1MC03 Main Works – Contract Lot S1

Water Resource Plan S1 and S2

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1. Definitions and Abbreviations

The tables below outline abbreviations and technical terms used within this management plan.

1.1 Abbreviations

Table 1: *List of Abbreviations*

Abbreviation	Definition
CFA	Community Forum Area
EMS	Environmental Management System
ES	Environmental Statement
GPCNs	General Principle Compliance Notes
HS2	High Speed 2 Ltd
ITT	Invitation to Tender
LEMP	Local Environmental Management Plans
LLAU	Limit of Land to be Acquired or Used
ML	Megalitres
MWCC	Main Works Civils Contract
PQQ	Pre-qualification Query
QA	Quality Assurance
SCS	Skanska Costain STRABAG
SPZ	Source Protected Zone
SSECP	Site Specific Environmental Control Plan
TBM	Tunnel Boring Machine
TS1	HS2 Technical Standard- Water Resources
U&As	Undertakings and Assurances
WFD	Water Framework Directive
WRP	Water Resource Plan

1.2 Technical Definitions

***Table 2**: List of technical terms*

Term	Definition
Superficial deposits	Geological deposits which form about less than 2.6 million years old
Bedrock	Solid rock underlying loose deposits such as soil or alluvium.
Groundwater	All water which is below the surface of the ground in the saturation zone and in direct contact with the ground or subsoil.
Surface Water	Water found on the Earth's surface including both the saltwater in the ocean and the freshwater in rivers, streams and lakes.
Aquifer	A subsurface layer or layers of rock or other geological strata of sufficient porosity and permeability to allow either a significant flow of groundwater or the abstraction of significant quantities of groundwater.
Unproductive Strata	These are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow.
Secondary A Aquifer	Permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of base flow to rivers. These are generally aquifers formerly classified as minor aquifers.
Principal Aquifer	These are layers of rock or drift deposits that have high intergranular and/or fracture permeability - meaning they usually provide a high level of water storage. They may support water supply and/or river base flow on a strategic scale. In most cases, principal aquifers are aquifers previously designated as major aquifer.
Surface water body	A significant accumulation of water on Earth's surface.
Groundwater body/ body of groundwater	A distinct volume of groundwater within an aquifer or aquifers.
Abstraction	The process of taking or extracting water from a natural source (rivers, lakes, groundwater aquifers) for various uses, from drinking to irrigation, treatment and industrial applications.
Water source	Refers to both surface water and groundwater.
Water supply	A source, means or process of supplying water to a community/for use.
Source Protection Zone	These zones show areas at risk of contamination from any activities that might cause pollution to a groundwater source.
Site of Special Scientific Interest	Describes an area that is of particular interest to science due to the presence of rare species of fauna and flora.

2 Introduction

2.1 Requirement

2.1.1 This Water Resource Plan (WRP) details how the Skanska Costain STRABAG (SCS) and its supply chain will deliver the environmental and sustainability requirements of the High Speed Two (HS2) Main Works Contract Civils (MWCC) for S1 and S2. More specifically it details how water requirements of the East, Central and West sections of MWCC will be managed in accordance with relevant legislation and regulations and HS2 Project Requirements Specification for Phase One. Maps of the areas for the geographic setting can be found in Appendix 1.

2.1.2 It is a mandatory requirement for a WRP to be produced as detailed in the HS2 Technical Standard – Water Resources (TS1). The philosophy underlying this is the water hierarchy to prevent, or reduce water usage, and reuse/recycle water during construction phase of HS2. It should also be noted that the footprint area that the plan considers, is not limited to the boundaries of construction, and should extend to a minimum distance of 1km from the site boundary as per the TS1 geographical scope definition.

2.2 Purpose

2.2.1 The purpose of this document, in line with the requirements of the TS1 is to:

- determine water requirements or demand;
- identify and characterise all potential water sources (including non-potable);
- propose options for potential water efficiencies and/or reuse;
- justify as to how the water consumption and source hierarchies, as defined in Table 1 of the TS1 have been complied with; and
- identify the next steps required as the scheme develops.

In addition, this document will consider:

- the water supply chain from initial abstraction until disposal/reuse;
- the requirement for the water to not cause deterioration in the environment;
- links to the carbon targets as described in the HS2 Technical Standard – Carbon Management;
- risks to water supply or consumption due to seasonal restriction; and
- construction and operation stages.

2.3 Context and Scope

2.3.1 This document outlines the responsibilities assigned to SCS (the Principal Contractor) that specifically relate to water resources. The document also acts as an assurance document for HS2 Limited (the Client), providing detail in response to how SCS intends to manage these responsibilities on behalf of the Client.

2.3.2 The TS1 indicates that the WRP should consider both the construction and operational stages of the railway. The operation of the railway is outside of SCS remit and so this document only considers the construction stage. However, SCS will construct the infrastructure for a permanent firefighting supply within the S1 and S2 area.

2.3.3 The TS1 also requires that the Contractor consult with the Environment Agency and relevant water companies to help to identify opportunities for water reuse, or for use of non-mains sources of water. This will include, exploring opportunities that follow the water consumption hierarchy, as follows:

- Prevent;
- Reduce; and
- Reuse and Recycle.

2.3.4 In addition, the TS1 requires review and updating of the Water Resources Plan before any new sources of water are developed, and at each new design stage.

2.4 Guidance Documents

2.4.1 The Water Resources Plan is drafted in line with Costain's EMS, certified to ISO14001:2015, which should be read in conjunction with the MWCC's Environmental Management Plan (EMP) (1MC03-SCJ-EV-PLN-S001-000003). Which provides a high-level overview of environmental and sustainability requirements associated with the project. This WRP should also be read in conjunction with the HS2 Code of Construction Practice (CoCP) which contains standards and control measures to be implemented.

2.4.2 There are several other documents that should be referred to alongside this document; these include, but are not limited to:

- TS1-Technical Standard Water Resources -(HS2-HS2-EV-STD-000-000016);
- HS2 Environmental Minimum Requirements (EMRs) And General Principles Compliance Notes (GPCNs);
- British Water, 2013, Code of Practice, Flows and Loads – 4, Sizing Criteria, Treatment Capacity for Sewage Treatment Systems, Ref: BW COP: 18.11/13;
- https://www.ofwat.gov.uk/nonhouseholds/supply-and-standards/; and
- https://www.ofwat.gov.uk/regulated-companies/resilience-2/climate-change/.

3 SCS Water Requirements

3.1 Programme

3.1.1 The SCS water requirements outlined in this document (detailed in Appendix 2) have been aligned to the Red Diamond Day 2 (RDD2) program. These values will act as the baseline moving forward.

3.1.2 The water requirements are directly dependent upon site activities, and as SCS has been split into sections East, Central and West this report will follow the same format. The potable water supply is from two water providers: Thames Water and Affinity Water. The division and locations assessed for water use are provided in Table 3. Locations of the compound names are shown in Appendix 1.

***Table 3**: SCS contract split, utilities divide and compound names for water requirements*

Utilities Provider	SCS Contract Split	Location	Compound Name
Thames Water	S1-East	Euston	Addison Lee Compound (Hampstead Road Bridge North Satellite Compound)
			Euston Throat (incl. Granby Terrace Bridge satellite compound)
			Euston Scissor Box
			Harvil Road Bridge Zone 5
			Euston Cavern and Shaft
	S1-Central	Adelaide Road	Adelaide Road Vent Shaft
		Canterbury Road	Canterbury Works Vent Shaft
		Old Oak Common	Atlas Road
			Willesden Euro Terminal
	S2-Central		Victoria Road Crossover Box
			VRCB Ancillary Shaft
			Flat iron
			Old Oak common
		Westgate	Westgate Vent Shaft
Affinity Water		Greenpark Way	Greenpark Vent Shaft
	S2-West	Mandeville Road	Mandeville Road Shaft
		South Ruislip	South Ruislip Shaft
		West Ruislip	West Ruislip Portal
			Breakspear Road/ River Pinn
			Harvil Road / Copthall Tunnel/ SPAs

3.1.3 There are substantial requirements for water supply during construction. The key activities contributing to these volumes are three tunnels constructed using Earth Pressure Balance tunnel boring machines (TBM), and the Sprayed Concrete Lined tunnels (SCL) along with the enabling works for the tunnelling such as shaft construction and piling.

3.1.4 These requirements have been estimated by SCS based on the proposed construction techniques and established water demands which are detailed in Tables 4, 5 and 6. The estimates for each site are provided in Appendix 2; each of East, Central and West area have their own spreadsheet, with an additional sheet for TBM tunnelling build up.

3.1.5 Requirements have been aligned with the abstraction year (April to March), used by the EA and water companies to report and assess abstraction returns. This has been applied in the graphs in Appendix 2.

3.2 Construction Phase Water Use Assumptions

3.2.1 The following assumptions have been used to derive the water use throughout the duration of each activity as per the current programme.

3.2.2 The water consumption has been estimated across the duration of construction to provide monthly (m^3/month) and daily demand (litres/day).

3.2.3 S1 and S2 have been subdivided into three areas for planning and delivering the works (see attached plan Appendix 1):

- West Area: Harvil Road to Greenpark Way Vent Shaft (including Copthall Cutting, West Ruislip and Northolt Tunnels West);
- Central Area: Greenpark Way Vent Shaft to west side of Euston Cavern (including Northolt Tunnels East, Victoria Road Crossover Box, Old Oak Common Tunnels and Euston Tunnels); and
- East Area: Euston (including Euston Cavern, Scissor Box and Hampstead Road Bridge and Granby Terrace Bridge).

The tunnels have various names. The names are as follows:

- S2 West upline/downline – Northolt West – West Ruislip
- S2 East upline/downline – Northolt East – Victoria Road Crossover
- S1 upline/downline – Euston or Old Oak Common
- S1 Service Tunnel – Atlas Road Service Tunnel

Programme

- Activities and durations based on the current programme (May 2021). East Area also incorporates the post RDD2 inclusion of Granby Terrace Bridge and the Vehicle Holding Area construction activities.
- Water demand is calculated monthly, with all water use assumed to apply to the full month. A 22-day working month is assumed for civils.

