
	Ruislip Northern Sustainable Placement																												
RNSP	ML024-RC012	507319.36	188149.39	269835.04	294220.02	34.95	61.88	30	33	31.88	28.88	SP	50					✓		✓			Wd	Wcs_Mfs	Md	Mcs_Qfs	ENV	**B**	Concept
RNSP	ML025-RC048	506935.59	188350.64	269456.82	294431.74	21.7	54.76	16	20	38.76	34.76	SP	50					✓	✓	✓			Wd	Wcs_Mfs	Md	Mcs_Qfs	ENV	**B**	Concept
RNSP	ML025-RC049	506885.88	188198.58	269402.96	294281.06	21.5	51.23	14	19	37.23	32.23	SP	50					✓	✓	✓			Wd	Wcs_Mfs	Md	Mcs_Qfs	ENV	**B**	Concept
RNSP	ML025-RC051	507179.59	188653.51	269709.07	294727.9	31	59.98	19	29	40.98	30.98	SP	50					✓	✓	✓			Wd	Wcs_Mfs	Md	Mcs_Qfs	ENV	**B**	Concept
RNSP	ML025-RC401	506785.4	187999.6	269297.0532	294084.8522	36.9	54	17	20	37.00	34.00	SP	35					✓		✓			2xWd	2xWcs_Mfs	Md	Mcs_Qfs	ENV	**B**	Concept
RNSP	ML025-RC401	506785.4	187999.6	269297.0532	294084.8522	36.9	54	25.5	35.5	28.50	18.50	SP	50									✓	2xWd	2xWcs_Mfs	Md	Mcs_Qfs	ENV	**B**	Concept
RNSP	ML025-RC402	507427.7	188127.7	269942.7704	294195.366	44.5	60.12	24	27	36.12	33.12	SP	35					✓		✓			2xWd	2xWcs_Mfs	Md	Mcs_Qfs	ENV	**B**	Concept
RNSP	ML025-RC402	507427.7	188127.7	269942.7704	294195.366	44.5	60.12	32.5	42.5	27.62	17.62	SP	35									✓	2xWd	2xWcs_Mfs	Md	Mcs_Qfs	ENV	**B**	Concept
	Ruislip Southern Sustainable Placement																												
RSSP	ML024-RC013	506744.01	186744.51	269221.35	292831.04	23.45	47.45	17	20	30.45	27.45	SP	50					✓	✓	✓			Wd	Wcs_Mfs	Md	Mcs_Qfs	ENV	**A**	Concept
RSSP	ML024-RC015	506581.44	186240.07	269045.01	292331.1	36.6	59.64	29	32	30.64	27.64	SP	50					✓	✓	✓			Wd	Wcs_Mfs	Md	Mcs_Qfs	ENV	**A**	Concept
RSSP	ML025-RC050	506372.55	186921.2	268854.77	293017.87	27	53.58	19.9	24.9	33.68	28.68	SP	50					✓		✓			Wd	Wcs_Mfs	Md	Mcs_Qfs	ENV	**A**	Concept
RSSP	ML025-RC403	506429.7	186667.5	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	SP	50					✓					Wd	Wcs_Mfs	Md	Mcs_Qfs	ENV	**A**	Concept
RSSP	ML025-RC403	506429.7	186667.5	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC	SP	50									✓	Wd	Wcs_Mfs	Md	Mcs_Qfs	ENV	**A**	Concept
	Copthall Tunnel																												
COP	ML025-CP122	506784.19	187509.69	269282.45	293595.03	33.77	61.1	28	33.7	33.1	27.4	SP	50					✓	✓	✓		✓	Wd	Wcs_Mfs	Md	Mcs_Qfs	ENV	**A**	Concept
COP	ML025-CR127	506168	187829	268675.07	293931.16	10	39.11	7	10	32.11	29.11	SP	35									✓	Wd	Wcs_Mfs	Md	Mcs_Qfs	ENV	**A**	Concept
COP	ML025-RC037	506339.92	187579.3	268840.14	293676.79	50	65.07	38	48	27.07	17.07	SP	50					✓	✓	✓		✓	Wd	Wcs_Mfs	NA	NA	ENV	**A**	Concept
COP	BH-HP0701	506210.5	187740.04	268715.1	293841	TBC	41.89	5.8	7.8	36.09	34.09	SP	50					✓					Wd	Wcs_Mfs	NA	NA	ENV	**A**	Concept
COP	BH-HP0701	506210.5	187740.04	268715.1	293841	TBC	41.89	13.8	15.8	28.09	26.09	SPIE	19									✓	Wd	NA	NA	NA	ENV	**A**	Concept
	River Pinn																												
	Great Crested Newt Pond																												
NEWT	ML024-WS412	507655	187404.2	270150.2575	293465.7326	5.7	39.99	4.5	5.1	35.49	34.89	SP	50				✓	✓					HI_Mdc	BWcs_BWfs	NA	NA	ENV	**A**	Concept
NEWT	ML024-WS413	507619.5	187396	270114.5381	293458.5046	4.8	39.29	2.8	4	36.49	35.29	SP	50				✓						HI_Mdc	BWcs_BWfs	NA	NA	ENV	**A**	Concept
	West Ruislip Area Structures																												
WRP	ML024-RC402	507206.73	187162.07	269695.43	293235.89	29.4	TBC	7.5	10.5	TBC	TBC	SP	TBC					✓	✓				Wd	Wcs_Mfs	Md	Mcs_Qfs	ENV	**A**	Concept
WRP	ML024-RC402	507206.73	187162.07	269695.43	293235.89	29.4	TBC	11.5	21.5	TBC	TBC	SP	TBC									✓	Wd	Wcs_Mfs	Md	Mcs_Qfs	ENV	**A**	Concept

		Coordinates						Response Zone (mbgl)		Response Zone (mOD)		Installation Details		Geology									Construction GW Monitoring		Post-Construction GW Monitoring				
Asset ID	Borehole ID	BNG	BNG	SG	SG	Depth (mbgl)	Ground Elevation (mOD)	Top	Bottom	Top	Bottom	Type	Pipe Diameter (mm)	MG	SUPD	LC	HAR	LMG	SU	UPR	TS	CHK	Level	Quality	Level	Quality	Purpose	Core Suite	Contractor
	West Ruislip Portal																												
WRP	CP1	508160.4449	186926.6969	270642.579	292974.46		TBC	TBC	TBC	TBC	TBC	SP	50									✓	HI_Wd_Wdc	NA	HI_Wd_Wdc	NA	ENV	NA	WJ
WRP	CP2	508176.6548	186956.7306	270659.6078	293004.0467		TBC	TBC	TBC	TBC	TBC	SP	50									✓	HI_Wd_Wdc	NA	HI_Wd_Wdc	NA	ENV	NA	WJ
WRP	LGP1	508182.5829	186954.5805	270665.4763	293001.7347		TBC	TBC	TBC	TBC	TBC	SP	50					✓					HI_Wd_Wdc	NA	HI_Wd_Wdc	NA	ENV	NA	WJ
WRP	LGP2	508163.0218	186954.9054	270645.9267	293002.5946		TBC	TBC	TBC	TBC	TBC	SP	50					✓					HI_Wd_Wdc	NA	HI_Wd_Wdc	NA	ENV	NA	WJ
WRP	LGP3	508160.236	186931.1233	270642.4911	292978.8916		TBC	TBC	TBC	TBC	TBC	SP	50					✓					HI_Wd_Wdc	NA	HI_Wd_Wdc	NA	ENV	NA	WJ
WRP	LGP4	508136.9801	186939.1936	270619.459	292987.597		TBC	TBC	TBC	TBC	TBC	SP	50					✓					HI_Wd_Wdc	NA	HI_Wd_Wdc	NA	ENV	NA	WJ
WRP	LGP5	508143.5476	186954.8218	270626.4529	293003.0437		TBC	TBC	TBC	TBC	TBC	SP	50					✓					HI_Wd_Wdc	NA	HI_Wd_Wdc	NA	ENV	NA	WJ
WRP	LGP6	508112.1782	186952.3427	270595.02	293001.423		TBC	TBC	TBC	TBC	TBC	SP	50					✓					HI_Wd_Wdc	NA	HI_Wd_Wdc	NA	ENV	NA	WJ
WRP	ML024-RC403	507974.44	187166.52	270463.1561	293219.3425	38.5	42.75	15	20	27.75	22.75	SP	19					✓	✓				Wd	Wcs_Mfs	HI_Md_Mdc	Mcs_Qfs	ENV	A	Concept
WRP	ML024-RC403	507974.44	187166.52	270463.1561	293219.3425	38.5	42.75	23	38	19.75	4.75	SP	50									✓	Wd	Wcs_Mfs	HI_Md_Mdc	Mcs_Qfs	ENV	A	Concept
WRP	ML023-RC011	508151	186969	270634.29	293017.02	30	42.46	25	30	17.46	12.46	SP	35									✓	Wd	Wcs_Mfs	HI_Md_Mdc	Mcs_Qfs	ENV	A	Concept
WRP	ML023-RC401	508285.11	186827.84	270764.52	292872.2	46.5	46.64	33.5	43.5	13.14	3.14	SP	50									✓	Wd	Wcs_Mfs	NA	NA	ENV	A	Concept
WRP	ML023-RO401	508296.79	186901.97	270778.23	292946.01	63.4	44.54	33.1	63	11.44	-18.46	SPIE	50									✓	Wd	Wcs_Mfs	NA	NA	ENV	A	Concept
	Cross-passages between West Ruislip Portal and South Ruislip Vent Shaft																												
CP-W2S	ML023-RC002	508513	186761	270990.56	292799.14	45.15	46.28	29	33	17.28	13.28	SP	35									✓	Wd	Wcs_Mfs	HI_Md_Mdc	Mcs_Qfs	ENV	A	Concept
CP-W2S	ML022-RC001	509550	186306	272014.97	292315.83	45.45	39.45	19	20	20.45	19.45	SPIE	25					✓					Wd	Wcs_Mfs	Qd	Qcs_Qfs	ENV	A	Concept
CP-W2S	ML022-RC001	509550	186306	272014.97	292315.83	45.45	39.45	25	29	14.45	10.45	SP	35									✓	Wd	Wcs_Mfs	HI_Md_Mdc	Mcs_Qfs	ENV	A	Concept
CP-W2S	ML022-RC002	509366	186388	271833.24	292402.85	42.55	41.37	19.5	20.5	21.87	20.87	SPIE	19					✓					Wd	Wcs_Mfs	Qd	Qcs_Qfs	ENV	NA	Concept
CP-W2S	ML022-RC002	509366	186388	271833.24	292402.85	42.55	41.37	27.65	30.65	13.72	10.72	SP	35									✓	Wd	Wcs_Mfs	HI_Md_Mdc	Mcs_Qfs	ENV	NA	Concept
CP-W2S	ML022-RC010A	508818	186657	271292.67	292686.81	36.5	45.88	27	30	18.88	15.88	SP	50									✓	Wd	Wcs_Mfs	HI_Md_Mdc	Mcs_Qfs	ENV	A	Concept
CP-W2S	ML021-RC005	509721	186220	272183.6	292225.16	45.1	37.9	17.5	18.5	20.4	19.4	SPIE	25					✓					Wd	Wcs_Mfs	Qd	Qcs_Qfs	ENV	A	Concept
CP-W2S	ML021-RC005	509721	186220	272183.6	292225.16	45.1	37.9	23	28	14.9	9.9	SP	35									✓	Wd	Wcs_Mfs	HI_Md_Mdc	Mcs_Qfs	ENV	A	Concept
	South Ruislip Vent Shaft																												
NSR	ML020-RC004	510595	185739	273044.32	291720.32	45.35	42.28	22.5	23	19.78	19.28	SPIE	25					✓	✓	✓			Wd	Wcs_Mfs	NA	NA	ENV	A	Concept
NSR	ML020-RC004	510595	185739	273044.32	291720.32	45.35	42.28	31	37	11.28	5.28	GMP	35									✓	Wd	Wcs_Mfs	NA	NA	ENV	A	Concept
NSR	ML020-RC401	510689.93	185686.56	273137.8	291665.29	50	42.54	13.5	15.5	29.04	27.04	SPIE	19			✓	✓	✓	✓				Wd	Wcs_Mfs	NA	NA	ENV	A	Concept
NSR	ML020-RC401	510689.93	185686.56	273137.8	291665.29	50	42.54	32	50	10.54	-7.46	SP	50									✓	Wd	Wcs_Mfs	NA	NA	ENV	A	Concept
NSR	ML020-RC403	510832.5	185688.5	273280.41	291663.33	48.8	TBC	38	48	TBC	TBC	SP	50									✓	Wd	Wcs_Mfs	Md_Mdc	Mcs_Qfs	ENV	A	Concept
NSR	ML020-RC404 (ML020-RC108 replacement)	510758.7	185574.5	TBC	TBC		TBC	TBC	TBC	TBC	TBC	SP	TBC					✓	✓				Wd	Wcs_Mfs	Md_Mdc	Mcs_Qfs	ENV	A	Concept
NSR	ML020-RC404 (ML020-RC108 replacement)	510758.7	185574.5	TBC	TBC		TBC	TBC	TBC	TBC	TBC	SP	TBC									✓	Wd	Wcs_Mfs	Md_Mdc	Mcs_Qfs	ENV	A	Concept
	Cross-passages between South Ruislip to Mandeville Road Vent Shaft																												
CP-S2M	ML020-RC002	511071	185421	273511.56	291389.34	45	37.78	24	27	13.78	10.78	SP	50					✓		✓			Wd	Wcs_Mfs	Md_Mdc	Mcs_Qfs	ENV	A	Concept
CP-S2M	ML019-RC006	511466	185339	273904.27	291296.55	40.5	34.59	18.5	19.5	16.09	15.09	SPIE	25					✓					Wd	Wcs_Mfs	Qd	Qcs_Qfs	ENV	A	Concept
CP-S2M	ML019-RC006	511466	185339	273904.27	291296.55	40.5	34.59	27	30	7.59	4.59	SP	35									✓	Wd	Wcs_Mfs	Md_Mdc	Mcs_Qfs	ENV	A	Concept
CP-S2M	ML018-XXXXX (ML018-RC002 partial replacement)	512989.95	184581.95	275407.34	290497.93	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC					✓					Wd	Wcs_Mfs	Qd	Qcs_Qfs	ENV	A	Concept
CP-S2M	ML018-RC002	512989.95	184581.95	275407.34	290497.93	50.6	41.42	46	50	-4.58	-8.58	SP	35									✓	Wd	Wcs_Mfs	Md_Mdc	Mcs_Qfs	ENV	A	Concept
CP-S2M	ML018-XXXXX (ML018-RC004 partial replacement)	512697.05	184798.73	275120.4	290722.69	TBC	TBC	TBC	TBC	TBC	TBC	TBC	TBC					✓					Wd	Wcs_Mfs	Qd	Qcs_Qfs	ENV	A	Concept
CP-S2M	ML018-RC004	512697.05	184798.73	275120.4	290722.69	50	45.32	47	50	-1.68	-4.68	SP	35									✓	Wd	Wcs_Mfs	Md_Mdc	Mcs_Qfs	ENV	A	Concept
CP-S2M	ML018-RC010	512310.6	184839.86	274735.11	290774.38	45.3	42.16	30	31	12.16	11.16	SPIE	25					✓					Wd	Wcs_Mfs	Qd	Qcs_Qfs	ENV	A	Concept
CP-S2M	ML018-RC010	512310.6	184839.86	274735.11	290774.38	45.3	42.16	35	35.75	7.16	6.41	SP	50					✓		✓		✓	Wd	Wcs_Mfs	Md_Mdc	Mcs_Qfs	ENV	A	Concept

