HIGH SPEED RAIL (LONDON - WEST MIDLANDS)

Supplementary Environmental Statement 2 and Additional Provision 3 Environmental Statement

Volume 5 | Technical appendices

Water resources

WR-002-001 and WR-003-001

September 2015

SES2 and AP3 ES 3.5.1.7

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Department for Transport

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This table shows the topics covered by the technical appendices in this volume, and the reference codes for them.

CFA name and number	Topic	Code
CFA1, Euston Station and Approach	Water resources and flood risk assessment	WR-002-001
		WR-003-001

HIGH SPEED RAIL (LONDON - WEST MIDLANDS)

Supplementary Environmental Statement 2 and Additional Provision 3 Environmental Statement

Volume 5 | Technical appendices
Water resources
WR-002-001

Environmental topic:	Water resources and flood risk assessment	WR
Appendix name:	Water resources assessment	002
Community forum area:	Euston – Station and Approach	001

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1 Introduction

1.1 Structure of the water resources and flood risk assessment appendices

1.1.1 This appendix provides an update to Appendix WR-002-001 water resources assessment from the main Environmental Statement (ES) (Volume 5, WR-002-001). This update replaces Appendix WR-002-001 water resources assessment from the main ES.

1.1.2 Two appendices for community forum area 1 (CFA1) Euston - Station and Approach are provided; these are:

- a water resources assessment (i.e. this appendix); and
- a flood risk assessment (Supplementary Environmental Statement 2 (SES2) and Additional Provisions 3 Environmental Statement (AP3 ES) Appendix WR-003-001).

1.1.3 Maps referred to throughout the water resources and flood risk assessment appendices are contained in the Volume 5 Map Book, Water Resources and Flood Risk Assessment, within this SES2 and AP3 ES or the Volume 5 Map Book, Water Resources and Flood Risk Assessment within the Main ES.

1.2 Study area

1.2.1 CFA1 covers approximately 1.3km of the route from Euston station north of the Euston Road to Park Street tunnels, where Parkway crosses the existing railway. CFA1 is entirely within the London Borough of Camden (LBC).

1.2.2 The spatial scope of the assessment was based upon the identification of surface water and groundwater features within 1km of the centre line of the route, except where there is clearly no hydraulic connectivity. For surface water features in urban areas, the extent was reduced to 500m. Outside of these distances it is unlikely that direct impacts upon the water environment will be attributable to the revised scheme. Where works extend more than 200m from the centre line, for example at stations and depots, professional judgement has been used in selecting the appropriate limit to the extension in spatial scope required. For the purposes of this assessment this spatial scope is defined as the study area.

1.2.3 The main environmental features of relevance to water resources within the study area comprise:

- Grand Union Canal (GUC) (the Regent's Canal);
- the Chalk Principal aquifer;
- the Lambeth Group and Thanet Sand Formation Secondary A aquifers; and
- the Lynch Hill Gravel Member Secondary A aquifer.

1.2.4 Key environmental issues relating to water resources include:

- the potential impacts to surface water quality; and
- the potential impacts to groundwater quality.

1.2.5 Where a residual impact or mitigation for water resources has a consequent effect on ecology, this is discussed further in SES2 and AP3 ES, Volume 2, CFA1, Section 7.

2 Baseline data

2.1 General

2.1.1 The following sub-sections provide a current description of water resources within the study area including surface water and groundwater features.

2.1.2 All water bodies in this area fall within the London sub-catchment of the Thames River Basin District (RBD) as defined under the Water Framework Directive[1] (WFD) and are covered by the River Basin Management Plan[2] (RBMP).

2.2 Surface water features

2.2.1 All surface water features within 500m of the revised scheme are presented in Table 1.

2.2.2 The current surface water baseline is shown on map WR-01-001 (SES2 and AP3 ES: Volume 5 Map Book, Water Resources and Flood Risk Assessment).

2.2.3 Water features with codes listed in Table 1 are shown on Map WR-01-001 (SES2 and AP3 ES: Volume 5 Map Book, Water Resources and Flood Risk Assessment).

2.2.4 The map reference is in one of two forms. If the feature has a specific reference number then this is provided (e.g. a surface water crossing (SWC)will be referenced as SWC-CFA01-01). If the feature has no specific reference its location on a specific map is provided e.g. WR-01-001, D6,where D6 is a grid reference using the map specific grid.

2.2.5 The surface water features are based on the Environment Agency's detailed river network (DRN) with the addition of water bodies noted on the Ordnance Survey's (OS) 'OS VectorMapDistrict'.

1 Water Framework Directive - Directive 200/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, Strasbourg, European Parliament and European Council.
2 Environment Agency (2009) River Basin Management Plan, Thames River Basin District.

Table 1 : Surface water features within 500m of the revised scheme

Water feature	Location description (SES2 and AP3 ES: Volume 5 Map Book, Water resources and flood risk assessment, map reference)	Watercourse classification[3]	WFD water body and current overall status	WFD status objective (by 2027 as in RBMP)	Receptor value[4]	Q95[5] (m^3/s)	Catchment area at crossing (km^2)	Notes
GUC (the Regent's Canal)	The Regent's Canal is located north of Regent's Park and close to the boundary of this study area. See Map WR-01-001 (SWC-CFA03-01)	Artificial	GUC, Uxbridge to Hanwell Locks, Slough Arm, Paddington Arm. GB70610078 Moderate	Good potential	High	Not applicable	Not applicable	Will not be crossed by the revised scheme in the study area.
Ponds and lakes	Located within Regent's Park and London Zoo. See Map WR-01-001 E7 and E8	Not applicable	Not assessed by the Environment Agency	Not assessed by the Environment Agency	Moderate	Not applicable	Not applicable	Isolated ponds not impacted by the revised scheme.

3 Water-feature classifications: Section 113 of the Water Resources Act 1991 defines a Main river as a watercourse that is shown as such on a Main river map. Section 72 of the Land Drainage Act 1991 defines an Ordinary watercourse as 'a watercourse that is not part of a Main river'. Section 221 of the Water Resources Act 1991 defines a watercourse as including 'all rivers and streams, ditches, drains, cuts, culverts, dikes, sluices, sewers (other than public sewers) and passages through which water flows'. Main rivers are larger rivers and streams designated by the Department for Environment, Food and Rural Affairs (Defra) on the Main river map and are regulated by the Environment Agency.
4 For examples of receptor value, see Table 43 in the Scope and Methodology Report (SMR) Addendum, Volume 5: Appendix CT-001-000/2 of the main ES.
5 Q95 is the flow which is exceeded for 95% of the time (i.e. it is a low flow and the river will only have flows less than this for 5% of the time).

2.2.6 No current surface water abstractions or discharge consents have been identified in the study area[6]. There is the potential for unlicensed abstractions to exist, as a licence is not required for abstraction volumes below 20m³ per day.

2.3 Groundwater features

2.3.1 A summary of the geological units present in the study area, along with their hydrogeological characteristics, is presented in Volume 2, CFA1, Section 8.

2.3.2 Map WR-02-001 (Main ES: Volume 5 Map Book, Water Resources and Flood Risk Assessment) illustrates the spatial distribution of the uppermost superficial and bedrock formations within the study area.

2.3.3 Superficial deposits comprising the Langley Silt Member and the Lynch Hill Gravel Member of the Maidenhead Formation are present in the southern part of the study area.

2.3.4 The Lynch Hill Gravel is classified as a Secondary A aquifer, but is considered to be of low value due to its limited extent and potentially poor water quality. The Langley Silt Member is classified as unproductive strata.

2.3.5 The London Clay Formation underlies the whole of the study area. It is a blue-grey clay that weathers to a brown colour in its upper part.

2.3.6 The geological succession beneath the London Clay Formation comprises, in turn the:

- Harwich Formation, a thin sandy deposit which may be present in some locations;
- Lambeth Group, (also termed the Upnor, Woolwich and Reading Formations) which comprises mixed sands and clays, and pebble deposits in some locations;
- Thanet Sand Formation, a greenish or brownish grey, silty, fine-grained sand; and
- White Chalk Subgroup, a succession of soft white limestones.

2.3.7 A schematic cross-section along the line of the route in this area showing geological strata, groundwater levels (where known) and the location of the revised scheme is presented in Figure 1. Figure 2 presents the groundwater elevation contours in the Chalk aquifer for this study area and adjacent areas using data from January 2015[7]. It should be noted that the Chalk aquifer is confined so the apparent water level is a representation of the water level that would be observed if the Chalk was penetrated by a borehole. It is not indicative of groundwater being present in the London Clay. Groundwater flow in the study area is towards the south/ south west as shown by the groundwater elevation contours in Figure 2.

6 Surface water abstractions for public supply are not included.
7 Environment Agency (2015), Management of the London Basin Chalk Aquifer Status Report 2015.

