1MC04 Main Works - Contract Lot S2

Flood Risk Assessment - Ruislip Golf Course S2

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	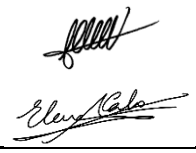					

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Contents

1 Introduction **3**
1.1 Background to the proposed development 3
1.2 Site location 3
1.3 Description of development 3
1.4 Summary of HS2 Environmental Statement FRA 4
1.5 Purpose of this document 8
2 Definitions and Abbreviations **9**
3 Review of relevant Legislation, Policy and Guidance **11**
3.1 European 11
3.2 National 11
3.3 Regional 12
3.4 Sub-Regional 15
3.5 Local 16
4 FRA Methodology **18**
4.1 Planning and flood risk 18
4.2 Source-pathway-receptor model 18
4.3 Flood risk categories 18
4.4 Climate change 19
5 Site description **20**
5.1 Description of the catchment 20
5.2 Catchment demarcation 22
5.3 Runoff estimation 24
6 Proposed development **25**
6.1 Description 25
6.2 Drainage strategy 25
6.3 Runoff estimation 26
6.4 Flood risk vulnerability classification 27
7 Existing flood risk **27**
7.2 Rivers 27
7.3 Surface Water 32
7.4 Groundwater 35
7.5 Drainage and Sewer Systems 39
7.6 Artificial Sources 40
7.7 Summary of baseline flood risk 42

8 Flood risk mitigation measures 43
8.1 Rivers 43
8.2 Surface Water 43
8.3 Groundwater 43
8.4 Drainage and Sewer Systems 43
8.5 Artificial Sources 43
9 Post development flood risk 44
9.1 Rivers 44
9.2 Surface Water 44
9.3 Groundwater 44
9.4 Drainage and Sewer Systems 44
9.5 Artificial Sources 44
9.6 Residual flood risks 44
10 Impact of climate change 46
10.2 Fluvial flooding 46
10.3 Water surface flooding 47
10.4 Groundwater, sewer and artificial flooding 47
11 Conclusions 48
11.1 Compliance with planning policy 48
11.2 Summary of flood risk 49
12 References and standard forms 50
12.1 Standard forms and templates 50
12.2 References 50
13 Appendices 50
Appendix A. Data Obtained from Ground Investigations 51

1 Introduction

1.1 Background to the proposed development

1.1.1 This 'Flood Risk Assessment' is prepared by Skanska Costain Strabag (SCS JV) on behalf of High Speed Two Ltd. (the applicant), to support the planning application for Ruislip Golf Course, London.

1.1.2 Ruislip Golf Course is a municipal golf course, owned and operated by the London Borough of Hillingdon (LB Hillingdon). It falls partially within the alignment of the HS2 development. The High Speed Rail (London-West Midlands) Act 2017 (the HS2 Act), which gained Royal Assent in February 2017, conferred the necessary powers required to construct Phase One of the railway from London Euston to Birmingham Curzon Street. The southern part of Ruislip Golf Course falls within this boundary.

1.1.3 Construction of HS2 will result in land take from Ruislip Golf Course. The applicant has committed to designing and delivering a reconfigured golf course as part of a number of Undertakings and Assurances (U&A) that were agreed with LB Hillingdon (and which eventually formed part of the Hillingdon Agreement) during the passage of the Hybrid Bill through parliament.

1.2 Site location

1.2.1 The application site is in west London within LB Hillingdon. The application site comprises the majority of the existing golf course, the area of which is 36 hectares.

1.2.2 It is located to the north of West Ruislip Station, and is bounded: to the north and north-east by the Glenhurst Avenue allotments and Hill Lane playground and the rear curtilages of residential properties on Field Way and Hill Rise; to the east and south-east by the rear curtilages of residential properties on Sharps Lane, Ickenham Road and Harwell Close; to the south-west and the far south-east by the boundary of the HS2 development; and to the west and north-west by the River Pinn.

1.3 Description of development

1.3.1 This application is for the redevelopment of the existing 18 hole Ruislip Golf Course to provide a nine hole golf course and six hole academy course, the creation of a new channel for the Ickenham Stream (canal feeder), the demolition and replacement of the driving range with a new 20-bay driving range and the construction of a single storey rifle range.

1.3.2 The description of development is as follows:

1.3.3 *Full application for remodelling of Ruislip Golf Course, incorporating: reconfiguration of 18 existing hole course into a nine hole course, short game practice area, putting green and six hole academy course; construction of a single storey rifle range; demolition of existing covered driving*

bays and construction of replacement 20 bay driving range, including associated floodlights and safety netting; a new drainage system and associated ponds; ecological and landscaping works; realignment and enhancement of the Hillingdon Trail and creation of a new public footpath; excavation of a new channel for the Ickenham Stream (canal feeder); and other associated works.

1.4 Summary of HS2 Environmental Statement FRA

1.4.1 A number of Flood Risk Assessments (FRAs) were undertaken for sections along the route of the HS2 development as part of the Environmental Impact Assessment (EIA). They were carried out in line with the NPPF (2012), as is the case with site-specific FRAs submitted with planning applications.

1.4.2 Despite the Hillingdon Golf Course is not covered specifically by the FRA undertaken as part of the Environmental Impact Assessment (EIA), the one which covers the area of the application site is consulted. It is considered of interest for the purposes of the current FRA as a background of the main assessment carried out. The HS2 development is the southern boundary of the application site, so both developments have some common sources of flood risk.

1.4.3 The areas covered by the FRAs from the EIA are identified using reference numbers for Community Forum Areas (CFAs). CFA6 is the reference for the 6.7km section of the HS2 Scheme in LB Hillingdon. CFA6 flood risk assessment is included in the HS2 Phase One Environmental Statement, Volume 5: water resources, Appendix WR-003-006.

1.4.4 This section summarises the key findings of CFA6 FRA, to set the background for the Flood Risk Assessment carried out in the current document.

Existing flood risk

1.4.5 The table below summarises the baseline flood risk for all sources of flooding in CFA6 FRA.

Source of flooding	Location of flooding source	Flood risk category	Elements at risk	Assessment of risk
Ickenham Stream	Ruislip Golf Course	High Close to Flood Zone 3a	West Ruislip portal	Risk of flooding to the West Ruislip portal from the small catchment of the Ickenham Stream to the south of the CML embankment
River Pinn	Ruislip Golf Course	High Flood Zone 3a	River Pinn underbridge	Sufficient freeboard from 1,000 year flood water levels to track
Groundwater	Ruislip Gardens	High	N/A	Proposed Scheme will be in tunnel
Surface water	South Ruislip industrial area	Low 200 years - shallow	South Ruislip vent shaft	No overland flowpaths present Drainage system will collect and attenuate runoff
Surface water	Ruislip Golf Course	Medium 200 years - deep	West Ruislip portal	Risk of flooding to the West Ruislip portal from the small catchment of the Ickenham Stream to the south of the CML embankment
Surface water	CML near Copthall Covert	Low 200 years - shallow	Cutting between Brakespear Road and Harvil Road	Landscape mitigation earthworks will separate surface water catchments
Artificial sources – Ruislip Lido	River Pinn	Low Artificial source with pathway	River Pinn underbridge	The Proposed Scheme will be on a bridge over the River Pinn
Artificial sources – water main	N/A	No risk Source but no pathway	South Ruislip vent shaft West Ruislip portal	Excavation will be too far from source to pose risk of flooding

Table 1 - CFA6 FRA baseline flood risk

Flood risk mitigation measures

Risk of flooding from rivers

At the crossings of the River Pinn and Newyears Green Bourne, replacement floodplain storage will be provided upstream of the HS2 development to mitigate for all losses in floodplain storage. Land has been made available in the design of the HS2 development for such areas.

Risk of flooding from surface water

1.4.6 No specific mitigation is required.

Risk of flooding from groundwater

1.4.7 No specific mitigation is required.

Risk of flooding from drainage systems

1.4.8 No specific mitigation is required.

Risk of flooding from artificial sources

1.4.9 Due to the extremely low probability of flooding due to a breach of Ruislip Lido and the likely low significance of any impacts arising from the HS2 development, it is not considered necessary to provide additional mitigation for this scenario.

Post HS2 flood risk

Impact on risk of flooding from rivers

Ickenham Stream at Ruislip Golf Course

1.4.10 The HS2 development will not cross the modelled floodplain of the Ickenham Stream. Flow in the watercourse to the north of the HS2 development will be diverted along the northern extent of the earthworks to an outfall with the River Pinn. The diversion will be designed to match the existing conveyance of the watercourse.

1.4.11 Due to the artificial nature of the watercourse current flow volumes in the Ickenham Stream are unknown. A site familiarisation visit, however, has shown that modifications to the channel, including regrading and diversion to create additional water hazards within the golf course, already result in the majority of the baseflow for the Stream discharging into the River Pinn catchment to the west. Further, the general topography of the golf course falls towards the River Pinn, suggesting that any out of channel flow is likely to discharge westwards to the river rather than reversing flows through the existing railway culvert.

1.4.12 Consequently, for a diversion channel between the crossing location and the River Pinn there will be a negligible change in the local contributing catchments and consequently no significant alteration to the risk of flooding in the local area.

1.4.13 There will not be an increase in the risk of flooding to the immediate south of the HS2 Proposed Scheme at the crossing of the Ickenham Stream. There will be no change in the risk of flooding to the north of the West Ruislip Portal on the Ickenham Stream.

River Pinn at Ruislip Golf Course

1.4.14 The presence of built volume within the floodplain in the form of approach embankments totalling 150m in length will displace flood waters and will consequently have an effect on flood water levels upstream.

1.4.15 Replacement upstream floodplain storage will be provided to mitigate for any loss of floodplain storage as a result of the proposed approach embankments for the crossing of the River Pinn.

1.4.16 There will be no resulting change in upstream or downstream water levels during flood events as a result of the HS2 development at the River Pinn.

Summary of potential impacts and effects on flood risk

1.4.17 The table below summarises the potential flood risk impacts and effects in CFA6:

Receptor	Vulnerability classification	Pathway	Impacts and effects
South Ruislip urban centre	More vulnerable	Flood Zone 2 and Flood Zone 3	No significant effects expected.
Ruislip Gardens urban centre	More vulnerable	Flood Zone 2 and Flood Zone 3 Surface water 30 years - shallow	No significant effects expected.
Ruislip Gardens LU Depot	Less vulnerable	Groundwater - high	No significant effects expected.
West Ruislip LU Station	Less vulnerable	Surface water 200 years - shallow	No significant effects expected.
The Greenway, West Ruislip	More vulnerable	Flood Zone 2 and Flood Zone 3 Surface water 200 years - shallow	Surface water runoff will be collected and attenuated before being discharged to the diverted TWUL sewer to the west of the existing culvert.
Ruislip Golf Course	Water compatible	Flood Zone 2 and Flood Zone 3 Surface water 200 years - shallow	No significant effects expected.
Oak Farm, Square Orchard and Old Priory	More vulnerable	Edge of Flood Zone 2 and Flood Zone 3	No significant effects expected.
Schering-Plough Animal Research Facility	Less vulnerable	Edge of Flood Zone 2 and Flood Zone 3	No significant effects expected.
CML cutting	Less vulnerable	Surface water 200 years - shallow	No significant effects expected.

Table 2 - CFA6 FRA flood risk impacts and effects

1.5 Purpose of this document

1.5.1 The purpose of this document is to assess about the flood risk on the application site and to ensure the compliance of the proposed development with the planning policy.

1.5.2 This document is structured as follows:

- Chapter1: introduces the Ruislip Golf Course project and summarises the flood risk assessment developed as part of the HS2 Environmental Impact Assessment (EIA)
- Chapter 2: defines the abbreviations used in the document;
- Chapter 3: provides a review of the relevant legislation, policy and guidance about flooding;
- Chapter 4: explains the methodology used for the flood risk assessment;
- Chapter 5: describes the existing site;
- Chapter 6: describes the proposed development;
- Chapter 7: assesses the existing flood risk;
- Chapter 8: describes the flood risk mitigation measures to be implemented in the proposed development;
- Chapter 9: assesses the post-development flood risk;
- Chapter 10: estimates the impact of climate change in the flood risk of the proposed development;
- Chapter 11: provides the main conclusions of this document; and
- Chapter 12: sets out references and standard forms.

2 Definitions and Abbreviations

Abbreviation	Definition
AStGWF	Areas Susceptible to Groundwater Flooding
CC	Climate Change
CDA	Critical Drainage Areas
CFA	Community Forum Areas
CFMP	Thames Catchment Flood Management Plan
DEM	Digital Elevation Model
EA	Environmental Agency
EIA	Environmental Impact Assessment
EU	European Union
FAS	Flood Alleviation Scheme
FRR	Flood Risk Regulations
FRA	Flood Risk Assessment
FWMA	Flood and Water Management Act
GIS	Geographic Information System
GLA	Greater London Authority
HS2	High Speed Two
LB	London Borough
LFRMS	Local Flood Risk Management Strategy
LIDAR	Light Detection and Ranging
LLFA	Lead Local Flood Authority
LPA	Local Planning Authority
NPPF	National Planning Policy Framework
PPG	Planning Practice Guidance
PRFA	Preliminary Flood Risk Assessment
RBD	River Basin District
RBMP	Thames River Basin Management Plan
RFRA	London Regional Flood Risk Appraisal
RMA	Risk Management Authorities

Abbreviation	Definition
RTD	River Terrace Deposit
SCS JV	Skanska Costain Strabag Joint Venture
SFRA	Strategic Flood Risk Assessment
SPG	Sustainable Design & Construction Supplementary Planning Guidance
SuDS	Sustainable Drainage Systems
SWMP	Surface Water Management Plan
TS	Technical Standard
WFD	Water Framework Directive
WLSFRA	West London Strategic Flood Risk Assessment

3 Review of relevant Legislation, Policy and Guidance

3.1 European

Floods Directive (2007/60/EC)

3.1.1 The aim of the Directive is to provide a consistent approach across the European Union to reducing and managing the risks posed by flooding to human health, the environment, cultural heritage and economic activity. The Floods Directive is to be delivered in conjunction with the objectives of the Water Framework Directive (2000/60/EC) to deliver a better water environment through river basin management.

3.1.2 In the UK, the Floods Directive is transposed into law via the Flood Risk Regulations (2009).

3.2 National

Flood Risk Regulations (2009)

3.2.1 The Flood Risk Regulations (FRR) 2009 set out duties for Lead Local Flood Authorities (LLFAs) and the Environment Agency (EA) to produce Preliminary Flood Risk Assessments (PFRAs), flood risk maps which show flooding extents and hazards, and flood risk management plans. These FRR requirements are completed on a six-year cycle and achieve the country's legal obligations of the EU Floods Directive 2007.

The Flood and Water Management Act (2010)

3.2.2 The Flood and Water Management Act (FWMA) 2010 provides a better, more sustainable and consistent management of flood risk in England and Wales. The FWMA was enacted following the Pitt Review of the 2007 flooding experienced across the country.

3.2.3 The FWMA defines the necessity of co-operation between relevant authorities at national, regional and local levels. It defines the roles of Risk Management Authorities (RMA), the bodies with flood risk-related responsibilities in England and Wales. RMAs includes the EA, Internal Drainage Boards, Water and Sewerage Companies and LLFAs.

National Planning Policy Framework (2018)

3.2.4 The revised National Planning Policy Framework (NPPF) was published on 24 July 2018 and sets out the government's planning policies for England and how these are expected to be applied. This revised Framework replaces the previous NPPF published in March 2012.

3.2.5 The NPPF provides guidance for Local Authorities to implement localised plans to meet the challenges presented by, amongst others, climate change, flooding and coastal change whilst achieving sustainable development. Paragraphs 155-165 specifically relate to planning and flood risk.

3.2.6 The NPPF states that all plans should apply a sequential, risk-based approach to the location of development - taking into account the current and future impacts of climate change - so as to avoid, where possible, flood risk to people and property. They should do this, and manage any residual risk, by:

a) applying the sequential test and then, if necessary, the exception test;

b) safeguarding land from development that is required, or likely to be required, for current or future flood management;

c) using opportunities provided by new development to reduce the causes and impacts of flooding (where appropriate through the use of natural flood management techniques); and

d) where climate change is expected to increase flood risk so that some existing development may not be sustainable in the long-term, seeking opportunities to relocate development, including housing, to more sustainable locations.

Flood Risk and Coastal Change Planning Practice Guidance (2014)

3.2.7 The 'Flood Risk and Coastal Change' section of the Planning Practice Guidance (PPG) was initially published in March 2014 and operates in conjunction with the NPPF. As it is intended to serve as a living document, it is subject to periodic updates.

3.2.8 Planning practice guidance will, where necessary, be updated in due course to reflect changes to the NPPF as the new version of which was published in July 2018. Where plans are being prepared under the transitional arrangements set out in Annex 1 to the revised NPPF, the policies in the previous version of the framework published in 2012 will continue to apply, as will any previous guidance which has been superseded since the new framework was published in July 2018.

3.2.9 This section of the PPG advises users on how to take account of and address the risks associated with flooding and coastal change in the planning process. The section defines flood risk and how to address all sources of risk. The PPG assesses the suitability of the development type with respect to the flood risk zone in which it lies. It provides information on how flood risk should be taken into account in the preparation of local plans and what SFRAs should include.

3.3 Regional

Thames Catchment Flood Management Plan (2009)

3.3.1 The Thames Catchment Flood Management Plan (CFMP) was published in December 2009 by the EA. Its purpose is to provide an overview of current and future flooding within the River Thames' catchment area. The Thames CFMP also sets out strategic policies to manage those flood risks over the next 50 to 100 years with climate change in mind.

3.3.2 The LB Hillingdon falls under Sub-area 5 (River Pinn sub-area). The Thames CFMP preferred policy for Sub-area 5 is Policy Option 6 where partnership actions are needed to store and manage runoff in locations with environmental or overall flood risk reduction benefits. The Policy Option states that the approach to flood risk management in these places uses the natural protection already provided by the river channel and the open spaces in the floodplain.

Thames River Basin Management Plan (2015)

3.3.3 The Thames River Basin Management Plan (RBMP) is part of a series of river basin district (RBD) documents that aim to provide a framework for the protection and enhancement of the benefits provided by the water environment. Prepared by the EA, RBMPs fulfil the requirements of the EU's Water Framework Directive (WFD) and are updated on a six-yearly cyclical basis.