Working Hours

The following working hours have been assumed:

- General (non-tunnelling) 11 hours/day, 22 days per month.
- Tunnelling 24hours/day, 30 days per month.
- SCL Shaft, Tunnels and Adits 24hours/day, 22-30 days per month.

Compound Types

- Main Compounds. Large sites supporting multiple activities. These comprise:
    - West Ruislip Area (the West Ruislip portal, West Ruislip Retained Cut and Ruislip Golf Course) which includes the Northolt Tunnels West Tunnel worksite;
    - Copthall Cutting Area (Copthall Tunnel, Gatemead Embankment, Sustainable Placement Areas and the Harvil Road Bridges) which includes the Muck Treatment area;
    - Victoria Road Crossover Box (VRCB and VRCB Ancillary Shaft) which includes the Northolt Tunnels East Tunnel and the Old Oak Common (OOC) SCL tunnelling worksites; and
    - Euston Area (Euston Cavern, Throat and Scissor Box).
- Tunnelling worksites. Located at West Ruislip and Victoria Road Crossover Box (both Main Compounds) and Atlas Road;
- Muck treatment areas. Located at Copthall Cutting (included in the Main Compound) and Willesdon Euro Tunnel (Old Oak Common);
- Satellite sites. Focused around a single asset, or relatively minor works – these include:
    - Adelaide Road, Canterbury Works, Westgate, Greenpark Way, Mandeville and South Ruislip ventilation shaft compounds;
    - Old Oak Common East Box (although the Euston Tunnel drives are launched here, all tunnelling activities are supported from Atlas Road);
    - Old Oak Common Flat Iron site (segment storage and conveyor access);
    - Breakspear Road and River Pinn (bridge construction);
    - Granby Terrace Bridge and Hampstead Road Bridge; and
    - Euston vehicle holding area.
- At West Ruislip and Copthall Cutting, due to the connected nature of the sites, all water uses for satellite sites have been included under the Main Compounds.

Staff and Labour

- Staff and labour numbers are based on the SCS Resourcing Plan and redistributed in accordance with the RDD2 programme.
- Welfare is provided at all sites with the following exceptions:
    - Welfare in the Copthall Cutting Area is provided both North and South of the Chiltern Line. These are used by all sites within the area;
    - The Euston Scissor Box works use the welfare at Granby Terrace Bridge; and
    - Hampstead Road Bridge works use the Addison Lee welfare.

3.3 Water Usage for Different Activities

3.3.1 Activity water usage values (Table 4) for the purposes of annual water supply volumes have been based on the peak and long-term average (LTA) average tunnelling rates. Annual Water demand is presented in m^3/month and ML/day in Appendix 2.

3.3.2 Water connection requirements and design of the pipework infrastructure will be based on peak demand.

3.3.3 The following assumptions in Table 4 have been adopted for calculating water usage at each site.

Table 4: *Water use assumptions used to produce total water use estimate*

Activity	Working Hours / Day	Days Worked	Usage (L/day unless stated otherwise)	Usage (m^3/day)	Comments
Welfare - Staff and Labour	n/a	22	40 Staff 60 labour	0.06 staff 0.06 labour	Usage based on British Water Code of Practice – Flows and Loads 4. Verified as in line with previous experience.
Road Sweeper	12	2	0.5 L/sec per sweeper Working 12 hours per day at 50% utilisation	10.8 per sweeper	One at each road with a compound exit Used for full duration of construction
Wheel Wash	12	22	1.5 m^3/hour per wheel wash Working 12 hours per day at 60% utilisation	18 per wheel wash	One at each compound exit Used for full duration of construction
Concrete batching	-	-	Not used, except for SCL. All concrete assumed to be pre-mix from local suppliers. SCS will engage with concrete suppliers once procured in order to understand their water management strategy, capacity and water usage requirements.		
Dust Control (West)	10	22	5000 L per water bowser per hour	50 per bowser Applied during Summer season (April to September)	Mainly rural. Dust control required for significant earthworks activities during summer months (April to September). - Copthall Cutting Area. Assume two bowsers for Copthall Tunnel, Sustainable Placement and Muck Treatment area. - West Ruislip Area. Assume one bowser for golf course construction and haul road. - Shafts. Covered under Miscellaneous, expect for Mandeville Road where additional allowance applied during major earthworks.

Activity	Working Hours / Day	Days Worked	Usage (L/day unless stated otherwise)	Usage (m^3/day)	Comments
Dust Control (Central)	-	22	-	30 per bowser	Mainly industrial. Allowance for one bowser at each site during summer months (April to September)
Dust Control (East)	12	22	2 L/sec per cannon working 24 hours per day at 40% utilisation	69 per cannon	Heavily residential and commercial. Continuous dust suppression required (based on ongoing EWC experience). Applied to every site.
Piling and Diaphragm Walls	12	22	See separate table (Table 5).		
Ground Treatment	12	22	1.5 m^3/hour per silo working 12 hours per day at 50% utilisation	18 per silo	Applicable to Area West only: 6No. silos at West Ruislip 2No. silos at South Ruislip and Mandeville Road
Miscellaneous	n/a	n/a	5% contingency allowance	Varies	Applied to all compounds where there are construction activities (not to welfare only sites) Calculated based on 5% of the monthly water usage excluding TBM tunnelling. May not be suitable for assessing peak flows, but sufficient for total demand.
TBM Tunnelling	24	30	See Tunnelling Water Consumption for Details (Table 6) Water usage per month based on peak and LTA Includes all tunnel related activities, including tunnelling workshop and cross passages		
SCL Shaft, Tunnels and Adits	24	Varies 22-30	See separate table (Table 6) Note. Cross passages included under TBM water usage figures		
Demolition Works – Pile Breakout	12	22	80 L/min at 80% utilisation	48m^3/day	Applicable to Granby Terrace Bridge works only

3.3.4 Pile and Diaphragm Wall Water Demand Summary

General Assumptions

The following general assumptions have been applied:

- Water consumption is based on piling methodology, number of piling rigs and associated plant and piling production per day.
- In East SCS polymer is being used. Polymer mixing uses large quantities of water as the medium of polymer is water.
- Bentonite is being used across the rest of the project.
- Cleaning demand depends on type and length of casings. Since the casings come into contact with concrete, the casings will have to be cleaned off immediately, and on a daily-basis.
- Concreting tube (tremie pipe) cleaning will have to be done every time these are used. Every rig will have a set of tremie pipes which will be used and cleaned after each pile completion.

The following location-specific water usage has been adopted in Table 5.

Table 5:*Water use assumptions used for pile and diaphragm walls*

Sl.	Asset Name	Piling Methodology	Number of Rigs	Polymer or Bentonite Mixing / Day (m^3)	General Cleaning/ Day (m^3)	TOTAL /Day (m^3	Comments
1	Euston Cavern Shaft/HH	Rotary short secant wall + bearing piles	1	Piles could be dry. To be decided.	3	3	Short casing for secant and HH
2	Adelaide Road Vent shaft HH	Rotary bearing piles	1	400 to start with and then 60-120 top up once a week	3	Day 1 - 400 then 20	Normal slip cased rotary piling Water use assumed based on Scissor Box piling
3	Canterbury Works Vent Shaft HH	Rotary bearing piles	1	400 to start with and then 60-120 top up once a week	3	Day 1- 400 then 20	Normal slip cased rotary piling Water use assumed based on Scissor Box piling
4	Atlas Road Launch Ramp	Rotary long cased secant walls	1	400 to start with and then 60-120m^3 top up once a week	3	Day 1 - 400 then 20	Fully cased and so cleaning of longer cases involved Water use assumed based on Scissor Box piling

SI.	Asset Name	Piling Methodology	Number of Rigs	Polymer or Bentonite Mixing / Day (m^3)	General Cleaning/ Day (m^3)	TOTAL /Day (m^3	Comments
5	Hampstead Road Bridge	Slip and Segmental cased rotary piling	2+1*	320 to start with and then 60-120 top up once a week.	9	Day 1 - 320 then 26	*1 mini piling rig ~ 1800/150mm diameter piles
6	Euston Throat	Rotary piling with slip casings	1	300 to start with and then 60-120 top up once a week.	3	Day 1 - 300 then 20	180mm(large) diameter piling
7	Scissor Box	Rotary piling with slip casings	2	400 to start with and then 60-120 top up once a week	6	Day 1 - 400 then 23	150mm diameter for tension piles
8	Grand Union Canal bridge	Rotary piling with slip casings	1	320 to start with and then 60-120 top up once a week	3	Day 1- 320 then 20	Atlas Road Compound
9	Victoria Road Crossover Box	Diaphragm Walls	Varies	Bentonite 179 ave	Incl.	179	Based on average distribution of total water quantity over diaphragm walling programme
10	Westgate Vent Shaft HH	Rotary bearing piles	1	400 to start with and then 60-120 top up once a week	3	Day 1 - 400 then 20	Water use assumed based on Scissor Box piling
11	Greenpark Way Vent Shaft HH	Rotary bearing piles	1	400 to start with and then 60-120 top up once a week	3	Day 1 - 400 then 20	Water use assumed based on Scissor Box piling
12	Mandeville Road Vent Shaft HH	Rotary bearing piles	1	400 to start with and then 60-120 top up once a week	3	Day 1 - 400 then 20	Water use assumed based on Scissor Box piling
13	South Ruislip Vent Shaft (incl. Ancillary Shaft) /HH	Diaphragm Wall and Rotary bearing piles	-	Bentonite 100	Incl.	101	Bearing piles assumed based on S1 shafts
14	West Ruislip Portal	Contiguous Bored Piles	-	Bentonite	3	15	

SI.	Asset Name	Piling Methodology	Number of Rigs	Polymer or Bentonite Mixing / Day (m^3)	General Cleaning/ Day (m^3)	TOTAL /Day (m^3	Comments
				15			
15	Copthall Tunnel	Bored Piles	-	Bentonite 100	Incl.	100	
16	Breakspear Road and River Pinn bridges	CFA piling	-	-	-	-	Cleaning only – covered under miscellaneous
17	Harvil Road bridges	CFA piling	-	-	-	-	Cleaning only – covered under miscellaneous

3.3.5 SCL Tunnelling Works – Water Demand Summary

General Assumptions

The following general assumptions have been applied:

- All SCL (shafts, adits and tunnels/caverns) considered below ground works so adopts 24 hour working. Working 5 days per week for shafts and adits, and 7 days for tunnels and caverns;
- Cross passage water usage is included under the TBM tunnelling water demand;
- Water usage is calculated as 210m^3 of SCL batched on site. This allows for 40% wastage from rebound, clearing of blockages etc; and
- Specific dust suppression water has also been allowed for the Euston cavern SCL works only.