Figure 1 : Schematic cross-section of the geology and route in the study area

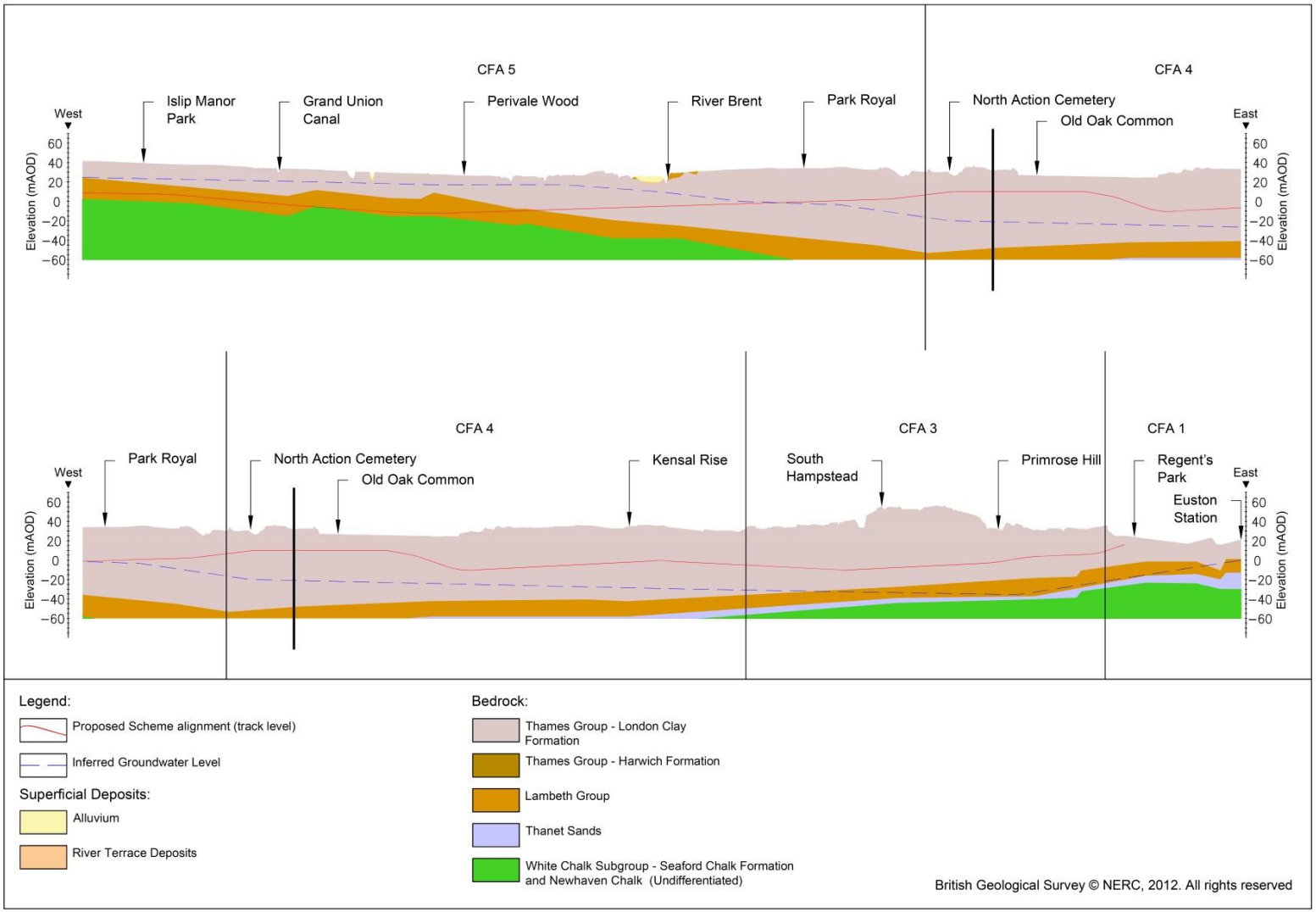
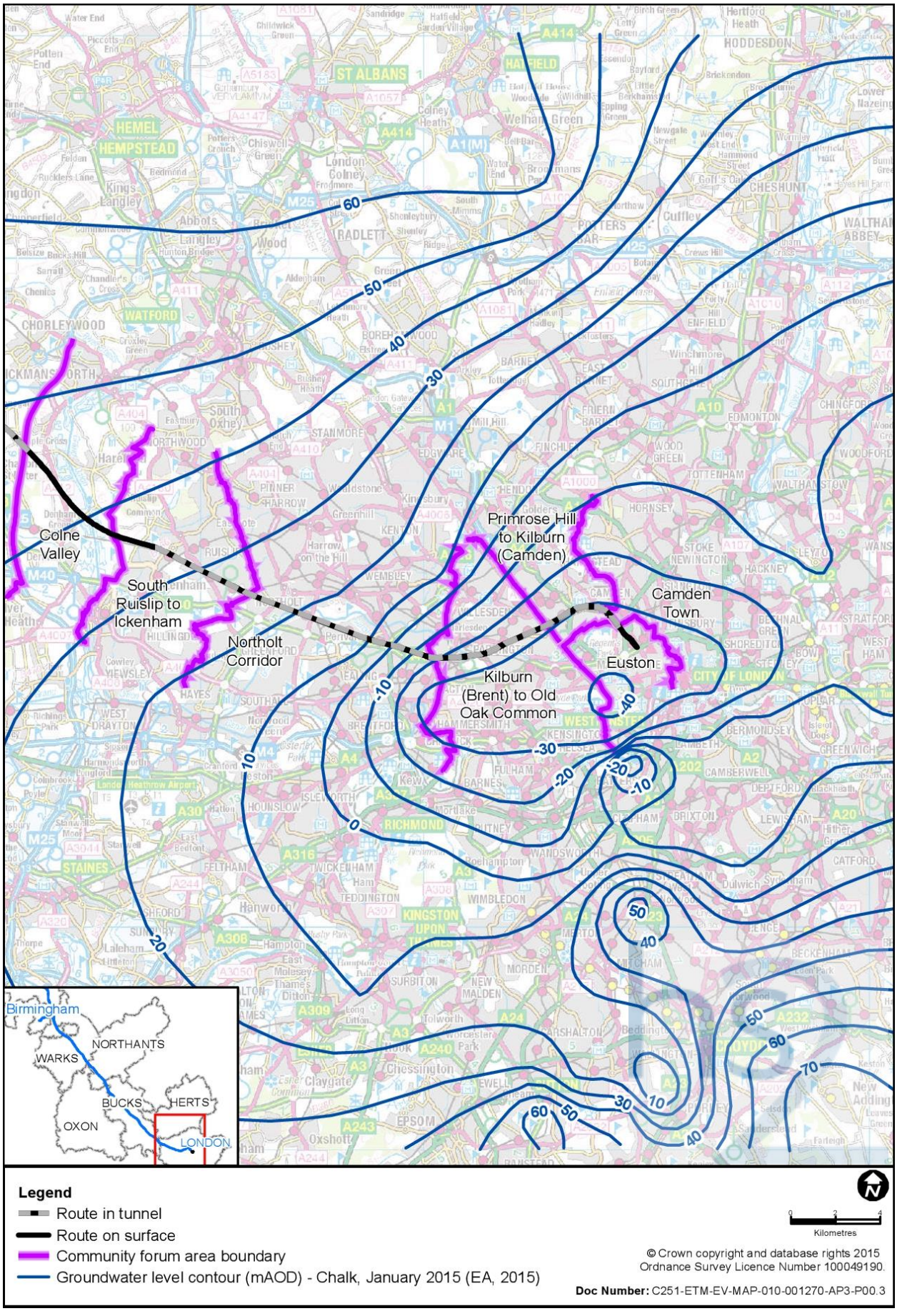


Figure 2 : Groundwater elevation contours for this study area and the surrounding area



2.3.8 Table 2 summarises licensed groundwater abstractions and groundwater source protection zones (SPZ) located within 1km of the revised scheme. There is the potential for unlicensed abstractions to exist, as a licence is not required for abstraction volumes below 20m³ per day.

Table 2 : Licensed groundwater abstractions

Licence identifier (map reference number and Environment Agency reference)	Distance and direction from revised scheme (m)	Abstraction horizon	Max annual abstraction quantity (m^3)	Max daily abstraction quantity (m^3/d)	Purpose	Number of boreholes
Public water supplies (PWS)						
SPZ located north of Regent's Park as shown on map WR-02-001, D6 (Licence number confidential)	SPZ1 will be 850m west of the revised scheme and SPZ2 will be 800m west of the revised scheme within the study area. The source is located in the Primrose Hill to Kilburn (Camden) CFA3	Chalk	631,000m^3	2,000m^3	PWS	1
Private abstractions						
GW92 (TH/039/0039/001)	380m east	Chalk	327,600m^3	1,260m^3	Heat pump	1
GW88 and GW89 (TH/039/0039/031)	750m south-east	Chalk	203,407m^3	558m^3	Heat pump	2
Gw85 (TH/039/0039/010)	880m south-west	Chalk	50,000m^3	400m^3	Heat pump	1
GW78 (TH/039/0039/022)	980m south-west	Assumed Chalk	118,260m^3	324m^3	Heat pump	1

2.3.9 Table 3 summarises groundwater discharge consents for discharge direct to groundwater or via land, within 1km of the revised scheme.

Table 3 : Discharge consents to groundwater

Reference number	Permit identifier	Distance and direction from revised scheme (m)	Discharge type	Receiving water body
CFA1WD4	Npswqd005471	310m east	Trade discharges - cooling water	Groundwater via re-injection borehole
CFA1WD6	Npswqd007488	870m south-west	Trade discharges - cooling water	Groundwater
CFA1WD9	Eprgp3123kg	720m south	Trade discharges - cooling water	Groundwater

Reference number	Permit identifier	Distance and direction from revised scheme (m)	Discharge type	Receiving water body
CFA1WD11	Eprgp3123kg	720m south	Trade discharges - cooling water	Groundwater
CFA1WD7	Npswd009408	975m west	Trade discharges - cooling water	Groundwater

2.4 Surface water/groundwater interaction

2.4.1 No surface water/groundwater interactions have been identified within 500m of the revised scheme in the study area.

2.5 Water dependent habitats

2.5.1 No water dependent habitats have been identified in the study area.

3 Design changes within the existing limits of the Bill

3.1.1 The key elements of the revised scheme which are relevant to this topic, include deep piles for the high speed station foundations designed to also provide support to potential future over station development (OSD). Although detailed design is not yet complete, it is assumed that piles for OSD support and the underground station development may extend down to 40m Ordnance Datum (OD) into the Chalk underlying the high speed station.

3.1.2 The revised scheme will include a basement beneath the high speed platforms (which are 4m lower than the conventional platforms) which will be constructed to provide servicing and logistics for the high speed station and trains. This basement will be constructed entirely within the London Clay, however some tension piles may extend into the Chalk.

3.1.3 The provision of platforms for high speed trains at Euston will require widening of the existing railway retained cutting, which is located to the north of Euston station (all constructed in the London Clay). The high speed railway will enter the proposed twin bore tunnel at the Euston portal about 100m south of Parkway. The high speed tracks will enter the tunnel at a deeper level than the existing railway. This will require the reconstruction of retaining walls on the western side of the existing cutting. The tunnel portal will extend into the Lambeth Group (Upnor Formation), and the retaining walls will be constructed within the London Clay.

3.1.4 The revised scheme also includes for the reinstatement of the existing railway dive under called Line X, to connect it back to the western approach track. This will be constructed above the HS2 dive under. The Line X dive under will be constructed in the London Clay, while piles for the HS2 dive under will extend into the Lambeth Group (lowest elevation -10m OD).

3.1.5 In addition, improvements will be made to Euston underground station. An additional ticket hall will be constructed at a lower level than the existing ticket hall with

connections to the high speed platforms via the London Underground (LU) circulation area. The deepest excavation for piles, escalator and lift shafts for the LU station and access to existing underground lines will generally be limited to the Lambeth Group, but some structures, such as the new LU box, may require tension piles that extend into the Chalk.

4 Site specific surface water assessments

4.1 Summary of assessment

4.1.1 Table 4 summarises new or different significant potential impacts and effects to surface water, from the revised scheme in the study area.

4.1.2 Table 4 only includes water features which could potentially be impacted by the revised scheme. Features such as isolated ponds and drains which will lie outside the construction footprint and area of impact of the revised scheme are not included. The table contains details of the assessment from the main ES for comparison so that changes can be readily identified.

Table 4 : Summary of potential impacts to surface water

	Surface water feature / receptor	Value of surface water feature	Design element	Magnitude of impact (no mitigation)	Potential impact to water resource	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Main ES	GUC (the Regent's Canal)	High	Demolition of buildings and bridges. Main construction compounds, satellite construction compounds, utility construction zone and temporary construction access.	Negligible impact Neutral effect (Not significant)	No works directly adjacent to the Regent's Canal so limited potential for surface water flow and quality effects.	Appropriate mitigation in the draft code of construction practice (CoCP), for polluting materials, management of earthworks and rate of surface runoff.	Negligible Neutral (Not significant)	None required	None	Not applicable
SES2	GUC (the Regent's Canal)	High	Demolition of buildings and bridges. Main construction compounds, satellite construction compounds, utility construction zone and temporary construction access.	Negligible impact Neutral effect (Not significant)	No works directly adjacent to the Regent's Canal so limited potential for surface water flow and quality effects.	Appropriate mitigation in the draft CoCP, for polluting materials, management of earthworks and rate of surface runoff.	Negligible impact Neutral effect (Not significant)	None required	None	Not applicable

	Surface water feature / receptor	Value of surface water feature	Design element	Magnitude of impact (no mitigation)	Potential impact to water resource	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Main ES	Ponds and lakes located within Regent's Park and London Zoo CFA01-P01	Moderate	Construction activities at Euston Station and Euston portal.	Negligible impact Neutral effect (Not significant)	Features are not hydraulically connected to areas where construction will take place so no potential for impacts.	None required as no hydraulic connection and no impact.	Negligible impact Neutral effect (Not significant)	None	None	Not applicable
SES2	Ponds and lakes located within Regent's Park and London Zoo CFA01-P01	Moderate	Construction activities at Euston Station and Euston portal.	Negligible impact Neutral effect (Not significant)	Features are not hydraulically connected to areas where construction will take place so no potential for impacts.	None required as no hydraulic connection and no impact.	Negligible impact Neutral effect (Not significant)	None	None	Not applicable

5 Site specific groundwater assessments

5.1 Summary of assessment

5.1.1 Table 5 summarises the potential impacts to hydrogeology (groundwater) and abstractions.

Table 5 : Summary of potential impacts to groundwater

	Groundwater receptor (and value)	Design element	Magnitude of impact (no mitigation)	Potential impact to groundwater	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
Hydrogeology (groundwater)									
Main ES	Lambeth Group Secondary A aquifer Thanet Sand Formation Secondary A aquifer White Chalk Subgroup Principal aquifer (High - assessed against highest value receptor - the Chalk Principal aquifer)	HS2 Station basement and LU new ticket hall	Negligible impact Neutral effect (Not significant)	The basement will extend to approximately 8m above Ordnance Datum (AOD), which is in the London Clay Formation. The top of the Lambeth Group is at approximately om AOD at this point. Local depressurisation of low to medium permeability strata may be required but the Lambeth and Chalk aquifers will not be pumped. Groundwater levels for the bedrock aquifers are between -30 and -40m AOD. No groundwater should be penetrated. Consequently construction will have a negligible impact on groundwater flow and quality.	None	Negligible impact Neutral effect (Not significant)	None	None	Not applicable
SES2	Lambeth Group Secondary A aquifer Thanet Sand Formation Secondary A aquifer White Chalk Subgroup	HS2 Station basement and LU new ticket hall	Negligible impact Neutral effect	The new LU ticket hall and HS2 station basement will extend to approximately 8m above Ordnance Datum (AOD), which is in the London Clay Formation. Basement structures will have under slab drainage to passively drain the underlying strata and	None	Negligible impact Neutral effect (Not	None	None	Not appplicable