		Coordinates						Response Zone (mbgl)		Response Zone (mOD)		Installation Details		Geology									Construction GW Monitoring		Post-Construction GW Monitoring				
Asset ID	Borehole ID	BNG	BNG	SG	SG	Depth (mbgl)	Ground Elevation (mOD)	Top	Bottom	Top	Bottom	Type	Pipe Diameter (mm)	MG	SUPD	LC	HAR	LMG	SU	UPR	TS	CHK	Level	Quality	Level	Quality	Purpose	Core Suite	Contractor
	Mandeville Road Vent Shaft																												
NMA	ML017-RO404	513406.87	184567.34	275823.81	290471.93	65	42.97	54	65	-11.03	-22.03	SP	50									✓	Wd	Wcs_Mfs	Md_Mdc	Mcs_Qfs	ENV	**A**	Concept
NMA	ML017-XXXX (RC003 replacement)	513631.49	184336.78	276042.11	290235.27	TBD	TBD	TBD	TBD	TBD	TBD	SP	TBD					✓					Wd	Wcs_Mfs	Md_Mdc	Mcs_Qfs	ENV	**A**	Concept
NMA	ML017-XXXX (RC003 replacement)	513631.49	184336.78	276042.11	290235.27	TBD	TBD	TBD	TBD	TBD	TBD	SP	50									✓	Wd	Wcs_Mfs	Md_Mdc	Mcs_Qfs	ENV	**A**	Concept
NMA	TW04	513481.83	184442.81	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	SP	TBD					✓					Wd	Wcs_Mfs	Md_Mdc	Mcs_Qfs	ENV	**A**	Concept
NMA	TW04	513481.83	184442.81	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	SP	50									✓	Wd	Wcs_Mfs	Md_Mdc	Mcs_Qfs	ENV	**A**	Concept
NMA	HFP1	513478.65	184461.7	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	SP	50				✓						Hl_Wd_Wdc	NA	Hl_Wd_Wdc	NA	ENV	NA	WJ
NMA	HFP2	513471.43	184446.7	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	SP	50				✓						Hl_Wd_Wdc	NA	Hl_Wd_Wdc	NA	ENV	NA	WJ
NMA	HFP3	513439.52	184461.54	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	SP	50				✓						Hl_Wd_Wdc	NA	Hl_Wd_Wdc	NA	ENV	NA	WJ
NMA	HFP4	513458.17	184474.32	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	SP	50				✓						Hl_Wd_Wdc	NA	Hl_Wd_Wdc	NA	ENV	NA	WJ
NMA	CP1	513469.92	184468.29	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	SP	50									✓	Hl_Wd_Wdc	NA	Hl_Wd_Wdc	NA	ENV	NA	WJ
NMA	CP2	513463.1	184459.48	TBD	TBD	TBD	TBD	TBD	TBD	TBD	TBD	SP	50									✓	Hl_Wd_Wdc	NA	Hl_Wd_Wdc	NA	ENV	NA	WJ
	Cross-passages between Mandeville Road and Greenpark Way Vent Shaft																												
CP-M2G	ML017-RC001	514103.15	184276.84	276512.08	290162.45	50	29.31	36.5	37.5	-7.19	-8.19	SPIE	25					✓					Wd	Wcs_Mfs	Qd	Qcs_Qfs	ENV	**A**	Concept
CP-M2G	ML017-RC001	514103.15	184276.84	276512.08	290162.45	50	29.31	49	50	-19.69	-20.69	SP	50									✓	Wd	Wcs_Mfs	Md_Mdc	Mcs_Qfs	ENV	**A**	Concept
	Greenpark Way Vent Shaft																												
GPW	ML016-RC007A	514892.33	183858.93	277289.75	289723.04	55	23.2	25	26	-1.8	-2.8	SPIE	25					✓					Wd	Wcs_Mfs	Qd	Qcs_Qfs	ENV	**C**	Concept
GPW	ML016-RC007A	514892.33	183858.93	277289.75	289723.04	55	23.2	40	45	-16.8	-21.8	SP	35					✓		✓		✓	Wd	Wcs_Mfs	Md_Mdc	Mcs_Qfs	ENV	**C**	Concept
GPW	ML015-RC401	515591.66	183650.19	277983.29	289495.22	61	28.06	45.5	55.5	-17.44	-27.44	SP	50									✓	Wd	Wcs_Mfs	Md_Mdc	Mcs_Qfs	ENV	**C**	Concept
GPW	EA Borehole (TQ18SE134)	515659.31	183844.58	278056.25	289687.73	122.04	30.44	45.74	122.04	-15.3	-91.6	NA	NA									✓	Wd	NA	NA	NA	ENV	NA	Concept
GPW	RW2	515596.00	183771.00	277985.17	289621.37	75	28.13	47	75	-18.87	-46.87	NA	200									✓	Wd	Wcs_Mfs	Md_Mdc	Mcs_Qfs	ENV	**C**	Concept
GPW	ML015-RC002	515880.76	183565.03	278270.02	289402.17	45.3	22.67	26.5	27.5	-3.83	-4.83	SPIE	25					✓					Wd	Wcs_Mfs	Qd	Qcs_Qfs	ENV	**C**	Concept
GPW	ML015-RC002	515880.76	183565.03	278270.02	289402.17	45.3	22.67	42.5	45	-19.83	-22.33	SP	50									✓	Wd	Wcs_Mfs	Md_Mdc	Mcs_Qfs	ENV	**C**	Concept
	Cross-passages between Greenpark Way and Westgate Vent Shaft																												
CP-G2W	ML014-RC004	516366	183375.34	278750.01	289199.25	40.35	20.53	37.35	40.35	-16.82	-19.82	SP	50					✓			✓		Wd	Wcs_Mfs	NA	NA	ENV	**A**	Concept
	Westgate Vent Shaft																												
	Atlas Road Logistics Tunnel																												
	Victoria Road Crossover Box																												
	Canterbury Works Vent Shaft																a												
	Adelaide Road Vent Shaft																												
	Euston Approach																												
EUS	ML000-RC014	529199.93	182887.01	291568.51	288360.33	61	23.12	56	59	-32.88	-35.88	SP	35									✓	Wd	Wcs_Mfs	NA	NA	ENV	**A**	Concept
EUS	ML000-RO401	529046.59	183039.07	291419.3552	288516.554	70	30.7	51	70	-20.3	-39.3	SP	50									✓	Wd	Wcs_Mfs	Hl_Md_Mdc	Mcs_Qfs	ENV	**A**	Concept
EUS	ML000-RO402A	529133.3	182948.89	291503.5837	288424.0193	59	25.3	51	59	-25.7	-33.7	SP	50									✓	Wd	Wcs_Mfs	Hl_Md_Mdc	Mcs_Qfs	ENV	**A**	Concept
EUS	ML001-RC036	528719.59	183463.54	291104.02	288949.89	60.35	35.71	56	60.35	-20.29	-24.64	SP	50									✓	Wd	Wcs_Mfs	Hl_Md_Mdc	Mcs_Qfs	ENV	**A**	Concept

Notes:

