



Highgate School Campus

Flood Risk Assessment

Revision B
23 January 2023

HIGHGATE

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Glossary of Terms

- +CC - Return period inclusive for the predicted effects of Climate Change
- 1D - One-Dimensional
- 2D - Two-Dimensional
- AMAX - A series containing the peak flows recorded at a gauge from each year
- AOD - Above Ordnance Datum (0m sea level, Newlyn, UK)
- Channel Cross Section - profile view of a river channel, normally obtained by surveying a line across the watercourse
- Critical Storm - A storm that produces peak run off in the watershed
- Culvert - A device used to channel water, similar to a pipe though may be larger
- Defended - A scenario in which river defences are used
- FEH - Flood Estimation Handbook
- Fluvial - Referring to the processes associated with rivers and streams
- FRA - Flood Risk Assessment
- GIS - Geographic Information System
- Hydraulic Model - The mathematical process of analysing the interaction of water and the connected environment
- Hydrology - The calculation of catchment based flow rates
- Inflow - Source of water within a modelled domain
- FMP Software - One-Dimensional hydraulic model – Representation of watercourses
- FMP-TUFLOW - Hydraulic program that dynamically links FMP and TUFLOW (1D-2D)
- LiDAR - Light Detection And Ranging, remote sensing technology to measure distance typically used to obtain topographic data over a large area
- Outflow - The method by which water may leave a modelled area
- Overtopping - Where water has passed over a feature that might ordinarily prevent flow
- f100 - 1% annual probability fluvial event
- f1000 - 0.1% annual probability fluvial event
- f100CC - 1% annual probability fluvial event with an allowance for the predicted effects of climate change
- QMED - The median of the set of annual maximum flow data (AMAX)
- TUFLOW Software - Two-Dimensional hydraulic model – Representation of floodplain
- Undefined - A scenario in which river defences are ignored

1 Introduction

1.1 General

Edenvale Young Associates Ltd. were commissioned by Capital Projects to undertake a site wide Flood Risk Assessment (FRA) in order to support the planning application relating to the Highgate School Campus development.

This FRA outlines flood risk to the two development sites (Bishopswood Road Campus and the Senior school Campus). These development sites consist of eight projects as outlined in Section 1.2. FRA's have been undertaken for individual projects. This FRA outlines flood risk for the development as a whole. This flood risk assessment is a desk based study which uses information from other sources, when used, are referenced appropriately.;

- The 'Haringey Council Strategic Flood Risk Assessment' (Level 2) (SFRA), 2015, JBA consulting
- 'London Borough of Haringey surface water management plan (SWMP)', 2011, Capita Symonds
- Flood map for planning online¹.

Other sources, when used, are referenced appropriately.

1.2 Site Details

There are no watercourses in the immediate vicinity of the sites. The proposed campus development is shown in Figure 1.2, for detailed description of proposed developments refer to the Planning Statement.

The Bishopswood campus consists of five development projects:

- The Mallinson Sports Centre (new sports hall replacing building at northern end of the site)
- Temporary accommodation within the current sports pitch (new building)
- The Richards Music Centre