	Groundwater receptor (and value)	Design element	Magnitude of impact (no mitigation)	Potential impact to groundwater	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
	Principal aquifer (High - assessed against highest value receptor - the Chalk Principal aquifer)		(Not significant)	prevent buoyant forces on the box. The top of the Lambeth Group is at approximately 2.5m AOD in this area. Local depressurisation of low to medium permeability strata may occur from the passive drainage but the Thanet Sand and Chalk aquifers will not be pumped or drained. Groundwater levels for the Chalk aquifer are between -30 and -40m AOD, and it is therefore unlikely that groundwater will be penetrated. Consequently construction will have a negligible impact on groundwater flow and quality.		significant)			
SES2	Lambeth Group Secondary A aquifer (Moderate)	LU platform tunnels and connecting escalators and passages.	Negligible impact Neutral effect (Not significant)	Active drainage measures including pumping may be necessary to dewater the Lambeth Group for tunnel construction below +3mAOD to provide stable excavation conditions. The platform tunnels, connecting escalators and passages will have a minimum finished floor level of -7m AOD, with the base of the tunnels likely to extend to approximately -11m AOD. The escalator barrels and machine rooms will extend below the floor level, but detailed design information is not available at the time of writing. For this assessment, a worst case is assumed that they will extend to the base of the Lambeth Group (maximum depth -15mAOD). In addition permeation grouting may be used to support tunnel construction in coarse	None required	Negligible impact Neutral effect (Not significant)	None	None	Not applicable

	Groundwater receptor (and value)	Design element	Magnitude of impact (no mitigation)	Potential impact to groundwater	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
				Lambeth Group strata. Local depressurisation of the low to medium permeability strata in the Lambeth Group will occur from the dewatering but the Thanet Sand and Chalk aquifers will not be pumped or drained. Depressurisation of the Lambeth group will be highly localised and will have a negligible impact on groundwater flow and quality.					
Main ES	Lambeth Group Secondary A aquifer Thanet Sand Formation Secondary A aquifer Chalk Principal aquifer (High - assessed against highest value receptor - the Chalk Principal aquifer)	Tension piles Toe of basement walls	Negligible impact Neutral effect (Not significant)	Construction of the piling for basement walls will be to approximately -18m AOD. The construction will be within the Lambeth Group and Thanet Sand Formation which could result in the introduction of contaminants into the aquifer from in situ concrete and cement grouts, their associated additives, and fluids in construction equipment. The creation of rapid pathways from overlying strata through the London Clay Formation could result in poorer quality water being introduced to the Lambeth Group and Thanet Sand Formation aquifers. However, the London Clay Formation will tend to self-seal around some piles so the method of piling will be important to determine mitigation requirements. The groundwater level of the underlying	Application of the mitigation measures set out in the draft CoCP will control the materials used in the aquifer and prevent the creation of pathways through the London Clay Formation.	Negligible impact Neutral effect (Not significant)	None	None	Construction (permanent)

	Groundwater receptor (and value)	Design element	Magnitude of impact (no mitigation)	Potential impact to groundwater	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
				aquifers is between -30 and -40m AOD and as such, no groundwater will be intercepted.					
SES2	Lambeth Group Secondary A aquifer Thanet Sand Formation Secondary A aquifer Chalk Principal aquifer (High - assessed against highest value receptor - the Chalk Principal aquifer)	Tension piles LU new ticket halls Piles for support of the OSD and basement Piles for Diveunder track	Moderate impact Moderate / Large effect (Significant)	The piles for the HS2 diveunder will extend to -10m AOD and therefore extend into the Lambeth Group. The designs for the tension piles beneath the ticket hall slabs, HS platform basement and the piles for the OSD support are not yet finalised, but may need to extend into the Chalk. This assessment assumes that the maximum pile depth is -40m AOD which means they will extend into the chalk aquifer. The construction through the Lambeth Group, Thanet Sand Formation and Chalk could result in the introduction of contaminants into the aquifer from in situ concrete and cement grouts, their associated additives, and fluids in construction equipment. The creation of rapid pathways from overlying strata through the London Clay Formation could result in poorer quality water being introduced to the Lambeth Group, Thanet Sand Formation and Chalk aquifers. However, the London Clay Formation will tend to self-seal around some piles so the method of piling will be important to determine mitigation	The piling method will be selected to avoid creating hydraulic pathways, such as cracks and cavities between the construction and the natural rock, and also to avoid creating pathways between the aquifer and overlying strata. Application of the guidance on protection of aquifers (EA, 2002)	Negligible impact Neutral effect (Not significant)	None	None	Construction (permanent)

	Groundwater receptor (and value)	Design element	Magnitude of impact (no mitigation)	Potential impact to groundwater	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
				requirements.	and the mitigation measures set out in the draft CoCP will control the materials used in the aquifer and prevent the creation of pathways through the London Clay Formation.				
Main ES	Chalk Principal aquifer (high)	Tension piles LU new ticket halls Piles for support of the OSD areas	Not Applicable	Impacts on these aquifers not applicable to main ES design	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
SES2	Chalk Principal aquifer (High)	Tension piles LU new ticket halls Piles for support of the OSD areas	Negligible impact Neutral effect (Not Significant)	The designs for the tension piles beneath the ticket hall slabs, HS platform basement and the piles for the OSD support are not yet finalised. For this assessment a worst scenario, that piles will extend into the Chalk, has been assumed. A maximum pile depth of -40m AOD is assumed. The groundwater level in the Chalk aquifer is between -30 and -40m AOD and as such, groundwater may be intercepted.	None required	Negligible impact Neutral effect (Not significant)	None	None	Construction (permanent)

	Groundwater receptor (and value)	Design element	Magnitude of impact (no mitigation)	Potential impact to groundwater	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
				Installation of piles could cause groundwater mounding due to groundwater flow being constricted between the pile groups beneath the station. See detailed assessment Section 5.2 of this report for further details, which demonstrates that there will be negligible mounding.					
Main ES	Lambeth Group Secondary A aquifer Thanet Sand Formation Secondary A aquifer (Moderate)	Barrette retaining walls Permanent Ground anchors for Line X reinstatement Barrette Wall	Not Applicable	Impacts on these aquifers not applicable to main ES design.	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
SES2	Lambeth Group Secondary A aquifer Thanet Sand Formation Secondary A aquifer (Moderate)	Barrette retaining walls Permanent Ground anchors for Line X reinstatement Barrette Wall	Negligible impact Neutral effect (Not significant)	Construction of the barrette retaining walls may extend down to around -15m AOD. The construction will require the use of support fluid and extend down into the Thanet Sand Formation. Permanent ground anchors will also be installed particularly along the west side barrette wall behind Park Village East. Temporary ground anchors may also be installed particularly along the new east side barrette wall behind the existing gravity retaining walls in the station approach. All the ground anchors will only extend into	Application of the guidance on protection of aquifers (EA, 2002) and the mitigation measures set out in the draft CoCP will control the	Negligible impact Neutral effect (Not significant)	None	None	Not applicable

	Groundwater receptor (and value)	Design element	Magnitude of impact (no mitigation)	Potential impact to groundwater	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
				the London Clay and therefore there is no pathway for impact on groundwater. Construction within the Lambeth Group and the Thanet Sand Formation could result in the introduction of contaminants into the aquifer from support fluids, in situ concrete and cement grouts, their associated additives, and fluids in construction equipment. The groundwater level of the underlying Chalk is between -30 and -40m AOD and as such, it is likely that no groundwater will be intercepted. Consequently construction will have a negligible impact on groundwater flow and quality.	materials used in the aquifer and prevent the creation of pathways through the London Clay Formation.				
Main ES	Lambeth Group Secondary A aquifer Thanet Sand Formation Secondary A aquifer (Moderate)	Barrette retaining walls	Not Applicable	Impacts on these aquifers not applicable to main ES design.	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
SES2	Lambeth Group Secondary A aquifer Thanet Sand Formation Secondary A aquifer (Moderate)	Barrette retaining walls	Negligible impact Neutral effect (Not significant)	Construction of the barrette retaining walls may extend down to around -15m AOD and may extend into the Thanet Sand. Passive drainage will be installed behind the barrette retaining walls. The groundwater level of the bedrock are recorded to be between -30 and -40m AOD	None required	Negligible impact Neutral effect (Not significant)	None	None	Not applicable

	Groundwater receptor (and value)	Design element	Magnitude of impact (no mitigation)	Potential impact to groundwater	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
				and as such, it is likely that no groundwater will be intercepted. Consequently construction will have a negligible impact on groundwater flow and quality.					
Main ES	Lynch Hill Gravel Secondary A aquifer (low)	General work below ground	Minor impact Neutral effect (Not significant)	Excavation and construction of below ground elements of the revised scheme will have the potential to interrupt groundwater flows and affect water quality.	Application of the mitigation measures set out in the draft CoCP including Section 16 will protect the aquifer.	Negligible impact Neutral effect (Not significant)	None	None	Not applicable
SES2	Lynch Hill Gravel Secondary A aquifer (low)	General work below ground	Minor impact Neutral effect (Not significant)	Excavation and construction of below ground elements of the revised scheme will have the potential to interrupt groundwater flows and affect water quality. Recharge to the Lynch Hill Gravel is limited since the predominant land cover is impermeable and hence groundwater levels are likely to be low.	Application of the mitigation measures set out in the draft CoCP including Section 16 will protect the aquifer.	Negligible Neutral effect (Not significant)	None	Neutral	Construction (temporary)
Main ES	Lynch Hill Gravel Secondary A aquifer	Barrette walls along western and southern side of	Not Applicable	Impacts on this aquifer not applicable to main ES design.	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable

	Groundwater receptor (and value)	Design element	Magnitude of impact (no mitigation)	Potential impact to groundwater	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
	(low)	HS2 Euston station platforms							
SES2	Lynch Hill Gravel Secondary A aquifer (low)	Barrette walls along western and southern side of HS2 Euston station platforms	Minor impact Neutral effect (Not significant)	Barrette walls along the western and southern edge of the new HS2 platforms at Euston will cut through the edge of the Lynch Hill Gravel outcrop and key in to the underlying London Clay. This will impact on groundwater flow and quality in the Lynch Hill Gravel. This wall will intersect a small section of the Lynch Hill Gravel and recharge to the Lynch Hill Gravel is limited since the predominant land cover is impermeable. Consequently construction will have a minor impact on groundwater flow and quality.	Application of the mitigation measures set out in the draft CoCP including Section 16 will protect the aquifer.	Negligible impact Neutral effect (Not significant)	None	None	Not applicable
Main ES	Lynch Hill Gravel Secondary A aquifer (low)	Compensation grouting	Not Applicable	Impacts on this aquifer not applicable to main ES design.	Not Applicable	Not Applicable	Not Applicable	Not Applicable	Not Applicable
SES2	Lynch Hill Gravel Secondary A aquifer (low)	Compensation grouting	Minor impact Neutral effect (Not significant)	Compensation grouting may be used as settlement compensation in various buildings in the area. Construction within the Lynch Hill Gravel could result in the introduction of contaminants into the aquifer from support fluids, in situ concrete and cement grouts, their associated additives, and fluids in construction equipment. This grouting will take place in the shallow ground from within the building footprint	Application of the mitigation measures set out in the draft CoCP including Section 16 will protect the aquifer.	Negligible Neutral effect (Not significant)	None	Neutral	Not applicable

	Groundwater receptor (and value)	Design element	Magnitude of impact (no mitigation)	Potential impact to groundwater	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
				and any impact on groundwater flow will be highly localised. Consequently construction will have a minor impact on groundwater flow and quality.					
Abstractions									
Main ES	SPZ located north of Regent's Park (Licence number confidential) GW92 (TH/039/0039/001) GW88 and GW89 (TH/039/0039/031) Gw85 (TH/039/0039/010) GW78 (TH/039/0039/022)	Tension piles Toe of basement walls	Negligible impact Neutral effect (Not significant)	The SPZ is up gradient of the revised scheme in this study area. The direction of groundwater flow will minimise the potential for any impact on the abstraction.	Application of the measures set out in the draft CoCP will ensure groundwater quality in the Lambeth Group, Thanet Sand Formation and Chalk aquifers will not be adversely impacted.	Negligible impact Neutral effect (Not significant)	None	None	Not applicable
SES2	SPZ located north of Regent's Park (Licence number confidential) (Moderate Value)	Tension piles LU new ticket halls Piles for support of the OSD areas	Negligible impact Neutral effect (Not significant)	Potential to impact groundwater quality at the source as a result of turbidity or fluids used in construction. The SPZ is up gradient of the revised scheme in this study area. The location of the construction work in the Chalk means it does not intersect with the SPZ for this borehole. The direction of groundwater	Application of the measures set out in the draft CoCP will ensure groundwater quality in the	Negligible impact Neutral effect (Not significant)	None	None	Not applicable

	Groundwater receptor (and value)	Design element	Magnitude of impact (no mitigation)	Potential impact to groundwater	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
				flow will minimise the potential for any impact on the abstraction.	Lambeth Group, Thanet Sand Formation and Chalk aquifers will not be adversely impacted.				
SES2	GW92 (TH/039/0039/001) GW88 and GW89 (TH/039/0039/031) Gw85 (TH/039/0039/010) GW78 (TH/039/0039/022) GW80 and GW 79 (28/039/0039/0215) (Moderate Value)	Tension piles LU new ticket halls Piles for support of the OSD areas	Negligible impact (GW92) Neutral effect (Not significant)	The piling may disrupt groundwater flow to, and quality at, groundwater abstractions that are close to the revised scheme. GW88 and GW89 are located across gradient from the revised scheme and flow directions will minimise potential for impact on these abstractions. GW85, GW78, GW79 and GW80 are located down gradient of the revised scheme. However, these small abstractions are located more than 850m from the revised scheme. In addition, these abstractions are used for heating / cooling and therefore water is returned to the ground after abstraction, reducing the likely influence of these boreholes further. Therefore, there is not likely to be an impact on these boreholes from the revised scheme. GW92 is located up gradient of the revised scheme, but construction will pass through	None required	Negligible impact Neutral effect (Not significant)	None	None	Not applicable

	Groundwater receptor (and value)	Design element	Magnitude of impact (no mitigation)	Potential impact to groundwater	Avoidance and mitigation measures	Magnitude of remaining impact and effect	Other mitigation measures	Residual effect	Duration of effect
				the outer protection zone for this abstraction[8]. See detailed assessment in Section 5.2 of this report for further details, which demonstrates that there will be negligible impact on this source.					