3.3.4 The current Thames RBMP was produced in 2015 and is the second of a series of six-yearly cyclical planning documents. It covers the entire Thames river system, and includes contributory and interconnected rivers, lakes, groundwater and coastal waters. The document provides a set of measures as part of the main programmes, and local measures for catchments within the Thames RBD.

Thames River Basin Flood Risk Management Plan (2016)

3.3.5 The Thames River Basin Flood Risk Management Plan (FRMP) is a set of documents published by the EA in March 2016. They are produced in line with FRR 2009 and the EU Floods Directive (2007). These documents are updated on a six-yearly basis, with the current cycle running from 2015 to 2021. They set out how RMAs will work with communities to manage flood and coastal risk over the next six years within the RBD.

The London Plan (2016)

3.3.6 The London Plan, last updated in March 2016, is the Greater London Authority's (GLA) spatial development strategy plan for London. It sets the framework for development in London over the next 20-25 years, linking key economic, environmental, transport and social priorities. The London Plan was first published in 2004 and has undergone various alterations since. A new London Plan is currently being drafted and expected to be finalised in 2019.

3.3.7 The London Plan sets out several objectives put forward by the Mayor of London. One of the objectives is to ensure London is a city that becomes a world leader in improving the environment. This includes responding to climate change, which is covered in Chapter Five of the London Plan. Within this chapter are several policies that cover flood risk and water resource matters:

- Policy 5.3: Sustainable Design and Construction
- Policy 5.11: Green Roofs and Development Site Environs
- Policy 5.12 Flood Risk Management. The policy states:

- development proposals must comply with the flood risk assessment and management requirements set out in the NPPF on flood risk over the lifetime of the development and have regard to measures proposed in Thames Estuary 2100 and Catchment Flood Management Plans;
- developments which are required to pass the Exceptions Test set out in the NPPF will need to address flood resilient design and emergency planning by demonstrating that the development will remain safe and operational under flood conditions; and
- development adjacent to flood defences will be required to protect the integrity of existing flood defences and wherever possible should aim to be set back from the banks of watercourses and those defences to allow their management, maintenance and upgrading to be undertaken in a sustainable and cost-effective way.

- Policy 5.13 Sustainable Drainage. The policy states that:
  - development should utilise SuDS unless there are practical reasons for not doing so, and should aim to achieve Greenfield runoff rates and ensure that surface water runoff is managed as close to its source as possible in line with the following drainage hierarchy:
    1) store rainwater for later use;
    2) use infiltration techniques, such as porous surfaces in non-clay areas;
    3) attenuate rainwater in ponds or open water features for gradual release;
    4) attenuate rainwater by storing in tanks or sealed water features for gradual release;
    5) discharge rainwater direct to a watercourse;
    6) discharge rainwater to a surface water sewer/drain; and
    7) discharge rainwater to the combined sewer.
  - drainage should be designed and implemented in ways that deliver other policy objectives of this plan, including water use efficiency and quality, biodiversity, amenity and recreation.

3.3.8 The GLA's associated Sustainable Design & Construction Supplementary Planning Guidance (SPG) provides guidance that supports the London Plan policies. Chapter 3.4 of the SPG focuses on flooding and provides links to guidance about SuDS.

The London Regional Flood Risk Appraisal (2014)

3.3.9 The London Regional Flood Risk Appraisal (RFRA), last updated in August 2014, is an accompaniment to the London Plan. It provides a strategic overview of all sources of flooding in London and addresses its probability and consequences. The findings of the London RFRA support information presented in the London Plan, and provides details which shape the Plan's policies. The London RFRA was first published in October 2009.

3.3.10 The 2014 London RFRA provides several revised recommendations, which are meant to be used as a monitoring tool on a borough-wide or London-wide level. Progress against these fourteen recommendations is reported annually in the London Plan Annual Monitoring Report

3.4 Sub-Regional

West London Strategic Flood Risk Assessment (2018)

3.4.1 The Flood Risk and Coastal Change PPG highlights the role of LPAs to utilise a risk-based approach to understand and manage flood risk from all sources. This includes the risks to and from surrounding areas in the same flood catchment. As a result, LPAs are required to produce SFRA to inform the preparation of Local Plans.

3.4.2 The West London Boroughs of Barnet, Brent, Ealing, Harrow, Hillingdon and Hounslow (hereinafter 'the Boroughs') have commissioned the production of a joint Level 1 SFRA (WLSFRA) (March 2018) to inform the preparation of Local Plans. The overarching aim of the WLSFRA is to provide the evidence base for ensuring development is steered away from areas identified most at risk from various flood sources, reducing the risk of flooding to its residents and buildings. This review is required to provide an update to existing borough specific SFRAs, which were predominantly completed in 2008.

3.4.3 The purpose of the WLSFRA is to provide a strategic overview of all forms of flood risk throughout the study area, now and in the future. This document and associated mapping delivered as part of the WLSFRA, is used as an evidence base by the Boroughs to inform the preparation of Local Plans, including the application of the sequential test to future site allocations.

3.4.4 The key differences within the WLSFRA compared to the previous SFRAs for all the Boroughs include the following:

- Definition of the Flood Zone 3a: Fluvial, tidal and surface water flood risks have been included within the Flood Zone 3a definition to reflect the significant nature of local flood risks within the heavily urbanised boroughs.
- Application of the Sequential Test and Exception Test: These two approaches include assessment of risk from all sources of flooding (not just fluvial and tidal as previously generally applied).
- Site-Specific Flood Risk Assessments: These will be required for all development proposals in Flood Zones 2, 3a and 3b – noting the definition of Flood Zone 3a in the WLSFRA includes surface water flood risk.
- Drainage Strategies: These are required for all Major developments not categorised as 'Change of Use'. All Minor developments and developments categorised as 'Change of Use' or proposed changes to Previous Approvals which modify existing surface water drainage will also require a Drainage Strategy.

3.5 Local

Hillingdon Local Plan (2012-2018)

3.5.1 Hillingdon's Local Plan is a collection of documents that provide the foundation for how planning will be controlled in the borough. The two primary documents are the Local Plan Part 1 - Strategic policies and the Local Plan Part 2.

3.5.2 Local Plan Part 1 was adopted in November 2012 and outlines LB Hillingdon's vision to 2026. Section 8 provides Core Policies around environmental improvement, in which Policy EM6: Flood Risk Management is included.

3.5.3 LB Hillingdon submitted the Local Plan Part 2 to the Secretary of State on 18 May 2018 to begin the examination in public phase. The Local Plan Part 2 comprises Development Management Policies, Site Allocations and Designations and Polices Map. Once adopted it will deliver the detail of the strategic policies set out in the Local Plan Part 1: Strategic Polices (2012). Together they will form a comprehensive development strategy for the borough up to 2026.

3.5.4 The Development Management Policies document provides detailed policies that will form the basis of the Borough's decisions on individual planning applications. Section 6 provides development management guidance and policies linked to environmental protection and enhancement. Of these policies, Policy DMEI 10: Management of Flood Risk provides policy and guidance on flood risk matters.

Flood Risk Management Documents

3.5.5 The LB Hillingdon has created a Flood Risk Management Portfolio of flooding documents, which will provide greater information on flood risk in the Borough, to meet the Council's responsibilities as a Lead Local Flood Authority. This is comprised of:

- Local Flood Risk Management Strategy (2016);
- Preliminary Flood Risk Assessment (2011);
- Strategic Flood Risk Assessment (2008) and Addendum to the Strategic Flood Risk Assessment and Sequential Test (2014);
- Surface Water Management Plan (2013); and
- Flood Risk Investigation Reports.

Local Flood Risk Management Strategy (2016)

3.5.6 Hillingdon's Local Flood Risk Management Strategy (LFRMS) was published in 2016. It provides an overview of previously undertaken flood risk studies. It also sets out a strategy for the management of flood risk in the local area, outlining the roles and responsibilities of key stakeholders. It is supported by other documents such as the Preliminary Flood Risk

Assessment (PFRA), Surface Water Management Plan (SWMP) and Strategic Flood Risk Assessment (SFRA).

3.5.7 Appendix 3 of the LFRMS provides a set of objectives, measures and actions. Objective three of the six objectives states *"Development in Hillingdon understands and takes account of flood risk issues and plans to reduce flood risk".* The measures associated with this objective are:

- influence the Local Plan and creation of suitable policies on flood risk;
- secure contribution to flood risk reduction from new developments;
- major landowners to develop site wide long-term plans for managing water; and
- continue influencing developments through the planning process to ensure they meet the requirements of National Standards for Sustainable Drainage and London Plan requirements.

Preliminary Flood Risk Assessment (2011)

3.5.8 The PFRA 2011 for Hillingdon provides a high level overview of flood risk from all sources within the Borough, including consideration of surface water, groundwater, ordinary watercourses and canals. This does not provide detailed site specific information to inform residents of specific risks. PFRAs were a requirement of the FRR, where areas of significant risk are identified, this is now superseded.

Strategic Flood Risk Assessment (2008-2015)

3.5.9 The SFRA 2008, and updated in 2015, collates all known evidence of flood risk and forms part of the evidence base for the vision and objectives of the Local Plan. It provides an understanding of all flood risks at that point in time. There may be additional information on flood risk collected subsequently. This document is now superseded the WLSFRA.

Surface Water Management Plan

3.5.10 The SWMP is divided into two sections. Part 1, the Evidence Base 2013, and Part 2 the Options and Actions Plan 2014.These documents outline the evidence and the surface water management strategy for Hillingdon. They include consideration of flooding from sewers, drains, groundwater and runoff from land, small watercourses and ditches that could occur as a result of heavy rainfall. They identify a number of 'Critical Drainage Areas' (CDA) within Hillingdon which require further investigation.

Flood Risk Investigation Reports

3.5.11 The Flood and Water Management Act 2010 requires the LLFA to investigate significant flood events. These provide a useful summary of key events that may have happened since the production of the Hillingdon's SWMP and identify sites where further investigation will be undertaken.

4 FRA Methodology

4.1 Planning and flood risk

4.1.1 The NPPF and PPG highlight that developments should be directed away from the highest areas of risk and that developments should be made safe without increasing flood risk elsewhere. Due to development needs and demands, the NPPF identifies that it may not always be possible to completely avoid flood risk areas.

4.1.2 The NPPF highlights the need for a sequential, risk-based approach to be considered for development. Implementation of this approach requires proposed development sites to be reviewed through the application of the Sequential Test and, in some instances, the Exception Test.

4.2 Source-pathway-receptor model

4.2.1 Flood risk is assessed using the source-pathway-receptor model. In this model individual sources of flooding within the study area are identified.

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

4.2.3 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. The vulnerability of each receptor is classified using Table 2 of the PPG.

4.2.4 The assessment then considers the vulnerability of the receptor with reference to the flood risk category of the source using Table 3 of the PPG and assesses whether the proposed development 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.

4.3 Flood risk categories

4.3.1 The level of flood risk is categorised according to the below.

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	No surface water flooding.	Surface water flooding <0.3m for a 1 in 200 year event.	Surface water flooding >0.3m for a 1 in 200 year event and Surface water flooding <0.3m for a 1 in 30 year event.	Surface water flooding >0.3m for a 1 in 30 year event.	

Source of Flooding	Flood Risk Category				
	No Risk	**Low**	**Medium**	**High**	**Very High**
Groundwater		Very low-low	Moderate	High – very high	
Drainage and Sewer Systems	No sewer in vicinity of site.	Surcharge point >20m 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.			

Table 3: Flood Risk Categories

4.4 Climate change

4.4.1 In accordance with the NPPF, an allowance for climate change is included in the assessment.

4.4.2 The HS2 Approach Document Climate change allowances for flood risk assessments and drainage design peak sets out the approach for applying climate change allowances to flood risk and drainage design assessments across all phases of HS2, taking into account the guidance produced by the EA in 2016.

4.4.3 The allowances used for peak river flow are selected according to the location (i.e. flood zone), river basin district and sensitivity of the individual receptors potentially affected.

5 Site description

5.1 Description of the catchment

5.1.1 The application site is within a drainage catchment area of 55.4ha as illustrated in Figure 1. The boundary of the catchment area closely aligns with the application site boundary. However, some residential areas located to the north-east and to the east of the application site drain to it from outside its limits. Although most of the catchment is quite flat, it mainly drains to the north (to the River Pinn) through the channels which form part of the existing golf course drainage system.

Figure 1 - Application site catchment area

5.1.2 The Ickenham Stream crosses the application site from the north-east to the south and leaves the application site through a tunnel beneath the Chiltern Mainline. The Ickenham Stream was originally constructed as a feeder for the Grand Union Canal from the Ruislip Lido reservoir. The Ickenham Stream is classified as a LLFA 'Ordinary Watercourse' as far south as the existing railway line, downstream of which the watercourse is an EA classified 'Main River', as illustrated in Figure 2. However, there is no significant water flow under the tunnel to the south of the application site. Therefore, the Chiltern Mainline can be considered the current boundary between the catchments of the River Pinn and the section of the Ickenham Stream classified as 'Main River', which joins downstream to the Yeading Brook western arm.

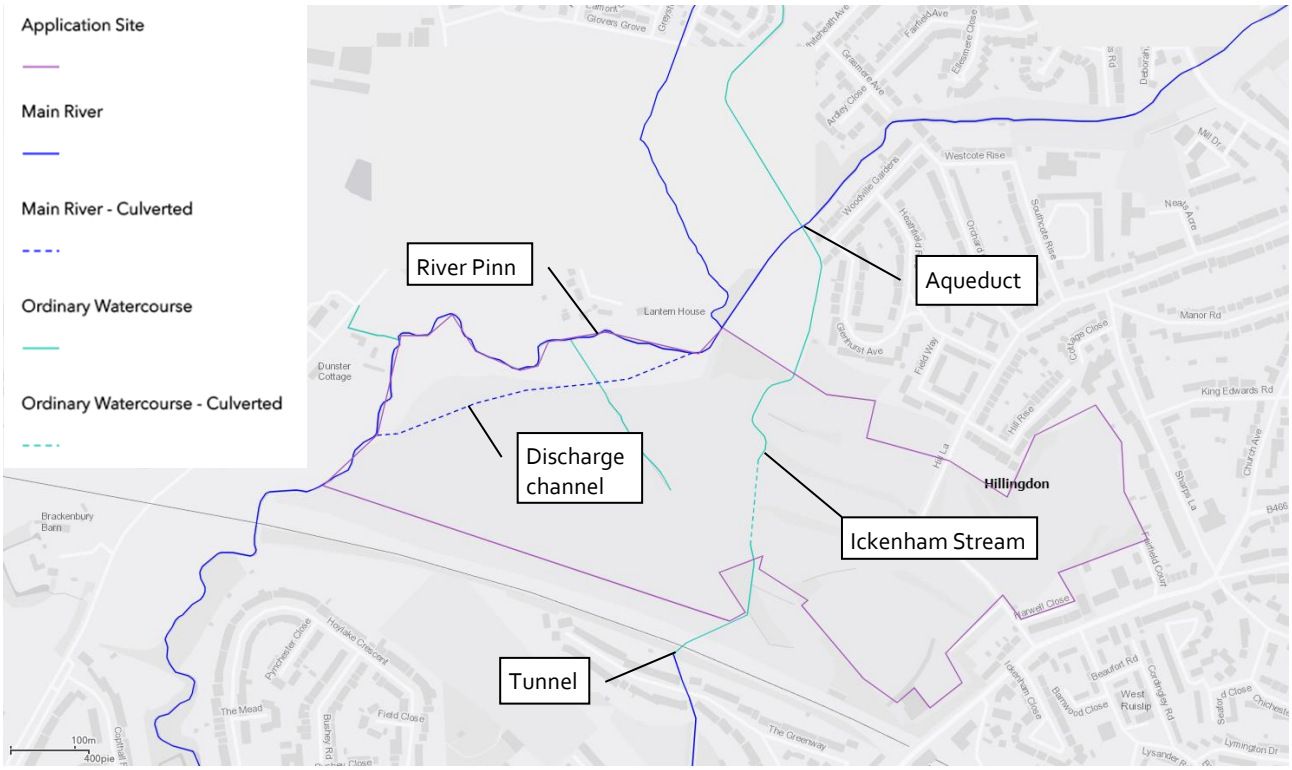


Figure 2 - EA River classifications

5.1.3 The Ickenham Stream is carried over the River Pinn on an aqueduct close to Woodville Gardens. As it crosses the application site it is intercepted by several channels which drain to the River Pinn. The Ickenham Stream channel is also interrupted in several points between the aqueduct and the northern edge of the application site. Once the Ickenham Stream enters the centre of the application site, it is connected to the channels which form part of the existing golf course drainage infrastructure.

5.1.4 The Ickenham Stream cannot be considered as a continuous channel between the aqueduct and the tunnel under the Chiltern Mainline. It locally intercepts the surface runoff along its route through the application site, but it does not run the drained water to the south of the Chiltern Mainline. Although the tunnel beneath the Chiltern Mainline is connected to the channels of the golf course drainage, these channels mainly drain to the north according to the ground elevations.

5.1.5 Figure 3 illustrates how the application site catchment currently operates from a hydrological-hydraulic point of view, according to the detailed digital elevation model (DEM) made for the HS2 development and several visits to the site.