The following location-specific water usage has been adopted in Table 6.

***Table 6**: Water use assumptions for SCL tunnelling works*

Activity	Site Compound	Days Worked per month	Water demand (m^3/day)	Comments
S1 Shafts and Adits	Adelaide Road, Canterbury Road and Euston Cavern	22	15	Based on maximum advance per day for shaft or adit, applied to full duration of SCL.
S2 Shafts and Adits	Victoria Road Crossover Box, Westgate, Greenpark Way, Mandeville Road and South Ruislip	22	20	Based on maximum advance per day for shaft or adit, applied to full duration of SCL.
Old Oak Common Tunnels	Victoria Road Crossover Box	30	25	Based on concurrent excavation of Upline and Downline Tunnels

Activity	Site Compound	Days Worked per month	Water demand (m^3/day)	Comments
Ancillary Shaft Back- and fore-shunt	Victoria Road Crossover Box	30	20	Based on sequential tunnel excavation for Upline and Downline tunnels
Old Oak Common Launch Stubs	Old Oak Common	30	20	Based on concurrent excavation of Upline and Downline Tunnels
Euston Cavern	Euston Cavern	30	15	Based on maximum cumulative advance for multiple drifts and headings within the cavern and the crossover tunnels.

3.3.6 TBM Tunnelling Works – Water Demand Summary

3.3.7 Table 7 provides a summary of peak and LTA overall consumption of water related to TBM tunnelling works.

Table 7: Peak and long-term average overall consumption of water for TBM tunnelling works from East area to West area

Tunnel Section	Water Consumptions Sections	Soil conditioning (m^3/day)	Grout (m^3/day)	Cleaning grout plant (m^3/day)	Cooling &cleaning (m^3/day)	Workshop (m^3/day)	Conveyor cleaning (m^3/day)	Cross passages (m^3/day)	Total daily consumption (m^3/day)
Long Term Average Production Demand									
Euston Tunnels	S1 Upline & S1 Downline	550.23	121.70	22.26	70.00	10	42	2.39	860
Atlas Road tunnel	S1 Service tunnel	155.79	36.52	7.77	70.00	10	62	0.00	363
Victoria Road Crossover	S2 East Upline & S2 East Upline	607.48	132.95	22.92	70.00	10	83	2.39	929
West Ruislip	S2 West Upline & S2 West Downline	294.8	56.75	(10.38)	(8.04)	(10)	(84)	(0.77)	704
Peak Production Demand									
Euston Tunnels	S1 Upline & S1 Downline	994.39	219.93	40.23	70.00	10	42	2.39	1420
Atlas Road tunnel	S1 Service tunnel	343.66	80.57	17.13	70.00	10	62	0.00	604
Victoria Road Crossover	S2 East Upline & S2 East Upline	1139.02	249.28	42.98	70.00	10	83	2.39	1597
West Ruislip	S2 West Upline & S2 West Downline	660.00	127.05	(23.24)	(18.00)	(10)	(84)	(0.77)	1574

(..) Water reused

4 Potential Water Sources

4.1 Introduction

4.1.1 The key aspects of water sources that need to be considered for supply are those associated with location, quantity and quality, with aspects such as certainty of supply and licensing requirements also of significant concern. The principal water demand is for the compounds and the tunnel boring machines (TBMs). The proximity of a compound to a supply source is therefore of greatest importance when evaluating the options for water supply.

4.1.2 According to HS2 they will not be seeking consent for an abstraction licence from the Environment Agency, Affinity Water or Thames Water. HS2 is working with Affinity Water and Thames Water to make available a supply to meet the overall requirements of ALIGN and SCS of up to 4.6 Ml/d by using a combination of Affinity Water supply and Thames Water importation to meet SCS and Align's demands of 4.6 Ml/d. Affinity Water can supply up to a max of 2 Ml/d specifically for SCS for the period 2021 -2023 (Affinity Water, April 2020, Water Resource Management Plan, 2020-2080).

4.2 Groundwater

Superficial deposits

4.2.1 The superficial deposits beneath and adjacent to East, West and Central areas comprise sands and gravels belonging to the Lynch Hill Gravel Member, Kempton Park Gravel Member, or Alluvium and Park Gravel Member, and clays and silts belonging to the Langley Silt Member.

4.2.2 The sand and gravel units are designated as Secondary A Aquifers and are located within the east and south of the East area, along the River Brent through the Central area and the West area, and also along the River Pinn in the West area.

4.2.3 The Secondary A Aquifers are capable of supporting water supplies at a local scale however, due to the limited thickness, limited areal extent and isolated deposits within the East, Central and West areas these are unlikely to provide a constant and reliable water source. Secondary A Aquifer superficial deposits are therefore excluded as being an appropriate water source.

4.2.4 The clay and silt units are designated as Unproductive Strata which have low permeability and negligible significance with regards to water supply and therefore are excluded as being an appropriate water source.

Bedrock

4.2.5 The London Clay Formation underlies the East area, Central area and the majority of the West area through to approximately the Breakspear Road Compound. From the Breakspear Road Compound to approximately the Harvil Road Compound, the Lambeth Group outcrops, and from the Harvil Road Compound to the end of the West area the Seaford Chalk Formation outcrops. The tunnel route is within the London Clay Formation for the entirety of the East area, and the majority of the

Central area, entering into the Secondary A Aquifer of the Lambeth Group approximately around Westgate Vent Shaft. The tunnel remains in the Lambeth Group before entering the Principal Seaford Chalk Aquifer at approximately South Ruislip Shaft.

4.2.6 The London Clay Formation is designated as Unproductive Strata and is not located within a groundwater body therefore, it is excluded as being an appropriate water source.

4.2.7 The Lambeth Group is designated as a Secondary A Aquifer and therefore is capable of water supply on a local scale. The Lambeth Group aquifer is located within the Radlett Tertiaries groundwater body (ID: GB40602G602800). This groundwater body is monitored by the Environment Agency (EA) under the Water Framework Directive (WFD) as part of the River Basin Management Plan (RBMP). The Chemical status of the water body is classified as 'Good' and the quantitative status is classified as 'Poor'. The EA do not attribute any sector responsible for the reason the water body is not achieving 'Good' status[1].

The Seaford Chalk Formation is designated as a Principal Aquifer; therefore, the aquifer provides a high level of water storage and may provide water supply and/or river base flow on a strategic scale. The Seaford Chalk Principal Aquifer is located within the Mid-Chilterns Chalk groundwater body (ID: GB40601G601200). This groundwater body is monitored by the Environment Agency (EA) under the Water Framework Directive (WFD) as part of the River Basin Management Plan (RBMP). The Chemical status of the water body is classified as 'Poor' and the quantitative status is classified as 'Poor'. The EA attribute the following reasons as the why the water body is not achieving 'Good' status (not exhaustive list): contaminated land, sewage discharge, poor nutrient management, and groundwater abstractions[2].

Secondary A Aquifers and Principal Aquifers are potential options for water supply to the Scheme. However, both the Radlett Tertiaries and Mid-Chilterns Chalk groundwater bodies are located within the Colne Catchment Abstraction Management Strategy (CAMS) area. The 2019 abstraction licensing strategy (ALS)[3] states that water is not available for licensing within this CAMS area. The ALS also indicates that consumptive water abstraction may only be available less than 30% of the time. As water is not available from this groundwater body, this would prevent SCSJV from installing their own abstraction boreholes and it may also limit or prevent Affinity Water obtaining an increase in their abstraction rates. Therefore, groundwater from these groundwater bodies has been excluded as a source of water supply.

4.2.8 The ALS divides the Colne CAMS area into 'unconfined chalk aquifer' (this is the Radlett Tertiaries and Mid-Chilterns Chalk groundwater bodies as discussed above) and 'confined chalk aquifer' (below the London Clay Formation along the route). The ALS states that the unconfined groundwater aquifer is closed to consumptive licences. However, new consumptive licences may be available from within the confined chalk aquifer. The confined chalk aquifer is discussed within

[1] Environment Agency, 2019, Catchment Data Explorer (online) available at: https://environment.data.gov.uk/catchment-planning/WaterBody/GB40602G602800 [accessed October 2019]
[2] Environment Agency, 2019, Catchment Data Explorer (online) available at: https://environment.data.gov.uk/catchment-planning/WaterBody/GB40601G601200 [accessed October 2019]
[3] Environment Agency, 2019, Colne Abstraction Licensing Strategy.

the Environment Agency's 'Management of the London Basin Chalk Aquifer' report which states that water is available for licensing[4]. Therefore, there is the potential for water supply to be obtained from the confined Chalk aquifer below the London Clay Formation.

4.2.9 The current assumption is that water can be abstracted for mains water by existing companies. There is a presumption against private water abstraction for the HS2 project following discussions between the Environment Agency and SCSJV/HS2.