8 The inner protection zone of a private water abstraction is defined as the 50-day travel time from any point below the water table to the source with a minimum 50m-radius and is equivalent to a PWS SPZ1. The outer protection zone of a private water abstraction is defined by a 400-day travel time from a point below the water table and equivalent to SPZ2 at a PWS.

5.2 Detailed groundwater assessments

Impact to groundwater flow from piling for over site development

5.2.1 A simple conceptual approach based on an assumption of uniform aquifer properties allows a conservative assessment of the permanent impacts from piling to be completed. Flow to a borehole is governed by three factors:

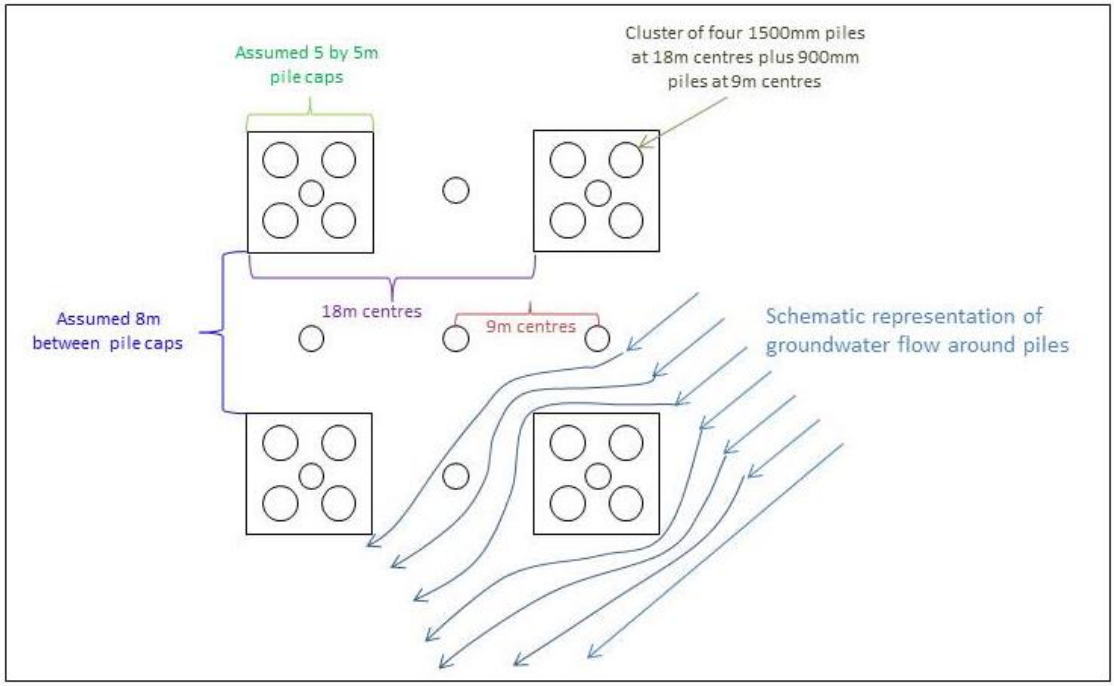
- the hydraulic gradient under which flow will occur, which increases when pumping commences and which is calculated as the change in groundwater level (dh) over a specific distance (dl) and is defined as 'dh/dl';
- the permeability (commonly indicated as 'k') of the formation providing the water (the Chalk in this case); and
- the cross-sectional area of aquifer through which groundwater can flow. The cross-sectional area is defined by the thickness of the aquifer (commonly indicated as 'b') and the width of the catchment supplying water to the borehole (commonly defined 'w').

5.2.2 Flow to the aquifer is represented by Darcy's Law:

Flow (Q) = -k b w dh/dl

5.2.3 The Euston OSD construction will comprise two sets of supporting piles; clusters of four 1500mm diameter piles at approximately 18m spacing and 900mm diameter piles at 9m spacing. The piling is anticipated to be to a maximum depth of -40m OD and as such the piles will penetrate the chalk aquifer. The piles could locally block groundwater flow that may in turn affect the operation of licensed abstraction GW92 which is located 380m up gradient of Euston station. Construction would pass through the outer protection zone for this abstraction. Figure 3 illustrates the pile construction through the Chalk aquifer system in this area.

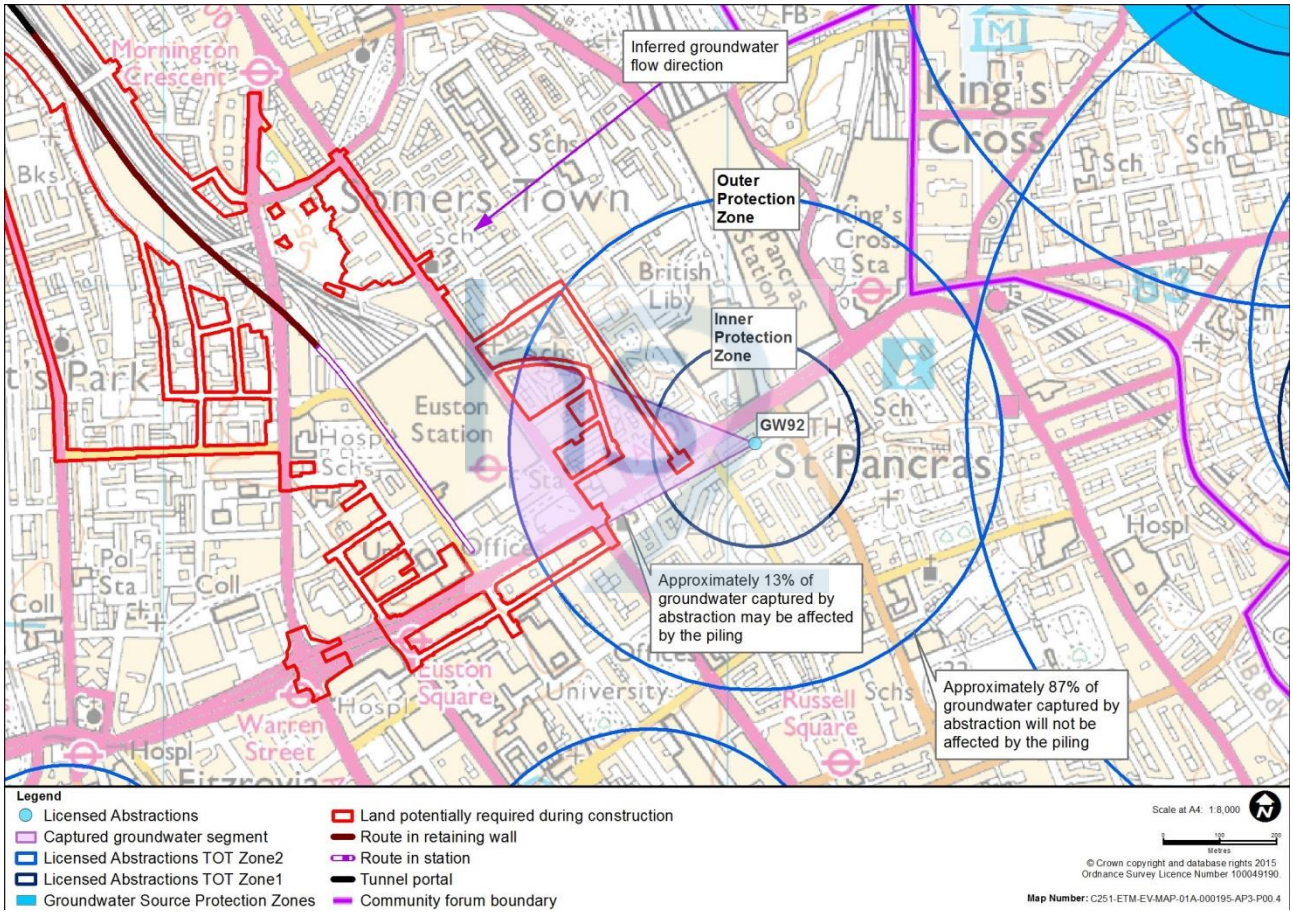
Figure 3 : Schematic diagram illustrating the pile cap construction and effect on groundwater flow



5.2.4 In homogenous conditions an abstraction borehole would induce radial flow to the point of abstraction, creating a cone of depression around the source. In the case of the source GW92, approximately an eighth or 13%, of the groundwater flowing to the abstraction will be from the west (Figure 4) and the rest from the north, south and east. The groundwater movement to the borehole however, is strongly influenced by the regional hydraulic gradient and most of the water abstracted from GW92 will be obtained from up-gradient of the borehole (i.e. to the north-east).

5.2.5 The station piles will intersect the borehole's capture zone to the west of the abstraction (i.e. the revised scheme is down-gradient of the abstraction). Figure 4 illustrates the approximate flow zones surrounding the abstraction that could be affected by the piles.

Figure 4 : Schmatic representation of effect of piles on protection zones for licensed abstractions



5.2.6 For the purpose of this assessment the pile clusters are conservatively assumed to completely obstruct groundwater flow over a 6m section in every 18m width of aquifer, as demonstrated in Figure 3. In practice, some flow may continue beneath the toes of the piles, or between the individual piles under a pile cap.

5.2.7 The assessment of impact to flow considers uniform radial flow to GW92 which provides an indication of the worst case impact expected from the piles. The original width accounting for flow to GW92 is taken to be w_o, with flow through that width following Darcy's Law and being dependent on k, dh/dl, w_o and b. The piles will effectively reduce the width available for flow (w_r) and therefore the flow from this area by 33%.

5.2.8 With regard to the effective flow to GW92, the effect of piling will only reduce flow from the western 13% of the capture zone, in other words the flow to the abstraction that will need to pass through the area of piling. Flow from the north, east and south will be unaffected. As such the reduction in flow will not be 33% but will be approximately 13% of that, i.e. 4% reduction in flow.

5.2.9 Due to the almost linear relationship between flow rate and drawdown (as described by Darcy's Law) for a given flow rate, the drawdown at the licensed abstraction would increase by up to 4% to account for a reduction in width and effective flow (assuming the capture zone does not increase in area to compensate which is also possible). Alternatively, to maintain a given drawdown, the abstraction rate at GW92 would be reduced by up to 4%.

5.2.10 It is important to note that this estimated impact is a conservative assessment under a series of significant assumptions including:

- the aquifer is homogenous;
- uniform groundwater flow is occurring - this is not likely to be the case and more flow will be obtained from up-gradient (i.e. from areas not affected by piling for the revised scheme); and
- all piles extend to the anticipated maximum depth(-40m AOD) - in practice some piles will not have to extend to this depth and there will be some flow between piles and beneath piles in places.