Borehole ID:	Yellow box: both groundwater level and quality monitoring are specified; White box: only groundwater level monitoring is specified; Purple text: Proposed new borehole.
Easting/Northing:	BNG: British National Grid; SG: Snake Grid.
Type:	**GMP - Groundwater Monitoring Point; SP - Standpipe; SPIE - Standpipe Piezometer**
Geology:	**CHK - Chalk; LC - London Clay; LMG - Lambeth Group; MG - Made Ground; SU - Sand Unit; SUPD - Superficial Deposits; TS - Thanet Sand; UPR - Upnor Formation.**
GW Monitoring:	Groundwater monitoring covers **construction** and **post-construction.**
Level:	**2xW (two times per week); Hl - Hourly (logger); Md - Monthly (dip); Wd - Weekly (dip); Mdc - Monthly (data collection); Wdc - Weekly (data collection)**
Quality:	**BW - Biweekly (once every 2 weeks); Mfs - Monthly (full suite); Qcs - Quarterly (core suite); Qfs - Quarterly (full suite); Wcs - Weekly (core suite); Mcs - Monthly (core suite)**
Figure no(s):	Refer to Figure number 1 - Index Plan for Figure title.
TBC:	To be confirmed.
NA:	Not Applicable
Purpose :	**ENV - Environmental Compliance**.
Core Suite:	For details on Core Suite analyte categories A, B, and C, see Appendix A.
Status:	In Use - monitoring is required, MUD - monitoring until decomissioned, D - decomissioned, TBD - to be decomissioned, RFP - removed from plan

Appendix D: Response to comments

1 HS2

1.1.1 Comments from HS2 were received on 2 September 2019. The responses are presented in Table 21 below:

Table 21: Response to comments from HS2

No	HS2 Comments	Responses
1	Section 2.2.5 This revision may not have details of, for example, trigger levels, reporting criteria or action plans, but comments on these aspects are required in the final monitoring plan that requires EA sign off. They need to be reassured that the monitoring has been thought through thoroughly. It is accepted that the monitoring plan will be revised in a risk-based way as datasets develop and construction activities progress.	See Section 5.5.
2	Section 3.4.2 Typo (reference to Table 2)	Corrected.
3	Section 3.4.2 This document should include all the water monitoring proposals, regardless of whether some monitoring is seen as being specifically related to certain U&As. All monitoring plays a part in fulfilling route-wide monitoring U&As with the EA.	Additional U&As relevant to groundwater monitoring have been added in Table 2 after consultation with the project team. At this time, all accumulated groundwater monitoring requirements have been included in this plan.
4	Table 2 What about U&As relevant to Stephenson Way?	Stephenson Way is related to the area Euston Station which is outside the SCS Scope of Works.
5	Section 4.3.5, Section 4.3.6 Agree that post-construction monitoring plan will be developed and agreed nearer the time, based on review of data collected during construction and residual risks. This is just good, active management.	Noted
6	Section 4.7 Title - Copthall Tunnel	Updated in Section 4.8.
7	Section 4.5 to 4.23 Need to include a comment on the relevance of monitoring a particular borehole for the structure/construction activity at issue. Perhaps add the elevation of the particular activity below ground alongside the borehole response zones in the tables so they are shown to be relevant?	Information has been included in the justification text for each asset which hopefully resolves this comment.

No	HS2 Comments	Responses
8	Section 5.2 Why is the Monitoring Schedule section assuming that monitoring will be ongoing only until Dec 2020? This monitoring plan should be a comprehensive plan pre, during and post-construction, accepting that it will evolve and be managed in a risk-based way. We need to show the EA a more comprehensive and strategic grasp of monitoring and its drivers.	This 2020 date was stated in error and has been removed.
9	Section 5.4 Reporting must also reference activities going on at the time in order to provide the right context for interpretation.	Ongoing site activities will be summarised in the report.
10	General Other than a reference to the Water Framework Directive Compliance Technical Standard, WFD is not mentioned in the report. One fundamental aim of this monitoring plan is to deliver the monitoring required to illustrate compliance. The EA is looking for this as part of their sign-off.	Compliance to the WFD is illustrated in Section 4.
11	General Acknowledged that the monitoring plan will be updated as design progresses. No further comments to the above.	Noted.
12	General Will this document be updated to include groundwater monitoring relating to construction compounds, temporary works design, construction methodologies and transports routes or will be that be covered elsewhere?	The monitoring is considered to include all aspects of the project as far as the site outlines have been indicated to Design House. Transport routes which leave the jurisdiction of the site boundaries haven not been considered in this monitoring plan.
13	Section 4.4/4.7 Copthall tunnel or Copthall cutting?	Text updated to Copthall tunnel.
14	Section 4.7 Is there any ongoing requirement to undertake radiological monitoring?	No
15	Section 5.2.1 Format error	Corrected
16	Section 5.2.2 Sentence incomplete?	Corrected
17	Section 5.2.4 Format error	Corrected
18	Appendix A/B The appendices appear to be embedded within the report text and report numbering continues through the appendices - is this correct format?	The format is updated.

No	HS2 Comments	Responses
19	Schedule A Suite F2 - re-consider switch to EPH. Did previous EPH monitoring indicate a potential problem? If so, wouldn't TPH CWG be better test to undertake?	We have switched to TPH CWG
20	Schedule B cf. 4.7 should any radiological testing be identified here?	Radiological related risks have been resolved following the review by the RPA. No further monitoring was recommended.
21	General Suggest a comment should be included to recognise that in the future, further monitoring points may be required to be installed where required to gain consent (e.g. EA) and that this would be covered in any update to the Plan.	Added to Section 5.5

1.1.2 Further comments from HS2 were received on November 2019. The responses are presented in Table 22 below:

Table 22: Response to comments from HS2

No	HS2 Comments	Responses
22	General Note response to comment 19 above wrt EPH. No further comments	No response needed
23	I understand Alcontrol are changing their approach to TPH CWG testing and it will potentially affect detection limit suchthat they may not be able to achieve the 10ug/l indicated.	We are happy to switch completely to TPH CWG; Appendix A schedule has been updated.
24	General No further comments. Additional information has been added to link the groundwater risks to the activities/assets and clarify the location of monitoring.	No response required
25	Table 4 and 5 Table doesn't give the monitoring requirements but is an impact assessment	Text has been updated and additional information has been provided.
26	General Tables have formatting errors (error reference source not found)	Revised

1.1.3 Further comments from Mike Hutchinson (HS2) were informally received regarding the Groundwater Monitoring Plan - West Ruislip Area Structures S2 (Document No. 1MC04-SCJ_SDH-GT-PLN-SS05_SL07-000001) by email on 17 April 2020. The responses are presented in Table 23 below:

Table 23: Response to comments from HS2

No	HS2 Comments	Responses
1	4.1.6 Would be more accurate to say "Following the direction of the EA, and in discussion with HS2, additional groundwater level and quality monitoring was undertaken as part of the NWR GI package from May 2018 to December 2018, following the initial 12 months of data collection".	Revised as requested.
2	4.2.1 I think it's important to say as much as we can about the additional SCS GI. We may not be able to say much more right now, but it will be important to bring it into the story as soon as possible, particularly where AfW are most interested.	Revised as requested.
3	4.3.1 AfW may expect to see more explicit reference to them in these bullet points.	Updated.
4	4.3.3 Where you say "additional SCS GI locations have been incorporated" does this contradict what is said in 4.2.1?	Additional SCS GI locations have been incorporated. Section 4.2.1 simply refers a few outstanding unknowns in the SCS dataset. Now clarified.
5	4.3.6 & 4.3.7 The monitoring plan should be considered a 'live' and 'reactive' document, constantly under review, led by the data coming back and shared with the EA and AfW. Note that the APA has a much longer post-construction backstop (up to 30 years!), but the last sentence in 4.3.6 holds.	Updated, reference to APA made and post-construction monitoring.
6	4.4.14 Is the word 'point' missing in the second sentence (after the word 'monitoring')?	Updated.
7	4.5.1 Will be interesting to see Richard's comment on the chainage applicable to the APA (unless this is something already agreed with AfW? I can't recall it being expressed like this but that's not to say it hasn't been agreed)	Updated.
8	4.5.2 Second sentence: to be provided?	Updated.

No	HS2 Comments	Responses
9	5.4 As mentioned earlier, AfW may expect more explicit reference to reporting to them, in line with the APA.	Noted, no AfW comments on this section.
10	App B and C I think this is the key part of the document from a practical perspective and the best way of communicating it to AfW. I haven't seen Richard's comments yet but you may need to expand the design of the table to include additional information on, for example, the driver for each monitoring point, e.g. proximity to AfW asset, equivalence of depth (response zone), link to specific construction activity etc. Just a thought.	Noted, AfW comments are addressed.

1.1.4 Further comments from HS2 were received via EMT in January 2021 regarding the Groundwater Monitoring Plan S1 and S2 (Version C04.1):

Table 24: Response to comments from HS2

No	HS2 Comments	Responses
1	Comment #: 28647 Recorded By steve.box@hs2.org.uk Recorded At 09-09-2020 Message: No Comment. I have reviewed this document and have no comments	Comment Status: Closed. Closed by: steve.box, Closed at: 09-09-2020
2	Comment #: 34058 Recorded By mike.hutchinson@hs2.org.uk Recorded At 05-10-2020 Message: This is what Alistair Brodie's first comment relates to and it just needs reference to which boreholes in S1/S2 had groundwater monitoring undertaken by the original GI contractors for 12 months, then which of those then were monitored under the extension mentioned here (presumably the same), and then how SCS has taken that monitoring on post Dec 2018. This could be a simple table here or later in the document. If it is included later, then just reference it here. See EA comments Table 33	Noted, and we have discussed priority BHs in version 4.2 and its revision.
3	Comment #: 34061 Recorded By mike.hutchinson@hs2.org.uk Recorded At 05-10-2020 Message: Delete and/or. Presume it is left over from when the bullet list was shorter.	Fixed in revision

1.1.5 Comments from HS2 were received via EMT on 23 February 2021 regarding the Groundwater Monitoring Plan - S1 and S2 (Document No. 1MC04-SCJ_SDH-GT-PLN-SS05_SL07-000001, Version C04.2):

Table 25: Comments from HS2

No	HS2 Comments	Responses
1	Comment #: 48324 Recorded by steve.box@hs2.org.uk Recorded at 11-01-2021 Message: No Comment. I have reviewed this document and have no comments	Noted.
2	Comment #: 49958 Recorded by mike.hutchinson@hs2.org.uk Recorded at 19-01-2021 Message: Similar to Alistair Brodie's comment, I can't see that my comments in the previous version have been responded to?	As discussed, comments to version 4.1 were received after we had issued version 4.2. this next version will incorporate all unaddressed comments received.

1.1.6 No further comments from HS2 were noted on 7 June 2022 via EMT regarding the Groundwater Monitoring Plan S1 and S2 (Version C06.1):

Table 26: Response to comments from HS2

No	HS2 Comments	Responses
1	Comment #: 180292 Recorded By chris.clews@hs2.org.uk Recorded At 03-05-2022 Message: No Comment. I have reviewed this document and have no comments	No response needed.
2	Comment #: 182282 Recorded By mark.lemmon2@hs2.org.uk Recorded At 09-05-2022 Message: No Comment. In accordance with the HS2 Technical Assurance strategy I consider that this document does not require my review	No response needed.
3	Comment #: 182961 Recorded By marian.markham1@hs2.org.uk Recorded At 10-05-2022 Message: No Comment. I have reviewed this document and have no comments	No response needed.