4.2.10 The tunnel route passes through a Source Protection Zone 2 (SPZ) after the Adelaide Road Compound within the Central area between chainage 3+000 and 4+000. However, this SPZ is likely to be attributed to the groundwater abstraction from the Chalk aquifer, which is not entered by the tunnel itself. The tunnel does however drill through an SPZ1 and SPZ2 west of West Ruislip Compound Works in the West area from chainage 24+000 to 28+000. Groundwater abstraction and water supply from these areas is unlikely to be feasible and therefore water supply to compounds and vent shafts within these areas cannot come from groundwater.

4.2.11 There is no further water available for licensing from the unconfined Chalk aquifer. As noted in para 4.2.8 there is the potential for new abstraction licences further towards central London within the confined part of the Chalk aquifer[4].

4.3 Surface Water

Rivers

4.3.1 There are seven main rivers crossing areas East, Central and West, these are from east to west: River Brent, Yeading Brook East Arm, Yeading Brook West Arm, Ickenham Stream, River Pinn, Newyears Green Bourne and the River Colne (see Appendix 3).

4.3.2 The River Brent and Yeading Brook (East and West Arms) are perched on low permeability London Clay. These rivers are likely to be supported by surface water runoff, precipitation and connecting tributaries receiving little to no baseflow from groundwater. The water availability of these watercourses is documented in the 'London Abstraction Licensing Strategy' (March 2019). The licensing strategy states 'Water Available' at Q30, 'Restricted Water Available' at Q50, and 'Water Not Available' at Q70 and Q95 flows. Water supply from these rivers will not be viable as they will not be able to provide a constant source of supply and abstraction will likely result in an adverse impact to the watercourses and therefore has been excluded as a possible source of water supply.

4.3.3 The River Pinn, Ickenham Stream and Newyears Green Bourne are located on the Secondary A Aquifer, Lambeth Group, within the West area. There is potential that these watercourses could receive baseflow from groundwater. However, site walkovers to these watercourses show that flows in the Ickenham Stream and Newyears Green Bourne are modest and particularly low (or absent) in the summer months. The River Pinn flows all year round, but comprises a small channel with limited depth, which is prone to seasonal flooding. These watercourses are also located within

[4] Environment Agency, 2018, Management of the London Basin Chalk Aquifer.

the Colne ALS where water is not available for licensing therefore these have been excluded as a possible source of water supply.

4.3.4 The River Colne is located on the Seaford Chalk Formation Principal Aquifer and is likely to receive base flow from groundwater. However, the River Colne flows through the Mid Colne Valley Site of Special Scientific Interest (SSSI) designated for its 'standing open water and canals'. In addition to this, the River Colne is located within the Colne ALS where water is not available for licensing therefore this is excluded as a possible source of water supply.

4.3.5 In addition to the main rivers identified above, there are smaller ordinary watercourses present within the vicinity of the East, Central and West areas. It is unlikely these ordinary watercourses could be able to provide a constant water supply and therefore have been excluded as a possible source of water for supply.

4.3.6 Discharges to watercourses could also be a potential source of water supply to SCSJV for activities where poorer water quality could be acceptable. However, as these watercourses are likely to receive little to no baseflow from groundwater, removing discharge to the rivers also reduces flows in the rivers and therefore have been excluded as a possible source of water for supply.

Lakes

4.3.7 There are no lakes or ponds within proximity of the route in the East or Central areas. There are several lakes within the West area located in the west of the section associated with the River Colne and the Mid Colne Valley SSSI. These lakes are within the LLAU but not in proximity to compound locations. These lakes are also located within the Colne ALS which states that no water is available for licensing, therefore lakes have been excluded as a possible source of water supply.

Canals

4.3.8 The Grand Union Canal (GUC) is present within both the East and Central areas, and closest to compounds for the Greenpark Vent Shaft worksite, Victoria Road worksite, and Euston Cavern compound worksite. The GUC, although likely to receive an element of inflow, is unlikely to be able to provide a sufficient and reliable water supply. The Colne ALS states the GUC is interlinking throughout the catchment with the Colne, Gade and Bulbourne Rivers, therefore the GUC is likely to be subject to the same water licensing restrictions as outlined in the Colne ALS. Therefore, the GUC has been excluded as a viable source of water supply.

4.4 Rainwater

4.4.1 Where able to, SCSJV will endeavour to install rainwater harvesting systems at their compounds. This will involve capture, storage, treatment and local use of the rainwater. However, available space at each compound to house a storage tank in addition to seasonal variation restricts the volume of water available and does not pose a constant, reliable water source. Therefore, rainwater has been excluded as a possible source of water supply.

4.5 Mains Water

4.5.1 There are two water utility supply areas crossed by the HS2 Route in East area, Central area and West area, which are Thames Water and Affinity Water. The entirety of the East area is located within Thames Water's coverage area, and the majority of the Central area to Westgate Vent Shaft. Greenpark Vent Shaft and the West area are located within Affinity Water's coverage area. There is an overlap of both the utility companies around Westgate Vent Shaft between approximate chainages 12+000 and 14+000.

4.5.2 As presented in Section 4.1.2, HS2 they will not be seeking consent for an abstraction licence from the Environment Agency, Affinity Water or Thames Water. HS2 is working with Affinity Water and Thames Water to make available a mains water supply to meet the overall requirements of SCS.

4.6 Implications of Water Source Selection

4.6.1 The water source that is selected for water supply to the construction works within the East, Central and West areas may have implications on the:

- Surface water features, i.e. impacts to flora and fauna and well as to users of the surface water features for recreational use or for businesses;
- Groundwater, i.e. impacts to baseflow to rivers as well as to users of abstractions for: potable water supply/agricultural use/industrial use;
- Construction works, i.e. the impact of any new infrastructures to move water from its source to point of use, including consideration of infrastructure routing, any planning requirements, programming, energy requirements, capital cost and running cost; and
- Programme planning, i.e. where new abstractions are proposed the permitting/consenting requirements will have implications for programming as there could be significant time required to get these in place prior to abstraction.

4.6.2 Other concerns regarding new abstractions are the implications for HS2 carbon targets. In addition, overarching legislation such as the Water Framework Directive needs to be considered to determine if selecting one source of water over another could result in a breach of legislation. Each of these is considered further below.

4.7 Effects on Environmental Receptors

4.7.1 Abstracting water has the potential to impact receptors within the vicinity of the abstraction either by direct abstraction, or indirectly i.e. abstraction from groundwater which subsequently reduces baseflow to surface water.

4.7.2 Each of the water supply options outlined above have the potential to affect environmental receptors and wider water supply users, these are summarised in Table 8.

Table 8: Implications of water supply source on environmental receptors

Water source	Potential Environmental Implications	Other Implications considered
Groundwater	Reduction in baseflow to rivers	Impact on other abstractions Impact on groundwater-fed wetlands Potential subsidence / settlement in some formations / structures
Rivers	Impacts on flora and fauna	Effect on amenity value Impact on other abstractions Impact on other users of the river i.e. recreational use
Lakes	Impacts on flora and fauna	Effect on amenity value Impact on other abstractions Impact on other users of the river i.e. recreational use
Canal	Impacts on flora and fauna	Effect on amenity value Effect on navigability and recreation use Effect on structural integrity of canal banks due to changing water levels
Rainwater	Reduction in runoff to surface watercourses and reduction in recharge to the underlying groundwater	Reduction land available for use, due to rainwater capture systems and for water storage facilities
Mains Water	Reduction in baseflow to rivers and flow to springs	Reduced resilience in water supply system

4.8 Carbon Targets

4.8.1 Water-related operations can play a significant role in carbon emissions both directly and indirectly. The most significant of which in the scope of SCSJV works being the emissions arising from the energy consumed for undertaking water movement and treatment activities.

4.8.2 HS2 has set a target of reducing its carbon footprint by 50% against the baseline carbon for the scheme, as calculated by SCSJV. This target is identified in the HS2 Technical Standard Carbon Management (HS2-HS2-SU-STD-000-000004 P07). A Carbon Management Plan (1MC03-SCJ-EV-PLN-S001-000002) that outlines the systems in place to ensure a culture of carbon reduction is in place through all value chain members has been prepared by SCSJV for Sectors S1 and S2. This is a live document that details the systems put in place as well as their development over the course of the project's progress to ensure the identification and delivery of carbon reductions throughout

the design, construction and legacy of Sectors S1 and S2. SCSJV is certified to PAS 2080: Carbon Management in Infrastructure and operating in line with its principles.

4.8.3 Regarding specific water-related operations with subsequent carbon implications, the following are considered by SCSJV wherever possible:

- Reducing overall water requirements;
- Avoidance of de-watering operations;
- Taking account of water quality requirements, and using raw water rather than potable water, as the latter has a much greater carbon footprint, especially where turbidity treatment is required;
- Managing water efficiently by using appropriately sized pumps and pipes, only using the number of pumps required, and where possible designing efficient systems;
- Using gravity fed water supply and drainage systems where practicable;
- Using rainwater harvesting; and
- Reusing water where possible, with treatment limited to that which is essential for its end use, albeit with a recognition that discharges to the environment may require high levels of treatment due to environmental sensitivity at Sector S1 and S2.

4.9 Implications of Water Framework Directive

4.9.1 A Water Framework Directive (WFD) compliance assessment was completed by HS2 during the planning stage to address the potential for the construction of areas East, Central and West to breach the requirements of the WFD legislation. This assessment was prepared by HS2's Engineering Delivery Partner (Atkins) in 2017. Requirements from the WFD include a number of elements, including: protection of all waters and improvement their ecological, physico-chemical and hydromorphological condition; achieving good quality status for all waters; conserving habitats and species that depend directly on water; progressively reducing the pollution of groundwater and preventing or limiting the entry of pollutants; and, reversing any upward trends in pollution. In addition to these, and of relevance to the water demand considered in this plan are that the WFD promotes the sustainable use of water, and it has a requirement to reduce over abstraction of groundwater.