5.2.11 With consideration of the potential reduction in flow and drawdown of 4% at GW92 calculated above, and assuming that the actual reduction could be lower, it is concluded that piling for Euston station OSD will only have a minor impact on the groundwater flow regime to GW92. The impact on pumped water levels in the source GW92 would therefore be not significant.

6 References

Environment Agency, (2002), *Piling into contaminated sites.*

Environment Agency, (2009), *River Basin Management Plan, Thames River Basin District.*

Environment Agency, (2015), *Management of the London Basin Chalk Aquifer Status Report 2015.*

European Commission, *(2000), Water Framework Directive - Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000 establishing a framework for Community action in the field of water policy, Strasbourg, European Parliament and European Council.*

Land Drainage Act, (1991), London, Her Majesty's Stationery Office.

Water Resources Act, (1991), London, Her Majesty's Stationery Office.

HIGH SPEED RAIL (LONDON - WEST MIDLANDS)

Supplementary Environmental Statement 2 and Additional Provision 3 Environmental Statement

Volume 5 | Technical appendices
Water resources
WR-003-001

Environmental topic:	Water resources and flood risk assessment	WR
Appendix name:	Flood risk assessment	003
Community forum area:	Euston – Station and Approach	001

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1 Introduction

1.1 Structure of the water resources and flood risk assessment appendices

1.1.1 This appendix provides an update to Appendix WR-003-001 Flood risk Assessment (FRA) from the main Environmental Statement (ES) (Volume 5, WR-003-001). This update replaces Appendix WR-003-001 FRA from the main ES.

1.1.2 Two appendices for community forum area 1 (CFA1) Euston - Station and Approach are provided; these are:

- a water resources assessment (Supplementary Environmental Statement 2 (SES2) and Additional Provisions 3 Environmental Statement (AP3 ES) Appendix WR-002-001);and
- a FRA (i.e. this appendix).

1.1.3 Maps referred to throughout the water resources and flood risk assessment appendices are contained in the Volume 5 Map Book, Water Resources and Flood Risk Assessment within this SES2 and AP3 ES.

1.2 Scope of this assessment

1.2.1 This FRA considers the assessment of flood risk in CFA1.The assessments reported within this FRA have been carried out in accordance with the requirements of the National Planning Policy Framework (NPPF)[1]. The NPPF aims to prevent inappropriate development in areas at risk of flooding and to ensure that, where development is necessary in areas at risk of flooding, it is safe to do so without increasing flood risk elsewhere.

Flood risk assessment methodology

Source-pathway-receptor model

1.2.2 Flood risk is assessed using the source-pathway-receptor model. In this model individual sources of flooding within the study area are identified. The primary source of flooding is rainfall which is a direct source in the short-term (surface water flooding) and can lead to flooding from watercourses (river flooding) and overloaded man-made collection systems (sewer flooding) in the short or medium-term. Stored rainfall, either naturally in below ground aquifers and natural lakes or artificially in impounded reservoirs and canals, can lead to flooding when the storage capacity of the system is exceeded. A final source of flooding arises from tidal effects and storm surges caused by low pressure systems over the sea.

1.2.3 For there to be a risk of flooding at an individual receptor there must be a pathway linking it to the source of flooding. The pathways within the study area

[1] Department for Communities & Local Government, 2012, The National Planning Policy Framework.

are assessed by reviewing national datasets that show the spatial distribution of flood risk. The associated risk magnitude is then categorised.

1.2.4 Receptors considered in this assessment include the revised scheme and existing development within 500m of the revised scheme. The revised scheme includes all associated permanent infrastructure. Areas of interest are identified through comparison of the national spatial datasets with the design drawings. Where a risk is identified mitigation is proposed in line with recommendations in the NPPF.

1.2.5 Existing receptors within the study area are identified using Ordnance Survey (OS) mapping. A high-level screening assessment is then undertaken to identify receptors that are within or in close proximity to an area of flood risk via pathways indicated using the flood risk data sources listed below. The vulnerability of each receptor is classified using Table 2 of the Planning Practice Guidance Flood Risk and Coastal Change[2].

1.2.6 The assessment then considers the vulnerability of the receptor with reference to the flood risk category of the source using Table 3 of the Planning Practice Guidance Flood Risk and Coastal Change and assesses whether the revised scheme has any potential to influence or alter the risk of flooding to each receptor. Where such potential has been identified, mitigation is proposed based on further analysis.

Flood risk categories

1.2.7 The level of flood risk is categorised by assessing the design elements against the datasets for each source. A matrix showing the flood risk category associated with each flooding source is presented in Table 1.

Table 1 : Flood risk category matrix for all flooding sources

Source of flooding	***Flood risk category***				
	No risk	***Low***	***Medium***	***High***	***Very high***
Rivers		*Flood Zone 1*	*Flood Zone 2*	*Flood Zone 3a*	*Flood Zone 3b*
Surface water		*Outside Updated Flood Map for Surface Water (uFMfSW) extents*	*Surface water flooding for 1 in 1,000 years event*	*Surface water flooding for 1 in 100 years event*	*Surface water flooding for 1 in 30 years event*
Groundwater		*Very low-low*	*Moderate*	*High-very high*	

[2] Department for Communities and Local Government, (Last updated 15 April 2015), Planning Practice Guidance Flood Risk and Coastal Change.

Source of flooding	*Flood risk category*				
Drainage and sewer systems	*No sewer in vicinity of site.*	*Surcharge pointless than20m from site and no pathways.*	*Surcharge point within 20m of site and restricted pathways.*	*Sewer network crosses site and pathways exist.*	
Artificial sources	*Outside of inundation mapping/no pathway exists.*	*Within inundation mapping/ pathway exists.*			

Regional and local flooding planning policy documents

1.2.8 The lead local flood authority (LLFA) is the London Borough of Camden (LBC) which is also the local planning authority (LPA) for CFA1. The recommendations from the LBC preliminary flood risk assessment (PFRA)[3] have been reviewed in undertaking this assessment. The LBC local flood risk management strategy (LFRMS)[4] was approved in June 2013.

1.2.9 LBC, acting as the local planning authority, has also produced a strategic flood risk assessment (SFRA)[5] in conjunction with a number of surrounding local authorities.

London Borough of Camden Preliminary Flood Risk Assessment

1.2.10 The LBC PFRA indicates that there have been no identifiable past floods in the borough that have had significant harmful consequences. Future flood risk in the borough, however, is estimated to be high based on the Drain London surface modelling outputs.

1.2.11 The LBC PFRA confirms that the extent of the Greater London indicative flood risk area is correct within the borough and that the entire borough lies within the indicative flood risk area. Further stages of the Flood Risk Regulations 2009[6] process (i.e. flood risk mapping and flood risk management plans) will therefore be undertaken by the LLFA in due course. The LBC PFRA states that the current locally agreed spatial surface water flood risk information dataset is from the modelling activities undertaken as part of the Drain London project.

London Borough of Camden Local Flood Risk Management Strategy

1.2.12 The LBC LFRMS guides the planning process in relation to flood risk across all categories and outlines key policies in relation to development within LBC. The strategy aims to:

- understand and explain the level of risk affecting the residents and businesses of Camden;

3 Halcrow, (2011), London Borough of Camden Preliminary Flood Risk Assessment.
4 London Borough of Camden, (2013), Managing flood risk in Camden: The Camden flood risk management strategy.
5 Mouchel, (2008), North London Strategic Flood Risk Assessment.
6 Flood Risk Regulations 2009 (SI 2009 No. 3042), London, Her Majesty's Stationery Office.

- provide an action plan for areas at particular risk from surface water flooding;
- highlight the actions that all partners, businesses and residents in Camden should be taking to manage flood risk; and
- take a sustainable and holistic approach to flood management, seeking to deliver wider environmental and social benefits.

Thames Region Catchment Flood Management Plan

1.2.13 The Thames Region catchment flood management plan[7] (CFMP) sets out policies for the sustainable management of flood risk across the Thames catchment over the coming 50-100 years taking climate change into account. CFA1 lies within the TE2100 Policy Unit, and the preferred policy is Policy 4 which includes areas of low, moderate or high risk where the Environment Agency is already managing the flood risk effectively but where further action may need to be taken to keep pace with climate change.

1.2.14 The Thames Region CFMP states that the most sustainable approach to managing future flood risk will be to bring about adaptation of the urban environment. It indicates that strategic scale planning is key to achieving the needs of the community and managing flood risk in a more sustainable way, and that emergency planning is integral to the approach to managing extreme flood events.

London Regional Flood Risk Appraisal

1.2.15 The London regional flood risk appraisal[8] (RFRA) provides a broad regional understanding of the risk of flooding in Greater London to feed into each of the LLFA, SFRA and PFRA reports. Recommendation seven states that, regeneration and redevelopment of London's river corridors offers a crucial opportunity to reduce flood risk in these areas.

London Plan

1.2.16 Policy 5.12 of the London Plan[9] states that development proposals must comply with flood risk assessment and management requirements set out in the NPPF. Policy 5.13 requires implementation of the 7-stage sustainable urban drainage system (SUDS) hierarchy. The accompanying Sustainable Design and Construction supplementary planning guidance (SPG)[10] requires rainwater to be and collected and stored for re-use "where practical", and requires the implementation of SUDS for all development, proportionate to the scale of development. A 50% attenuation of pre-development runoff rates is "the minimum expectation from development proposals", and greenfield rates should be achieved unless it can be clearly demonstrated that "all opportunities

7 Environment Agency, (2008), Thames Catchment Flood Management Plan.
8 Greater London Authority, (2009), London Regional Flood Risk Appraisal.
9 Mayor of London, (2015), Further Alterations to the London Plan.
10 Mayor of London, (2014), Sustainable Design and Construction SPG.

to minimise final site runoff, as close to greenfield rate as practical, have been taken".

North London Strategic Flood Risk Assessment

1.2.17 The North London SFRA was completed in 2008 as part of the evidence base for the North London Waste Plan. LBC is one of seven participating boroughs that are included in the report. The North London SFRA states that LBC has a particularly high risk of flooding from sewer and surface water sources, while river flood risk remains low due to the lack of watercourses.

London Borough of Camden Core Strategy

1.2.18 Policy CS13 of the LBC adopted Core Strategy[11] seeks to make Camden a water efficient borough and minimise the potential for surface water flooding by requiring development to avoid harm to the water environment, water quality or drainage systems and prevent or mitigate local surface water and down-stream flooding, especially in areas up-hill from, and in, areas known to be at risk from surface water flooding.

London Borough of Camden Adopted Development Polices

1.2.19 Policy DP23 of the LBC adopted development policies[12] requires that developments reduce their water consumption and the risk of flooding by:

- incorporating water efficient features and equipment;
- limiting the amount and rate of runoff and waste water to reduce the risk of flooding;
- reducing the pressure placed on the storm water and sewer network; and
- ensuring that development is assessed for upstream and downstream groundwater flood risks in areas where historic underground streams are known to have been present.

1.2.20 Policy DP23 requires all new developments in areas identified as having a risk of surface water flooding in LBC to achieve a greenfield rate of runoff. All other development that increases the amount of impervious surface is expected to minimise the amount and rate of runoff from the site to at least the existing rate. The revised scheme will pass through areas that are identified as having historically flooded within LBC during the 1975 and 2002 events. It will not pass through areas however, with the potential to be at risk of surface water flooding as shown in Map 2 within the LBC adopted development policies document.

1.2.21 Policy DP22 requires development to be resilient to climate change by ensuring schemes include appropriate adaptation measures, such as limiting runoff and reducing water consumption.

11 London Borough of Camden, (2010), Adopted Core Strategy.
12 London Borough of Camden, (2010), Adopted Development Policies.

Design criteria

1.2.22 It is a requirement of the design that the revised scheme shall be protected against flooding from any source during the 1 in 1,000 years return period (0.1% annual probability) rainfall event with water levels not rising closer than 1m to the top of rail level.

1.2.23 In accordance with the NPPF and the associated Environment Agency guidance[13] an allowance for climate change is included in the assessment by assuming that peak rainfall intensity will increase by 30%, and that peak river flows will increase by 20%.

Data sources

Primary datasets

1.2.24 Consistent with the requirements of the NPPF this assessment considers the risk of flooding from rivers, direct surface water runoff, rising groundwater, overwhelmed drainage and sewer systems, and artificial sources such as reservoirs, lakes and canals.

1.2.25 The revised scheme lies entirely outside the extent of flooding from the sea and therefore the risk of flooding from tidal sources is not considered in this assessment.