2 Environment Agency (EA)

2.1.1 Comments from the EA were received on 17 July 2019. The responses are presented in Table 26 below:

Table 27: Response to comments from the EA

EA comments	Responses
Overarching Comments: We need to understand the construction techniques to be employed (and review the associated groundwater risk assessments in relation to U&A49) in order to be able to agree that the proposed monitoring is relevant. We acknowledge that detailed scheme design is on-going but referencing broad principles of construction would help to justify the monitoring proposed. For example are there construction specific WQ determinants such as related to TBM soil conditioning products and TBM greases? It is assumed that the monitoring frequencies set out in Tables 3 - 21 apply to both the baseline / pre-construction phase and the actual construction phase. There is a need to consider and justify the frequency of monitoring (and reporting) at key times during construction e.g. is increased WQ monitoring required during D-walling at vent shafts or as a TBM passes a monitoring location, is increased WL monitoring required during de-watering / depressurisation? It is unclear from the report if it addresses WFD monitoring requirements of that will be covered in a separate 'Water Resources & Flood Risk Monitoring Plan' as referenced in the 'Water Resources and Flood Risk Monitoring Technical Standard'.	The Groundwater Monitoring Plan was further reviewed with reference to the 'Groundwater Decision Tree' taking in account the WFD and Site Scale Impacts of the assets as stipulated in the 'Water Resources and Flood Risk Monitoring Technical Standard (HS2-HS2-EV-STD-000-000029). Given the lack of detail in the design, the proposed determinands list covers a range of potential chemicals by including acrylamide and tentatively identified compounds (TICs) in the VOC and SVOC suites. The frequency and duration of groundwater level and quality monitoring during the construction and operational phase were addressed in Section 5.5. The Groundwater Monitoring Plan was further reviewed with reference to the WFD and Site Scale Impact as discussed in Section 4.4.
Section 3.2.1 In selecting the monitoring locations was any reference made to the Decision Trees and Advisory Sheets for selecting monitoring locations discussed in this document? Does the proposed monitoring address the WFD monitoring requirements (which are an integral part of the 'Water Resources and Flood Risk Monitoring Technical Standard' - see Figure 1)?	The 'Groundwater Decision Tree' and relevant Advisory Sheets GW1 and GW2 were used in the revised Groundwater Monitoring Plan (this document). WFD monitoring requirements were reviewed and discussed in this revised document. No WFD impacts have been identified for the assets along S1 and S2, except the Ruislip Sustainable Placements.
Section 3.4 Table 2 What about the U&As listed in Appendix A of the SW Monitoring Strategy which relate to groundwater and properties around Euston Station?	We have reviewed with the project team and provided the U&As that are considered to be appropriate.
Section 4.1.1 It would be useful to see the drawings in Appendix B.	The drawings are hopefully attached in this revision (this time).

EA comments	Responses
Section 4.4 - Assets requiring monitoring It would be useful to briefly comment why monitoring is required at these locations e.g. 'because they will intersect or potentially impact the Lower Aquifer' • Tunnel cross-passages between Greenpark Way Ventilation Shaft and Westgate Ventilation Shaft; • Westgate Ventilation Shaft; • Victoria Road Crossover Box; • Atlas Road Logistics Tunnel; • Tunnel cross-passages between Canterbury Road Ventilation Shaft and Old Oak Common; • Canterbury Road Ventilation Shaft; • Adelaide Road Ventilation Shaft; and • Euston Approach.	The rationale for the monitoring basis for these asset locations has been added (see Sections 4.17 to Section 4.24)
Section 4.8 - Table 6 West Ruislip Area Structures Please explain why GW Quality monitoring is limited to one location only.	Rationale has been added in the appropriate section.
Section 4.9 - Table 7 West Ruislip Portal Please explain why GW Quality monitoring is limited to one location only.	Rationale has been added in the appropriate section.
Section 4.10.1 'Review of Hydrogeology Relevant to Shafts and Cross-Passages at S2' - This might aid with understanding the proposed monitoring? Could this also address U&A 49?	Rationale has been added in the appropriate section.
Section 4.10.2 Table 8 - WRP to South Ruislip Please explain why GW Quality monitoring is limited to two locations only.	Rationale has been added in the appropriate section.
Section 4.11.1 Table 9 - South Ruislip Ventilation Shaft Please explain why GW Quality monitoring is limited to one location only.	Rationale has been added in the appropriate section.
Section 4.12 Table 10 - South Ruislip to MDR Please explain why GW Quality monitoring is limited to one location only.	Rationale has been added in the appropriate section.
Section 4.13.1 Table 11 - MDR Please explain why GW Quality monitoring is limited to one location only.	Rationale has been added in the appropriate section.
Section 4.14.1 Table 12 - MDR to GPW Please explain why GW Quality monitoring is limited to one location only.	Rationale has been added in the appropriate section.
Section 4.15 - Table 13 - GPW Please explain why GW Quality monitoring is limited to one location only.	Rationale has been added in the appropriate section.

EA comments	Responses
Section 4.16 - Table 14 - Between GPW and Westgate Please state why monitoring is proposed at these locations. Is it because of interaction with the Lower Aquifer? Why isn't any GW Quality monitoring proposed?	Rationale has been added in the appropriate section.
Section 4.17 - Westgate What about in relation to U&A 2508 related to Ground Source Cooling System at Westmark Investment Properties Limited?	U&A 2508 is added to Table 2. Rationale has been added in the appropriate section.
Section 4.18 - Victoria Road Crossover Box No groundwater quality monitoring is required - please comment why not	Rationale has been added in the appropriate section.
Section 4.19 - Atlas Road Logistics Tunnel Is this structure entirely in the London Clay as per Victoria Road Crossover Box?	Rationale has been added in the appropriate section.
Section 4.20 - Old Oak Common to Canterbury Works No groundwater quality monitoring is required - please comment why not	Rationale has been added in the appropriate section.
Section 4.21 - Canterbury Works No groundwater quality monitoring is required - please comment why not	Rationale has been added in the appropriate section.
Section 4.22.1 - Adelaide Road Ventilation Shaft No groundwater quality monitoring is required - please comment why not	Rationale has been added in the appropriate section.
Section 4.23 - Table 21 Euston Approach Please explain why GW Quality monitoring is limited to one location only.	Rationale has been added in the appropriate section.
Section 5.4.5 Monitoring results should be reviewed on receipt. Reports should include an interpretation of the data. There should be provision for reporting exceptional data / events to the relevant stakeholders immediately. For example a sudden change in water level or quality (particularly if there are enabling works on-going in the vicinity).	A section on use and selection of groundwater control and trigger levels has been included.
Schedule A for SPAs Has this been reviewed in light of proposed changes to the design at Copthall Cutting / Tunnel?	Yes
Schedule B for all remaining groundwater quality monitoring locations How do these Detection Levels compare against those set out in the HS2 'Schedule 1 - Specification for Ground Investigation'? Is there any specific determinants required as certain locations? For example related to the use of soil conditioning products and greases in TBMs?	The maximum allowable limit of detection in Schedule B has been updated with reference to the HS2 'Schedule 1 - Specification for Ground Investigation'. Given the lack of detail in the design, the proposed determinands list covers a range of potential chemicals by including acrylamide and tentatively identified compounds (TICs) in the VOC and SVOC suites.

2.1.3 Further comments from the EA were received via email on 4 December 2019. The responses are presented in Table 27 below:

Table 28: Response to comments from the EA

EA comments	Responses
1. Overarching Comments: The document is an overall summary / outline of the proposed monitoring with 2.1.3 commenting that: '*This monitoring plan has been prepared based on the current information available regarding design and construction methodology, sequencing and programme provided at the time of writing. The specification should be reviewed should these assumptions change. A revision of this plan is therefore recommended once detailed construction methodology and temporary works design information becomes available.*' Similarly it is acknowledged in relation to each structure that: '*…groundwater quality monitoring analytes may change following future regulatory requirements.*' Additionally 5.5.7 comments that: *'The EA will be consulted throughout the process illustrated above, including the selection of triggers, once sufficient baseline data is available. Alterations to monitoring plan and remediation action will be agreed with site operator and the EA.'* The key is the mechanism for agreeing the further detail of the monitoring.	Construction monitoring requirements and basis has now been included. As noted, trigger and control levels are recommended in separate site-specific baseline monitoring reports. Revisions to this document will be provided and used as a mechanism to alter future monitoring requirements.

EA comments	Responses
2. For C1 we've agreed a similar outline Monitoring Position Statement and the intention is that the consent applications for each structure will include individual 'Environmental Water Management Plans' with further details of the construction monitoring following confirmation of the final design. We need to make sure SCS have a similar integrated approach. For example we have received a consent application for the foundations for West Ruislip Retain Embankment, River Pinn Underbridge and Breakspear Road Underbridge (referred to as the 'West Ruislip Area Structures' in the GW Monitoring report) which references the GW Monitoring Report without providing any additional commentary on the monitoring requirements set out in 'Table 11: Monitoring locations and requirements at West Ruislip Area Structures'. The 'Groundwater Risk Assessment S2' (1MC04-SCJ-GT-REP-S002-000037) doesn't address the monitoring requirements in any further detail either.	We have received the C1 construction monitoring plan and version of the Monitoring Position Statement. We have tried to apply similar logic to the S1/S2 monitoring plan.
3. In this particular case only one groundwater quality monitoring location is proposed which is at the up-gradient end of the works. Given the location in SPZ1 (albeit the Affinity Water Ickenham source) this isn't sufficient. I'll raise this issue in response to the consent application. In selecting / agreeing monitoring locations there needs to be consideration of groundwater risk assessments. For example, as noted above the proposed monitoring at the West Ruislip Structures is up-gradient of the structures. Additionally only one groundwater quality monitoring location is proposed at each vent shaft in S2 - given the scale and duration of the dewatering this may not be sufficient. These decisions will need to be further justified as part of the revision of this plan once detailed construction methodology and temporary works design information are available.	Please refer to the latest update of the Groundwater Monitoring Plan (Drawing 5, Appendix C). Groundwater quality monitoring are proposed in two existing boreholes in Chalk. Two new boreholes are also proposed with multi-level installations to monitoring groundwater quality in Lambeth Group and Chalk. As discussed, one of these proposed new boreholes can be an alternative if Thames Water boreholes cannot be used during the construction stage.
4. Para 5.4.1 comments that: Reporting will be undertaken and shall be submitted by the end of the second calendar week of the month following the relevant monitoring period as agreed between SCSJV and the Contractor. Data shall be reviewed upon receipt of factual reports by SCSJV. The use and selection of control and trigger levels is described below. Reporting timescales may need to increase for certain activities at higher risk structures or activities e.g. piling and dewatering around West Ruislip or large scale de-watering at vent shafts. Again this is detail that we'll need to agree at some point.	Understood.

EA comments	Responses
5. The revised content with respect to WFD is welcome. Are SCS going to provide a separate WFD report to summarise all the issues in their section?	A lotwide WFD Assessment update and Compliance Summary Reports will be prepared by SCS later in detailed design.
Site Specific Comments A. South Ruislip Vent Shaft: GW Quality monitoring is proposed in ML020-RC108 which is off-set from the vent shaft. Table 14 'Monitoring locations and requirements at South Ruislip Ventilation Shaft' indicates weekly GW level monitoring at this borehole during construction. It is unclear why this borehole has been selected for monitoring rather than the closer boreholes ML020-RO401 or ML020-RC109.	Please refer to the latest update of the Groundwater Monitoring Plan (Drawing 8, Appendix C). Four boreholes are proposed for groundwater water quality monitoring. Three of those closer to the shaft or asset footprint are assumed to be decommissioned. ML020-RC108 away from the asset is likely to be retained for quality monitoring during construction and post-construction stages.
B. Old Oak Common to Canterbury Works Ventilation Shaft: 4.21.1 comments that: *'Between Old Oak Common and Canterbury Works Ventilation Shaft, there are no planned construction assets (with the exception of the tunnels). Thus the two recommended monitoring locations for groundwater level are related to geotechnical issues and are unrelated to compliance with the HS2 Water Resources and Flow Risk Monitoring Technical Standard [R15].'* The 'Groundwater Risk Assessment S1' (1MC03-SCJ-GT-REP-S001-000030) indicates that there are cross passages in this section of the tunnel albeit this section of the tunnel is entirely within London Clay strata so no environmental impacts are expected.	These monitoring locations are vibrating wire piezometers installed specifically to measure groundwater pressures in areas of interest around the tunnel. Monitoring is for geotechnical purposes.
C. Canterbury Works and Adelaide Road Ventilation Shafts: There is a lot of GW level monitoring proposed around these locations despite them being fully within London Clay strata.	To date, we have very little groundwater monitoring data for the S1 section where these shafts are located. As such, we have listed several points to be monitored to provide some contingency in case of problems with access. These may be reviewed at a later date when sufficient monitoring data is available.
D. Euston Approach: Table 26 indicates only one GW quality monitoring location at this series of structures despite piling extending through the London Clay. I've received applications for consent for some of this piling work so will again address the monitoring via the consenting.	Please refer to the latest update of the Groundwater Monitoring Plan (Drawing 20, Appendix C). Two boreholes are proposed for groundwater quality monitoring in Chalk until they are decommissioned.