4.9.2 The Technical Standard – Water Framework Directive (WFD) Compliance Process (document number: HS2-HS2-EV-STD-000-000012) outlines four key WFD objectives against which WFD Compliance Assessments are made as follows:

- Objective 1: The Proposed Scheme will not cause deterioration in any element of water body classification.
- Objective 2: The Proposed Scheme will not prevent the WFD status objectives from being reached within the water body or other connected water bodies.

- Objective 3: The Proposed Scheme will not negatively impact critical or sensitive habitats within the water body.
- Objective 4: The Proposed Scheme will contribute to the delivery of the relevant RBMP which the assessed water bodies are situated within.

4.9.3 SCSJV will prepare an updated Water Framework Compliance Assessment for areas East, Central and West and provide updates to HS2's Routewide WFD Compliance Assessment update from 2017, during detailed design. The HS2 philosophy to water consumption is prevent, reduce and reuse/recycle which will be adhered to throughout the design for areas East, Central and West.

4.9.4 Consent applications for works with the potential to impact the quality of surface water or groundwater bodies will be accompanied by a WFD Compliance Form (Template in Appendix A of the HS2 Technical Standard - Water Framework Directive Compliance Process - Hs2-HS2-EV-STD-000-000012) completed by SCSJV to confirm compliance with the HS2 WFD Compliance Process. This is a requirement of the HS2 Technical Standard Water Resources and Flood Risk Consents (HS2-HS2-EV-STD-000-000015).

4.9.5 Two initial high-level assessments have been undertaken within this section to assess the activity of 'water supply' in relation to areas East, Central and West against the four key objectives outlined in HS2 Technical Standard - Water Framework Directive Compliance Process - Hs2-HS2-EV-STD-000-000012). One assessment assessing water supply from each potential water source and associated waterbody against the WFD compliance for that particular waterbody; and one assessment assessing the water supply from the preferred water supply source (mains water), on the WFD compliance of the waterbodies within areas East, Central and West. These assessments can be found in Table 1 and Table 2 in Appendix 4 and summarised below.

- If water supply was sourced from the Radlett Tertiaries and the Mid-Chiltern Chalk groundwater bodies, then this activity would prevent the waterbodies from achieving Good quantitative status and would not meet objectives 1 to 4. However, water abstraction from these groundwater bodies will not prevent them achieving/maintaining Good chemical status.
- If water supply was sourced from the main rivers, there is the potential that the reduction in water level could have an adverse impact on the ecological designation of the waterbodies and potentially not meet objectives 1 to 4. It could also have an adverse impact on the quality of the watercourse due to reducing the volume of water available for dilution within the watercourses.
- If water supply was sourced from mains water supply and abstracted from the Principal Aquifer located below the London Clay Formations, this mains supply is taken from the confined part of the Mid-Chiltern Chalk groundwater body, so could result in failure to meet Objectives 2 and 4 for groundwater quantitative status. However, provision of HS2 water supplies using mains water abstracted from the confined Mid-Chiltern Chalk groundwater would not threaten achievement of

objectives 1 and 3.

4.9.6 The mains water will be supplied within the limits of the Thames Water and Affinity Water abstraction licenses and all four objectives will be complied with.

5 Water Quality Requirements

5.1.1 The quality of water required by SCS for construction varies according to the sensitivity of the use, with some end uses requiring potable quality water, and others non-potable. However, it should be noted that even untreated groundwater from the Chalk aquifer is of high quality and is close to potable. The quality requirements are broadly summarised in Table 9.

Table 9: Water quality requirements

Activity	Acceptable water quality	Selected Source
Bentonite plants	Recycled water	Potable water from Affinity / Thames Water – will be recycled and re-used
Wheel washing	Recycled water	Potable water from Affinity / Thames Water.
Dust suppression, vehicle washing	Recycled water	Potable water from Affinity / Thames Water.
Facilities – consumption	Potable water	Potable water from Affinity / Thames Water.
Facilities – washing	Raw water	Potable water from Affinity / Thames Water.
Facilities – toilet flushing	Recycled water, Raw water	Potable water from Affinity / Thames Water.
Workshop washing bay	Recycled water	Potable water from Affinity / Thames Water, if attenuation pond treated water is not viable or available in sufficient quantity.

Tunnelling activities

Activity	Acceptable water quality	Selected Source
TBM cooling water	Good quality, no organic matter, requirement from TBM supplier	Potable water from Affinity / Thames Water. Proposal to use recycled water from cross-passage dewatering for West Ruislip.
Tunnel / Cross passage / TBM activities	Raw water	Potable water from Affinity / Thames Water. For West Ruislip, conveyor cleaning and cross-passage from recycled water from cross-passage dewatering.

		Treatment and recycling of tunnel water.
Grout for tunnel annulus	Raw water	Potable water from Affinity / Thames Water. For West Ruislip, grout cleaning from recycled water from cross-passage dewatering.
Workshop washing bay	Recycled water	Potable water from Affinity / Thames Water, if attenuation pond treated water is not viable or available in sufficient quantity. For West Ruislip, recycled water from cross-passage dewatering.

6 Selected Water Supply

6.1 Preferred Options for Supply

6.1.1 The above options have been considered, but in the most part mains water has been selected as the most cost effective, and in some instances only viable option for supply. The option for separate potable and raw water supply pipes is being discussed with Thames and Affinity Water supply in order to reduce treatment requirements at source. This notwithstanding, designs, techniques and equipment have all been considered to determine the most sustainable options.

6.1.2 The connections to potable water supplies varies between sites, those with historical connections in place will be taken over by SCS, however for the most part new connections will be required. The SCS utilities team is working with Thames Water and Affinity Water infrastructure teams in order to make the connections for supply and discharge. The timescales for these works vary across the project due to the differences in program requirement.

6.1.3 SCS is currently considering dewatering options for cross passages and shafts:

- Greenpark Way and Mandeville Vent Shafts require grouting.
- South Ruislip Vent Shaft requires a diaphragm wall.
- Two of the twenty cross passages require grouting.

6.1.4 Grouting of the Chalk is being considered for these shafts/cross-passages because of the anticipated high flow rates within the Chalk and the potential for basal heave. SCS is also considering the storage and recycling of water produced during the dewatering of the cross-passage for use in West Ruislip tunnelling. The tunnelling peak rate water demand is estimated to be 1,669 m^3/d, and the long-term average is estimated to be 798 m^3/d (see Appendix 2). The daily recycled water is estimated to be 95 m^3/d, or 6% and 12% of the total demand, respectively. Similarly for the Atlas Road Service Tunnel and Euston tunnel the intention is to reuse tunnel water, combined with Atlas Road compound surface water and site wastewater, to supply a peak flow rate of approximately 300 m^3/d. This corresponds to 15% of the tunnel peak demand.

6.1.5 The distance between the sites in Central and West means that transporting by road between sites would require an increase in lorry movements which could lead to other environmental effects in the locality. Installing pipelines between the sites is an option which is being assessed.

6.1.6 The most likely scenario is that the dewatering volumes from West Ruislip Portal and the cross-passages will be discharged to the River Pinn. And the dewatering volumes from South Ruislip Vent Shaft will be discharged to the Yeading Brook, and Greenpark Way Vent Shaft and Mandeville Vent Shaft discharged to the Grand Union Canal. Moreover, the reinjection of water back into the Chalk aquifer is being considered for West Ruislip Portal and Greenpark Way Vent Shaft. The upper limit of the volume of the West Ruislip Portal recharge is 45 l/s of which the Chalk reinjection rate is estimated to be 8 l/s. The volume of the potential recharges for the other assets is currently being assessed.

6.1.7 This Water Resources Plan will need to be updated once the volumes and potential disposal routes of dewatering water have been confirmed as this could provide a significant source of water.

6.2 Risks to SCS Water Supply

6.2.1 SCS are entitled to request that the water company provides a domestic supply for welfare facilities that will cover drinking water, and sanitary facilities such as toilets and showers.

6.2.2 The first risk to SCS water supply is the non-domestic supply. A water company has to ensure that it can meet all existing and potential demand for supplies for domestic purposes. The non-domestic water demands for SCS are higher and pivotal in the construction of HS2. There is already significant domestic demand pressure within Affinity Water's supply area (Affinity Water, April 2020. Water Resource Management Plan, 2020-2080), which is the sole supplier for the west section of SCS works.

6.2.3 Climate change significantly influences the water cycle which in turn affects the long-term sustainability of the water sector if it cannot adapt to the changing environment. According to Ofwat, this will affect SCS supply and discharge in the following ways:

Precipitation. Changing rainfall patterns may make it harder to meet demand and could increase the risk of droughts affecting the supply of water.

Abstraction. Higher temperatures and less rainfall in the summer means there will be more stress on already scarce water resources when they are needed the most.

Treatment. More frequent heavy downpours and changes to the ecology of rivers may reduce the quality of the water we take from the environment, requiring more treatment.

Distribution. Key assets may be at greater risk of being flooded and changes in soil moisture levels may lead to changing patterns of pipe bursts and leaks.

Consumption. As the climate warms, demand for water is likely to increase from both household and non-household consumers. In some areas, there may also be increased competition for raw water resources from other sectors, especially during the summer months.

Drainage. Changing rainfall patterns challenge the current approach to drainage. Climate change will increase the risk of surface water flooding and sewer flooding, which is one of the most serious types of service failure. Climate change may also increase the damage caused by overflows of untreated wastewater into the environment.

Wastewater treatment and discharge. Reduced river flows could mean more carbon-intensive sewage treatment is required to ensure rivers are protected.

6.2.4 There is limited resilience present in the water supply network. Thames and Affinity Water's main commitment is to provide existing residential customers with water. The network can become stretched during the peak demand period (June to September), and especially if the preceding winter has been relatively dry with only limited recharge of groundwater bodies. In such instances it could be that the mains supply volume to SCS is, by necessity, reduced to allow demand to be effectively managed across the wider network.