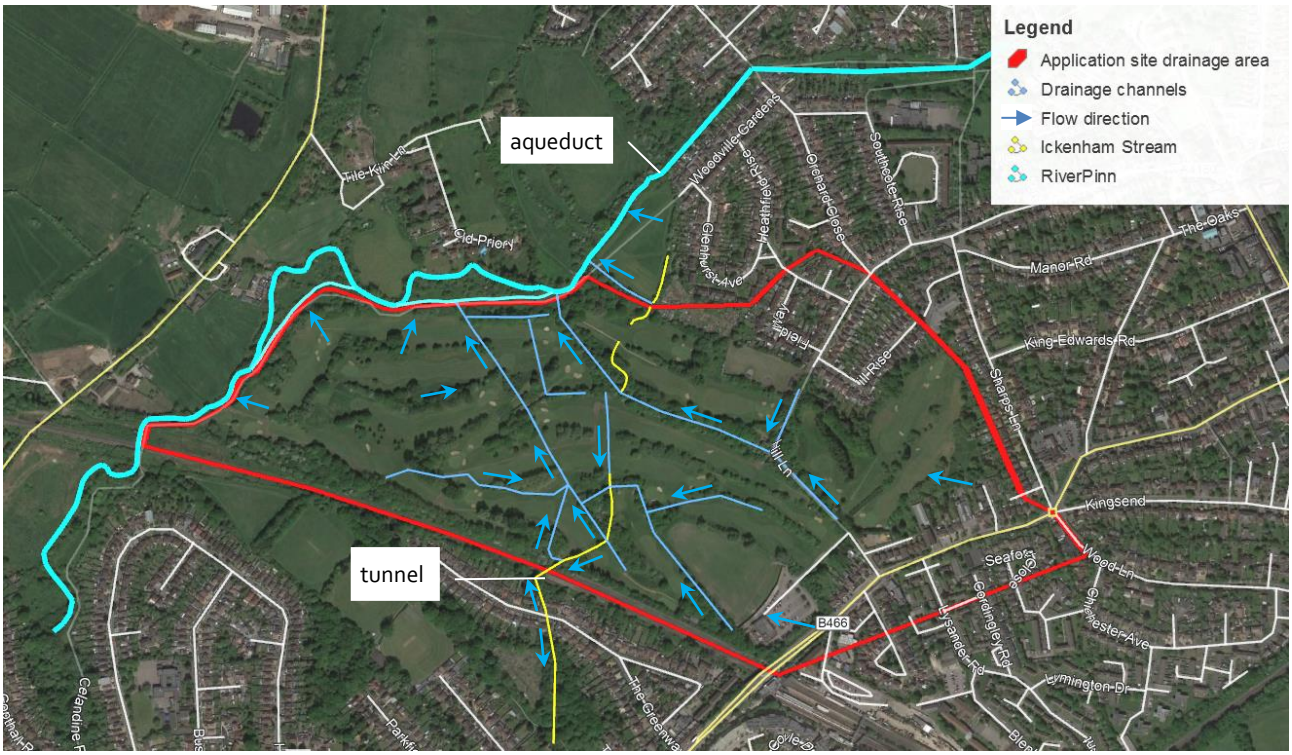


Figure 3 - Hydrological-hydraulic operation of catchment

5.1.6 The existing tunnel under the Chiltern Mainline will be closed because of the HS2 development. As shown in Section 5.3, there will be a negligible change in the local contributing catchments to the north of the Chiltern Mainline and consequently no significant alteration of the water flows within the application site. However, this closure could locally affect to the drainage of the small sub-catchment to the south of the Chiltern Mainline.

5.2 Catchment demarcation

5.2.1 Catchment boundaries have been obtained based on the following information:

- HS2 LIDAR, cell size 0.20 m
- Environmental Agency LIDAR, cell size 1.0 m
- SCS JV utilities map: Thames Water sewer network
- Site visits

5.2.2 ArcMap software within the terrain processing module has been used to demarcate catchments boundaries and drainage flow paths. Resulting drawings have been checked and, when necessary, corrected in order to make them coherent with the DEM data and other information sources.

5.2.3 The application site catchment area is 55.4ha. As Figure 4 illustrates, this catchment has been divided into three sub-catchments, depending on the discharging points to the River Pinn:

- SC1 sub-catchment: area to the north of Clacks Lane that drains to the River Pinn;
- Golf course sub-catchment: it comprises the SC2 sub-catchment plus the SC4 (area to the south of Chiltern Mainline). It drains to the River Pinn through the central channel;
- SC4 sub-catchment: it comprises the area located to the south of the Chiltern Mainline and to the north of the Greenway Road which partially drains to the north;
- Ickenham sub-catchment: it comprises the area of the SC2 sub-catchment to the east of the Ickenham Stream. It drains to the tunnel and central channel; and
- SC3 sub-catchment. It drains to the River Pinn along the west boundary of the application site.

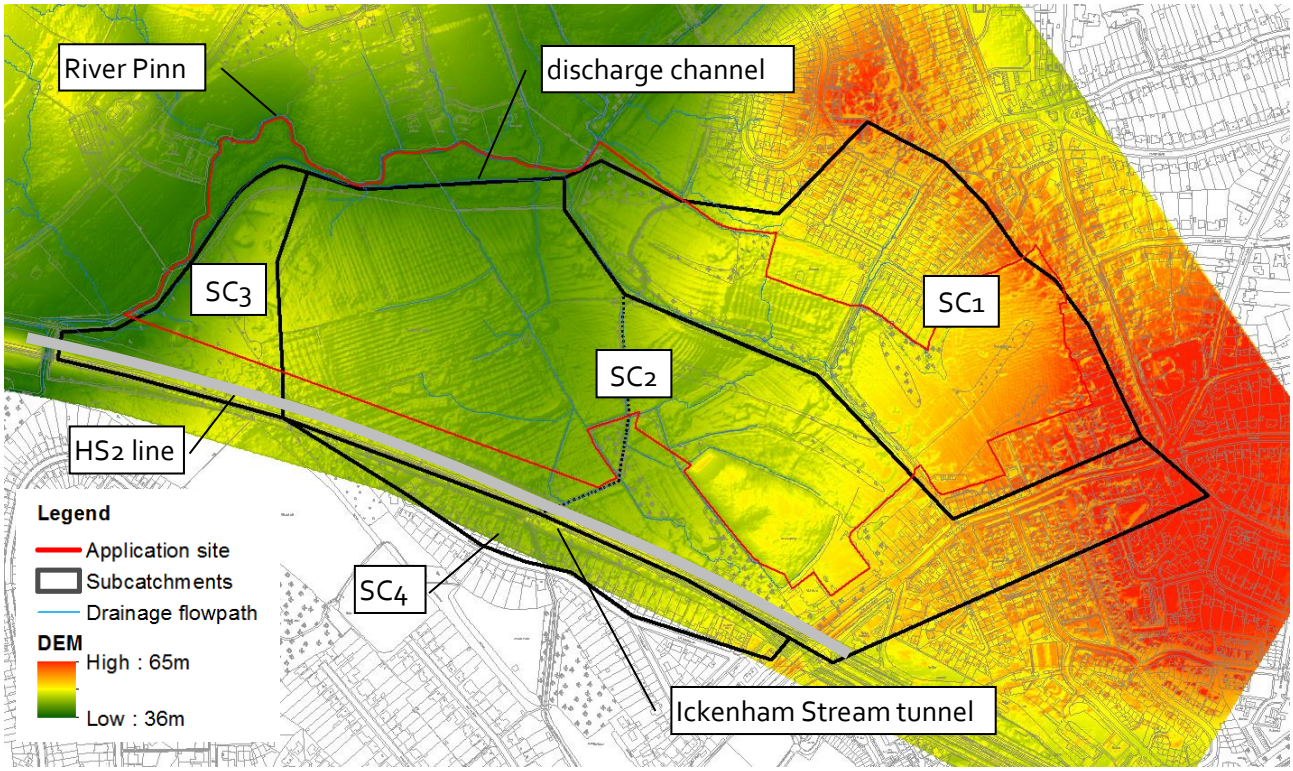


Figure 4 - DEM and sub-catchments

5.2.4 The main characteristics of the sub-catchments above are described as follows:

Sub-catchment	Area (ha)	Type	Drains to
SC1	18.2	Mixed: rural (71%), urban (29%)	Clacks Lane´s channels to the River Pinn
Golf course (SC2+SC4)	35.5	Mixed: rural (82%), urban (18%)	central channel to the River Pinn
Ickenham (part of SC2)	16.8	Mixed: rural (67%), urban (33%)	tunnel / central channel

Sub-catchment	Area (ha)	Type	Drains to
SC4	2.8	Mixed: rural (70%), urban (30%)	tunnel / Ickenham south
SC3	4.6	Rural	River Pinn

Table 4 - sub-catchment characteristics

5.3 Runoff estimation

5.3.1 Runoff estimation has been developed in the Drainage Report which accompanies this application. Main results have been extracted and are showed in Table 5 and Table 6:

Sub-catchment	Cv,sum	Cv,wint	Storm duration (min)	Q2 (l/s)	Q30 (l/s)	Q100 (l/s)	Q100+40% (l/s)
SC1	0.25	0.33	30	463	1,144	1,509	2,101
Golf course (SC2+SC4)	0.15	0.24	60	481	1,195	1,583	2,215
Ickenham (part of SC2)	0.28	0.36	30	450	1,114	1,480	2,064
SC4	0.26	0.34	30	106	243	323	450

Table 5 - mixed type sub-catchments runoff flow results

Sub-catchment	Cv,sum	Cv,wint	Storm duration (min)	V2 (m³)	V30 (m³)	V100 (m³)	V100+40% (m³)
SC1	0.25	0.33	360	1,783	3,553	4,741	6,050
Golf course (SC2+SC4)	0.15	0.24	360	2,527	5,037	6,720	8,792
Ickenham (part of SC2)	0.28	0.36	360	1,790	3,568	4,760	6,075
SC4	0.26	0.34	360	282	562	749	1,048

Table 6 - mixed type sub-catchments runoff volume results

5.3.2 Runoff estimation for rural sub-catchment is showed in Table 7:

Sub-catchment	Area (ha)	Qmed (l/s)	Q2 (l/s)	Q30 (l/s)	Q100 (l/s)
SC3	4.6	21.0	21.0	46.5	62.6

Table 7 - rural sub-catchment runoff flow results

6 Proposed development

6.1 Description

6.1.1 This application is for the redevelopment of the existing 18 hole Ruislip Golf Course to provide a nine hole golf course and six hole academy course, the creation of a new channel for the Ickenham Stream (canal feeder), the demolition and replacement of the driving range with a new 20 bay driving range and the provision of a single storey rifle range.

6.1.2 The remodelling of the golf course necessitates modifying the existing ground levels in parts of the application site. However, there are some areas that remain at the existing levels as shown in Figure 5.

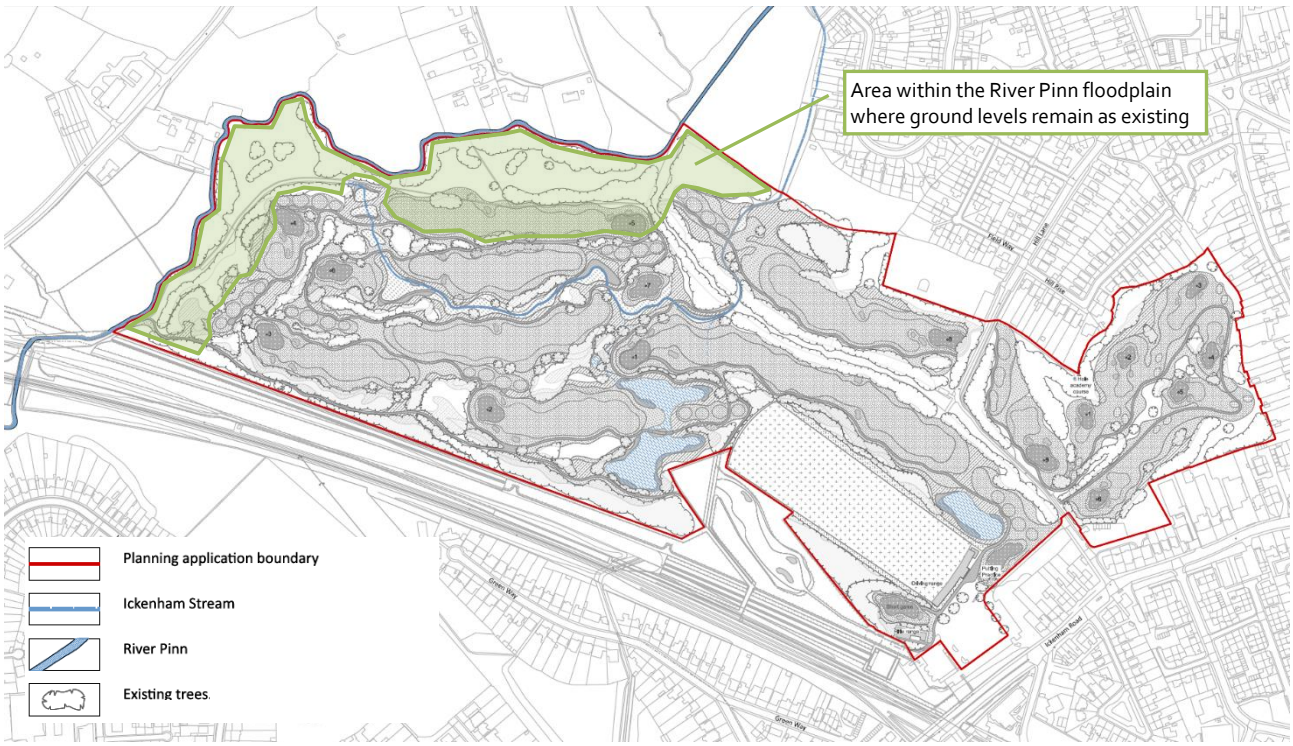


Figure 5 - Proposed General Arrangement

6.2 Drainage strategy

6.2.1 A new drainage network has been designed for the proposed development. The main features of the proposed drainage network for the application site are summarised below. Further details can be found in the Drainage Report which accompanies this application.

6.2.2 The proposed drainage network discharges into the River Pinn, as it currently does. The Ickenham Stream diversion is integrated into the proposed drainage network of the golf course.

6.2.3 A surface drainage system is provided for the fairways and rough areas. Surface water is collected by gullies located along the perimeter of the playable areas and run into the main gravity drain pipes. The drainage network will be designed for a 1 in 5 return period rainfall.

6.2.4 Green and tee areas, bunkers and the driving range outfield are drained by subsurface drainage which is connected to the main gravity drain pipes. Footpaths are drained by gullies or filter drains. The rest of the application site is drained by open drain elements as channels and swales. These watercourses would also collect the surface runoff in an intense rainfall event which exceeds the design return period.

6.2.5 The irrigation needs of the application site are entirely met by drained water which is collected and stored on site. A water harvesting system is designed as part of the drainage network. The drainage network is connected to three ponds and three tanks which provide the required water storage volume.

6.2.6 The designed drainage network will reduce the current runoff flow rates to the River Pinn. The 1 in 100 rainfall event plus 40% of climate change allowance is attenuated to the Greenfield rates. The attenuation is achieved by providing additional volume in the water harvesting ponds and tanks.

6.3 Runoff estimation

6.3.1 Runoff estimation has been developed in the Drainage Report which accompanies this application. Main results have been extracted and are showed in Table 8.

Discharge point	Catchment	Q2 (l/s)	Q30 (l/s)	Q100 (l/s)	Q100+ 40% (l/s)	V2 (m^3)	V30 (m^3)	V100 (m^3)	V100+ 40% (m^3)
River Pinn (Ickenham diversion)	East	324	635	823	1,103	1,866	3,963	5,236	7,389
	East and West	216	406	483	583	1,776	3,373	4,763	7,359

Table 8 - runoff estimation. Post-development

6.3.2 Comparing the results between the existing and post-development states shows how flow rates and volumes that discharge to the River Pinn are reduced in the post-development state, due to the designed attenuation areas. The post-development discharging point is located downstream of the two existing discharging points and its flow and volume rates are lower than the sum of the two existing discharging points.

6.3.3 The sub-catchment SC3 which drains to the River Pinn in the west of the application site is not modified from the existing state.

6.3.4 The closure of the tunnel under the Chiltern Mainline by the HS2 development will avoid the area to the south of the railway line draining to the application site.

6.4 Flood risk vulnerability classification

6.4.1 The proposed use of land will remain be the same, i.e. a golf course.

6.4.2 Table 2 of the PPG categorises different types of uses and development according to their vulnerability to flood risk. Table 2 classifies as water-compatible development the following uses: a*menity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing room.* Use as a golf course is therefore classified as water-compatible.

7 Existing flood risk

7.1.1 From here on, in current and following sections, the flood risk assessment is carried out.

7.1.2 The following sources of flood risk have been reviewed in accordance with the NPPF and PPG:

- fluvial/tidal flooding;
- surface water flooding (pluvial);
- groundwater;
- sewer flooding; and
- artificial sources of flooding (including reservoirs, burst water mains and canals).

7.2 Rivers

7.2.1 The application site is bounded to the west and north-west by the River Pinn. The River Pinn is an EA 'Main River' and has a catchment size of 29km² at the Chiltern Mainline crossing location. It is the only source of fluvial flooding considered for the application site.

Historic Flood Events

7.2.2 The LB Hillingdon SFRA identifies that substantial historical flooding occurred on the River Pinn in 1977 when residential and non-residential properties were affected. Following this flooding event the River Pinn Flood Alleviation Scheme was implemented and included channel improvement works between 1980 and 1989. Records indicate that further flooding occurred in 1984, 1987, 1988, and in 2000 and 2001 after the completion of the River Pinn Flood Alleviation Scheme.

7.2.3 The River Pinn flood historic information comes from the EA's Recorded Flood Outline dataset which shows all EA records of historic flooding and the EA's Historic Flood Map which shows the maximum extent of all individual recorded flood outlines. Figure 6 shows the maximum historic flood extent at the application site which corresponds to the event occurred in 1977.