1.2.26 The primary datasets for each source of flooding used to assess the design elements are presented in Table 2. A high-level review of the risk of flooding and potential impacts is undertaken on the basis of these datasets across all flood sources. Where this review indicates potentially significant impacts on the risk of flooding, or a risk of flooding to the revised scheme, further investigation in the form of hydraulic modelling is undertaken.

Table 2 : Flood risk assessment data sources

Source of flooding	Datasets reviewed	Data owner
Rivers	Flood zone mapping. Detailed River Network (DRN). Catchment hydraulic models.	Environment Agency
Surface water	uFMfSW. Local surface water flood mapping.	Environment Agency LLFA

[13] Environment Agency, (September 2013), Climate change allowances for planners. Guidance to support the National Planning Policy Framework.

Source of flooding	Datasets reviewed	Data owner
Groundwater	Areas susceptible to groundwater flooding. 1:50,000 geological mapping (superficial and bedrock). Potential for elevated groundwater.	British Geological Survey (BGS) LLFA
Drainage and sewer systems	Sewer network plans. Lost river location plans.	Thames Water Utilities Limited (TWUL) Local planning authority
Artificial sources	Reservoir inundation mapping. Canal infrastructure locations. Trunk water main asset plans.	Environment Agency Canal and River Trust TWUL

Site familiarisation visits

1.2.27 No site familiarisation visits were undertaken within CFA1.

2 Design changes within the existing limits of the Bill

2.1 Topography and land use

2.1.1 The topography of the study area within CFA1 is generally flat with a gentle rise of approximately 15m from Euston Station to Parkway. The area is predominantly urban in character and is dominated by commercial and residential buildings.

2.1.2 Euston Station, the West Coast Main Line (WCML), and associated operational and maintenance facilities are key elements of the urban environment in the area. The existing railway corridor runs north-west in cutting from Euston station, through the districts of Somers Town to the east and Regent's Park to the west.

2.2 Local flood risk receptors

2.2.1 The vulnerability of each local receptor with an identified pathway within the study area is presented in Table 3. The vulnerability is classified in accordance with the recommendations of Table 2 in the NPPF Technical Guidance Document and the Scope and Methodology Report (SMR) (see Volume 5,Appendix CT-001-000/1) and the SMR Addendum (see Volume 5, Appendix CT-001-000/2) of the main ES.

Table 3 : Vulnerability of local receptors in CFA1

Local receptor	Description	Vulnerability classification	Source/pathway
University College Hospital	Hospital	More vulnerable	Surface water –1 in 30 years
Euston Tap Public House	Public house	Less vulnerable	Surface water –1 in 30 years
University College London (UCL)	Educational establishment and halls of residence	More vulnerable	Surface water –1 in 100 years
Walkden House, Melton Street	Railway infrastructure	More vulnerable	Surface water –1 in 30 years
Regnart Buildings	Residential dwellings	More vulnerable	Surface water –1 in 30 years
Dwellings on Taviton Street and Endsleigh Street	Residential dwellings	More vulnerable	Surface water –1 in 1,000 years
Premier Inn, Euston Road	Hotel	More vulnerable	Surface water –1 in 100 years
Drummond Crescent and Church Way, Somers Town	Residential dwellings including basement dwellings	Highly vulnerable	Surface water –1 in 30 years

Local receptor	Description	Vulnerability classification	Source/pathway
Thistle and Ibis Hotels and National Temperance Hospital	Hotels and Hospital, including basement (not self-contained)	More vulnerable	Surface water –1 in 30 years
Buildings to the east and west of Hampstead Road	Commercial properties	Less vulnerable	Surface water –1 in 30 years

2.2.2 There are no additional receptors relative to the main ES.

2.3 Description of scheme

2.3.1 The case for HS2, with a terminus at Euston, is well established in national and regional transport and planning policy. This was set out in the HS2 Strategic Case, summarised in Volume 1, Sections 2 and 10 of the main ES.

2.3.2 In November 2013, a scheme for Euston Station and approach was included in the HS2 Bill ('the Bill') as deposited and assessed in the main ES. This is described in this report as the 'original scheme'. This had been selected, taking account of programme, budgetary and other constraints, after an extensive consideration of alternatives in 2012 and early 2013 and was reported in the main ES.

2.3.3 Following deposit in November 2013 and subsequent consultation with stakeholders, Hs2 Ltd. undertook a wide ranging review of the delivery of HS2 Phase One, as set out in HS2 Plus[14], in March 2014.

2.3.4 The principal elements of the AP3 revised scheme and the changes from the original scheme are:

- the revised scheme includes the staged construction of the high speed station, with sub-surface platforms and ground level concourses, which is designed to enable over-site development (OSD) to meet the aspirations of the Euston Area Plan (EAP)[15]. The high speed railway approach to the north of the station will be decked over in some parts to enable further OSD, also proposed in the EAP;
- the redesign of the replacement Hampstead Road Bridge to facilitate OSD and access to an underground basement to be used for station servicing;
- the revised scheme includes the construction of foundations and supporting structures for OSD as well as includes utility diversions and improvements for the high speed station and, where necessary, active or passive provision to support that development;
- the revised scheme will implement a staged provision of improved access

[14] HS2, March 2014, HS2 Plus : A report by David Higgins.
[15] London Borough of Camden, (2015), Euston Area Plan.

and public transport facilities to support the high speed and conventional stations and to facilitate further development including:

- direct access to the London underground from the high speed platforms and a new entrance near Euston Square Gardens;
- sub-surface pedestrian links to Euston Square underground station and under Euston Road;
- new taxi facilities to the north of the high speed station; and
- a linear bus station north of Euston Square Gardens;

- the revised scheme does not include the redevelopment of the conventional station, but provides Network Rail with a number of options, which may include a comprehensive redevelopment, which could support further OSD, and would go further in delivering the wider development and regeneration vision of the EAP;
- the revised scheme includes improvements to the public realm in Euston Square Gardens and will facilitate the longer term aspirations for improved pedestrian permeability; and
- the revised scheme reversed the proposal to close an existing railway dive under beneath the conventional railway approach north of Mornington Street Bridge, called Line X, because it conflicted with HS2 works. Instead the dive under will be closed for three years during construction, prior to reinstatement and connection back into the western, fourth, approach track, providing greater resilience for conventional services and greater capacity for growth in conventional rail services after 2026.

2.3.5 The design and construction programme of the revised scheme for Euston will minimise disruption to the operation of the existing station. Sixteen platforms in the conventional station will be retained until 2026 to meet train operator requirements. After 2026, the existing station will be reduced to 11 platforms, with additional capacity for travel to and from the West Midlands provided by the six high speed platforms, which will be operational by this stage. On completion in 2033, there will be 11 conventional platforms and 11 high speed platforms, which will ensure long term capacity. The high speed station will be therefore be constructed in two stages; the first to allow operation of HS2 Phase One to commence in 2026 (Stage A, between 2017 and 2026) and the second to provide additional platforms for HS2 Phase Two services in 2033 (Stage B1, between 2026 and 2033).

2.4 Existing flood risk

Historic flooding incidents

2.4.1 The Camden PFRA does not identify any past floods within this study area that have had significant harmful consequences that would be reportable to the European Union (EU).

2.4.2 The North London SFRA reports that a large area in the north of Camden was affected by surface water flooding in August 2002 which was the result of heavy rainfall inundating the public sewer system. A similar area of Camden was affected by surface water/sewer flooding in 1975. Euston Station was forced to close during the 2002 event. The station itself, however, was not recorded to have flooded in this event.

2.4.3 The Camden PFRA states that sewer flooding occurred within the borough in August 2004, September 2005 and July 2007. Specific locations of these flood incidents are not provided in the document.

2.4.4 The North London SFRA reports that no groundwater flooding incidents have been recorded by the Environment Agency in LBC.

Risk of flooding from rivers

2.4.5 The revised scheme will not intersect with any Environment Agency designated main rivers or ordinary watercourses within this study area, and the entire study area is within Flood Zone 1. Therefore there is a low risk of flooding to the revised scheme from rivers.

Risk of flooding from surface water

2.4.6 Environment Agency uFMfSW has been reviewed to form the basis of the assessment of the risk of surface water flooding. In general each of the LLFAs reports a good correlation between the uFMfSW and the Drain London modelling. The Drain London modelling, however, considers the underground drainage infrastructure in a higher level of detail and is considered to be the superior dataset. The uFMfSW therefore includes the Drain London modelling, combined with other sources and the original FMfSW. The Environment Agency uFMfSW is shown on Map WR-01-001 (SES2 and AP3 ES: Volume 5 Map Book, Water resources and flood risk assessment).

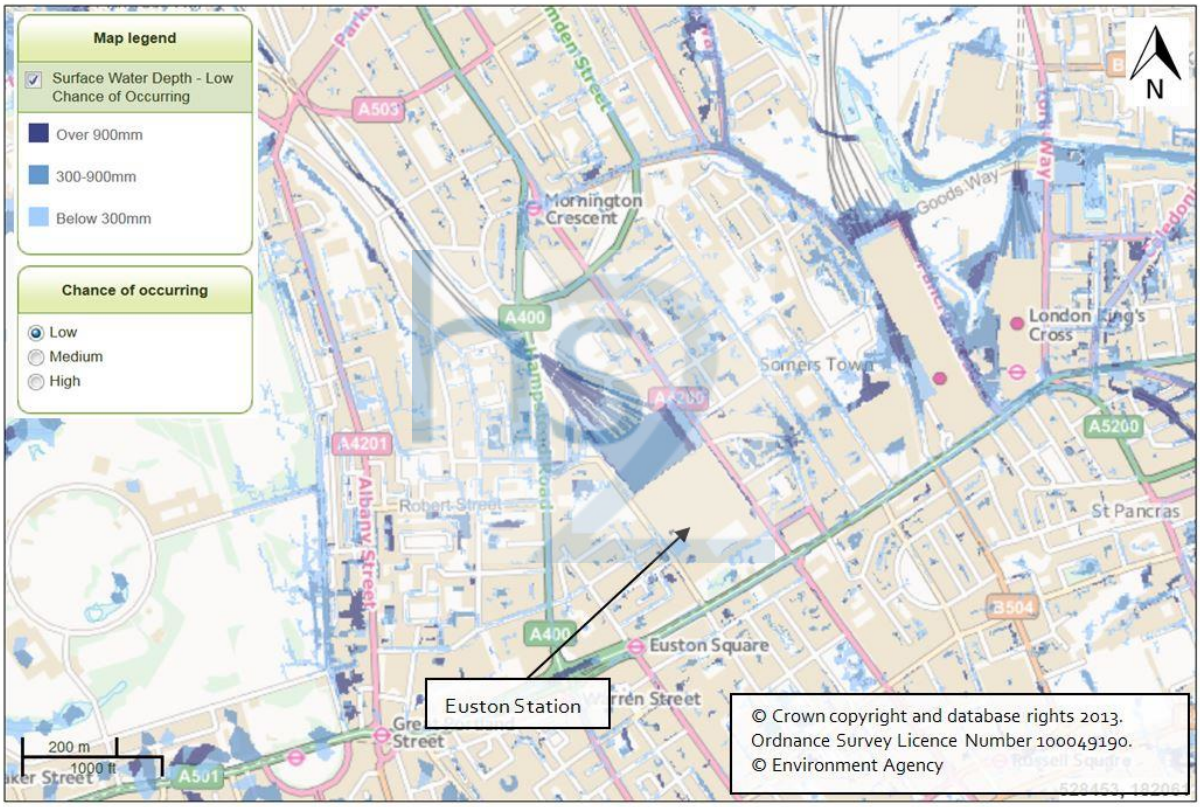
2.4.7 There are areas within CFA1 that have a high risk of surface water flooding. This assessment focuses on the areas at risk of surface water flooding adjacent to the revised scheme.

Euston Station

2.4.8 Surface water flooding datasets from the LBC PFRA show parts of the rails of the WCML and London Overground (LO) lines, immediately to the north of Euston Station, to be at risk of flooding during the 1 in 1,000 years return period (0.1% annual probability) flood event to depths of over 0.9m, as shown in Figure 1. These areas are also at risk of surface water flooding during the 1 in 30 years

return period (3.33% annual probability) flood event. Euston Station will be extended to the west, with the extended station approximately 70m wider than the existing.

Figure 1 : 1 in 1,000 years return period (0.1% annual probability) surface water flood depth at Euston Station from uFMfSW



2.4.9 The existing track level of the WCML is between 19m above Ordnance Datum (AOD) and 20m AOD throughout this area at risk of surface water flooding. Surrounding ground levels are at approximately 24m AOD. The high speed lines will be set at 16.5m AOD within the station, between 2.5m and 3.0m lower than the WCML.