6.2.5 The EA abstraction licence position is that there is no new groundwater available for abstraction from the Chalk in this part of Affinity Water's area. HS2 is working closely with all relevant parties to deliver a water supply solution that does not require the supply to SCS to be temporarily restricted or stopped. HS2 is working closely with Thames Water, Affinity Water and the Environment Agency to deliver a water supply solution that does not add any significant new abstraction burden to the Chalk aquifer, nor take any water from vulnerable chalk streams. As part of that work, HS2 is looking at how it can reduce the pressure on water resources over the short to medium term and improve water supply resilience into the future.

6.2.6 Extensive infrastructure will be required for supply pipes, drains and sewers to SCS sites. SCS will be responsible for maintenance of the pipes within our site boundaries, which will include leak detection, repairs and replacement over the duration of the project. If the supplier records leakage but cannot source the leak, SCS may be issued a legal notice under the Water Industry Act 1991 to fix this, as SCS works stretch between Euston and West Ruislip this is a very wide network to manage.

6.2.7 SCS is likely to be affected by all types of leakage across the project. The operational strategies of the water company could result in poor pressure delivered to site, which would reduce the speed in which SCS sites are supplied. For many areas, the network characteristics are the current biggest risk for the utilities team because no connections to the mains currently exist.

6.2.8 The current assets in use for discharge were built in the 1800s. This aging infrastructure will need to be surveyed and, in some places, will require upgrade in order to transmit the SCS discharge.

6.2.9 Although water companies give 48 hours' notice for planned interruptions, when the tunnel boring machines have been launched, they will require a supply 24/7 as the operation cannot be stopped. SCS will need to have a contingency plan in place from the water companies.

7 Sustainable Water Use

7.1 Opportunities: Construction

Table 10: Opportunities - Construction

Activity	Opportunity	Comments
Tunnelling – see next page for breakdown (TBM)	• Recycle cross passage dewatering for TBM operations. Develop strategy for all sites focusing on soil conditioning, cleaning grouting plant, cooling and cleaning inside tunnel (up to 80% could be recycled), workshop and conveyor cleaning. • Assess returns to Chalk aquifer. • Assess water quality at each stage and consider volumes available for reuse in other activities.	• 3 sites: Atlas Road, VCRB and Ancillary Shaft and West Ruislip Portal. • Permitting requirements need to be explored – dewatering, groundwater control, possible permit to use before discharge.
Piling	• Develop a strategy for Euston Scissor Box, Euston Throat (incl. Granby Terrace Bridge), Harvil Road, HRB Zone 5 and West Ruislip Portal • Utilise alternative sources of water e.g. recycled water or raw water from rain water harvesting (RWH) (where RWH is feasible)	• 6 other sites with negligible water demand for piling (25 – 88 m^3/month)
SCL	• Develop strategy for all sites • Potential to use admixtures (plasticisers) to achieve low water: cement ratios, thereby reducing water requirement	• Demand across the 10 sites is similar, ranging from 518 to 760 m^3/month, with one site (VCRB and Ancillary Shaft) requiring 440 m^3/month and 600 m^3/month, respectively.
Diaphragm Walling	• Seepage ingress – can be treated and repurposed (preliminary estimate available to be reviewed)	• Permitting requirements need to be explored – de watering, GW control, possible permit to use before discharge
Ground Treatment	•Develop strategy for Mandeville Road shaft, South Ruislip shaft and West Ruislip Portal •Utilise alternative sources of water e.g. recycled water or raw water from RWH (where RWH is feasible)	

7.2 Opportunities: TBM Tunnelling

Table 7: *Opportunities – TBM tunnelling*

TBM Construction Activities	Quality Requirements	Consumptive Demand?	Comments	Re-use Opportunity?
Soil Conditioning	Raw water*	• No	• A percentage** is lost to evaporation.	• Runoff to be collected in construction attenuation ponds. Opportunity for recycling
Grouting	'Raw water'	• Consumptive	• This water becomes bound in the grout and is hence not available for recycling.	• No
Cleaning Grouting Plant	Recycled water*	• No	• A percentage** is lost to evaporation.	• Yes
Cooling and Cleaning Inside	'Good quality, no organic matter, requirement from TBM supplier'	• No	• Potentially up to 80% could be recycled through a treatment plant with the remaining 20% lost to a combination of evaporation and losses in the tunnel. • TBC with contractor – if consumptive use estimate is considered to be similar for these areas and construction methods.	• Yes
Cross Passages	'Raw water'	• Consumptive	• It is assumed that this water becomes bound in the grout and is hence not available for recycling (TBC)	• No
Workshop	'Recycled water'	• No	• A percentage** is lost to evaporation.	• Yes
Conveyor Cleaning	Recycled water*	• No	• A percentage** is lost to evaporation.	• Runoff to be collected in construction attenuation ponds. Opportunity for recycling
Notes: **More work required to investigate the percentage loss *Quality requirements are assumed and subject to change as more information becomes available for the works				

7.3 Opportunities: Site Management

***Table 8**:Opportunities – Site Management*

Activity	Opportunity	Comments
Staff and Labour	• Develop strategy applicable at all sites with facilities • Reduce per capita demand across the board to 90 l/c/d from 100 l/c/d, across the board • Additional reductions in potable water on 6 sites requiring >300 m³/month, for example using raw or recycled water for toilet flushing • Greywater reuse from wash basins	• Reduce per capita demand through water efficient fixtures and water use messaging • Potential to use RWH or recycled water, subject to WQ
Wheel Wash	• Develop strategy applicable at all sites, noting that Harvil Road >> other sites • Develop separate strategy for Harvil Road, if necessary • Utilise alternative sources of water e.g. recycled water or raw water from RWH (where RWH is feasible)	• Consistent requirement at all sites, except Addison Lee Compound, Euston Cavern and Shaft (no demand) and Harvil Road (475 m³/month) • Limited opportunity to reduce on flow rate of 1.5 m³/hr per wheel wash
Road Sweepers	• Develop strategy applicable at all sites • Utilise alternative sources of water e.g. recycled water or raw water from RWH (where RWH is feasible)	• Consistent requirement at all sites, bar two (Addison Lee Compound, Euston Cavern and Shaft) • Limited opportunity to reduce on flow rate of 0.5 L/sec
Dust Control	• Develop strategy focusing on 11 sites with demand of 1,500 m³/month or greater • Avoid using potable water for dust control: where feasible recycled water or RWH	• Water quality may be an issue • Suspended solids removal at the very least to avoid blockages
Miscellaneous (Contingency)	• Reduce contingency allowance by achieving efficiencies in above activities • Provide contingency from recycled or reused water, or from RWH	• Could be significant

7.4 Opportunities: Options in the Supply Chains

7.4.1 SCS will follow industry best practice by considering the water hierarchy to eliminate wastewater, improve efficiency and use alternative sources, reuse water and recycle water where construction methodology allows.

7.4.2 SCS will procure wheelwash systems which reuse water to reduce demand. Dry wheel washing systems such as the eco ramp is not likely to be viable for SCS due to space constraints on the sites.

7.4.3 Dust suppressions is one of the highest activities for water use that is not directly related to the choice of construction methodology. Polymer additives can be used to reduce water use on site.

Dust suppressant polymers such as Dust Ace was shown to reduce the frequency of dampening down requirements on the Tideway East project. Tramfloc dust suppressant polymer has additional benefits, and it is known to control slope erosion, improved road surfaces reduced watering and road grading, which will provide varied benefits for SCS if implemented.

7.4.4 Settlement and filtration for water reuse have become industry standard within construction in order to meet water discharge consent requirements. SCS we will look to use the weirs, silt busters and high flow pressure filter vessels to treat water before reuse on site for applications such as wheel wash, dust suppression and most importantly where the water quality meets construction requirements it can be used actively onsite.

7.4.5 SCS will seek to employ the lessons learnt from large infrastructure projects. Crossrail shared the following lessons through https://learninglegacy.crossrail.co.uk/documents/water-data/:

- Using Groundwater or Tunnel Ingress Water instead of Potable Water;
- Closed loop or semi closed loop drainage systems where water used is recycled;
- Using Recycled Groundwater in Bentonite Mixing, Slurry Dilution and Grout Mixing (C310); and
- Re-use of Tunnel Ingress Water in Grouting, Cleaning and Dust Suppression (C315).

7.5 Opportunities: By Location (Priority 1)

Table 9: *Opportunities – By location- Priority 1- Sites with the largest demand*

Locations	Opportunity	Comments
Atlas Road	• Potential for 80% reduction through reuse of tunnel cooling and cleaning water	• Tunnelling is largest demand, but site management strategy to be applied
Euston Scissor Box	• Treatment and reuse of piling water • Apply common site management strategy for all applicable site activities	• Piling is largest demand, but site management strategy to be applied
Euston Throat (incl. Granby Terrace Bridge satellite compound)	• Potential for RWH from site office – size TBC	• Piling is largest demand, but site management strategy to be applied
Granby Terrace Bridge	• Treatment and reuse of piling water	• Piling is largest demand, but site

Locations	Opportunity	Comments
	• Apply common site management strategy for all applicable site activities	management strategy to be applied
HRB Zone 5	• Treatment and reuse of piling water • Apply common site management strategy for all applicable site activities	• Piling is largest demand, but site management strategy to be applied
Victoria Road Crossover Box and Ancillary Shaft	• Potential for RWH from 11,000 m^2 of roof on mechanical stores, workshops, site offices and general stores. • Proposed water treatment unit for SW and wheel wash; 14 tanks (37 m^3) TBC	• Existing surface water attenuation tank – retain and use
West Ruislip Area	• Potential for 80% reduction through reuse of tunnel cooling and cleaning water • Treatment and reuse of piling water • The total water demand does not include dewatering. The reinjection of water back into the Chalk aquifer is being considered	• Tunnelling and piling are largest demands, but site management strategy to be applied

7.6 Opportunities: By Location (Priority 2)

***Table 10**: Opportunities –Priority 2*

Locations	Opportunity	Comments
Greenpark Way Vent Shaft	• Apply common site management strategy for all applicable site activities • The total water demand does not include dewatering. A grout curtain is being used and will reduce flows. • The reinjection of water back into the Chalk aquifer is being considered	• Limited roof area for RWH (2.8 x 7.6 m^2)
Harvil Road / Copthall Tunnel/ SPAs	• Treatment and reuse of piling water	
Mandeville Vent Shaft	• The total water demand does not include dewatering. A grout curtain is being used and will reduce flows.	
South Ruislip Vent Shaft	• RWH from 1,175 m^2 of roof on site offices and workshop. Potential space for RWH tank • The total water demand does not include dewatering. A d-wall is being used and will reduce flows.	• Potential uses include toilet flushing, wheel washing and workshop (10 m^3/d)
Westgate Vent Shaft	• RWH from approx. 300 m^2 roof area of office and accommodation. • Area of hardstanding, approx. 60 x 10 m which is assumed to drain to SW system could be collected, treated and reused.	• Potential to treat surface water from hardstanding area for wheel wash, dust suppression or road sweepers.