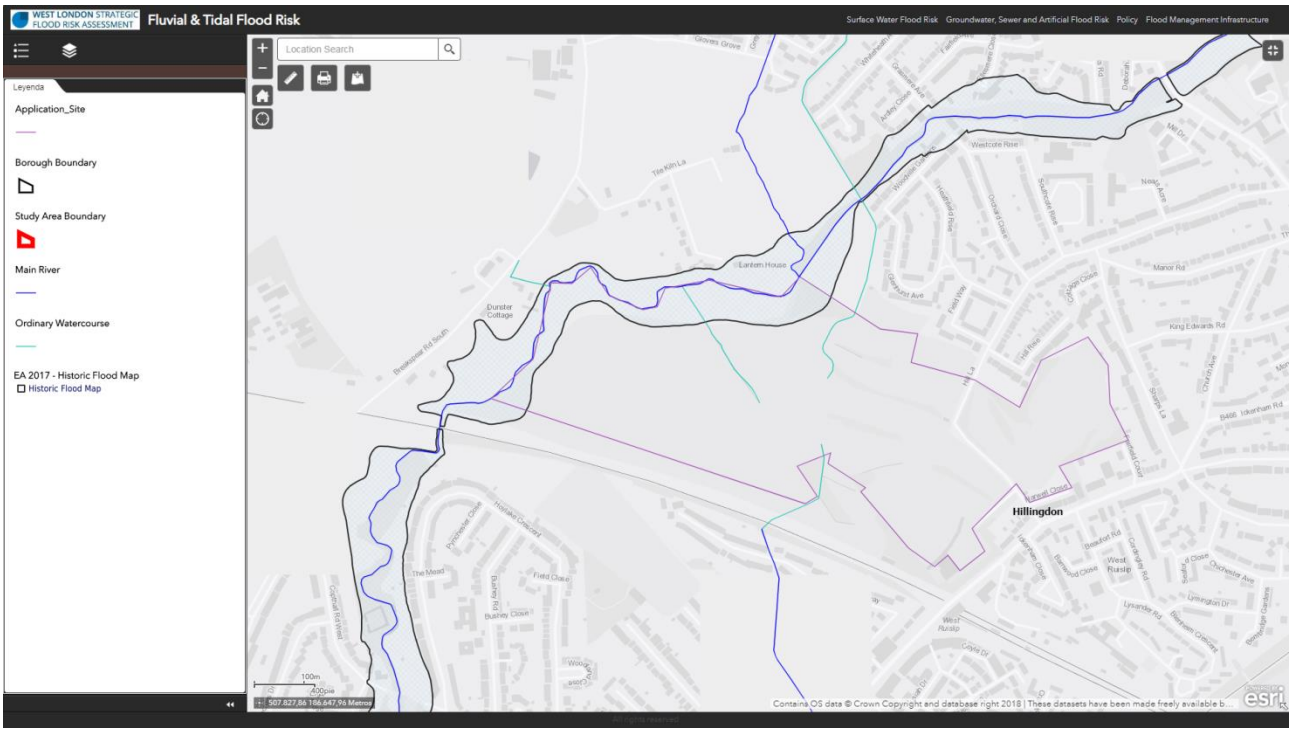


Figure 6 - River Pinn historic flooding (WLSRFA Fluvial and Tidal Flood Risk Map)

Fluvial flood risk maps

7.2.4 The EA produces floodplain maps for the UK, which show the areas at risk of fluvial and/or tidal flooding. The magnitudes of the flooding events considered are defined in terms of an annual probability of occurrence. Although parts of the country are protected by flood defences, the EA flood maps identify undefended floodplain, giving the horizontal extent of the zones defined in Table 1 of the PPG:

Flood zone	Definition
Zone 1 - Low Probability	Land having a less than 1 in 1,000 annual probability of river or sea flooding. (Shown as 'clear' on the Flood Map – all land outside Zones 2 and 3)
Zone 2 - Medium Probability	Land having between a 1 in 100 and 1 in 1,000 annual probability of river flooding; or land having between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (Land shown in light blue on the Flood Map)
Zone 3a - High Probability	Land having a 1 in 100 or greater annual probability of river flooding; or Land having a 1 in 200 or greater annual probability of sea flooding.(Land shown in dark blue on the Flood Map)
Zone 3b - The Functional Floodplain	This zone comprises land where water has to flow or be stored in times of flood. Local planning authorities should identify in their Strategic Flood Risk Assessments areas of functional floodplain and its boundaries accordingly, in agreement with the Environment Agency. (Not separately distinguished from Zone 3a on the Flood Map)

Table 9 - Flood zones definition (Table 1 of the PPG)

7.2.5 As illustrated by the WLSFRA Policy Map, where the EA Flood Map for Planning is concluded (see Figure 7) the northern and western areas of the application site which are attached to the River Pinn are located in Flood Zone 2 and 3.

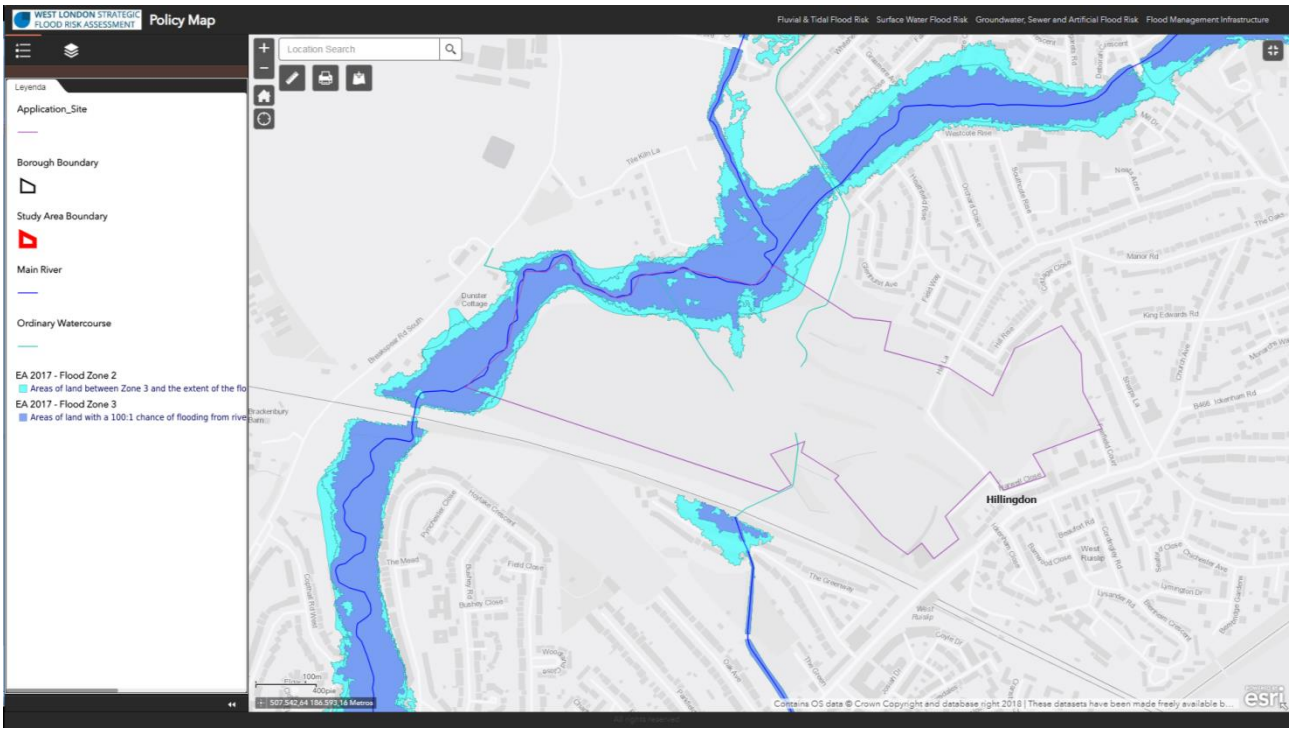


Figure 7 - Flood zones for planning (WLSRFA Policy Map)

7.2.6 Approximately 1.4ha (4.0%) of the application site area (36ha) are inside Zone 2 and 2.4ha (6.7 %) are inside Zone 3. However, most of these areas are located between the River Pinn and the playable area of the golf course, as shown in Figure 8 . These areas are not currently in use by the golf course and can be considered as part of the riverbed. Only a small part of the playable area of the golf course is inside Zone 3.

7.2.7 Figure 7 also shows the floodable area to the south of the tunnel under the Chiltern Mainline, which is out of the application site boundary. The Chiltern Mainline is the boundary of the River Pinn and River Crane hydraulic models performed by Environmental Agency. Existing tunnel under the railway line is not included in these models so the transfer of water between both sides of the line is not assessed.

7.2.8 Figure 8 illustrates the correct route of the discharge channel of the River Pinn which runs along the northern side of the application site, parallel to the Celandine Route footpath. This discharge channel is not accurately represented in the EA´s maps where it is defined as "Main River-Culvert". The area between the River Pinn and this discharge channel is in a natural state and can be considered as part of the riverbed.

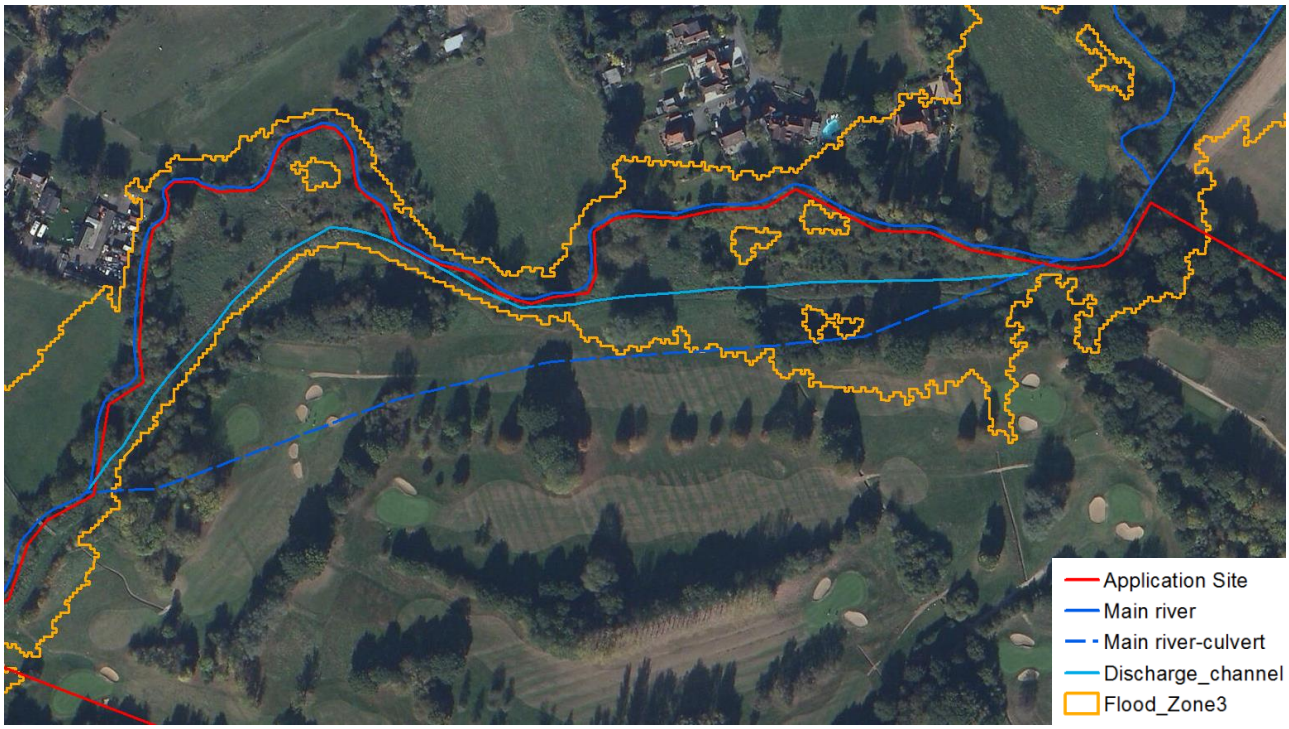


Figure 8 - River Pinn flooding in the Golf Course

7.2.9 The PPG states that the extent of the functional floodplain, also known as Flood Zone 3b, should be defined by LPAs within their SFRAs. This allows for the incorporation of local circumstances and must be agreed with the EA and the boroughs' LLFAs.

7.2.10 The WLSFRA defines Flood Zone 3b (Functional floodplain) as:

- land within EA modelled fluvial and tidal flood risk extents predicted for up to and including 1 in 20-year return period events allowing for the impact of flood defences; and
- land which is included within the EA's Flood Storage Areas dataset.

7.2.11 Flood Zone 3a is defined as:

- land within EA modelled fluvial flood risk extents predicted for up to and including 1 in 100-year return period events;
- land within EA modelled tidal flood risk extents predicted for up to and including 1 in 200-year return period events; and
- land within EA modelled surface water flood risk extents predicted for up to and including 1 in 100-year return period events – Flood Zone 3a (surface water).

7.2.12 The WLSRFA Policy Map shows the extents of the Flood Zone 3a and 3b according to the above definitions, as showed in Figure 9. This map includes as Zone 3b the flood mitigation

areas which are proposed by Flood Alleviation Scheme (FAS) for the River Pinn. Figure 10 shows the planned FAS. According to these maps, a flood mitigation area is proposed within the boundaries of the application site.

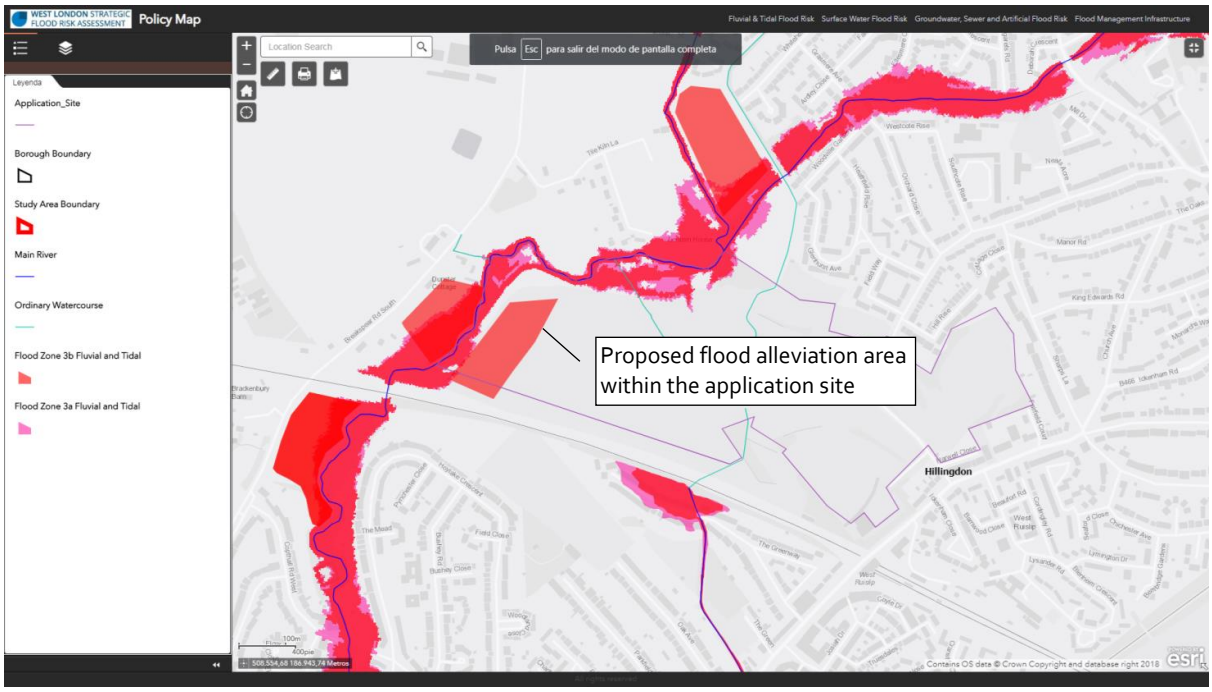


Figure 9 - Fluvial Flood Zone 3a and 3b (WLSRFA Policy Map)

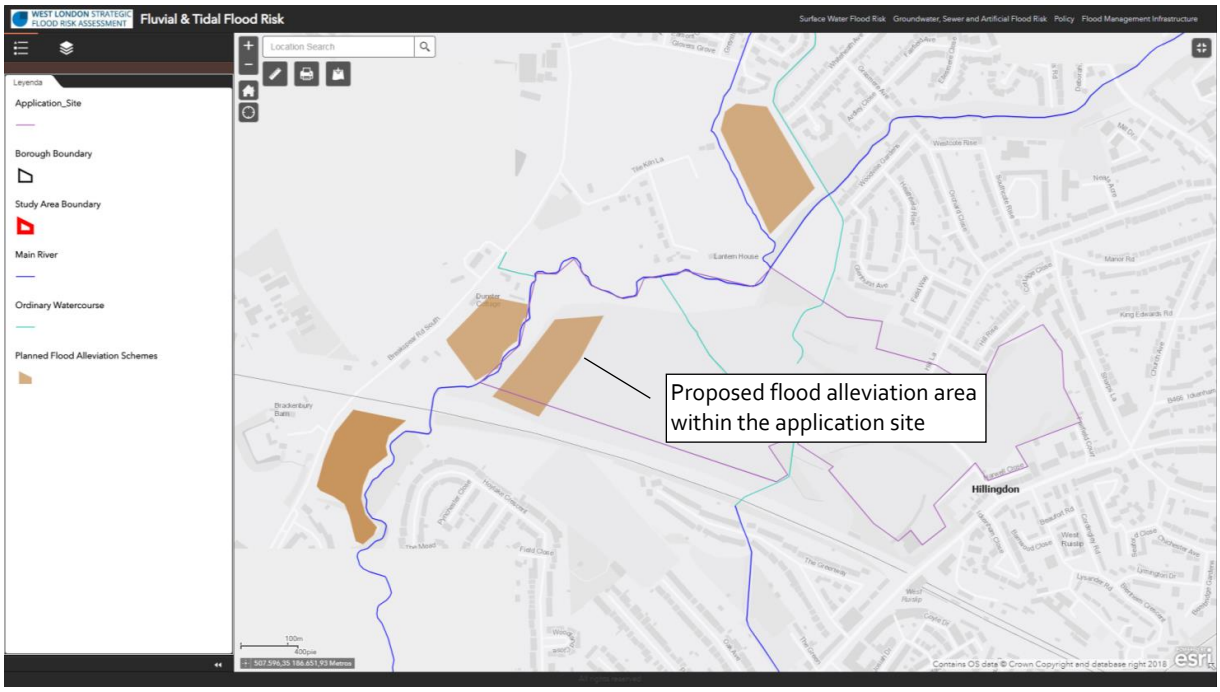


Figure 10 - Planned FAS (WLSRFA Fluvial and Tidal Flood Risk Map)

7.2.13 The River Pinn FAS is being developed by the EA and LB Hillingdon. It was subject to public consultation from March to April 2018 through the document 'River Pinn and Cannon Brook flood reduction proposals. In this consultation document there is not any flood storage area proposed within the application site as Figure 11 shows. Therefore, the information regarding the River Pinn FAS provided in the WLSRFA Policy Map is not coherent with the consultation documents.