2.1.4 Further comments from Alistair Brodie (EA) were informally received by email on 2 March 2020 regarding the Groundwater Monitoring Plan - West Ruislip Area Structures S2 (Document No. 1MC04-SCJ_SDH-GT-PLN-SS05_SL07-000001). The responses are presented in Table 28 below.

Table 29: Response to comments from the EA

No	EA Comments	Responses
1	Section 4.6 West Ruislip Area Structures *4.6.6 To date, the following baseline monitoring has been performed:* It would be useful to state which locations the baseline monitoring has been undertaken at.	The monitoring plan will refer to the baseline monitoring report, and this report should be referred to review the information you are interested in. To facilitate the review for West Ruislip, we've attached a figure indicating the monitoring locations.
2	Proposed Additional Baseline Monitoring *4.6.9 As indicated in Table 5, groundwater monitoring requirements from the GW2 Advisory Sheet are appropriate. Consisting with monitoring performed under the direction of HS2, one existing monitoring location in Chalk (ML024-RC005) has been selected for monthly groundwater level and groundwater quality monitoring until it is decommissioned to support the progression of construction.* It would be helpful to indicate when ML024-RC005 is expected to be lost (e.g. immediately once piling starts?) and comment on whether it will be replaced. Presumably the intention is that the proposed new monitoring boreholes (ML024-RC403 & ML024-RC402) will replace ML024-RC005? If so it would be useful to discuss any proposed cross-over of the monitoring at these locations so that some comparison can be made between the baseline data collected at ML024-RC005 and that subsequently collected at ML024-RC402 & ML024-RC403.	You are correct that the intent is to have a period of cross over monitoring. As it stands, that period will be as long as possible, however it is difficult to define the minimum. Our understanding is that the GI Contractor has been instructed, but we do not, when they will install new wells, also, we do not know when well to be decommissioned will be abandoned. The baseline monitoring report will be generated to provide some discussion on the risks associated with this scheduling uncertainty, and how SCS can manage this risk.
3	*4.6.12 Weekly groundwater level and monthly groundwater quality monitoring (full suite) are proposed in accordance with Advisory Sheet GW2.* Please confirm what the weekly groundwater quality monitoring (core suite) parameters are - presumably those listed in Table 15: Water quality parameters for all groundwater quality monitoring locations except the SPAs?	You are correct that for West Ruislip, the weekly GW monitoring (i.e. the core suite) that we're proposing are located in Table 15. The full monthly suite is provided in Schedule 1, in Appendix A. Construction monitoring for the Ruislip Sustainable Placements is not included in this West Ruislip monitoring plan. The Ruislip Sustainable Placements will be documented in the full GW monitoring plan. Note that we have added turbidity to the field water quality monitoring requirements (i.e. the core suite).
4	4.7 West Ruislip Portal The numbering from the section 'Summary of Identified Groundwater Risks' needs to be updated to continue from the preceding section to avoid duplication.	Updated.

No	EA Comments	Responses
5	Table 12: A summary of the proposed construction method involving piling [R41]: This doesn't reflect what has been applied for under HS2 Act Schedule 33 consent for the below groundwater construction activity. Table 12 indicates that the West Ruislip Portal requires 28 piles, to a depth of +4.0 mOD. However the Schedule 33 application is for contiguous piled walls for the TBM launch chamber and buried (eastern) section of porous portal, piles for the exposed (western) section of porous portal and the extension of the south wall and pile walls for the open cut section. There is also piling for the base slabs. The GW Monitoring Plan just needs to reflect what is going to be constructed.	Table 12 has been updated to document the 226 planned contiguous piles as part of the retaining wall, to extend 1.5 m in the Chalk fm and the 42 base slab piles to extend more than 5 m into the Chalk fm at the Portal. Table 11 has been similarly updated for the other West Ruislip assets discussed in this document.
6	*4.7.4 (Summary of Baseline Monitoring): To date, the following baseline monitoring has been performed:* It would be useful to state which locations the baseline monitoring has been undertaken at and whether baseline monitoring in the 4 installations in the Chalk formation has continued post May 2019 (and if not, why not)?	See response for comment number 1.
7	Proposed Additional Baseline Monitoring *4.7.6 Based on the conditions above, groundwater monitoring requirements from GW1 and GW2 Advisory Sheets are appropriate. Three existing monitoring locations in Chalk (ML023-RO006, ML023-RO401 and ML023-RC012) have been selected for hourly groundwater level and monthly groundwater quality monitoring (as recommended for baseline monitoring where dewatering is planned). ML023-RO006 and ML023-RO401 can be monitored until they are decommissioned to support the progression of construction.* It would be helpful to indicate when ML023-RO006 and ML023-RO401 are expected to be lost (e.g. immediately once piling starts?) and comment on whether they will be replaced. Presumably the intention is that the Thames Water wells will replace these locations? If so it would be useful to discuss any proposed cross-over of the monitoring at these locations so that some comparison can be made between the baseline data collected at ML023-RO006 & ML023-RO401 and that subsequently collected at the Thames Water wells.	See response to comment number 2; in addition, it is still the intention to utilise the Thames Water monitoring wells. However, this has not yet been confirmed.

No	EA Comments	Responses
8	5.5 Groundwater Control and Trigger Levels 5.5.7 The EA will be consulted throughout the process illustrated above, including the selection of triggers, once sufficient baseline data is available. Alterations to monitoring plan and remediation action will be agreed with site operator and the EA. Agree. The confidence in calculating the mean will depend on the number of samples and the period of time over which they have been taken. The trigger levels should also take account local sensitivities. Are triggers going to be derived for the piling works?	Trigger levels will be provided in the baseline monitoring report. We will provide triggers related to piling, and then may adjust these once the dewatering contractor has been procured.
9	I've remembered that previously I mentioned the need to monitor both the Chalk and Lambeth Group strata (see my e-mail Sent: 06 February 2020 10:25, Michael.Chendorain@arup.com). For the WR Portal ML023-RC012 is screened across the Lambeth Group / Sand Unit and this borehole is not expected to be lost due to construction. For WR Structures the two existing monitoring borehole (ML024-RC005) is screened across the Chalk and the new wells (ML024-RC402 and ML024-RC403) are proposed to be screened across the Chalk. Could these new boreholes have multi-level installations to monitor the Lambeth Group and the Chalk?	We have made this change to the monitoring plan.

2.1.5 Further comments from Alistair Brodie (EA) were informally received regarding the Groundwater Monitoring Plan - West Ruislip Area Structures S2 (Document No. 1MC04-SCJ_SDH-GT-PLN-SS05_SL07-000001) by email on 17 April 2020. The responses are presented in Table 29 below:

Table 30: Response to comments from the EA

No	EA Comments	Responses
1	Groundwater Monitoring Plan - West Ruislip Area Structures S2 (1MC04-SCJ_SDH-GT-PLN-SS05_SL07-000001, C01, 30th March 2020) Para 4.3.3 states: *This plan currently includes provision for monitoring of existing installations completed during the HS2 Ground Investigation for the purposes set out in Section 4.3. In addition, SCS Additional GI locations have also been incorporated in the monitoring locations (Section 4.6 to 4.7) such that this document comprises a consolidated set of monitoring locations and requirements for assets indicated above, including all requirements listed in Section 4.2 above.* Please confirm that the baseline monitoring will include the HS2 GI locations *and* the proposed	Updated for clarity.

No	EA Comments	Responses
	additional baseline monitoring discussed in paras 4.7.7 - 4.7.11 (WR Structures) and 4.8.9 - 4.8.14 (WR Portal) as indicated by Appendix C of this document and Tables 1 & 2 of the 'Groundwater Baseline Monitoring Report - West Ruislip Area S2' (1MC04-SCJ_SDH-GT-REP-SS05_SL07-000032, C01, 26th March 2020). Currently the wording of para 4.7.8 could be interpreted as meaning that only existing boreholes (ML024-CP007 and ML024-RC005) and two new boreholes (ML024-RC402 and ML024-RC403) will be monitored in the vicinity of the West Ruislip Structures during the baseline.	
2	Table 8 'Advisory Sheet GW1 relevant to West Ruislip Portal along S1 and S2' refers to the need for a *'Minimum of 3x monitoring boreholes in each disturbed aquifer - one up and two down hydraulic gradient of the disturbance including at least one between disturbed zone and each flagged receptor in the ES'*. The proposed monitoring regime does not achieve that criteria - for example at the portal there are only 2 monitoring locations during the construction phase (ML023-CP009 (Lambeth) & ML023-RC012 (Chalk)). We note the comments to justify the reduced level of monitoring at the West Ruislip Structures (para 4.7.12) and Portal (4.8.15) but in order to confirm our agreement with this approach please provide the risk assessment documents referenced in paras 4.7.2 and 4.8.2.	Additional monitoring installation has been selected during construction monitoring.
3	Para 4.8.19 comments on the potential use of Thames Water wells for monitoring purposes during construction activities. Please provide more detail on when these will be available for use, the strata they will monitor and justification for how representative they will be (i.e. with reference to the risk assessments).	Now that more information is available, we are not recommending that these installations be used.

2.1.6 Comments from Alistair Brodie (EA) were informally received on 2 October 2020 regarding the Groundwater Monitoring Plan - S1 and S2 (Document No. 1MC04-SCJ_SDH-GT-PLN-SS05_SL07-000001, Version C04.1). The responses are presented in Table 30 below:

Table 31: Response to comments from the EA

No	EA Comments	Responses
1	Comments on C04, 03/09/2020 provided to EMT this week. General agreement with the plan but there may be a need for more monitoring once the details of the construction are confirmed (particularly dewatering / depressurisation and grouting).	Understood.

No	EA Comments	Responses
2	The main issues to address are: Absence of reference to EA Priority Monitoring.	The status of EA Priority Monitoring has been discussed within this version of the plan noting that the plan supersedes the priority monitoring.
3	West Ruislip Area Structures: The absence of monitoring between the River Pinn and Breakspear Road Underbridges and the Affinity Water Ickenham source to replace ML024-CP007.	ML024-RC402 has been installed as a replacement well for ML024-CP007 and is discussed in the West Ruislip Area Structures section.
4	Greenpark Way Vent Shaft: Only one monitoring borehole proposed. Need to consider if the high transmissivity indicated by pumping test means there is higher potential for migration of construction fluids (grout). If so additional monitoring may be required.	As per your comments on the GW risk assessment for GPW, there will be additional discussion on the management of grout during construction. The method will draw from the method in place at West Ruislip Portal for piling works.
5	Westgate Vent Shaft: EA need to review the GWRA for this structure and cross-passages between Westgate and Greenpark Way vent shafts due to proximity to licensed groundwater abstractions TH/039/0038/002 and TH/039/0038/014. Asset Specific Baseline Monitoring reports will be required prior to construction. These should include engagement protocols with the EA (and Affinity Water where relevant).	Given the lack of impact to the Lower Aquifer from cross passages between GPW and Westgate, and the lack of impact to the Lower Aquifer at Westgate (as indicated in corresponding GRA) no additional monitoring is deemed to be required. Reference to asset specific baseline monitoring reports includes the requirement for engagement protocols with the EA and AfW. SCS is in the process of updating these reports.