7.7 Opportunities: Rainwater Harvesting and Recycling on Site

7.7.1 The construction phase drainage has been designed to consider reuse of treated surface water where possible and the collection and use of rainwater. Rainfall over the site can be separated into: (i) preventing clean land runoff from entering the site by collecting the water along the site boundary and discharging the water downstream of the site; and (ii) dirty land runoff, roof runoff and runoff from hard surfaces which will be collected and routed to the on-site attenuation and treatment system

7.7.2 The procurement of site offices has included requirements for units which use grey water systems and rainwater harvesting for use in selected office facilities and where possible on site.

7.7.3 Mains inflow to the sites is used for processes including d-walling, piling, and for the TBM. Where practicable, mains water is replaced by treated water, although significant volumes of treated water (i.e.from the recycling of cross passage dewatering) are not available until the TBM is operational and so mains water will be required at the start of activities at the larger compounds. Further details regarding water use and reuse are provided below.

7.7.4 It will be important to collect rainfall runoff and capture wastewater from the bentonite plant and any soil treatment. The attenuation and treatment system provide untreated water storage and a further capacity for treated water storage, with the possibility of using the water for dust suppression, as presented in Table 15 below.

7.7.5 The attenuation ponds at Breakspear Road and Harvill Road (north) used to attenuate water inputs so that discharges do not exceed runoff rates for storms with a 1 in 5-year return period. To allow such attenuation, headroom needs to be allowed in the storage ponds to accommodate rainwater inflows. However, reducing stored water to provide headroom restricts the amount of water that can be used for dust suppression. Although there will be less of a need for dust suppression during periods of rainfall.

7.8 Reduction in Water Use

7.8.1 There are a number of options available to reduce the volume of water used. These can include selection of methods of construction that involve low water use, or selection of plant and machinery that is water efficient. These can include direct effects on the volume of water used, in addition to effects on water quality, which if reduced can mean that more good quality water is available for use. Those techniques used at Sectors S1 and S2 are summarised in Table 15.

***Table 11**: Opportunities –Reduction in water use*

Activity	Selected technique	Benefit	Significance*
Seeding of stockpiles where relevant	Any stockpiles that are to be left for more than 6 months will be seeded with grass to prevent dust generation	Negate any requirement for water sprays to prevent dust generation	Low-small amount of water in comparison to other uses
Tree planting during landscaping	Do not plant during dry summer months or programme once heavy water use activities are complete Use grey water	Reduction in water use	Low – small volume of water in comparison to other uses
Dust suppression along roads	Use of grey water	Reduction in potable water use	Moderate – due to saving in use of good quality (potable) water, but dust suppression

			will still use a large volume of water.
Site welfare facilities	Selection of water efficient facilities	Reduction in potable water use	Low – small volume savings in comparison to other uses
Recycling of water produced during the dewatering of cross passages	Will be used during tunnelling in the west section	Reduce the pressure on water demand and reduction in potable water use	Moderate– will not reduce total volume required but will reduce path supply requirements.
Reduction of on-site batching (concrete delivery from local suppliers)	Will be used for diaphragm walling, piling and in-situ concrete in the west section.	Reduction in water use	Moderate – assuming supplier capacity (and hence water use) will not be increased as a result.