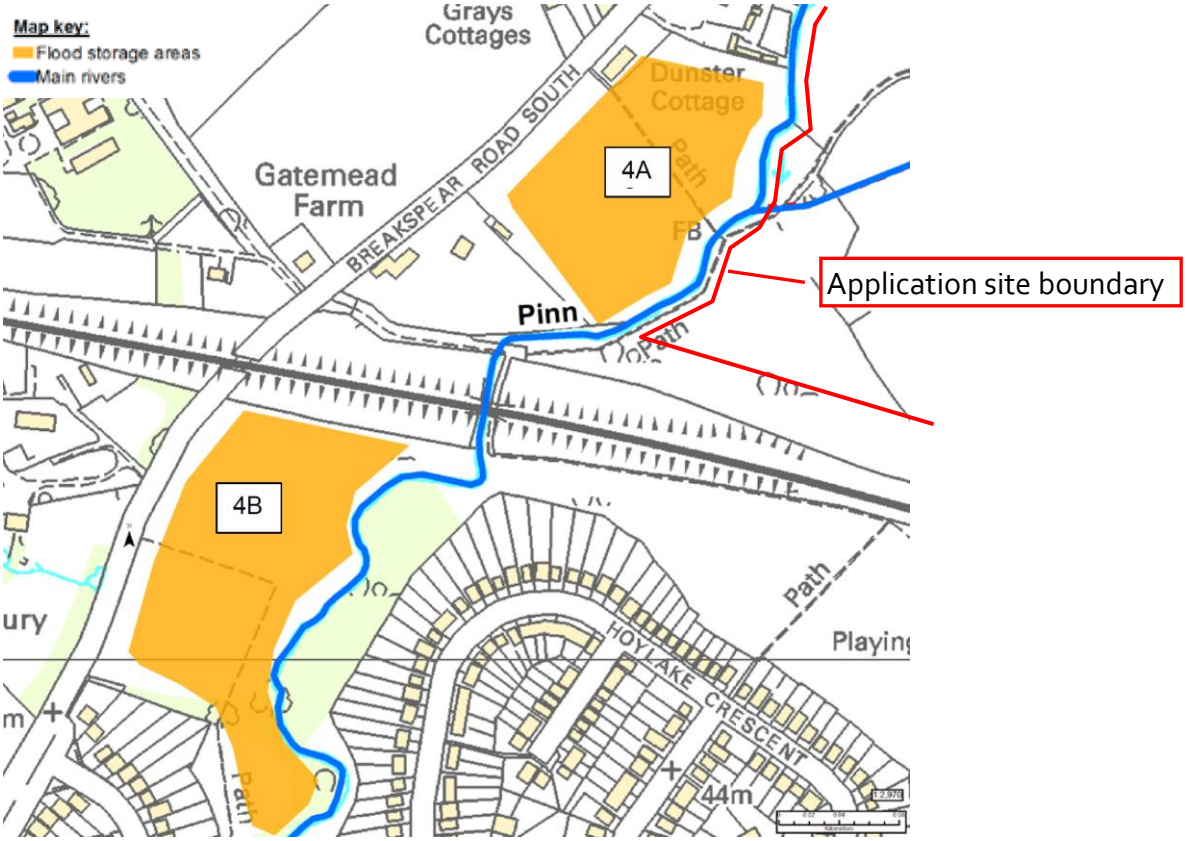


Figure 11 - River Pinn and Cannon Brook flood reduction proposals consultation document. Ickenham flood reduction options (Map 1)

7.2.14 In conclusion, the flood risk of the application site from fluvial source is high-very high, due to its location in Zone 2 and Zone 3 (3a and 3b). However, only approximately 10% of the total area of the application site is inside these Flood Zones.

7.3 Surface Water

7.3.1 Surface water flooding occurs as a result of high intensity rainfall when water is ponding or flowing over the ground surface before it enters the underground drainage network or a watercourse. Ordinary Watercourse flooding occurs under similar circumstances but is associated with non-main river watercourses or ditches.

7.3.2 The section of the Ickenham Stream within the application site is classified as an 'Ordinary Watercourse'. In this FRA, the risk of flooding from ordinary watercourses is covered within

the 'surface water' terminology. This aligns with the inclusion of ordinary watercourse flood risks within the EA's *Risk of Flooding from Surface Water* mapping.

Historic Flood Events

7.3.3 Past records of surface water flooding within Hillingdon have been gathered from sources such as the EA, London Underground as well as LB Hillingdon. These incidents have been mapped in the SWMP and are showed in Figure 12. No incidents have been recorded within the application site.

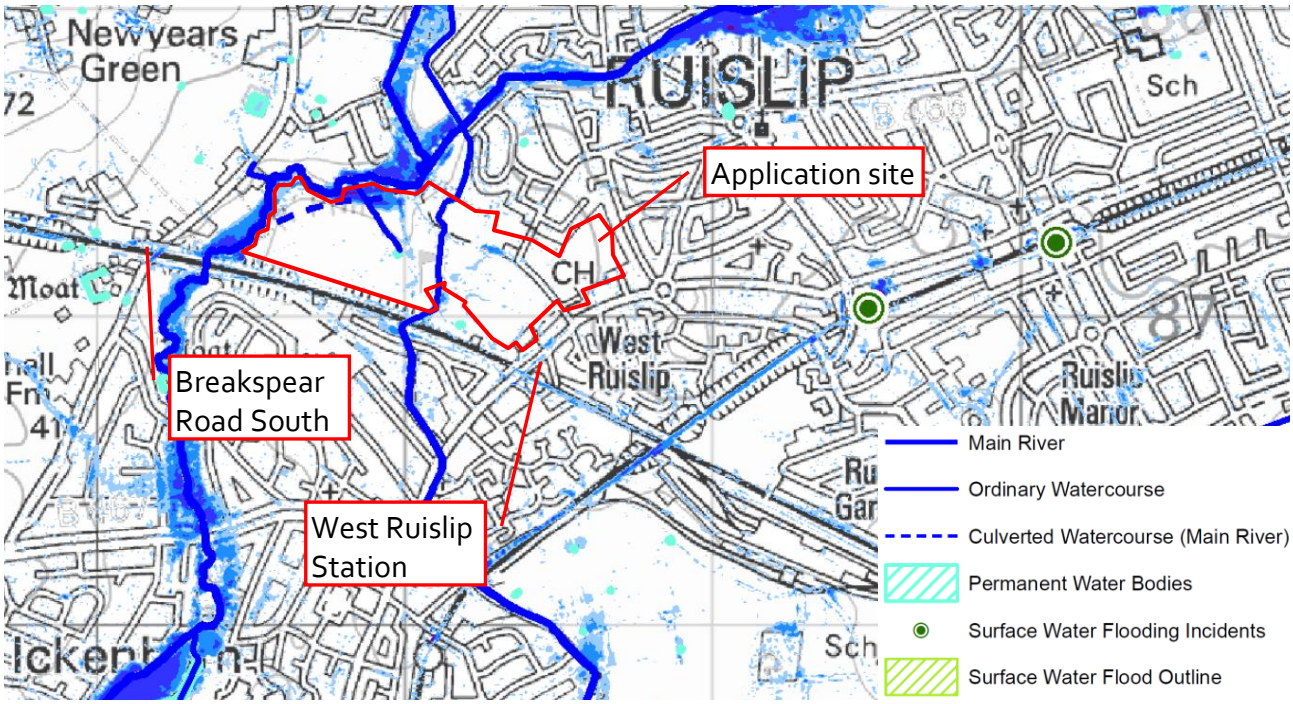


Figure 12 - Surface water flooding incidents (LB HIlingdon SWMP)

7.3.4 As an LLFA LB Hillingdon is also responsible for investigating significant flooding events. LB Hillingdon has produced three Flood Investigation Reports for December 2013 to June 2014, 28th July 2014 and 23rd June 2016. According to these reports flooding in LB Hillingdon is caused by interaction between several sources of flood risk, and the last three significant events have been caused by high intensity summer storms lasting about an hour.

7.3.5 The application site is not identified as a location affected by flooding in any of these reports. However, nearby West Ruislip Station area, located to the south-east of the application site, is affected by flooding according to the July 2014 report. The underpass of Breakspear Road South beneath the Chiltern Mainline, located to the south-east of the application site, is also identified in the three event reports as being affected by flooding.

Surface water flood risk maps

7.3.6 The EA updated the surface water flood models in 2017, and these are shown in the WLSRFA Surface Water Flood Risk Web Map. Figure 13 shows the risk of flooding from surface water for a 1 in 30, 1 in 100 and 1 in 1000 annual probability. The flood depth is also illustrated.

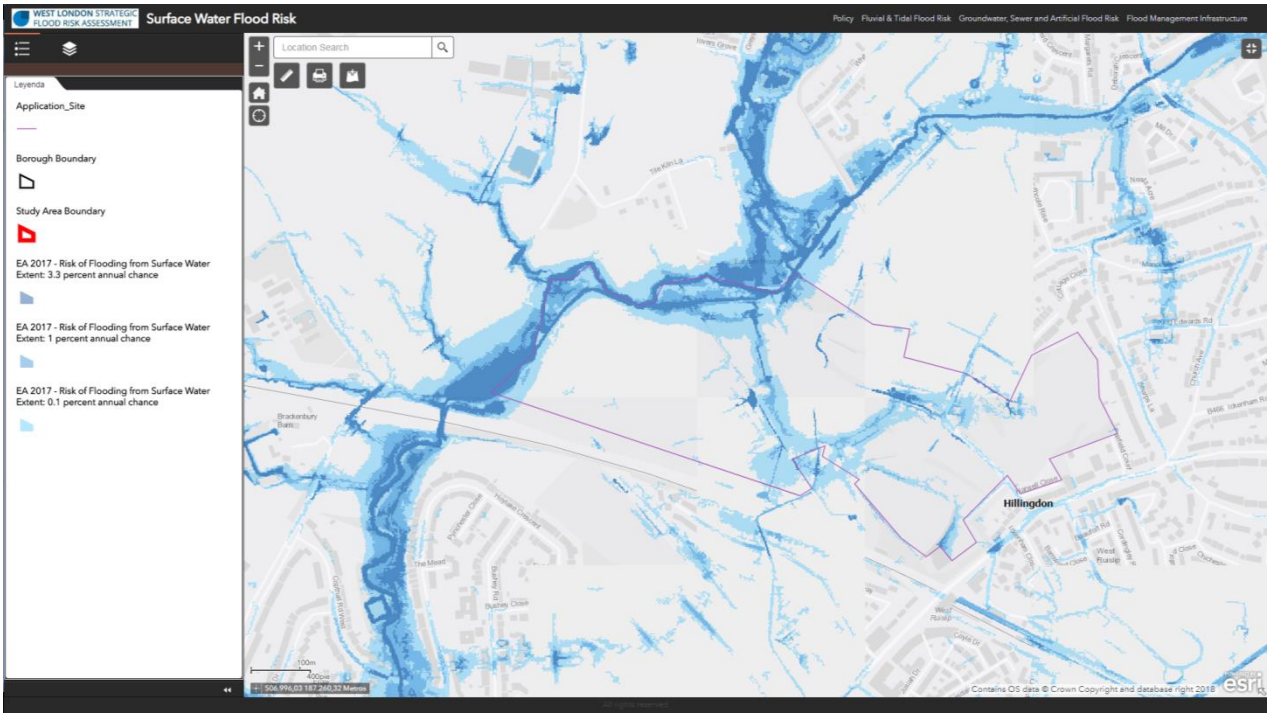


Figure 13 - Risk of flooding from surface water (WLSFRA Surface Water Flood Risk Map)

7.3.7 The areas at risk of flooding in the application site mainly correspond to the ponds, ditches and channels which form the drainage network of the golf course. Additionally, the driving range building is at risk of flooding due to surface runoff from the parking area. In most of these areas at risk of flooding, the flood depth is higher than 0.3m for a 1 in 30-year event. Therefore, the risk of flooding for surface water is high.

7.3.8 The WLSRFA map also highlights Critical Drainage Areas (CDAs). These areas are defined locally by a Borough's SWMP and do not include areas with critical drainage problems as designated by the EA. Heavy rainfall and severe weather leave CDAs at risk from multiple flood risk sources, mainly surface water flooding but typically heavily interrelated with sewers and/or watercourses. According to the WLSRFA Policy Map, there are not any CDAs within the application site. Figure 14 shows the identified CDAs to the west and to the south-east of the application site as well the Zone 3a due to surface water flooding according to the definition in the previous section (1 in 100-year return period event).

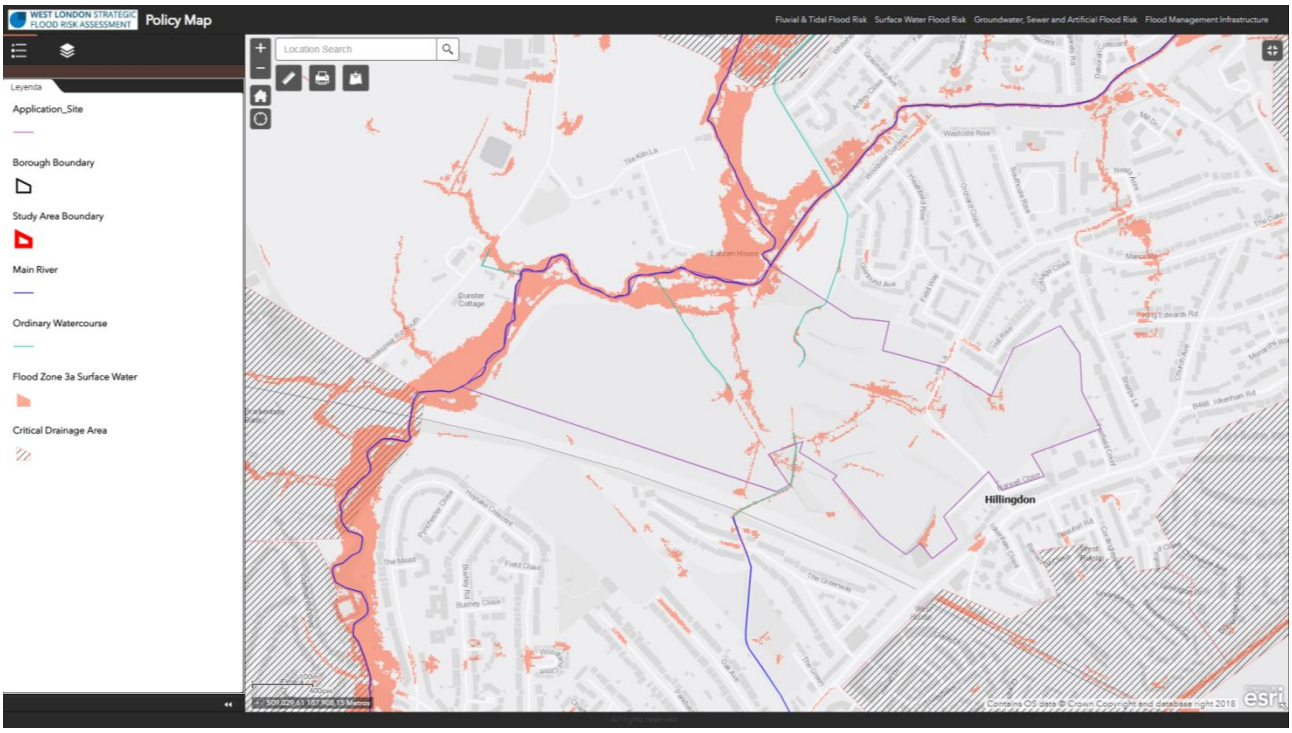


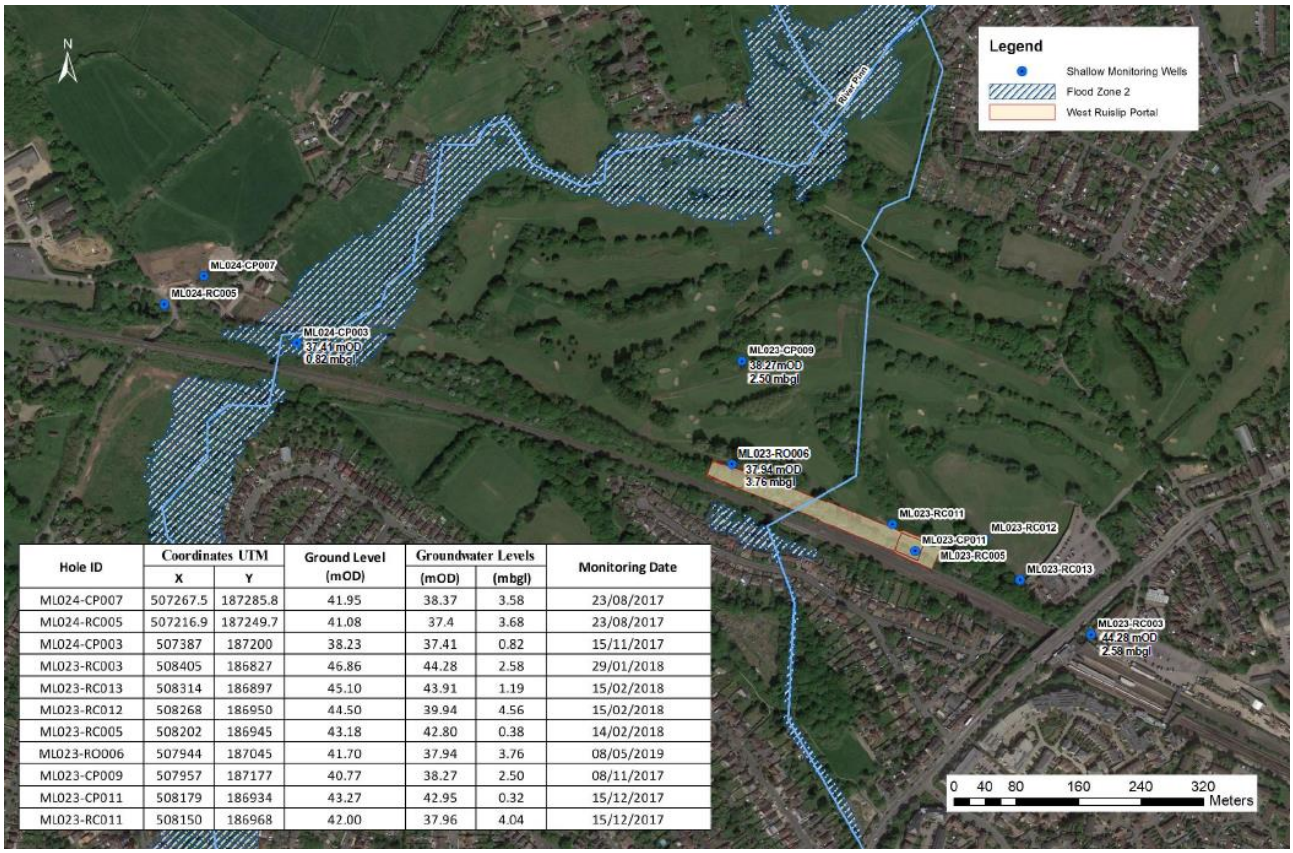
Figure 14 - Surface water Flood Zone 3a and Critical Drainage Areas (WLSFRA Policy Map)

7.4 Groundwater

7.4.1 Groundwater flooding occurs when the groundwater surface rises to or above the ground surface, causing flooding in extreme circumstances. This source of flooding tends to occur after extensive periods of heavy rainfall causing groundwater rise.