2.1.7 Further comments from Alistair Brodie (EA) were informally received on 20 October 2020 regarding the Groundwater Monitoring Plan - S1 and S2 (Document No. 1MC04-SCJ_SDH-GT-PLN-SS05_SL07-000001, Version C04.1). The responses are presented in Table 31 below:

Table 32: Response to comments from the EA

No	EA Comments	Responses
1	I agree that given the high transmissivity and general uncertainty of the distribution of fractures within the Chalk Fm monitoring is difficult. There are no immediate receptors (the nearest licensed abstraction is 1.6 km away) so it is the potential impacts on general groundwater quality that is the concern. As you say, one of the key issues is the control measures for the use of grout. The other aspect that will need consideration is the risk assessment for the specific grouts to be used as per my e-mail Sent: 02 October 2020 11:45: *Grouting will require Schedule 33 consent. We need to understand what risks this activity poses to GW quality i.e. what is the grout (in particular does it contain any*	Grouting assessment will be included in the Groundwater Risk Assessment for the Greenpark Way Ventilation Shaft.

No	EA Comments	Responses
	Hazardous Substances), how far might it travel into the aquifer (given the properties of the grout, the geology as proven by the GI data and considering any consequences due to the high transmissivity at GPW) and what risk would this pose to groundwater quality? How will its use be monitored and controlled? This activity is not covered in the FWRAs. I've attached a withdrawn Regulatory Position Statement about grouting which provides some further guidance on this risk assessment. The Schedule 33 consent will replace the requirements of the Regulatory Position Statement. I'm happy for you to proceed on the basis of the current proposal but please keep in mind that we may consider additional monitoring is required depending on the outcome of the risk assessment for the specific grouts. I note that para 4.18.13 of the Monitoring Plan refers to the potential need for additional dewatering related monitoring so there may well be revisions to the monitoring anyway.	

2.1.8 Further comments from the EA were forwarded by SCS via email on 11 November 2020. The responses are presented in Table 32 below:

Table 33: Response to comments from the EA

No	EA Comments	Responses
1	From: Brodie, Alistair <Alistair.Brodie@environment-agency.gov.uk> Sent: 11 November 2020 16:00 To: Sophie Hart <sophie.hart@scsrailways.co.uk> Cc: Crossland, Richard <richard.crossland@affinitywater.co.uk>; Mike Hutchinson <Mike.Hutchinson@hs2.org.uk>; wetrockwr <wetrockwr@gmail.com>; Michael Chendorain <Michael.Chendorain@scsrailways.co.uk>; Jon Leech <Jon.Leech@arup.com>; Peter Johnston <Peter.Johnston@scsrailways.co.uk> Subject: RE: Baseline Monitoring Reports I've had a look through the report. The report is dated July 2020 and para 2.1.1 comments that there is little data from 2020 due to COVID-19. Has monitoring re-started since the summer? The report highlights a number of data gaps - in particular that not all of the boreholes have been monitored. Have the boreholes that are to be monitored during piling at West Ruislip Portal	Through a series of recent meetings with the EA and Affinity Water, SCS has updated its construction groundwater monitoring and report plan, which has led to the consent by the EA to allow piling to proceed at West Ruislip Portal. This current version incorporates those updates.

No	EA Comments	Responses
	(retained boreholes ML023-RC004, ML023-RC011 and ML023-RC012 and new borehole ML024-RC403) been surveyed to confirm they are available for use? Has any monitoring been undertaken at these locations in recent weeks / months? What monitoring will be undertaken at these locations before construction commences at the portal? The monitoring frequency (as set out in Appendix C of the 'Groundwater Monitoring Plan S1 and S2' 1MC03-SCJ-EV-PLN- S001-000030, C04) is: • Level: Hourly logger and weekly dip. • Quality: Weekly core suite (pH, Temperature, DO, EC, Redox potential, Turbidity) and monthly full suite (as set out in Appendix A (PDF page 101) of the 'Groundwater Monitoring Plan S1 and S2' 1MC03-SCJ-EV-PLN- S001-000030, C04). I note that the full suite does not include Aluminium. Affinity Water have requested analysis for Aluminium (total and dissolved) in Sector C1 as an indirect tracer of the dispersion of bentonite in water. Therefore these parameters should be added to the analytical suite. The other item to resolve is reporting. What frequency do you propose to provide data to the Environment Agency and Affinity Water? I hope this helps to keep the conversation moving. Perhaps it will be easiest to have a call when Affinity Water have had a look with the aim of resolving the outstanding issues?.	

2.1.1 Further comments from the Environmental Agency (EA) were received via EMT in January 2021 regarding the Groundwater Monitoring Plan S1 and S2 (Version C04.1):

Table 34: Response to comments from the EA

No	EA Comments	Responses
1	Comment #: 33588 Recorded By Alistair.Brodie@environment-agency.gov.uk Recorded At 01-10-2020 Message: 4.1 - Background to previous monitoring: There is no reference to the EA Priority Monitoring. What is the progress with this monitoring? It would be helpful to note which locations have transferred into this strategy and why monitoring is not continuing at the other locations (presumably because they will be lost to construction). Please also comment on whether this strategy is consider sufficient to replace the coverage of the lost Priority Monitoring locations. I can't see where this is specifically discussed in the text e.g. for Copthall Tunnel (section 4.9) where a number of the Priority Monitoring locations have been / will be decommissioned. Please provide a comment (in the sections 4.9 for Copthall Tunnel, 4.10 / 4.11 for WR Structures / Portal and 4.13 for South Ruislip vent shaft) regarding the justification / suitability of the proposed monitoring regime as a replacement for the Priority Monitoring locations. Appendix E (PDF page 136) is missing: • ML020-RO004: South Ruislip Vent Shaft, 510808,185658 – see comments below with respect to 4.13.17. • ML023-RO006: West Ruislip Portal and West Ruislip Retained Embankment, 507930,187046. This has been dealt with via WR Portal / Structures consenting but worth commenting as such in section 4.10 / 4.11. • ML025-CR127: Colne Valley South Embankment – just north of NYG Bourne, 506168,187829. Still proposed for monitoring.	The revision to version 4.2 has added a section on priority monitoring. Note that ML020-RO004 was a failed attempt to install a well to perform a pumping test. This borehole was never successfully completed, and thus never sampled. In addition, ML020-RO004 is not considered to have been one of the EA priority boreholes. Justifications for monitoring plan are provided in sections related to specific assets.
2	Comment #: 33592 Recorded By Alistair.Brodie@environment-agency.gov.uk Recorded At 01-10-2020 Message: 4.7.14 Nature of the identified risk: Refers to piling at Sustainable Placment?	Fixed in revision:
3	Comment #: 33595 Recorded By Alistair.Brodie@environment-agency.gov.uk Recorded At 01-10-2020 Message: 4.7.23: Please confirm what 'project commissioning' means – presumably 2 years following construction of a structure (or completion of landfilling in the case of Sustainable Placement)?	Clarified as (where commissioning means two years following construction of a structure or completion of land-filling, as in the case of the Sustainable Placements)

No	EA Comments	Responses
4	Comment #: 33596 Recorded By Alistair.Brodie@environment-agency.gov.uk Recorded At 01-10-2020 Message: 4.8.13 Nature of the identified risk: Refers to piling at Sustainable Placement?	Updated as previous
5	Comment #: 33598 Recorded By Alistair.Brodie@environment-agency.gov.uk Recorded At 01-10-2020 Message: 4.9.15 & 4.9.16: Lists 4 monitoring locations for GW level monitoring but only 3 to be used for GW quality monitoring. The reasoning for this is unclear.	Comment Status: Closed. Closed by: Alistair Brodie, Closed at: 18-01-2021 Comment is considered no longer relevant as the asset is out of baseline monitoring. To be honest, i don't remember why we added the extra BH for GW level monitoring.
6	Comment #: 33600 Recorded By Alistair.Brodie@environment-agency.gov.uk Recorded At 01-10-2020 Message: 4.9.20: As discussed in 4.9.12, if the GW regional groundwater flow direction of the Chalk Aquifer is to the south / southeast then won't both ML025-CR127 and ML025-CP122 be up-gradient? Suggest that proposed new borehole ML024-RC402 should also be used to monitor the construction of Copthall Tunnel.	There is a local change in groundwater flow direction in this area. The text has noted this. Also ML024-RC402 will be monitoring as part of the monitoring (although is it listed for West Ruislip area.
5	Comment #: 33616 Recorded By Alistair.Brodie@environment-agency.gov.uk Recorded At 01-10-2020 Message: 4.10.18: Agree that given the proximity to Affinity Water's abstraction source this level of monitoring in the Chalk is applicable but please confirm which three locations are to be monitored noting that Appendix C indicates the only construction monitoring locations in the Chalk are ML024-RC402 and ML024-RC403.	There is overlap in monitoring in this area between the portal, Copthall Tunnel, and the WR area. The overlap of monitoring to cover WR area will be clarified in the revision.
6	Comment #: 33618 Recorded By Alistair.Brodie@environment-agency.gov.uk Recorded At 01-10-2020 Message: 4.10.19: Appendices B and C indicate ML024-CP007 is to be decommissioned. Please clarify.	Comment Status: Closed. Closed by: Alistair Brodie, Closed at: 18-01-2021
7	Comment #: 33621 Recorded By Alistair.Brodie@environment-agency.gov.uk Recorded At 01-10-2020 Message: 4.13.8 - During temporary works, the local groundwater regime of the Lower Aquifer will be dominated by the dewatering to facilitate shaft construction. Thus, the local gradient will shift during temporary works towards the shafts: Dewatering will not be undertaken during d-walling according to the FWRA and d-walling poses the most risk to GW quality.	Similar to the piling works at West Ruislip portal, the construction monitoring will be based on the use of support fluids and grout and monitoring the volumes added. This will be the principal method to evaluate whether construction methods will impact groundwater quality during D-wall construction. This will been clarified in the revision. Monitoring during non-dewatering periods have now been addressed.