Appendix 1: **SCS Maps**

Figure1. S1-East

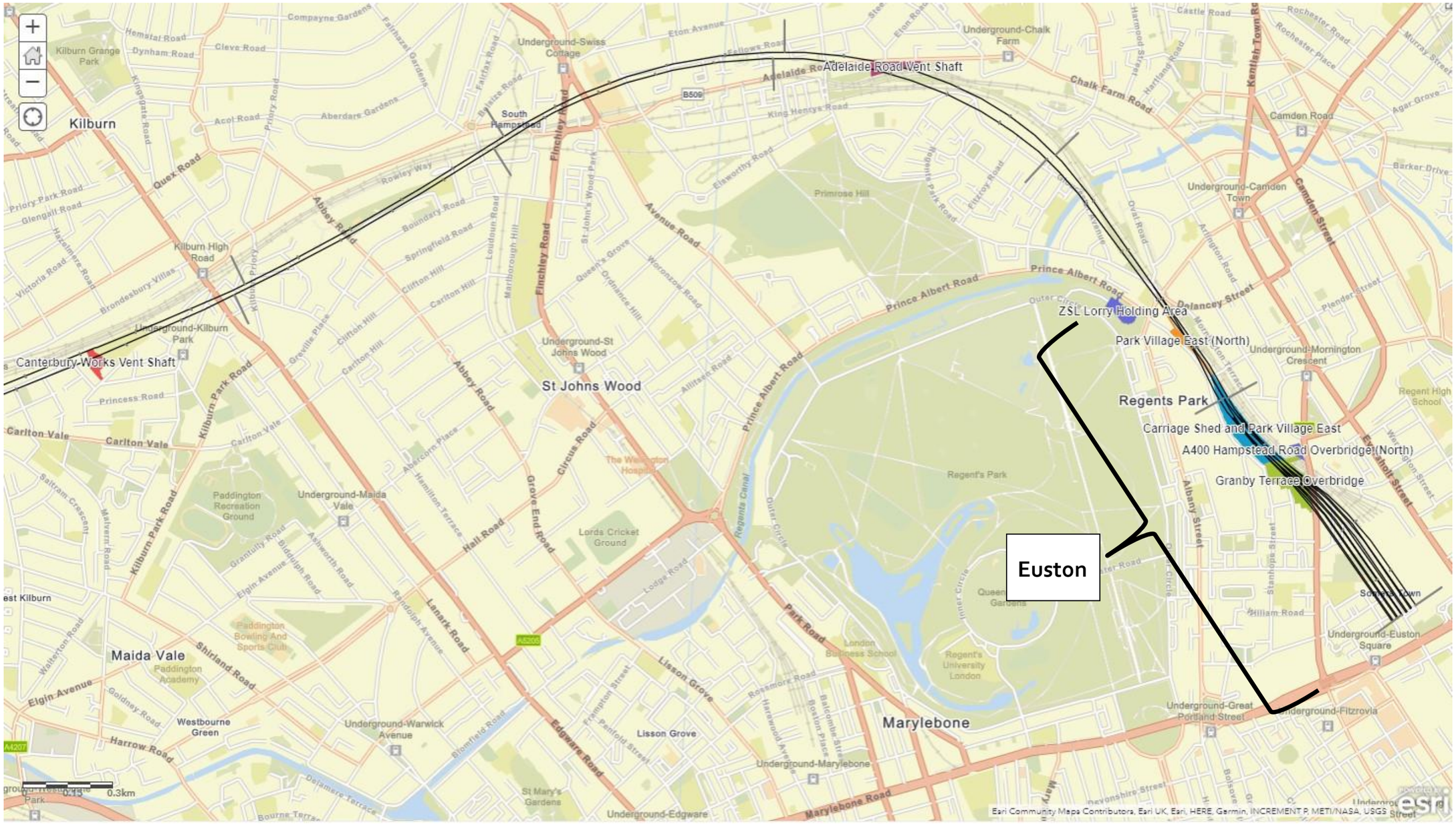


Figure2. S1-and S2 Central

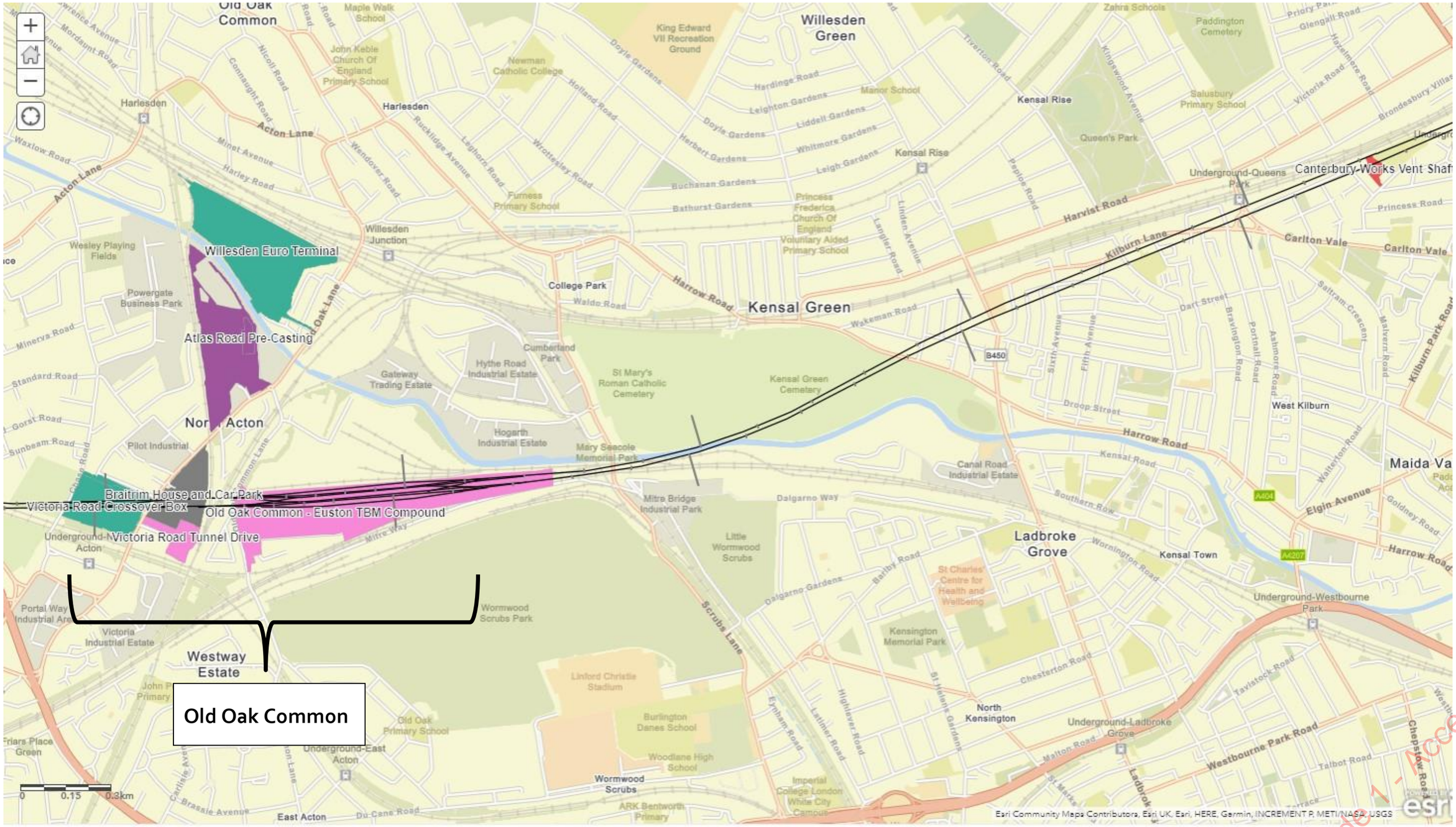
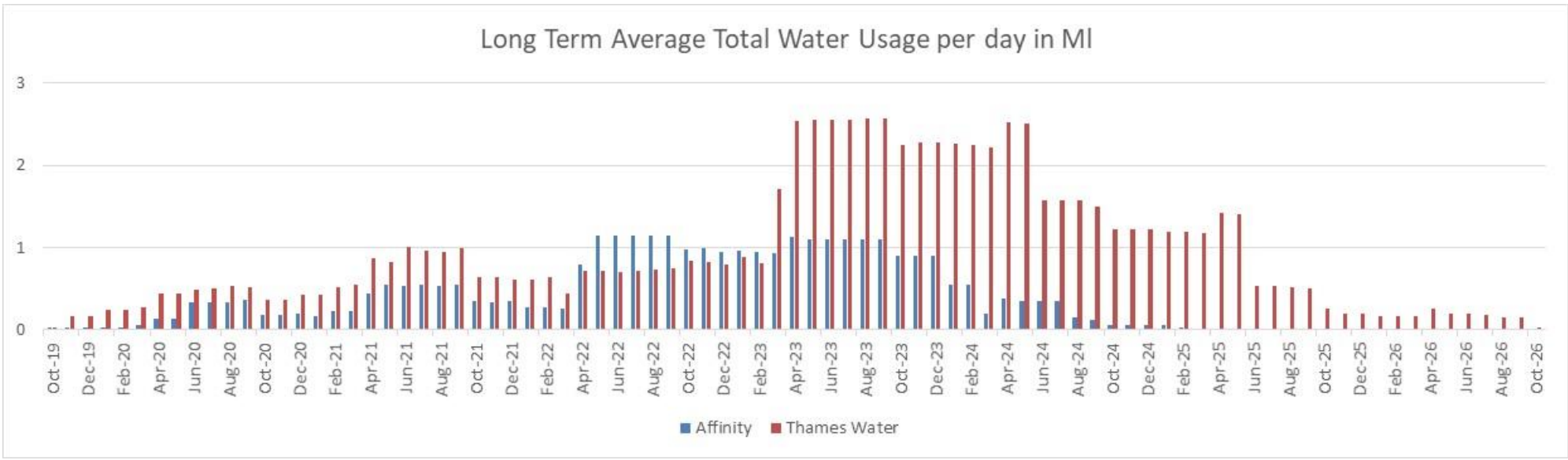


Figure3. S2 West

Appendix 2: Construction Phase Water Demand 03.05.21

See Spreadsheet 1MC03-SCJ-EV-PLN-S001-000036 C04 Appendix 2

Figure 4. Long term average and peak water demand for Affinity Water and Thames Water areas.



Appendix 3: **Rivers**

River Brent

Image obtained from Bing maps under licence 'free to share and use commercially'.

Yeading Brook

Image obtained from Bing maps under licence 'free to share and use commercially'

Ickenham Stream

Image original taken on site walkover for HS2.

Northward-flowing part of the Ickenham Stream in West Ruislip Golf Course (within the Pinn catchment)

Southward-flowing part of the Ickenham Stream at The Greenway (within the Crane catchment).

River Pinn

Image original taken on site walkover for HS2. Location: south of Chiltern Main Line looking north.

Newyears Green Bourne

Image original taken on site walkover for HS2. Location: Harvill Road bridge

River Colne

Image obtained from Bing maps under licence 'free to share and use commercially'

Appendix 4: WFD Assessment

Table 1 and Table 2 summarise the assessment of the 'water supply' activity against the four key WFD objectives as outlined in HS2 Technical Standard – Water Framework Directive (WFD) Compliance Process (document number: HS2-HS2-EV-STD-000-000012):

- Objective 1: The Proposed Scheme will not cause deterioration in any element of water body classification.
- Objective 2: The Proposed Scheme will not prevent the WFD status objectives from being reached within the water body or other connected water bodies.
- Objective 3: The Proposed Scheme will not negatively impact critical or sensitive habitats within the water body.
- Objective 4: The Proposed Scheme will contribute to the delivery of the relevant RBMP which the assessed water bodies are situated within.

Table 1: WFD compliance for water supply from each waterbody assessed against the four key objectives

Table 1 assesses abstraction from each potential water supply source (and associated waterbody) and the impacts this abstraction could have on its associated waterbodies WFD status and ability to achieve/maintain Good status.

Table 1: WFD compliance for water supply from each waterbody assessed against the four key objectives

Abstraction from (potential water supply source):	Quantitative (groundwater body) or Ecological (surface waterbody)					Chemical (groundwater and surface water body)				
	Current WFD Status	Objective 1	Objective 2	Objective 3	Objective 4	Current WFD Status	Objective 1	Objective 2	Objective 3	Objective 4
Groundwater within the Secondary A Aquifer (Radlett Tertiaries groundwater body: GB40602G602800)	Poor					Good				
Groundwater within the Principal Aquifer (Mid-Chiltern Chalk groundwater body: GB40601G601200)	Poor					Poor				

Table 1: WFD compliance for water supply from each waterbody assessed against the four key objectives										
Abstraction from (potential water supply source):	**Quantitative (groundwater body) or Ecological (surface waterbody)**					**Chemical (groundwater and surface water body)**				
	Current WFD Status	**Objective 1**	**Objective 2**	**Objective 3**	**Objective 4**	**Current WFD Status**	**Objective 1**	**Objective 2**	**Objective 3**	**Objective 4**
Surface water from the River Brent (Lower Brent surface water waterbody: GB106039023590)	Moderate					Good				
Surface Water from Yeading Brook East and/or West Arms (Yeading Brook surface water body: GB106039023051)	Moderate					Good				
Surface water from the River Pinn (Pinn surface water waterbody: GB106039023070)	Moderate					Good				

Table 1: WFD compliance for water supply from each waterbody assessed against the four key objectives										
Abstraction from (potential water supply source):	**Quantitative (groundwater body) or Ecological (surface waterbody)**					**Chemical (groundwater and surface water body)**				
	Current WFD Status	**Objective 1**	**Objective 2**	**Objective 3**	**Objective 4**	**Current WFD Status**	**Objective 1**	**Objective 2**	**Objective 3**	**Objective 4**
Surface water from the River Colne and lakes (Colne Confluence with Chess to River Thames water waterbody: GB106039023090)	Moderate					Good				

Table 2: WFD compliance for water supply from the preferred water source (mains water) for each waterbody assessed against the four key objectives

Table 2 assesses the WFD compliance on the waterbodies within East, Central and West areas if abstraction and water supply were to be taken from the preferred water supply source, mains water.

Table 2: WFD compliance for water supply from the preferred water source (mains water) for each waterbody assessed against the four key objectives										
Waterbodies	Quantitative (groundwater body) or Ecological (surface waterbody)					Chemical (groundwater and surface water body)				
	Current WFD Status	Objective 1	Objective 2	Objective 3	Objective 4	Current WFD Status	Objective 1	Objective 2	Objective 3	Objective 4
Radlett Tertiaries groundwater body: GB40602G602800	Poor					Good				
Mid-Chiltern Chalk groundwater body: GB40601G601200 (confined beneath London Basin)	Poor					Poor				
Lower Brent surface water waterbody: GB106039023590	Moderate					Good				
Yeading Brook surface water body: GB106039023051	Moderate					Good				
Pinn surface water waterbody: GB106039023070	Moderate					Good				
Colne Confluence with Chess to River Thames water waterbody: GB106039023090	Moderate					Good				

	Does not require assessment.
	Low risk of non-compliance with WFD
	Medium risk of non-compliance with WFD
	High risk of non-compliance with WFD