7.4.2 According to the WLSRFA, most of the application site is underlain by London Clay, a composition of clay, silty clay/mudstone, sandy silts and sandy clayey silts. This geological unit generally has a low hydraulic conductivity which means water does not easily move through it. However, because of this characteristic and poor drainage, ponding can occur. HS2 ground investigations have monitored groundwater levels at this area. The results show in Figure 15 that piezometric surface is mostly between 1m t and 4m below ground level with exception of less than 1m depth at 3 locations. However, the locally elevated water levels are most likely due to poor infiltration, demonstrated by large disparity between neighbouring boreholes; rather than being an indicator of a high rising groundwater table. For borehole installation detail and groundwater level data, refer to Appendix A.

7.4.3 Geological mapping indicates that superficial deposits are present along a narrow ribbon of alluvium associated with the River Pinn. Superficial deposits in the region are predominantly River Terrace Deposits (RTDs) which are comprised of sand and gravel, with lenses of silt, clay or peat. The RTDs unit is a Secondary A aquifer, often referred to as the Upper Aquifer within the London area. The Lower Aquifer is present within the basal sands and the Chalk, its piezometric head is lower than that of London Clay, indicating underdrain situation.



Hole ID	Coordinates UTM		Ground Level (mOD)	Groundwater Levels		Monitoring Date
	X	Y		(mOD)	(mbgl)	
ML024-CP007	507267.5	187285.8	41.95	38.37	3.58	23/08/2017
ML024-RC005	507216.9	187249.7	41.08	37.4	3.68	23/08/2017
ML024-CP003	507387	187200	38.23	37.41	0.82	15/11/2017
ML023-RC003	508405	186827	46.86	44.28	2.58	29/01/2018
ML023-RC013	508314	186897	45.10	43.91	1.19	15/02/2018
ML023-RC012	508268	186950	44.50	39.94	4.56	15/02/2018
ML023-RC005	508202	186945	43.18	42.80	0.38	14/02/2018
ML023-RO006	507944	187045	41.70	37.94	3.76	08/05/2019
ML023-CP009	507957	187177	40.77	38.27	2.50	08/11/2017
ML023-CP011	508179	186934	43.27	42.95	0.32	15/12/2017
ML023-RC011	508150	186968	42.00	37.96	4.04	15/12/2017

Figure 15 groundwater monitoring from HS2 investigations

Historic Flood Events

7.4.4 The Hillingdon SWMP provides a summary of the previous records of flooding attributed to of groundwater. Figure 16 extracted from SWMP, shows the geographical locations on these incidents within the Borough.

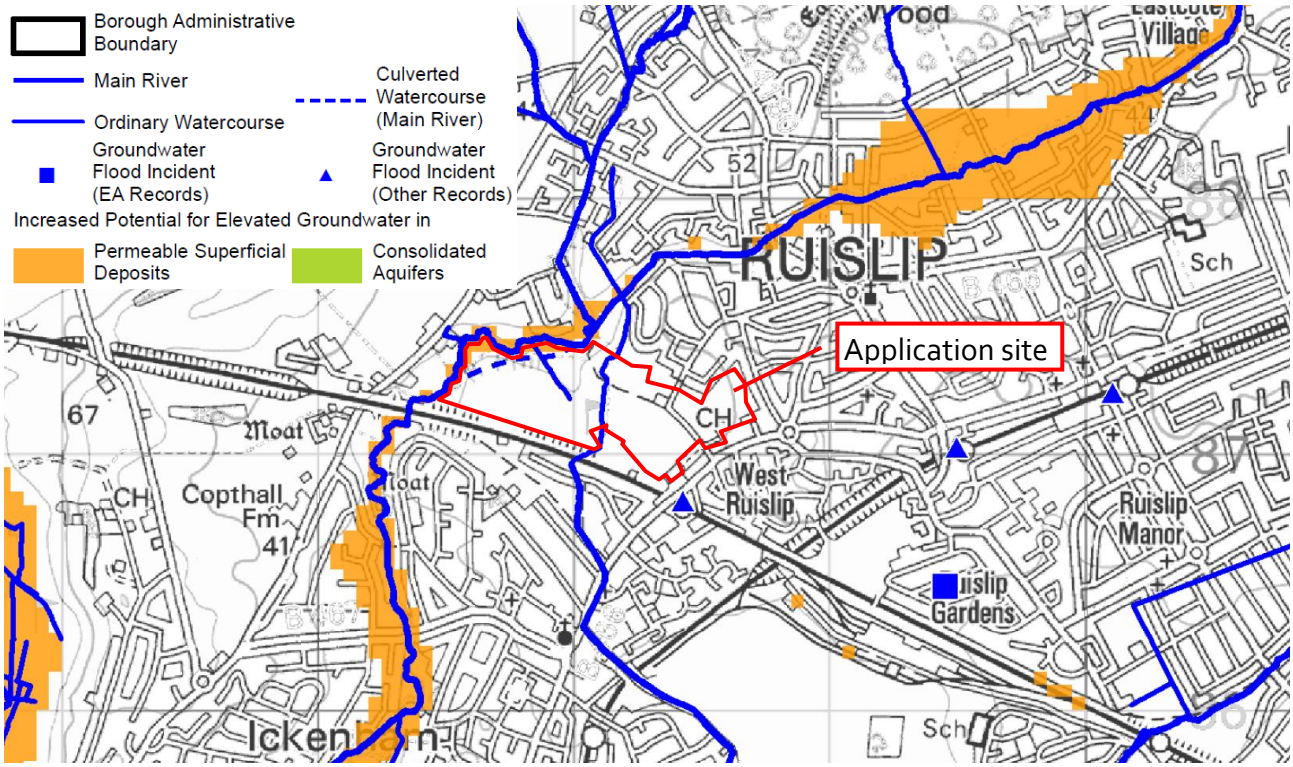


Figure 16 - Map of historic groundwater flood incidents (LB Hillingdon SWMP)

Groundwater flood risk maps

7.4.5 Figure 17 shows the Areas Susceptible to Groundwater Flooding (AStGWF) which were identified by the EA in 2017 and are included in the WLSFRA Sewer, Groundwater & Artificial Flood Risk Web Map. The ATtGWF map is a scale map showing groundwater flood areas on a 1km square grid. The map shows the proportion of each 1km grid square where geological and hydrogeological conditions show that groundwater might emerge, but does not show the likelihood of groundwater flooding occurring. The data should not be interpreted as identifying areas where groundwater is likely rise above the ground surface (i.e. pond or flow), thus causing flooding.

7.4.6 According to the AStGWF, the application site has a low susceptibility (<25%) to groundwater flooding. This is in agreement with our judgement of groundwater flooding potential in the area.

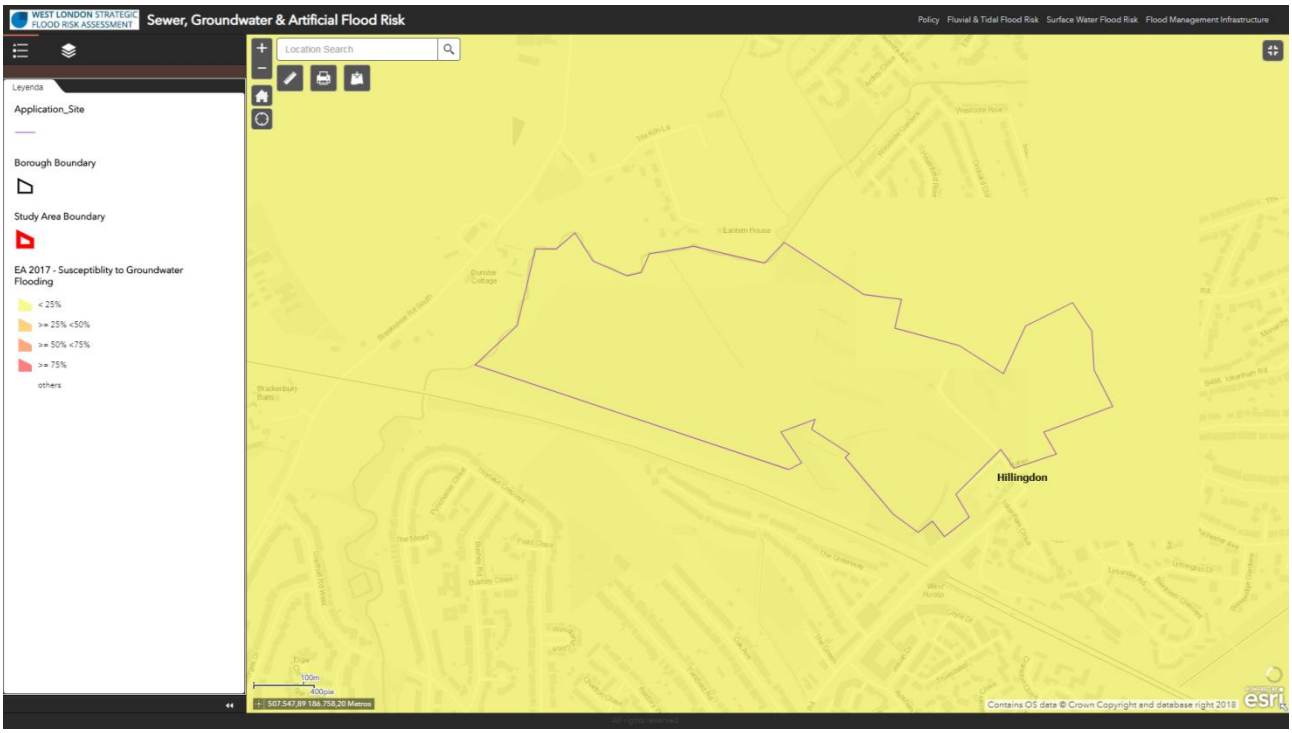


Figure 17 - Susceptibility to groundwater flooding (WLSFRA Groundwater, Sewer and Artificial Flood Risk Map)

7.4.7 Figure 18 shows the Increased Potential for Elevated Groundwater Map (GLA Drain London, 2011) which is also included in the WLSFRA Web Map. This map identifies the areas where there is an increased potential for groundwater to rise sufficiently to interact with the ground surface or be within 2m of the ground surface.

7.4.8 According to this map, the permeable superficial deposits that exists along the River Pinn is an area where the groundwater may become elevated in response to higher than average recharge from rainfall or from elevated river levels.

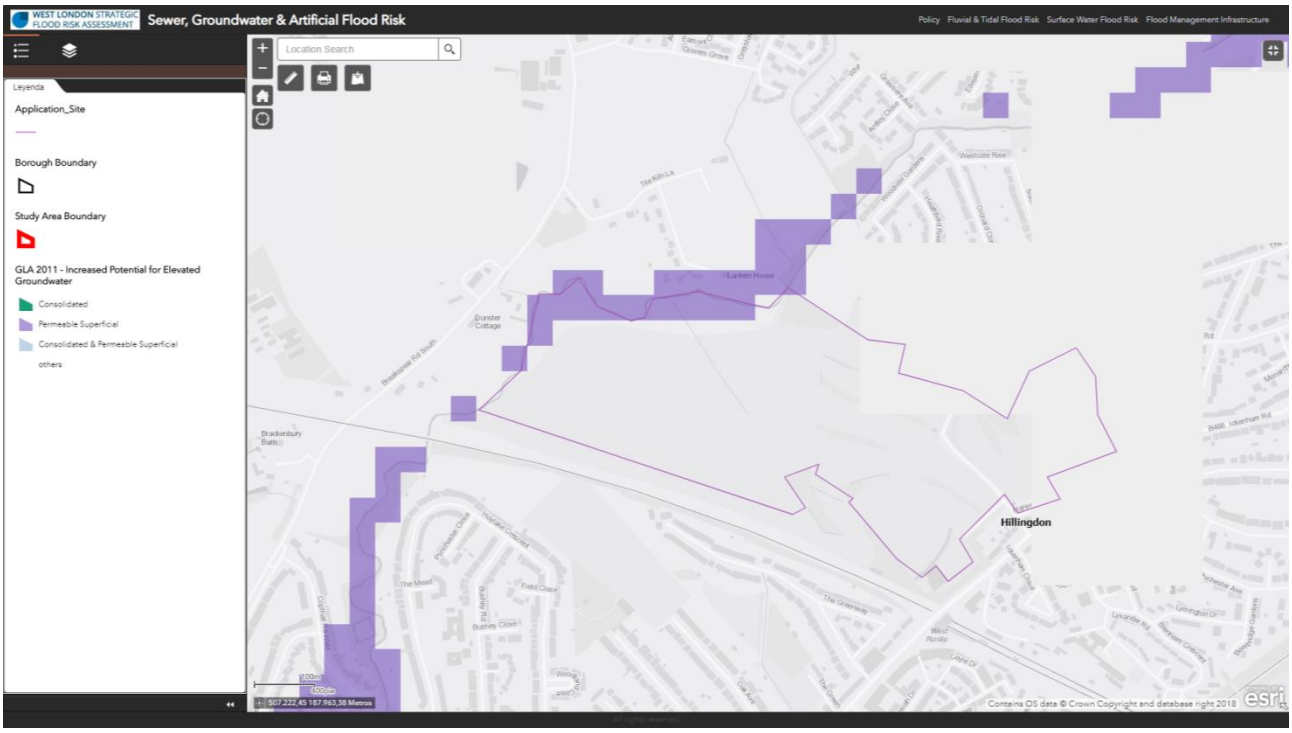


Figure 18 - Increased Potential for Elevated Groundwater (WLSFRA Groundwater, Sewer and Artificial Flood Risk Map)

7.4.9 The existing infrastructure of the application site is above-ground. Therefore, according to the previous information, there will be no significant risk of groundwater flooding to within the application site.

7.5 Drainage and Sewer Systems

7.5.1 Flooding from foul and combined sewers occurs when rainfall exceeds the capacity of networks or when there is an infrastructure failure.

7.5.2 In LB Hillingdon the sewer network is a largely separated foul and surface water system with some areas still utilising a combined system (in a combined system foul sewage and rain water are drained using the same pipes). Drainage in the sub-region is serviced by Thames Water Utilities Ltd (Thames Water). According to the data provided by Thames Water to SCS JV, there is not a developed sewerage network within the application site. However, there is an internal surface water network for collecting the rain water from the golf course parking area and the driving range and club house buildings. This network discharges into the golf course drainage system, as several surface water pipes external to the application site area do. In addition, a foul drainage pipe crosses the application site from north to south.

7.5.3 According to the SWMP, there are no historic records of flooding attributed to the sewerage network in LB Hillingdon.

7.5.4 The Thames Water historical sewer flooding dataset provides details on the number of reported sewer flood incidents in postcode sectors (a four-digit postcode). The WLSFRA

reports an updated number of historical incidents of sewer flooding in the Web Map according to the Thames Water data (2017); the exact location of these incidents, however, is not available. Figure 19 shows these sewer flooding records (no. of instances). There are no sewer flooding reports in the application site.

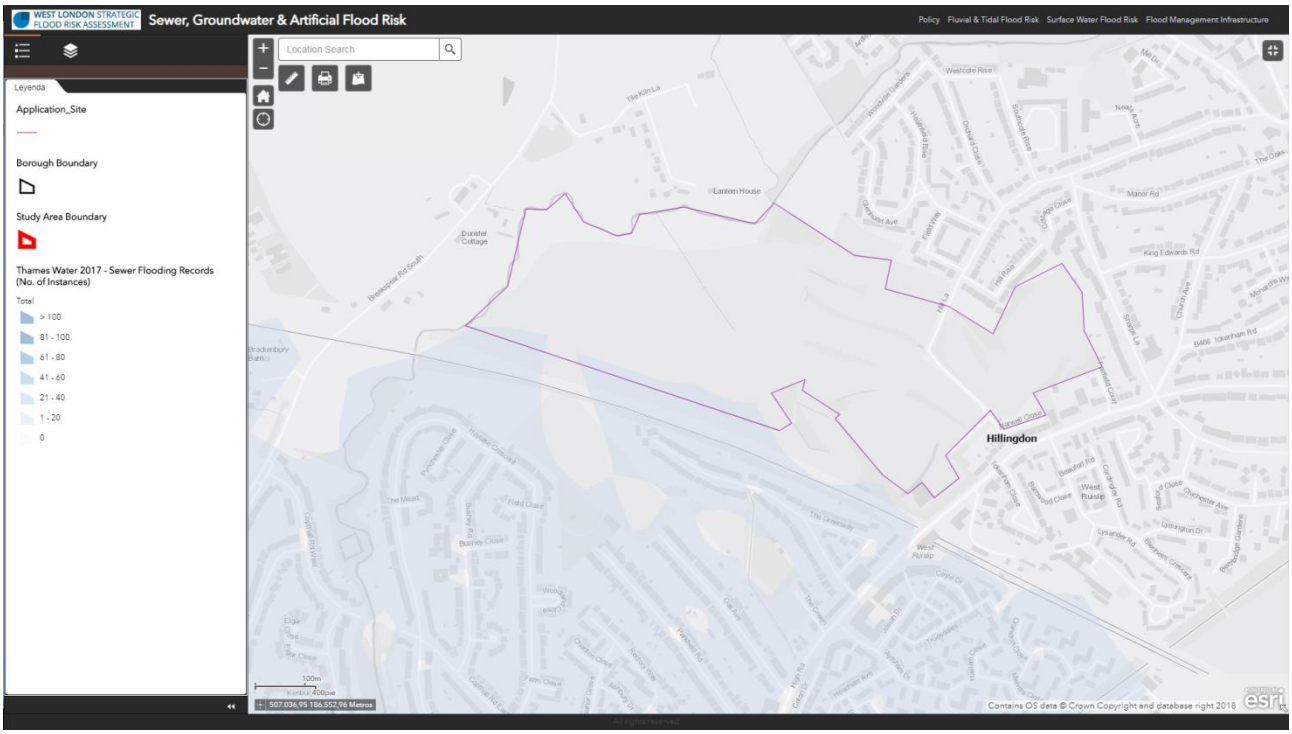


Figure 19 - Sewer flooding records (WLSFRA Groundwater, Sewer and Artificial Flood Risk Map)

7.5.5 In conclusion, the risk of flooding by sewer and drainage sewer is considered medium. Although there is not a developed sewerage network in the application site, the existing foul drainage pipe which crosses the application site and the internal drainage system of the parking area and the buildings are potential sources of flooding. The risk of flooding due to the surface pipes which discharge into the existing drainage system is covered by the 'surface water flood risk' analysis.