2.4.10 A flood wall will be provided in the design to separate the high speed tracks and platforms from the conventional tracks and platforms. The height of this flood wall will be 1m. This is based on surface water flooding datasets and will include a freeboard to allow for modelling uncertainty and unforeseen effects. This will ensure both that there is no risk of flooding onto the high speed tracks from the higher conventional tracks, and to separate the sub-catchments to enable drainage to be designed appropriately without affecting the existing provisions. A second high containment reinforced concrete parapet will be constructed along the western side of the high speed tracks at least 1.8m above existing ground level which will serve to protect the tracks from surface water flooding from the west.

2.4.11 To the west of the existing station there are areas at risk of surface water flooding. These areas are isolated and do not appear to form part of a wider surface water flow path. Euston Station is to be extended to the west and will intercept some of these areas of surface water flooding. Based on light

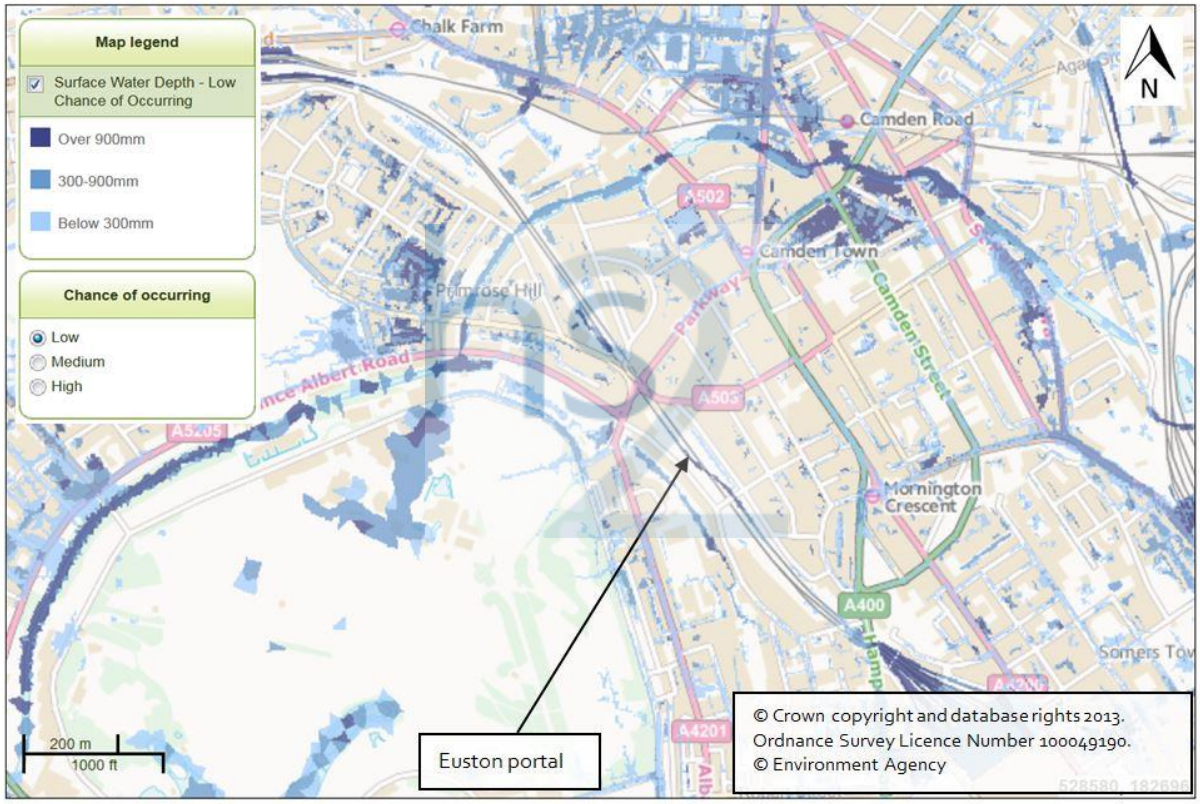
detection and ranging (LiDAR) information the areas of flooding are associated with topographic low points and are at approximately 22m AOD. The station concourse will be at approximately 24.5m AOD and will prevent the entry of floodwater to the excavation. Rainfall within the station excavation itself will be managed by the revised scheme drainage network.

2.4.12 As a result of the proposed flood walls and elevated station concourse, there will be no significant risk of surface water flooding to the revised scheme at the Euston Station.

Euston portal

2.4.13 Further to the north-west within the existing excavation of the WCML and LO tracks there are areas shown to be at risk of flooding during the 1 in 1,000 years return period (0.1% annual probability) flood event to depths up to 1.5m, as shown in Figure 2. These areas are also at risk of surface water flooding during the 1 in 30 years return period (3.33% annual probability) flood event. In this location the tracks of the WCML and LO are at multiple levels. The high speed tracks remain at 16.5m AOD to 450m beyond the platforms, where the dive under begins, with the upper deck rising to a maximum level of 19.9m AOD, down to 12.6m AOD where it enters the tunnel.

Figure 2 : 1 in 1,000 years return period (0.1% annual probability) surface water flood depth at the Euston portal



2.4.14 Euston portal will be located to the west of the existing WCML cutting. A parapet wall will be installed along the top of the contiguous bored pile wall to separate the portal excavation from the surrounding area. This will ensure that there will be segregation in the respective high speed and conventional rail

catchments, and will prevent surface water flooding from entering the tunnel portal. As part of the design of the drainage and surface water management strategy for Euston Station, flood modelling was undertaken using MicroDrainage (WinDes) and MicroDrainage Floodflow module software to determine the required specification for the proposed flood and parapet walls that protect the high speed tracks from flooding. The model incorporated LiDAR ground level information and TWUL sewer asset data to determine flood extents and levels for the 1 in 1,000 years return period (0.1% annual probability) rainfall event. The model results were used to determine that the design of the revised scheme is sufficient to prevent any internal flooding of the station or flooding of the high speed tracks during this event.

2.4.15 Line X partially occupies the space above the high speed tracks between the Euston portal and just south of the existing conventional dive under. The proposed 1m flood walls will prevent surface water flowing onto Line X, which will have a designated surface water collection system. To maintain separation between the conventional and high speed drainage systems, surface water will be pumped to Eversholt Street, with the system designed to manage events up to the 1 in 1000 years (0.1% annual probability) rainfall. There will be no significant risk of flooding to the high speed tracks from the reinstated Line X.

2.4.16 There will be no significant risk of surface water flooding to the revised scheme at the Euston portal.

Risk of flooding from groundwater

2.4.17 According to the LBC PFRA, there is an area to the immediate south of Euston Station that is shown to have an increased potential for groundwater emergence. This area is associated with the superficial Lynch Hill Gravel deposits. This area is confirmed in the BGS susceptibility to groundwater flooding dataset.

2.4.18 The CFA1 water resources assessment (Volume 5, Appendix WR-002-001) concluded that recharge to the Lynch Hill Gravel is limited since the predominant land cover is impermeable. Groundwater levels in the deposits are therefore likely to be low. Drainage will be provided to dewater the excavation if local perched groundwater is encountered. Consequently, there will be a low risk of groundwater flooding to the revised scheme within the study area.

Risk of flooding from drainage systems

2.4.19 The revised scheme will pass through heavily urbanised areas within the study area and therefore above ground infrastructure will be located close to the existing sewerage network and associated manholes. The LBC PFRA and LBC SFRA report a number of historical incidents of sewer flooding, however, the exact location of these incidents are not available.

2.4.20 The sewer network in this area is predominantly combined (i.e. conveys both foul water and surface water). In the event of surcharging within the sewer

network, the areas at risk of flooding are comparable to those at risk of surface water flooding, described in Section 2.4.6 to 2.4.16 of this report.

2.4.21 There are large diameter sewers in the vicinity of Euston Station associated with the historical alignment of the River Fleet. These are connected to the local public sewer network.

2.4.22 The large diameter trunk sewers and storm relief sewers will be assessed to determine their structural stability prior to commencement of tunnelling works. Any mitigation required to prevent the collapse of the sewers will be installed prior to tunnelling.

2.4.23 Details of TWUL sewer assets was incorporated into modelling undertaken to inform the design of Euston Station, as described in Section 2.4.6 to 2.4.16 of this report. There will therefore be no significant risk of flooding from drainage and sewer systems to the revised scheme within the study area further to the risk from surface water described in Section 2.4.6 to 2.4.16 of this report.

Risk of flooding from artificial sources

Canals

2.4.24 The Grand Union Canal (Regent's Canal) lies within the study area to the north of Regent's Park. However, the crossing of the canal (SWC-CFA3-01) is located within CFA3, as shown on Map WR-01-003 (SES2 and AP3 ES: Volume 5 Map Book, Water resources and flood risk assessment), and is therefore not considered further in this FRA.

Reservoirs

2.4.25 Within the study area there are no areas that are shown to have a residual risk of flooding from failure of impounded reservoirs. There will be no risk of flooding to the revised scheme as a result of a failure of impounded reservoirs.

Water mains

2.4.26 The revised scheme will cross a number of TWUL water supply mains within the study area. At the majority of locations, the revised scheme will be in a tunnel, and in these cases, there will be no significant risk of flooding to the revised scheme.

2.4.27 There are trunk water mains in the streets surrounding the existing Euston Station. There is a 1,067mm diameter cast iron water main in the carriageway of Euston Road, a 1,067mm diameter cast iron water main in Melton Street, and a 406mm diameter cast iron water main in Eversholt Street. The excavation for the extension to Euston Station will involve the abandonment and diversion of the water main in Melton Street. The diversion will be undertaken using a material of higher tensile strength than cast iron, and thence better able to withstand differential ground movements.

2.4.28 There is a further 406mm diameter cast iron water main within the bridge deck of the Hampstead Road Bridge, and a 1,067mm diameter cast iron water main in

the bridge deck of Mornington Street Bridge. These bridges will be demolished and replaced; with the replacement water mains constructed using more ductile materials that are able to withstand some movement of the bridge deck. Therefore the risk of flooding due to a failure of a water main is low.

2.4.29 Two water mains are identified as being within the carriageway of the A4201 Parkway at the boundary between CFA1 and CFA3, the diameters of which are both 914mm. Euston portal will lie approximately 120m to the south. There is a wall at the edge of the bridge over the existing WCML. In addition, a parapet wall will be constructed at the edge of the portal excavation to separate the surface water catchments. Should either of these mains in the A4201 fail, this wall will prevent the flooding of the tunnels.

2.4.30 The risk of flooding to the revised scheme from these water mains is therefore low.

Summary of baseline flood risk

Table 4 : Summary of baseline flood risk for all sources of flooding in CFA1

Source of flooding	Location of flooding source	Flood risk category	Elements at risk	Assessment of risk
Surface water	WCML and LO track beds on approach to Euston Station	High uFMfSW –1 in 30 years	Euston Station	Parapet wall will be provided to separate surface water catchments - low risk
			Euston portal	Parapet wall will be provided to separate surface water catchments - low risk
Groundwater	Lynch Hill Gravel to south-west of Euston Station	High	Euston Station	Excavation will lie at edge of flood risk area with drainage provided - low risk
Artificial sources (water mains)	Euston Road and A4201	Low	Euston Station	Walls along bridge extent and parapet wall will protect excavation - low risk

2.5 Flood risk management measures

Risk of flooding from rivers

2.5.1 There will be no risk of flooding from rivers to the revised scheme, nor any anticipated effects on the risks of flooding from rivers within the study area arising from the revised scheme. Therefore, no specific mitigation will be required.

Risk of flooding from surface water

2.5.2 A flood wall will be provided within the design to ensure that the drainage sub-catchments are separated. This will minimise the risk of flooding to the revised scheme from the surrounding conventional rail lines and also prevent any

increase in the volume of surface water that could arise from the revised scheme collecting in the tracks of the conventional rail at Euston Station. A parapet wall will be provided along the western extent of the excavation and at bridges. No further specific mitigation will be required. There will not be any anticipated changes to the risk of flooding from surface water sources as a result of the revised scheme within CFA1; therefore no further mitigation will be required.

Risk of flooding from groundwater

2.5.3 There will be no significant risk of flooding from groundwater to the revised scheme, nor any anticipated effects on the risks of flooding from groundwater within the study area arising from the revised scheme. Therefore, no specific mitigation will be required.