No	EA Comments	Responses
8	Comment #: 33623 Recorded By Alistair.Brodie@environment-agency.gov.uk Recorded At 01-10-2020 Message: 4.13.17: Recommend that the proposed borehole monitors both the Lambeth Group and the Chalk. Priority Monitoring Location ML020-RO004 is at this shaft. What has happened to this? ML020-RO004 is not included in Appendix E.	ML020-RO004 has been added to Appendix E. An additional borehole, ML020-RC403 has been included in the monitoring plan for Chalk monitoring (as it does not have a Lambeth group monitoring zone.
9	Comment #: 33627 Recorded By Alistair.Brodie@environment-agency.gov.uk Recorded At 01-10-2020 Message: 4.17.18: Accepting that there will be additional GW level monitoring in relation to required dewatering there is a need to consider the high transmissivity indicated by pumping. Does this mean higher potential for migration of construction fluids (grout)? If so additional monitoring may be required. There is also the EA Greenpark Way OBH close to the site (TQ 15650 83850). OK – this issue needs to be covered in the GWRA or FWRA for this structure i.e. what is the reason for the higher transmissivity and what are the possible consequences in terms of risks to groundwater quality with respect to use of construction fluids. I have version C01.2 of the FWRA to review on EMT so maybe that addresses this?	Additional monitoring for GW level during dewatering will be documented in the sub-contractor's detailed design. The specialist dewatering sub-contractor will also be responsible for this additional monitoring (and has thus been left out of this plan). At this time, TQ 15650 83850 is not included in the monitoring plan The higher transmissivity is noted in the basis for this plan, we will expand on this in the GW risk assessment as well.
10	Comment #: 33629 Recorded By Alistair.Brodie@environment-agency.gov.uk Recorded At 01-10-2020 Message: 4.18.17: There is also the EA Hoover Building OBH (TQ 16730 82960). It may be useful to monitor at this location as well.	Comment Status: Closed. Closed by: Alistair Brodie, Closed at: 01-10-2020

No	EA Comments	Responses
11	Comment #: 33646 Recorded By Alistair.Brodie@environment-agency.gov.uk Recorded At 01-10-2020 Message: 4.19.10: Agree in principle with this conclusion but need to review the groundwater risk for this structure and cross-passages between Westgate and Greenpark Way vent shafts due to the following issue noted in the Environmental Statement: LONDONWEST MIDLANDS ENVIRONMENTAL STATEMENT Volume 5 | Technical Appendices CFA5 | Northolt Corridor Water resources assessment (WR-002-005) Water resources (November 2013) - Table 7: Summary of potential impacts to groundwater receptors: GW53 (TH/039/0038/002) Notwithstanding this, in the unlikely event that groundwater quality is affected, the effect on this abstraction would be significant as it is used for domestic purposes and could be used as a potable supply. Although unlikely, where there is the potential for significant adverse effects on the licensed private water abstraction during construction, monitoring of groundwater turbidity will be used to verify if effects are occurring and provide evidence to justify further intervention, should that be required. There is also U&A 2508 relating to Ground Source Cooling System at Westmark Investment Properties Limited (TH/039/0038/014) to consider.	Westgate GRA has been provided.
12	Comment #: 33648 Recorded By Alistair.Brodie@environment-agency.gov.uk Recorded At 01-10-2020 Message: 5.4.2: The engagement protocols with the EA (and Affinity Water where relevant) will need to be agreed via Schedule 33 consenting process.	Noted and clarified in the revision.
13	Comment #: 33650 Recorded By Alistair.Brodie@environment-agency.gov.uk Recorded At 01-10-2020 Message: 5.6.3: Agree. We are in general agreement with the plan but there may need to be more monitoring once the construction details of the various structures are confirmed. In the meantime implementation of this plan will provide a baseline.	Comment Status: Closed. Closed by: Alistair Brodie, Closed at: 01-10-2020

2.1.2 Comments from the Environmental Agency (EA) were received via EMT on 23 February 2021 regarding the Groundwater Monitoring Plan S1 and S2 (Version C04.2):

Table 35: Response to comments from the EA

No	EA Comments	Responses
1	Comment #: 49505 Link to comment #48152 Recorded By Alistair.Brodie@environment-agency.gov.uk Recorded At 18-01-2021 Message: It appears that the majority of my comments on C04.1 have not been addressed. Apologies if I have missed where the responses are.	As discussed, comments to version 4.1 were received after we had issued version 4.2. this next version will incorporate all unaddressed comments received.

2.1.3 Comments from the Environmental Agency (EA) were received via EMT on 7 June 2022 regarding the Groundwater Monitoring Plan S1 and S2 (Version C06.1):

Table 36: Response to comments from the EA

No	EA Comments	Responses
1	Comment #: 181619 Recorded By Alistair.Brodie@environment-agency.gov.uk Recorded At 06-05-2022 Message: I cannot see any justification of the different Core Suites A, B and C. Apologies if I've missed something but please add if not already included.	Michael Chendorain (DH GW technical lead) met with Alistair Brodie on 10 June 2022 to provide the basis for the updated to the Core suites, which is roughly to consolidate monitoring requirements across the project. Core A is for all assets which the exception of RNSP (Core B), and Greenpark Way (Core C).
2	Comment #: 181632 Recorded By Alistair.Brodie@environment-agency.gov.uk Recorded At 05-05-2022 Message: It would be helpful to highlight the changes in some way. From what I can tell the changes (other than Appendix A - see comment 181619) are refinements of the monitoring locations but please let me know if there is something more fundamental.	Michael Chendorain (DH GW technical lead) has provided Alistair Brodie with a detailed list of comments between this version and earlier versions. We also met on 10 June 2022 to go through the detailed list and review the changes.

3 Affinity Water

3.1.1 Comments from Richard Crossland were informally received on 5 March 2020 regarding the Groundwater Monitoring Plan - West Ruislip Area Structures S2 (Document No. 1MC04-SCJ_SDH-GT-PLN-SS05_SL07-000001). The responses are presented in below:

Table 37: Response to comments from Affinity Water

No	Affinity Water Comments	Responses
1	A schedule of milestone dates for each main element of work, as per the Align Construction Monitoring Plan, is required	Section 4.5 has been included which refers to the Asset Construction 'Look-ahead' document, which is provided separately.
2	Review what the APA requires to be included in this plan as noted in Section 2 (page 15) and Schedule 3 (page 64)	Section 4.5 has been included which documents how the APA requirements have been addressed.

3.1.2 Further comments from Rob Sage (Affinity Water) regarding the Groundwater Monitoring Plan - West Ruislip Area Structures S2 (Document No. 1MC04-SCJ_SDH-GT-PLN-SS05_SL07-000001) were informally received by email on 17 April 2020. The responses are presented in Table 36 below:

Table 38: Response to comments from Affinity Water

No	Affinity Water Comments	Responses
1	**West Ruislip Monitoring Plan (**Document no.: 1MC04-SCJ_SDH-GT-PLN-SS05_SL07-000001 30/03/2020) It is recognised that this report sets out the requirements for monitoring and reporting for the specified assets. The Baseline Report sets out the control and trigger settings, based on the data already collected, which is different both in OBH location and parameters measured to that now proposed for the construction and post construction phases of monitoring. As both reports are interlinked, where relevant in the comments below, reference is made to the relevant sections of both reports.	We understand that this is a general comment which provides context for the comments provided both to this document and the associated baseline monitoring report.
2	4.1.5. No data loggers were installed as part of the baseline monitoring, but one is proposed as part of the ongoing monitoring.	Correct.
3	4.1.6. Whilst additional data has been collected as stated, it has been used to help define control and trigger levels, comments on the value of this data are discussed below.	Noted.

No	Affinity Water Comments	Responses
4	4.3.6. As this document has only just been published, it was unable to inform data collection for baseline assessment in a meaningful way, which is acknowledged in 4.1.2 and other sections of the baseline report, but is very helpful in defining the during construction monitoring regime, on which further comments are given below.	For clarification, the report commented on is only one iteration of many documents. In fact, this is the 3rd revision of the West Ruislip groundwater monitoring plan, the first of which was issued to SCS on 7 February 2020. Other points in this comment are noted.
5	4.4.15/16. It is acknowledged that this plan may need to change as construction progresses, dependant on what results are obtained from the monitoring.	Consistent with comments from HS2, this document is intended to be a living document (see response to HS2 Comment ID 5 dated 17 April 2020 in Appendix D)
6	In Table 10, the note stating that the full suite will be taken, rather than the core, due to the relatively short time remaining prior to construction is helpful, but it is unclear if this will be weekly or monthly until construction begins. If weekly, this should supply additional data to help refine the control and trigger levels.	Monthly (full suite) additional baseline monitoring will be taken until construction starts, as stated in a more detailed note in Table 10 and Appendix C. The table note is updated for clarity.
7	4.8.6 & 4.9.1. No mention is made here of where any de-watering water will be discharged to. This will be important and should be notified as soon as possible to determine what quality standards will need to be applied to this discharge, based on assumed water quality from the baseline assessment, followed by analysis of the initial water discharged once the de-watering scheme has been installed.	Requirements from discharge are documented in the Surface Water Monitoring Plan S1 & S2 [Document No. 1MC03-SCJ-EV-PLN-S001-000029].
8	4.8.11. It is good to see that 2 groundwater loggers will be installed, one in each water bearing strata, as this is a serious omission from the baseline data. Continued monitoring of R009 and RO401 (or RC401?, see below) will also provide a useful comparison until these boreholes are decommissioned, assuming the two new boreholes will be completed before these existing ones are lost.	Your comment is noted.
9	4.8.19. What are the formations encountered and what will be measured at the TWUL boreholes?	See response to EA comment no. 3 dated 17 April 2020.
10	4.8.24. Table 14, not 13?	Updated.
11	5.2.2. This monitoring should not be delayed, as there is already only a very limited data set currently being collected according to the Monitoring Report.	Noted.
12	5.3.2. Do current sampling rounds also include a groundwater level dip? If so, then these could supplement data presented in the Monitoring Report, unless already included.	All groundwater level data that has been collected has been used in the baseline dataset.

No	Affinity Water Comments	Responses
13	5.3.7. A statement should be made here with regard to the labelling of sample bottles, whilst laboratory dependant, minimum generic requirements should be requested here.	Updated.
14	5.3.12. Have such QA/QC measures been taken in the sampling to date? If so, where have they been reported?	QA/QC measures have been improved and will be as required in the specification moving forward. If still required, a separate note on QA/QC can be generated.
15	5.3.15. We note that you require Ionic Balances taken on full samples. However, to achieve this, magnesium, sodium and potassium need to be added to schedule 1, as well as a line showing the ionic balance results. Magnesium is shown in the results for the Baseline data, but not sodium or potassium.	Noted, Schedule B has been updated.
16	5.3.17 & 18. These QA/QC samples need to be reported somewhere to both demonstrate that they have been undertaken, and that the results are valid.	Updated as requested.
17	5.3.19. Laboratory Electrical Conductivity measurements also need to be added to Schedule 1. No conductivity measurements (field or Lab) are presented in the Baseline Report.	Updated as requested. Field data from the contractor is being chased and can be included in a later revision, once obtained.
18	5.4.6. In addition to the report on the current sampling rounds, this data should be added to a database of all historic information, so that results can be graphically represented and compared, not just with control and trigger values, but also trends (seasonal and upward/downward) and help outliers be identified, which may require a repeat sampling round for that determinant/location.	The mechanism to document all available data is currently being developed by SCS and will be documented in a future report when that method is available. Comment is noted.
19	7.1.6. Again a note on minimum labelling requirements are required here, and the reports should include Laboratory reference number.	Updated.
20	Schedule 1. As stated above, this should be enlarged to include, laboratory electrical conductivity, sodium, potassium, magnesium and result of ionic balance (sum of cations, sum of anions and % difference)	Noted as indicated above.
21	Appendix C Table. From this table, going forward, once two new OBH have been drilled and commissioned, and other monitoring points de-commissioned, there will be three chalk monitoring locations (one with a wl data logger) and four Lambeth Group (one with a wl logger), all with weekly level dips, weekly core sampling and monthly full sampling. A total of 7 data sets. These maybe supplemented once the dewatering at the West Ruislip Portal has been finalised. This would appear, based on current measurements to be realistic for monitoring of the proposed construction activities.	Correct.