7.6 Artificial Sources

Reservoir flooding

7.6.1 As shown in Figure 20, the application site is situated within the extent of potential reservoir flooding, from the Ruislip Lido. This reservoir historically fed the Grand Union Canal by way of an artificial watercourse (the Ickenham Stream canal feeder) and is currently owned by LB Hillingdon.

7.6.2 The Reservoir Flood Map Outline provided by the EA shows the largest area that might be flooded if a reservoir were to fail and release the water it holds. Since this is a prediction of a

credible worst-case scenario, it's unlikely that any actual flood would be this large. This data is intended for emergency planning only and not reliable for large scale flood risk assessments.

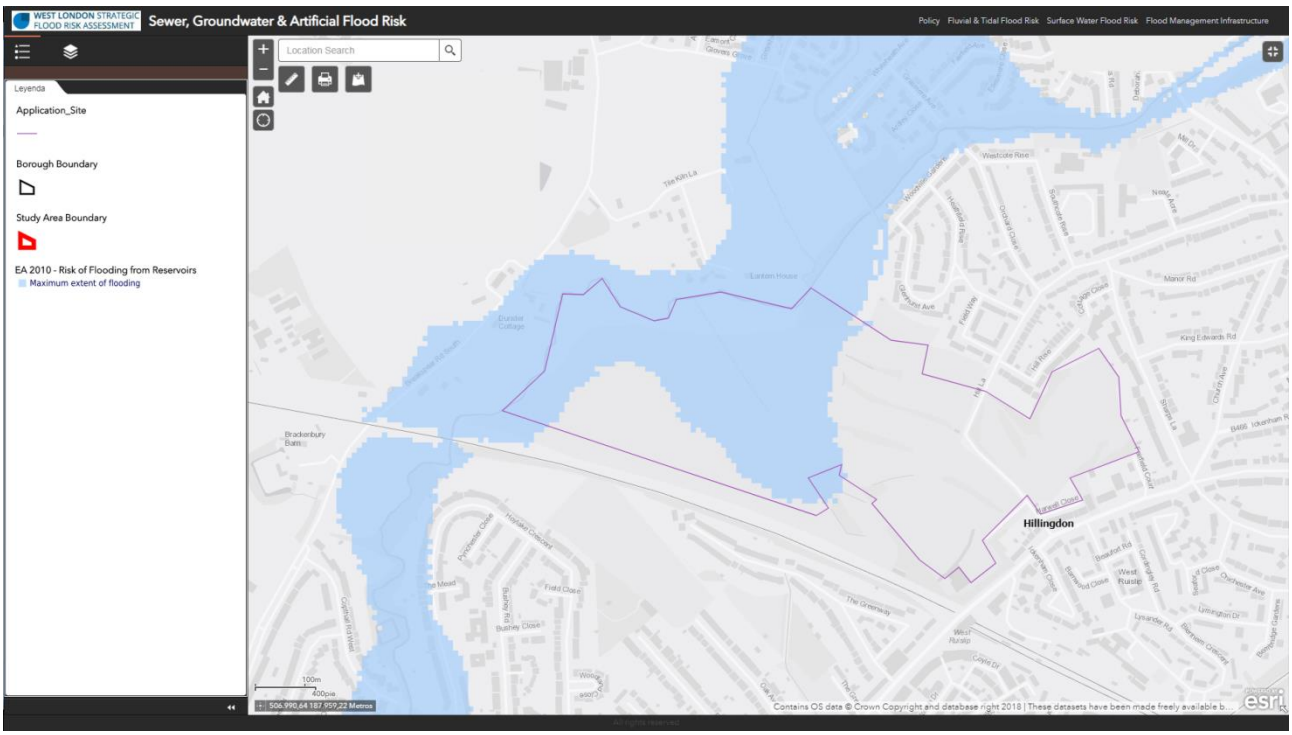


Figure 20 - Maximum extent of flooding from reservoirs (WLSFRA Groundwater, Sewer and Artificial Flood Risk Map)

7.6.3 In response to planned improvements by LB Hillingdon at Ruislip Lido in 2011 a FRA was undertaken to assess the current risk of flooding and the possible changes in water level. Consequently, the normal water level was lowered in order to prevent or limit any outflow from the Ruislip Lido. LB Hillingdon has a strategy in place for monitoring water levels in the reservoir.

7.6.4 Although there is the potential to have an impact on the residual risk of flooding from the reservoir the likelihood of such flooding occurring is very low.

Water mains

7.6.5 According to the SCS JV utilities map (Affinity Water network), there are no water mains in the vicinity of the application site that could pose a flood risk within the study area. Only small sized pipes (3" diameter) run along Ickenham Road to supply the properties.

Canals

7.6.6 There are no canals in the vicinity of the application site that could pose a flood risk within the study area.

7.7 Summary of baseline flood risk

7.7.1 The table below summarises the baseline flood risk for all sources of flooding in the application site.

Source of flooding	Location	Flood Risk Category	Elements at risk	Assessment to the risk
River Pinn	Area comprised between the River Pinn and the golf course play area	Very High Flood Zone 3b	None	Golf course play area are not inside the functional floodplain of the river.
	Golf course play area	Medium Flood Zone 2	None	Floodplain compatible with golf course (water-compatible use)
Surface water	Golf course play area	High Flood depth >0.3m for a 1 in 30 year event	None	The channels and ponds which form part of the drainage network of the golf course are flooded
	Parking area at the driving range building	Medium Flood depth <0.3m for a 1 in 30 year event	Driving range building	Driving range building is at the lowest point of the parking area where the surface runoff is accumulated
Groundwater	Application site	Low	None	The existing infrastructure of the application site is above-ground
Drainage and sewer systems	Application site	Medium Surcharge point within 20m of site and restricted pathways.	Driving range building	Surface sewer network along the eastern boundary of the application site. A foul sewer line crosses the application site from north to south
Artificial sources – Ruislip Lido	Golf course play area	Low Within inundation mapping/pathway exists.	None	
Artificial sources – water main	Application site	N/A	N/A	There are no water mains in the vicinity of the application site
Artificial sources – canals	Application site	N/A	N/A	There are no canals in the vicinity of the application site

Table 10 - Baseline flood risk for all sources of flooding

8 Flood risk mitigation measures

8.1 Rivers

8.1.1 The ground levels and land use of the portion of the application site which is inside the floodplain of the River Pinn are not modified.

8.2 Surface Water

8.2.1 The proposed drainage network will collect and attenuate the surface water runoff before discharging it to the River Pinn.

8.3 Groundwater

8.3.1 There is no significant risk of flooding from groundwater, nor is there any anticipated effect on the risk of flooding from groundwater within the study area as a result of the proposed development. Consequently, no specific mitigation is required.

8.4 Drainage and Sewer Systems

8.4.1 The proposed drainage network of the development will collect and attenuate the surface water runoff before discharging to the River Pinn.

8.5 Artificial Sources

8.5.1 There are no instances where the proposed development will be at significant risk of flooding from artificial sources and consequently no specific mitigation is required.

8.5.2 Due to the extremely low probability of flooding due to a breach of Ruislip Lido and the likely low significance of any impacts arising from the proposed development, it is not considered necessary to provide additional mitigation for this scenario.

9 Post development flood risk

9.1 Rivers

9.1.1 The impact of the proposed development on the existing flood risk from the River Pinn is not significant. The proposed development does not modify the floodplain of the River Pinn. In addition, the use of land remains the same as the existing use which is classified as water-compatible by PPG.

9.2 Surface Water

9.2.1 The proposed development will alter overland flow routes, such as the Ickenham Stream. However, the proposed drainage system will collect the surface water runoff and attenuate it before discharging to the River Pinn.

9.2.2 Therefore, the flood risk from surface water will be decreased.

9.3 Groundwater

9.3.1 The proposed development will not lead to a change in the risk of flooding from groundwater.

9.4 Drainage and Sewer Systems

9.4.1 The proposed drainage network has considered the surface runoff water that could enter the application site from the external sewer network. Therefore, if the sewer network in the vicinity of the application site is surcharged resulting in flooding of the application site, the proposed drainage network will be able to collect it appropriately.

9.4.2 The risk of flooding of the application site will therefore be lower than existing.

9.5 Artificial Sources

9.5.1 The impact of the proposed development on the actual risk of flooding from impounded reservoir failure will be negligible.

9.6 Residual flood risks

9.6.1 Residual flood risks arise in situations that are not included in standard design scenarios. All design is generally undertaken assuming that existing infrastructure is functioning under normal conditions. Consequently, there may be areas where the potential severity of flooding may exceed the design standard under certain circumstances.

Residual flood risks from rivers

9.6.2 There are no locations in the River Pinn where the failure or blockage of a hydraulic structure would lead to an increase in the severity of flooding sufficient to create a residual risk of flooding to the application site.

9.6.3 The WLSFRA Fluvial & Tidal Flood Risk Web Map highlights areas at risk of fluvial flooding that currently benefit from flood defence schemes. Structural failure of fluvial flood defences presents a residual risk due to breaching or overtopping of these defended areas. However, the application site does not currently benefit from any flood defence scheme

Residual flood risks from surface water and minor watercourses

9.6.4 A failure or blockage of the culverts or the flow control structures in the proposed drainage network could increase the severity of flooding. However, outflow structures (weirs) are provided to these elements in order to ensure the water flows in a controlled way in any case. This increment of flooding would only affect to the golf course playable area.

Residual flood risks from groundwater

9.6.5 The risk of flooding from groundwater already considered presents an absolute risk and there are no significant residual risks arising from this source.

Residual flood risks from drainage systems

9.6.6 A failure or blockage of the pipes of the proposed drainage network could increase the severity of flooding. However, water flooding would run over the surface to lower ground levels where proposed open channels and ponds would collect it.

Residual flood risks from artificial and surface waterbodies

9.6.7 The only area of flood risk associated with an artificial or surface waterbody is the inundation area associated with failure of Ruislip Lido. The EA methodology considers the consequences of total failure of the reservoir and therefore no further residual risks arise.

10 Impact of climate change

10.1.1 The NPPF set out how the planning system should help minimise vulnerability and provide resilience to the impacts of climate change. The WLSFRA Web Map shows the impacts of climate change on the various sources of flood risk.

10.2 Fluvial flooding

10.2.1 The River Pinn has been assessed for impacts of climate change using the allowances defined in the EA Guidance for Flood Risk Assessment (2016). Figure 21 shows flood mapping for the following climate change scenarios:

- 1 in 100 probability event
- 1 in 100 + 25% increase in peak river flow
- 1 in 100 + 35% increase in peak river flow
- 1 in 100 + 70% increase in peak river flow

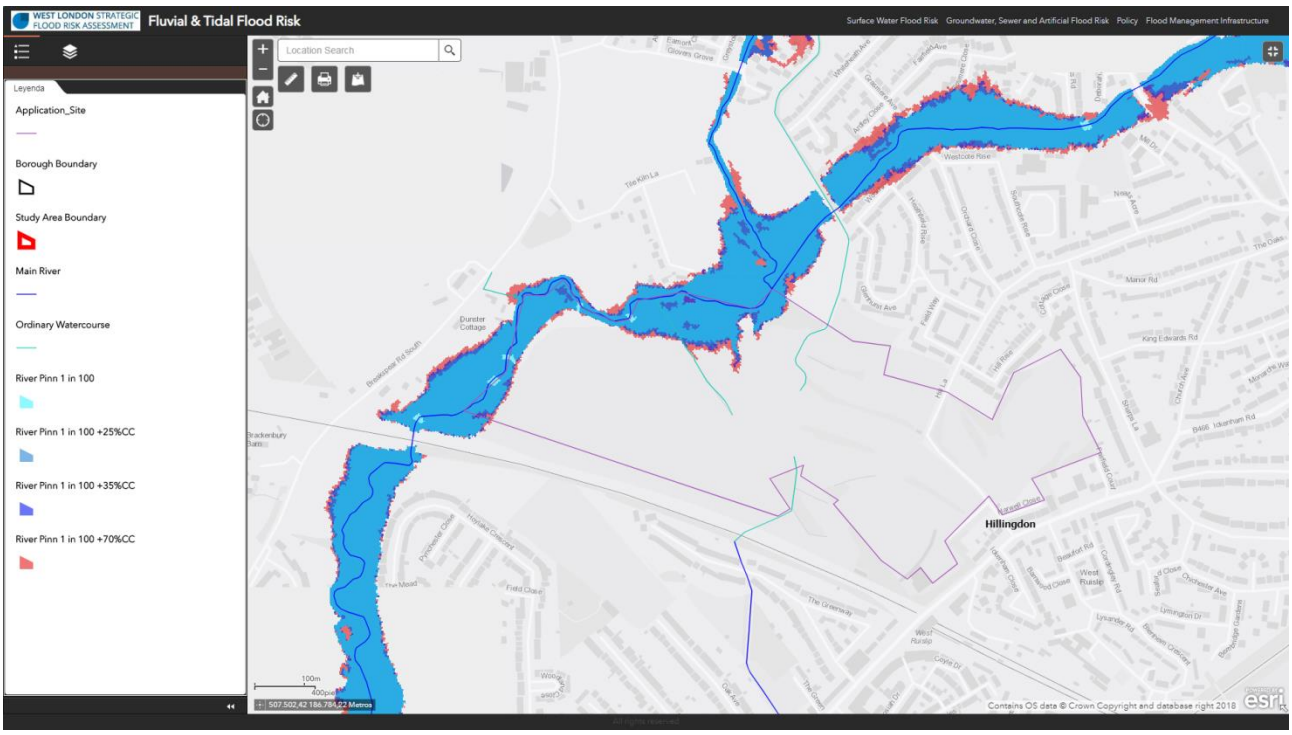


Figure 21 - River Pinn climate change scenarios (WLSFRA Fluvial and Tidal Flood Risk Map)

10.2.2 The flood extent of the climate changes scenarios do not change significantly from the 1 in 100 years flood extent. In addition, the flood extent of the maximum scenario (1 in 100+70%CC) is inside the 1 in 1000 years flood extent (Flood Zone 2). Therefore, the impact of

climate change in the proposed development is considered low. The assessed flood risk for the development is considered still valid in climate change scenarios.

10.2.3 According to technical standard HS2-HS2-EV-STR-000-000022 Climate Change Allowances for Flood Risk Assessments and Drainage Design, based on the EA Guidance for Flood Risk Assessment (2016), an allowance of 25% shall be used for a peak river flow in Thames basin, Central category (water compatible infrastructure).

10.3 Water surface flooding

10.3.1 The WLSFRA Surface Water Flood Risk Web Map shows a range of surface water flood event annual probabilities (3.33%, 1% and 0.1%) in the Risk of Surface Water Flooding map. The 3.3% annual probability extent is considered to represent the current likely risk and the 1% annual probability extent represents the potential climate change adjusted impact of current risk.

10.3.2 The proposed drainage network has been designed to attenuate the 1 in 100+40%CC rainfall event to the Greenfield flow rate.

10.4 Groundwater, sewer and artificial flooding

10.4.1 No specific climate change impact assessments have been completed for these flood risk sources

11 Conclusions

11.1 Compliance with planning policy

Sequential and Exception Test

11.1.1 According to the NPPF, the PPG, the WLSFRA and LB Hillingdon's Local Plan Policy EM6: Flood Risk Management, a Sequential and Exception Test are required for the proposed development.

11.1.2 Most of the application site (approximately 90%) is within Flood Zone 1 which means it has a low probability of flooding. The remaining part of the application site (approximately 10%) is within the floodplain of the River Pinn (Flood Zone 2, 3a and 3b) and therefore has a high probability of flooding.

11.1.3 The proposed use of the application site will remain as a golf course which is 'water-compatible' according to Table 2 of the PPG.

11.1.4 According to Table 3 of the PPG, a water-compatible development is appropriate for Flood Zones 2, 3a and 3b. However, for Zones 3b (functional floodplain), the development should be designed and constructed to:

- remain operational and safe for uses in times of flood;
- result in no net loss of floodplain storage; and
- not impede water flows and not increase flood risk elsewhere.

11.1.5 The part of the application site within Zone 3b is not currently used as a playable area. This area is in a natural state and can be considered as part of the riverbed. The proposed development does not change the current use and no earthworks are planned in this area.

11.1.6 The WLSRFA Policy Map includes a proposed Flood Alleviation Scheme for the River Pinn in the Flood Zone 3b. This Flood Alleviation Scheme proposed a flood mitigation area within the boundaries of the application site area. However, in the more recent consultation documents (March 2018) this flood mitigation area is not included. Therefore, this mitigation area has not been considered in the proposed development.

Sustainable Drainage Systems

11.1.7 Policy 5.13 of the London Plan is a key policy with regards to flood risk and water resource management. The current London Plan drainage hierarchy is as follows:

1. store rainwater for later use;
2. use infiltration techniques, such as porous surfaces in non-clay areas;
3. attenuate rainwater in ponds or open water features for gradual release;

4. attenuate rainwater by storing in tanks or sealed water features for gradual release;
5. discharge rainwater direct to a watercourse;
6. discharge rainwater to a surface water sewer/drain; and
7. discharge rainwater to the combined sewer.

11.1.8 Similarly, LB Hillingdon has developed sustainable drainage requirements as set out in the Sustainable Drainage Design and Evaluation Guide.

11.1.9 The proposed drainage system has been designed in accordance with relevant planning policy. In summary:

- irrigation needs of the application site are entirely met by drained water which is collected and stored on site. A water harvesting system is designed as part of the drainage network. The drainage network is connected to three ponds and three tanks which provide the required water storage volume; and
- designed drainage network will reduce the current runoff flow rates to the River Pinn. The 1 in 100 rainfall event plus 40% of climate change allowance is attenuated to the Greenfield rates. The attenuation is achieved providing additional volume in the water harvesting ponds and tanks.

11.2 Summary of flood risk

11.2.1 The risk of flooding of the proposed development is considered acceptable because:

- most of the application site (90%) is within Flood Zone 1 (low flood risk). Part of the application site within the River Pinn floodplain (Flood Zone 2 and 3) has a high flood risk. However, according to PPG, the current and proposed land use is classified as 'water-compatible' and therefore the proposed development is appropriate; and
- surface water flooding is managed through the proposed drainage network.

11.2.2 Flood risk is not increased elsewhere for all flood sources because:

- the floodplain of the River Pinn is not modified.
- the proposed development does not change the existing hydrological catchments. The application site will continue drain to the River Pinn, as it does currently; and
- SuDS techniques are included in the proposed drainage network and current runoff rates are attenuated.