Risk of flooding from drainage systems

2.5.4 There will be no significant risk of flooding from drainage systems to the revised scheme, nor any anticipated effects on the risks of flooding from drainage systems within the study area arising from the revised scheme. Therefore, no specific mitigation will be required.

Risk of flooding from artificial sources

2.5.5 There will be no significant risk of flooding from artificial sources to the revised scheme, nor any anticipated effects on the risks of flooding from artificial sources within the study area arising from the revised scheme. Therefore, no specific mitigation will be required.

Summary of baseline flood risk

2.5.6 The proposed Euston Station development will be raised above surrounding ground, while Euston portal will be protected from surface water flooding by raised flood walls and/or parapet walls, and the risk of flooding from surface water is therefore low. There is no significant risk of flooding from other sources.

2.6 Post-design change flood risk assessment

Local receptors

2.6.1 In addition to the risk of flooding that exists to the revised scheme, there is potential for the revised scheme to affect the risk of flooding to third party receptors by altering flow mechanics across the range of flood sources. All local receptors with a potential flood risk are identified in Section 2.2 of this report. For the revised scheme to have an impact on a given receptor, the identified pathway for that receptor must be shared by both the subject receptor and the revised scheme, with the result that a number of cases can be excluded immediately. Table 5 summarises the shared pathways between the revised scheme and each receptor, and identifies cases where no shared pathway exists.

Table 5 : Shared flood risk pathways in CFA1

Local receptor	Vulnerability classification as per the NPPF	Pathway	Shared pathway between revised scheme and receptor
University College Hospital	More vulnerable	Surface water –1 in 30 years	No shared pathway.
Euston Tap Public House	Less vulnerable	Surface water –1 in 30 years	No shared pathway.
UCL	More vulnerable	Surface water –1 in 100 years	No shared pathway.
Walkden House, Melton Street	More vulnerable	Surface water –1 in 30 years	No shared pathway.
Regnart Buildings	More vulnerable	Surface water –1 in 30 years	No shared pathway.
Dwellings on Taviton Street and Endsleigh Street	More vulnerable	Surface water –1 in 1,000 years	No shared pathway.
Premier Inn, Euston Road	More vulnerable	Surface water –1 in 100 years	No shared pathway.
Drummond Crescent and Church Way, Somers Town	Highly vulnerable	Surface water –1 in 30 years	No shared pathway.
Hospital and hotels to the north and west of St James's Gardens	Highly vulnerable	Surface water –1 in 30 years	Euston Station
Buildings to the east and west of Hampstead Road	Less vulnerable	Surface water –1 in 30 years	Euston Station

2.6.3 There is also the potential for the revised scheme to change the baseline risk of flooding described in Section 2.4 of this report. Though designed such that the probability of the revised scheme flooding in any given year is less than 1 in 1,000, any change to the baseline risk of flooding could impact on the assessment of flood risk to the revised scheme. All cases of flood risk discussed in Section 2.4 of this report are therefore reconsidered regardless of the presence or otherwise of third party local receptors.

Impact on risk of flooding from rivers

2.6.4 The revised scheme will not cross any Environment Agency designated main rivers or ordinary watercourses within CFA1 and the revised scheme will, therefore, not lead to a change in the risk of flooding local receptors from rivers.

Impact on the risk of flooding from surface water

2.6.5 Any above ground infrastructure has the potential to alter overland surface water flow routes, thereby changing the risk of flooding to local receptors through displacement of flood waters and alteration to flow conveyance times.

Euston Station

2.6.6 There will be extensive development to above ground infrastructure at Euston Station with an extension of the station excavation to the west. Although the Euston area is currently heavily urbanised this development will lead to changes in the surface characteristics of the area. The revised scheme provides significant decking to enable the OSD component above the high speed station, station entrance and approaches. All surface water will ultimately discharge to the existing TWUL combined sewers.

2.6.7 The station area will be separated into sub-catchments for the purpose of managing surface water. The flood wall between the conventional and high speed tracks will ensure that there is no increase in the risk of surface water flooding to the Network Rail tracks in Euston Station.

2.6.8 Rainfall will be collected within the sub-catchments and will be attenuated to 50% of the calculated existing runoff rate in accordance with the minimum standard specified in the London Plan SPG. Attenuation will be in the form of underground storage tanks located within the station basement, with separate tanks and pumped storage for each catchment area. Total attenuation volumes of approximately 8,200m^3 will be required for the Euston Station area, as presented in Table 6. Any connection and allowable discharge rates will be agreed in advance with TWUL.

2.6.9 Surface water flooding in the area surrounding the extended Euston Station is formed of isolated areas of ponding in low topographic points. There is no connectivity between these areas. Some of the deepest areas of predicted surface water flooding will be within the boundary of the station extension. Rain falling in these areas will be collected within the station drainage system. There will be no deflection of overland flow in this area and there will be, therefore, no increase in the risk of flooding from surface water outside of the station footprint.

2.6.10 The revised scheme will not significantly affect the risk of surface water flooding at or in the vicinity of Euston Station.

Euston portal

2.6.11 A new dive under will be constructed as part of the revised scheme to the north of Granby Terrace Bridge. Three drainage options were considered, with the preferred option to divert as much surface water as possible away from the Euston portal to be combined with the high speed track drainage discharging to Euston Station. This is possible via gravity for the upper deck of the dive under (approximately 0.77ha); however the exposed portion of the lower deck will need to be managed within the portal.

2.6.12 Rainfall will be collected from an approximately 0.35ha area and will be attenuated to 50% of the calculated existing runoff rate. Attenuation will be in the form of underground storage tanks housed beneath the upper deck within the portal structure and will be pumped to a new outfall. Runoff from the lower

deck will need to be pumped to the attenuation tank. Attenuation volumes of approximately 410m3 will be required for runoff draining towards the portal while a further 900m3 is required for the gravity system, to be housed in the station basement. Any connection and allowable discharge rates will be agreed in advance with TWUL.

2.6.13 The drainage design was undertaken prior to the decision to reinstate Line X. Line X will partially occupy the area above the high speed tracks within the Euston Portal, as well as resulting in the removal of some OSD areas. This will cause a slight reduction in the catchment area draining to the high speed drainage network. Since the reduction in catchment will result in lower runoff rates than those used to size the attenuation volume, no additional calculations have been undertaken, and the attenuation as currently proposed is sufficient. As part of the Line X reinstatement work, track drainage for the line will also be reinstated.

2.6.14 There are no construction works outside of existing rail land in this area that have the potential to affect the risk of surface water flooding.

2.6.15 Therefore, the revised scheme will not significantly affect the risk of surface water flooding at or in the vicinity of the Euston portal.

Table 6 : Summary of attenuation storage required

Drainage area	Attenuation volume	Location of attenuation
High speed tracks draining towards Euston portal	410m^3	Euston portal
High speed tracks draining towards high speed station	900m^3	Station basement
OSD external to station box and approaches	1,835m^3	Station basement
Station box/OSD deck slab and access ramp	4,670m^3	Station basement
Soft and hard landscaping (external to station box)	1,680m^3	Station basement

Impact on the risk of flooding from groundwater

2.6.16 The excavation at Euston Station within the superficial Lynch Hill Gravel deposits is relatively minor and is on the periphery of the deposits. Given the urban nature of the surrounding land there is likely to be very limited recharge to these deposits. The CFA1 water resources assessment (Volume 5, Appendix WR-002-001) concluded that there will be no significant change in groundwater levels or flows within these deposits. Therefore, the revised scheme will not impact on groundwater levels and consequently there will be no effect on the risk of flooding from groundwater within the study area.

Impact on the risk of flooding from drainage systems

2.6.17 Connections to the foul and surface water sewer network from Euston Station and Euston portal will be agreed with TWUL in order to avoid creating additional burden on the existing sewer networks. There will not be a significant increase in the area of impermeable surface following construction as the sites are already developed. The revised scheme will therefore not lead to a change in the risk of flooding from drainage and sewer systems within the study area.

2.6.18 Any dewatering from the Lynch Hill Gravel deposits south of Euston Station will be discharged to the existing sewer networks, potentially increasing the load. Discharge rates for dewatering will be agreed in advance with TWUL, which will avoid creating a significant additional burden. Consequently, the revised scheme will not result in an increase in the risk of flooding from drainage and sewer systems due to dewatering discharges.

Impact on the risk of flooding from artificial sources

Canals

2.6.19 The potential impacts on the risk of flooding from the Grand Union Canal (Regent's Canal) is within the flood risk assessment for CFA3 (Main ES: Volume 5, Appendix WR-003-003) where this canal is crossed by the revised scheme. The proposed changes do not alter the potential impacts from this source.

Impounded reservoirs

2.6.20 There are no areas with a risk of flooding due to the failure of impounded reservoirs within the study area and therefore there will be no change in the risk of flooding from reservoirs as a result of the revised scheme.

Water mains

2.6.21 The settlement of the ground along the length of all water mains due to tunnelling, and the potential damage to the pipes due to additional strain in the material, will be assessed prior to and during construction. Although there is an increased risk of failure during construction, this will be managed as part of the construction programme. So long as construction is appropriately managed, the risk of failure of these water mains in the permanent case will not be increased as a result of the revised scheme.

Summary of potential impacts and effects on flood risk

Table 7 : Summary of potential impacts and effects on flood risk

Receptor	Vulnerability classification	Pathway	Impacts and effects
Revised scheme	N/A	Rivers	No effects expected.
		Surface water	Rainfall to be collected attenuated and discharged to existing sewerage infrastructure. No effects expected.

Receptor	Vulnerability classification	Pathway	Impacts and effects
		Groundwater	No effects expected.
		Drainage systems	Surface and foul discharges at Euston Station to be collected, attenuated and discharged to existing sewerage infrastructure. No effects expected.
		Artificial sources	No effects expected.
Dwellings to the north and west of St James's Gardens	Highly vulnerable	Surface water 200 years - deep	To be demolished. Drainage to be separated and surface water flooding modelled. No effects expected.
Buildings to the east and west of Hampstead Road	Less vulnerable	Surface water 200 years - deep	To be demolished. Drainage to be separated and surface water flooding modelled. No effects expected.

2.7 Conclusions

Summary

2.7.1 The revised scheme within CFA1 extends from the existing Euston Station to the A4201 Parkway. The study area includes all areas within 500m of the revised scheme, which includes areas at risk of flooding from the following sources:

- areas at risk of surface water flooding surrounding Euston Station; and
- areas with a risk of flooding due to the failure of trunk water mains.

2.7.2 Drainage will be provided to ensure that the top of rail levels of the revised scheme will be at least 1m above design flood water levels within all areas at risk of flooding. Residual risks from these sources will be negligible.

2.7.3 The study area is heavily urbanised, with substantial residential and industrial development within the study area. There are areas at risk of flooding as a result of direct surface water runoff in rainfall events as well as overloaded sewers and failed water mains. Although some construction is proposed within areas at risk, the flood mechanisms in the area are largely the result of localised ponding, rather than overland flow of floodwaters. Rainwater falling on these areas will be collected into the proposed surface water management system for the Ap3 revised scheme, and consequently will have no direct impact on the risk of flooding in the area. Surface water runoff at Euston Station will be collected, attenuated and discharged to existing sewers at pre-agreed rates, and will not create an additional burden on the existing drainage infrastructure. The condition of trunk sewers and water mains will be monitored prior to and during construction to ensure no increased risk of failure due to settlement arising from the proposed tunnels. There will be no increased risk of failure to underground surface water infrastructure from the revised scheme in the permanent case.

2.7.4 There will be no significant increase in the risk of flooding to third party receptors arising from the revised scheme.

Residual flood risks to scheme

2.7.5 There will be no significant residual risks of flooding to the revised scheme.

Residual effects of the revised scheme on flood risk

2.7.6 The revised scheme will not create an additional risk of blockage of sewer systems and will not lie within any area of significant risk of flooding. There will therefore be no significant impact arising from the revised scheme on the residual risk of flooding to third parties.

Compliance with local planning policy

2.7.7 The revised scheme includes an allowance for future increases in the risk of flooding as a result of climate change by including a 30% increase to rainfall intensities and flows in minor watercourses as recommended in the NPPF technical guidance document. Attenuation will be provided to ensure that the rate of runoff from permanent infrastructure, such as at the HS1 link portal, will not increase as a result of the revised scheme. This will ensure that there will be no increase in the risk of surface water flooding, especially in areas where a risk currently exists. The proposed drainage strategy is designed to produce a 50% reduction in runoff rates in accordance with the minimum standard specified in the London Plan SPG. The revised scheme will be in compliance with the recommendations of the LBC SFRA, core strategy and adopted development policies.

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