No	Affinity Water Comments	Responses
22	**Discrepancy between Plan and Rep Borehole numbering** In the Plan, Drawing C shows ML023-RO401 highlighted yellow and linked to the table in Appendix C, and that this borehole will be decommissioned. It also shows that ML23-RC401 (to the south of the rail tracks) will also be decommissioned. However, in the Report, Figure B1 shows a water level value of 39.51maOD at the location of RO401, whilst the data in Table B1, and Figure B2 refers to RC401, whilst RO401 is not mentioned in Table B1, (but is shown in Figure A3). So either the water level data belongs to RO401, and is numbered incorrectly in Table B1, but plotted correctly in Fig B1; or it is RC401, so is plotted incorrectly in Fig B1, and thus in the Appendix C table of the Plan should read RC401, not RO401 and the yellow colouring on Drawing C needs to be moved! Which is correct? Also, not all of the monitoring points used in the Baseline Report are shown to be decommissioned in drawings B and C in the Plan, or shown in the Table in Appendix C, thus making comparison of the two documents difficult. The Table in Appendix C in this report should be expanded to include all the data points in Table B1 of the Report, and RO401 added to table B1 in the Baseline report.	The yellow colouring indicates where both groundwater quality and groundwater level monitoring is proposed for groundwater protection purpose. Yellow labelling at ML023-RO401 is correct where there is existing water quality data. In the Groundwater Baseline Monitoring report, it includes all HS2 GI locations with groundwater monitoring instrumentation, whilst the Groundwater Monitoring Plan only shows those selected GI locations proposed for additional baseline monitoring.

3.1.3 Comments from Richard Crossland were informally received on 2 October 2020 regarding the Groundwater Monitoring Plan - S1 and S2 (Document No. 1MC04-SCJ_SDH-GT-PLN-SS05_SL07-000001, Version C04.1). The responses are presented in below:

Table 39: Response to comments from Affinity Water

No	Affinity Water Comments	Responses
1	General To include the publication date of all the references they quote.	Given that only the most recent issued version document is considered by HS2 to be the in-place version, document dates are typically left off of HS2 documents
2	General No monitoring data has yet been received. Please indicate when is likely to get the first batch data.	A schedule for the delivery of baseline monitoring reports has been provided separately.

3.1.4 No comments from Richard Crossland was noted via EMT on 23 February 2021 regarding the Groundwater Monitoring Plan - S1 and S2 (Document No. 1MC04-SCJ_SDH-GT-PLN-SS05_SL07-000001, Version C04.2). The is recorded below:

Table 40: No comments from Affinity Water

No	Affinity Water Comments	Responses
1	Comment #: 48152 Recorded by richard.crossland@affinitywater.co.uk Recorded at 08-01-2021 Message: No Comment. I have reviewed this document and have no comments	Noted.

4 SCS

4.1.1 Comments from Peter Johnston were informally received in October 2020 regarding the Groundwater Monitoring Plan (Version C04.1). The responses are presented in below:

Table 41: Response to comments from SCS

No	SCS Comments	Responses
	16 Oct 2020 Looks sensible to me. What about using a turbidity data logger in the borehole so we can monitor the groundwater quality in real time?	17 Oct 2020 It's a good idea, and we can consider it, but it will come down to staging. There may not be too many dewatering wells in place until the grouting is performed. You'll see in the email I send that I include some words on that option.
	18 Oct 2020 I mean using a turbidity logger during grouting. The logger can be placed in the high flow zone and we will be able to use telemetry to monitor. So we are not just doing precise monitoring for the grout management. We are also doing for the monitoring well.	Turbidity monitoring has now been incorporated into the construction monitoring programme.

4.1.2 Comments from SCS were forwarded via email on December 17, 2020 regarding the Groundwater Monitoring Plan - West Ruislip Area Structures S2 (Document No: 1MC04-SCJ_SDH-GT-PLN-SS05_SL07-000001):

Table 42: Response to comments from SCS

No	SCS Comments	Responses
16301	6 April 2020 Recorded by jega.sittampalam@scsrailways.co.uk No comment	Ok noted
16480	7 April 2020 Recorded by john.cathro@scsrailways.co.uk Has the amended ES been issued to SCS	The West Ruislip Monitoring Plan has been superseded by alignment wide Groundwater Monitoring Plan.
16484	7 April 2020 Recorded by john.cathro@scsrailways.co.uk Page 50 Why is there no answer here? will the wells be destroyed during piling? do they have to be replaced if they are ? do the thames water wells do this and are they adequate? What crossover time for monitoring is required?	This West Ruislip Monitoring Plan has been superseded by alignment wide Groundwater Monitoring Plan. The monitoring overlap issue has now been resolved.
16483	7 April 2020 Recorded by john.cathro@scsrailways.co.uk Page 12 Who has this data and has it been passed to the design house?	Data sharing has been temporarily resolved and will be incorporated eventually in the I&M system.

No	SCS Comments	Responses
16481	7 April 2020 Recorded by john.cathro@scsrailways.co.uk Page 11 when did this fieldwork start and finish? is it ongoing? are data loggers still in place?	The West Ruislip Monitoring Plan has been superseded by alignment wide Groundwater Monitoring Plan.
16482	7 April 2020 Recorded by john.cathro@scsrailways.co.uk Page 11 are these data loggers still in place and being monitored?	The West Ruislip Monitoring Plan has been superseded by alignment wide Groundwater Monitoring Plan. The GI contractors have not yet placed the loggers but SCS is coordinate for that to happened in Jan 2021.
18189	29 April 2020 Recorded by mike.hutchinson@hs2.org.uk Note: I have reviewed and provided comment back to author outside of EMT. Comments have also been logged on eB.	OK noted.

4.1.3 Further comments from SCS were received via EMT in January 2021 regarding the Groundwater Monitoring Plan S1 and S2 (Version C04.1):

Table 43: Response to comments from SCS

No	SCS Comments	Responses
1	Comment #: 31304 Recorded By sophie.hart@scsrailways.co.uk Recorded At 22-09-2020 Message: please check EA have seen all the GRA S1 and S2, I think they have but please provide evidence of this either way just so we can record the engagement please	We have now received EA comments on v4.1, and have responded as indicated above.
2	Comment #: 31305 Recorded By sophie.hart@scsrailways.co.uk Recorded At 22-09-2020 Message: check you are using correct version I think we are now on 15.1 for HS2 technical standards	Ok noted
3	Comment #: 32019 Recorded By craig.speed@scsrailways.co.uk Recorded At 24-09-2020 Message: Same abbreviation used twice.	Fixed in revision
4	Comment #: 32020 Recorded By craig.speed@scsrailways.co.uk Recorded At 24-09-2020 Message: It might be worth being consistent with terms by using 'Monitoring Advisory Sheets' to remain consistent with Section 4.4.10 terminology and in previous sentence indicate that GW1-GW3 relate to specific 'Monitoring Advisory Sheets' or these codes are potentially unclear in Table 5.	Fixed in revision

No	SCS Comments	Responses
5	Comment #: 33295 Recorded By Laura Newton@scsrailways.co.uk Recorded At 30-09-2020 Message: No Comment. I have reviewed this document and have no comments	Comment Status: Closed. Closed by: Laura Newton, Closed at: 30-09-2020
6	Comment #: 35061 Recorded By craig.speed@scsrailways.co.uk Recorded At 10-10-2020 Message: pH	pH has been globally edited to be its correct capitalization
7	Comment #: 35062 Recorded By craig.speed@scsrailways.co.uk Recorded At 10-10-2020 Message: pH	Fixed in revision
8	Comment #: 35063 Recorded By craig.speed@scsrailways.co.uk Recorded At 10-10-2020 Message: pH	Fixed in revision
9	Comment #: 35064 Recorded By craig.speed@scsrailways.co.uk Recorded At 10-10-2020 Message: Recommendation: It would be helpful to split this into bicarbonate alkalinity and carbonate alkalinity, as a check on pH. This can be very useful as a quality assurance as the shift from bicarbonate to carbonate at about pH8.3 can back up evidence of alkaline effects that may be due to concrete/grout leachates. It is also best practice for ionic balance.	Noted, we will correct for the revision to version 4.2

4.1.4 Further comments from SCS were received via EMT on 23 February 2021 regarding the Groundwater Monitoring Plan S1 and S2 (Version C04.2):

Table 44: Response to comments from SCS

No	SCS Comments	Responses
1	Comment #: 48278 Recorded By craig.speed@scsrailways.co.uk Recorded At 11-01-2021 Message: For accuracy etc - Comment #: 32019 in previous version unaddressed. Ruislip Northern and Southern Sustainable Placement Areas (RNSP, RNSP). - change to RNSPA, SSPA?	Fixed in revision.
2	Comment #: 49774 Recorded By laura.newton@scsrailways.co.uk Recorded At 19-01-2021 Message: No Comment. I have reviewed this document and have no comments	Noted.

4.1.5 No further comments from SCS were noted on 7 June 2022 via EMT regarding the Groundwater Monitoring Plan S1 and S2 (Version C06.1):

Table 45: Response to comments from SCS

No	SCS Comments	Responses
1	Comment #: 178301 Recorded By peter.johnston@scsrailways.co.uk Recorded At 28-04-2022 Message: No Comment. I have reviewed this document and have no comments	No response needed.
2	Comment #: 180603 Recorded By mostyn.woodhouse@scsrailways.co.uk Recorded At 04-05-2022 Message: No Comment. I have reviewed this document and have no comments	No response needed.
3	Comment #: 183099 Recorded By phil.allvey@scsrailways.co.uk Recorded At 10-05-2022 Message: No Comment. I have reviewed this document and have no comments	No response needed.
4	Comment #: 183198 Recorded By rolf.peters@scsrailways.co.uk Recorded At 11-05-2022 Message: No Comment. I have reviewed this document and have no comments	No response needed.
5	Comment #: 183412 Recorded By elizabeth.lyon@scsrailways.co.uk Recorded At 11-05-2022 Message: No Comment. I have reviewed this document and have no comments	No response needed.

Appendix E: EA Priority Monitoring

1.1.1 Appendix E provides a summary of the conclusion of EA priority monitoring which occurred early in the project. Note that this groundwater monitoring plan supersedes that former priority monitoring for the reasons described in this report.

Table 46: EA priority boreholes

Asset Location	Borehole ID	Geology of Response Zone	Available Monitoring	Carried Forward or to be Decommissioned?
Northern SPA	ML024-RC012	Lambeth Group	24 water levels and 15 water quality	Retained
Southern SPA	ML024-RC013	Lambeth Group	30 water levels and 19 water quality	Retained
Southern SPA	ML024-RC015	Lambeth Group	27 water levels and 16 water quality	Retained
Northern SPA	ML025-RC048	Lambeth Group	32 water levels and 19 water quality	Retained
Northern SPA	ML025-RC049	Lambeth Group	30 water levels and 18 water quality	Retained
Southern SPA	ML025-RC050	Lambeth Group	29 water levels and 18 water quality	Retained
Northern SPA	ML025-RC051	Lambeth Group	31 water levels and 16water quality	Retained
Copthall Tunnel / West Ruislip Area Structures	ML024-RC005	Chalk	34 water levels and 18 water quality	To be Decommissioned
Copthall Tunnel / West Ruislip Area Structures	ML024-RC007	Chalk	34 water levels and 17 water quality	Decommissioned
Copthall Tunnel	ML025-CP122	Chalk and Lambeth Group	38 water levels and 16 water quality	Retained
Copthall Tunnel	ML025-RC020	Chalk and Lambeth Group	33 water levels and 12 water quality	Decommissioned
Copthall Tunnel	ML025-RC023	Chalk and Lambeth Group	33 water levels and 10 water quality	Decommissioned
Copthall Tunnel	ML025-RC030	Chalk and Lambeth Group	33 water levels and 16 water quality	Decommissioned
Copthall Tunnel	ML025-RC032	Chalk	36 water levels and 13 water quality	To be Decommissioned
Copthall Tunnel	ML025-RC033	Chalk	34 water levels and 16 water quality	Decommissioned
Copthall Tunnel	ML025-RC037	Chalk and Lambeth Group	14 quality samples	To be Decommissioned
Copthall Tunnel	ML025-RO107	TBC	14 quality samples	Decommissioned

Notes: TBC – to be confirmed.