11.2.3 The proposed development is therefore considered appropriately flood resilient and resistant; and any residual risk can be safely managed.

12 References and standard forms

12.1 Standard forms and templates

Title	Reference
Technical Standard - Flood Risk	HS2-HS2-EV-STD-000-000011
Water Framework Directive Compliance Process	HS2-HS2-EV-STD-000-000012
Watercourse Diversions and Realignments	HS2-HS2-EV-STD-000-000014
Water Resources and Flood Risk Consents Strategy	HS2-HS2-EV-STD-000-000015
Approach Document: Climate Change Allowances for Flood Risk Assessments and Drainage Design	HS2-HS2-EV-STR-000-000022
Template-Flood Risk Assessment Report	HS2-HS2-EV-TEM-000-000022

12.2 References

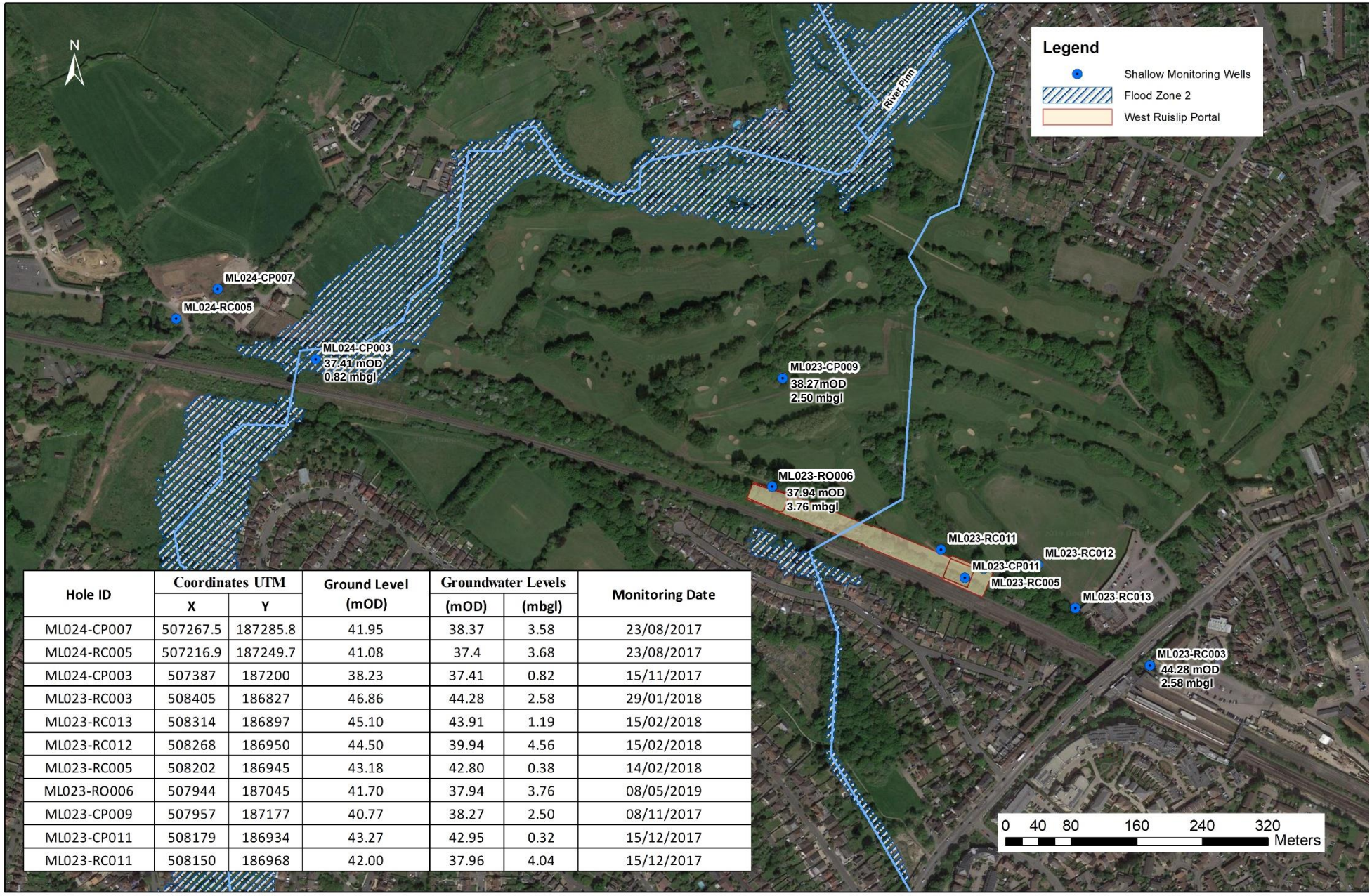
Title	Reference
The SuDS Manual	CIRIA Document C753, Construction Industry Research and Information Association, 2015
Rainfall runoff management for developments	Report SC030219, Environmental Agency 2013
National Planning Policy Framework (NPPF)	Ministry of Housing, Communities and Local Government
Flood risk and coastal change Planning Practise Guidance (PPG)	Ministry of Housing, Communities and Local Government
West London strategic flood risk assessment	The West London Boroughs of Barnet, Brent, Ealing, Harrow, Hillingdon and Hounslow, 2018
Flood risk management portfolio	LB Hillingdon
London sustainable drainage action plan	Greater London Authority

13 Appendices

Appendix A: Data Obtained from Ground Investigations

Appendix A. Data Obtained from Ground Investigations

This appendix covers the HS2 South Package B (SPB) and West Ruislip (NWR) investigations, including borehole installation and groundwater hydrographs.



Hole ID	Coordinates UTM		Ground Level (mOD)	Groundwater Levels		Monitoring Date
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ML024-CP007	507267.5	187285.8	41.95	38.37	3.58	23/08/2017
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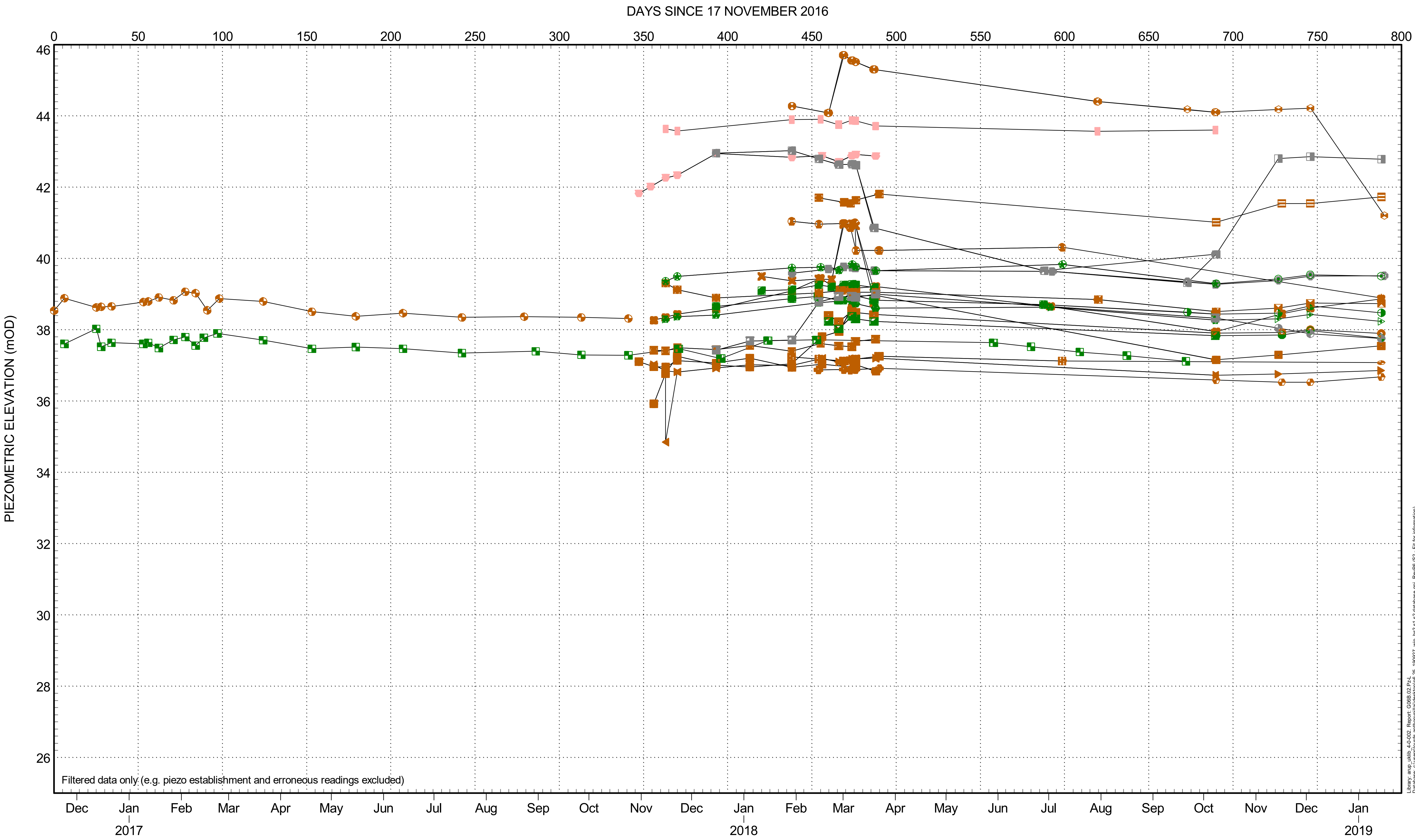
ML023-CP011	508179	186934	43.27	42.95	0.32	15/12/2017
ML023-RC011	508150	186968	42.00	37.96	4.04	15/12/2017

Borehole	Instrumentation	Easting	Northing	Ground Level (mOD)	Final Depth (m)	Top of the Strata (mbgl)	Base depth of Strata (mbgl)	Geologic Formation	Response Zone (mbgl)		Response Strata	Min Observed Water Depth	Max Observed Water Depth
									Top	Base			
ML023-RC002	SPIE: 12.50 [12.00-13.00] SP: 33.00 [29.00-33.00]	508513	186761	46.28	45.11	2.1 6.71 10.23 26.26 27.5	6.71 10.23 26.26 27.5	London Clay Harwich Formation Reading FM. Lower Mottled Clay Upnor Formation Seaford Chalk	12	13	Sand Channels in RF & MC	5.3	7.52
									29	33	Seaford Chalk	7	7.18
ML023-RC003	SPIE: 12.00 [11.50-12.50] SP: 45.00 [35.00-45.00]	508405	186827	46.86	46	4 9.95 11.61 26.5 30.25	9.95 11.61 26.5 28.8	London Clay Harwich Formation Reading FM. Lower Mottled Clay Upnor Formation Seaford Chalk	11.5	12.5	Sand Channels in RF & MC	1.15	2.77
									35	45	Seaford Chalk	7.09	7.58
ML023-RC005	SPIE: 10.00 [9.50-10.50] SP: 31.00 [27.00-31.00]	508202	186945	43.18	40.65	0.3 8 11.2 26.43 26.5	8 11.2 26.43 26.5	London Clay Harwich Formation Reading FM. Lower Mottled Clay Upnor Formation Seaford Chalk	9.5	10.5	Harwich Formation	0.15	3.52
									27	31	Seaford Chalk	4.15	4.74
ML023-RC011	SPIE: 12.00 [12.00-13.00] SP: 30.00 [25.00-30.00	508151	186969	42.46	30	0.25 1.2 3.7 5 20.78 20.92	1.2 3.7 5 20.78 20.92	London Clay Harwich Formation Assumed Zone of Core Loss Reading FM. Lower Mottled Clay Upnor Formation Seaford Chalk	12	13	Sand Channels in RF & MC	3.15	3.95
									25	30	Seaford Chalk	3.64	4.22
ML023-RC013	GMP: 8.50 [8.00-9.00] SP: 32.00 [29.00-32.00]	508314	186897	45.1	40.1	0.4 7.42 10.95 27.88 28.1 33.51	7.42 10.95 27.88 28.1 33.51	London Clay Harwich Formation Reading FM. Lower Mottled Clay Upnor Formation Seaford Chalk B2 Seaford Chalk B1	8	9	Harwich Formation	1.19	1.53
									29	32	Seaford Chalk	5.26	5.8
ML023-CP002	SPIE: 16.00 [15.50-16.50]	508092	186979	41.76	21.7	0.1 4 5.4 20.7 21	4 5.4 20.7 21	London Clay Harwich Formation Reading FM. Lower Mottled Clay Upnor Formation Seaford Chalk	15.5	16.5	Sands in Lower Mottled Beds	4.55	4.92
ML023-RO004	EPIE: 16.50; EPIE: 8.00	508156	186966	42.47	29.5	0.2 1.2 4.4 15.5 21.4	1.2 4.4 15.5 21.4	London Clay Harwich Formation Reading FM. Lower Mottled Clay Sand gravel and flints Seaford Chalk			Sand Channels in RF & MC	0.66	0.92
											Sand gravel and flints	5.55	5.94
ML023-RO006	SPIE: 10.00 [9.50-10.50] SP: 30.00 [25.00-30.00]	507944	187045	41.7	31.5	0.6 1.2 4 24	1.2 4 24	London Clay Harwich Formation Reading FM. Lower Mottled Clay Seaford Chalk	9.5	10.5	Sand Layers in Mottled Clay	3.18	3.79
									25	30	Seaford Chalk	3.32	3.86
ML023-CP011	SPIE: 5.00 [5.00-5.50]	508179	186934	43.27	25	0.35 4.15 5.8 22.6 23.5	4.15 5.8 22.6 23.5	London Clay Harwich Formation Reading FM. Lower Mottled Clay Upnor Formation Seaford Chalk	5	5.5	Harwich Formation	0.32	1.44
ML023-CP009	SP: 6.00 [3.00-6.00]	507957	187177	40.77	10.95	0.3 3.1 4.1 5.8	3.1 4.1 5.8 10.95	London Clay Harwich Fm. Swanscombe Member Harwich Formation Reading FM. Lower Mottled Clay	3	6	Harwich Formation	1.32	2.82
ML024-CP003	SP: 9.50 [7.50-9.50]	507387	187200	38.23	20.37	1.3 2.9 10.45 10.8	2.9 10.45 10.8	Alluvium Reading FM. Lower Mottled Clay Upnor Formation Seaford Chalk	7.5	9.5	Sand Channels in RF & MC	0.49	0.83
ML024-RC005	50mm SS, Slotted Section	507216.91	187249.67	41.08	34.9	0.7 1.9 2.5 9.35 9.85 12.6	1.9 2.5 9.35 9.85 12.6	Superficial Deposits Cohesive Assumed Zone of Core Loss Reading FM. Lower Mottled Clay Assumed Zone of Core Loss Upnor Formation Seaford Chalk	15	25	Seaford Chalk	3.05	3.96
ML024-RC006	EPIE: 5.00; EPIE: 14.00	507828	187077	42.53	30.65	0 1.2 15.35 18.32	1.2 15.35 19.38	Alluvium Reading FM. Lower Mottled Clay Upnor Formation Seaford Chalk			Sand Channels in RF & MC	1.48	2.3
ML024-RC008	SPIE: 7.00 [6.50-7.50]	507570	187180	42.21	31.2	0 1.2 15.25 15.4	1.2 15.25 15.4	Alluvium Reading FM. Lower Mottled Clay Upnor Formation Seaford Chalk	6.5	7.5	Sand in Reading F. Mottled Clay	3.21	4.78
ML024-CP001	SPIE: 9.50 [9.00-10.00]	507705	187131	43.95	20.45	0.2 17.5 18.7	17.5 17.8	Reading FM. Lower Mottled Clay Upnor Formation Seaford Chalk	9	10	Sand Channels in RF & MC	0	8.02
ML024-CP007	35mm, SP, Tip 4.7	507267.47	187285.82	41.95	10	0.3 1.2	1.2 10	Superficial Deposits Cohesive Reading FM. Lower Mottled Clay	4	5	Sand in Reading Formation - Lower Mottled Clay	0	2.63

Table A1: Borehole installation detail.



Harwich Formation (HAR)
Lambeth Group (LMG)
Chalk (CHK)
Unknown
ML023-CP002 @ 25.8mOD
ML023-CP002 @ 25.8mOD
ML023-CP009 @ 34.8mOD
ML023-CP009 @ 34.8mOD
ML023-CP011 @ 38.3mOD
ML023-CP011 @ 38.3mOD
ML024-CP001 @ 34.5mOD
ML024-CP001 @ 34.5mOD
ML024-CP001 @ 27.0mOD
ML024-CP001 @ 27.0mOD
ML024-CP003 @ 28.7mOD
ML024-CP003 @ 28.7mOD
ML024-CP007 @ 37.3mOD
ML023-RO004 @ 34.5mOD
ML023-RO004 @ 34.5mOD
ML023-RO004 @ 26.0mOD
ML023-RO004 @ 26.0mOD
ML023-RO006 @ 31.7mOD
ML023-RO006 @ 31.7mOD
ML023-RO006 @ 11.7mOD
ML023-RO006 @ 11.7mOD
ML023-RC002 @ 33.8mOD
ML023-RC002 @ 33.8mOD
ML023-RC002 @ 13.3mOD
ML023-RC002 @ 13.3mOD
ML023-RC003 @ 34.9mOD
ML023-RC003 @ 34.9mOD
ML023-RC003 @ 1.9mOD
ML023-RC003 @ 1.9mOD
ML023-RC005 @ 33.2mOD
ML023-RC005 @ 33.2mOD
ML023-RC005 @ 12.2mOD
ML023-RC005 @ 12.2mOD
ML023-RC011 @ 30.5mOD
ML023-RC011 @ 30.5mOD
ML023-RC011 @ 12.5mOD
ML023-RC011 @ 12.5mOD
ML023-RC013 @ 36.6mOD
ML023-RC013 @ 13.1mOD
ML023-RC013 @ 13.1mOD
ML024-RC005 @ 16.1mOD
ML024-RC006 @ 37.5mOD
ML024-RC006 @ 37.5mOD
ML024-RC006 @ 28.5mOD
ML024-RC006 @ 28.5mOD
ML024-RC008 @ 35.2mOD
ML024-RC008 @ 35.2mOD

ARUP gINT v8.30.004
Made by Lourdes Anthonypillai on 22-Oct-19

HS2
PIEZOMETRIC DATA VS TIME
RUISLIP GOLF COURSE

256905; 256906

A1