¹<https://flood-map-for-planning.service.gov.uk/>

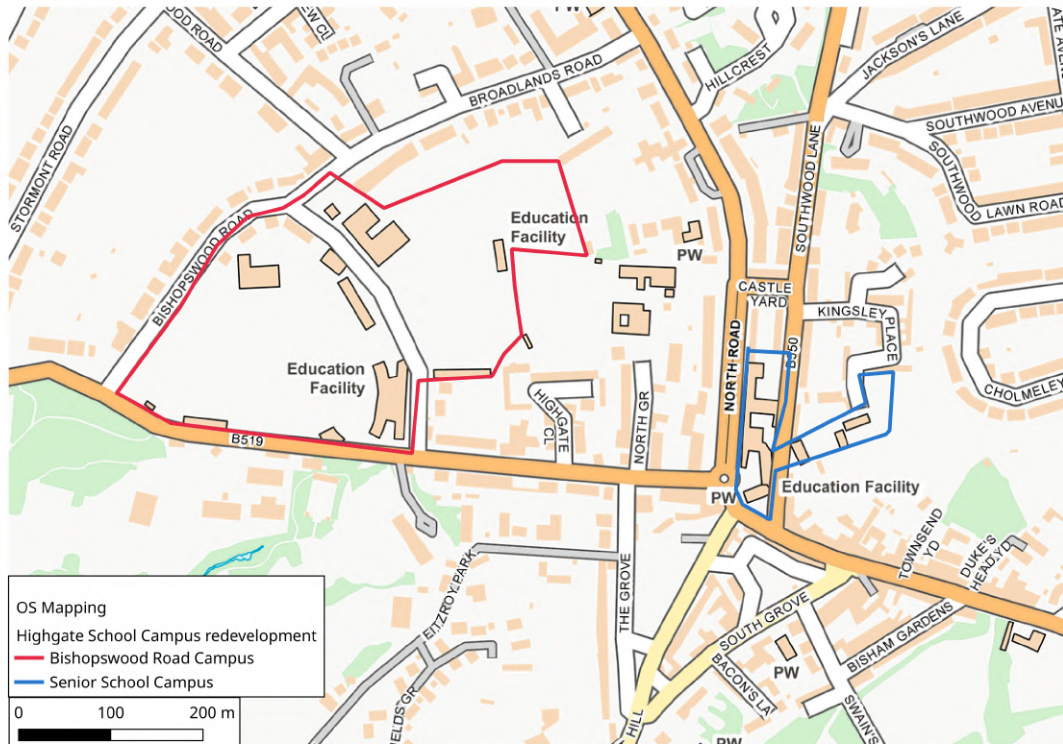


Figure 1.1: Highgate school campus developments, approximate site boundaries

- The Orchard Synthetic Pitch (new sports pitch facility and amphitheatre)
- Tatham's Field Synthetic Pitch (new sports pitch facility)

The Senior school campus consists of three development projects:

- The RMC Science block (refurbishment and new extension of the Biology block including a 4-storey steel frame and basement)
- The Island Site Tunnel Building
- Dyne House

1.3 Local Geology, Hydrology and Hydrogeological details

British Geological Survey (BGS) mapping² has recorded no superficial deposits. The bedrock geology is recorded as follows:

- **Bishopswood Road Complex** comprises "Claygate Member - Clay, silt and sand. Sedimentary bedrock formed between 56 and 47.8 million years ago during the Palaeogene period".
- **Senior School Campus** consists of "Bagshot Formation - Sand. Sedimentary Bedrock formed approximately 48 to 56 million years ago in the Palaeogene Period".

²<http://mapapps.bgs.ac.uk/geologyofbritain3d/index.html?>

1.4 Existing surface water drainage

Existing surface water drainage for the Mallinson sports centre is discussed further in the Highgate School MSC 4-Phase FRA prepared by Edenvale Young. The conclusions are that *"surface water flows in a north-westerly direction towards Broadlands road"* surface water flood risk is discussed later in Section 3.2.2.

Surface water drainage for the RMC Science block is discussed in the Science block FRA written by Price and Myers in April 2019 (see Appendix A). The report concludes that: *"surface water drainage of the senior school is connected to the surface water public sewer downstream of manhole 3504 on Southwood Lane."*

1.5 Appendices

The FRA should be read in conjunction with the following Appendices:

- Appendix A – Basement Impact Assessment Report
- Appendix B - SWMP GP4 Haringey Fig9 Sewer Incidents
- Appendix C - SWMP GP4 Haringey Fig10 Potential Elevated Ground Water

School Campus Masterplan

- Since 2004 the School has been carrying out the regeneration of its Bishopswood Road and Senior School Sites. This has comprised multiple projects, most notably:
 - Restoration of historic buildings: Big School, Chapel, Mills Centre, Central Hall
 - Extension to existing buildings: Science Block, Garner Building, Pre-Prep School, Pre-Prep Dining Hall (HGY/2018/1551)
 - New buildings and facilities: Charter Building, Junior School, Junior Field Synthetic Pitch, as well as many minor projects
- The School understands the need to minimise disruption to the local community during the delivery of our construction projects; our previous experience of managing complex projects, such as the above, has allowed us to learn from and develop techniques to mitigate impacts upon the local community generated from our building work.
- This board provides a location map of the School's academic buildings and photographs of the locations for future proposed projects.



Highgate School Introduction

Figure 1.2: Highgate school campus plan

HIGHGATE

2 Planning Policy

2.1 National Planning Policy

The National Planning Policy Framework (NPPF) clauses 159 to 169 details the policy associated with flooding with clause 161 giving the sequential, risk-based approach for managing flood risk. This includes:

- Sequential Testing - Clause 162
- Exception Testing - Clauses 163 to 165

The NPPF Sequential Test is used to, where possible, steer development to sites at a lesser risk of flooding. Given that the development site is located in the current EA flood zone 1, it does not apply to this development. An Exception Test is not required for either site as they lie within flood zone 1 (see Section 3.1).

2.2 Strategic Flood Risk Assessment

2.2.1 Overview

A Level 2 Strategic Flood Risk Assessment (SFRA) for Haringey Council was completed in February 2015, to refine information of the probability of flooding, taking other various sources of flooding and the impacts of climate change into account.

The over-arching principles (Section 9.1), that all proposed developments should follow according to the SFRA are outlined below:

- *“In line with the NPPF guidance and evidence from the LB of Haringey Level 2 SFRA development proposals should:*
- *show development not at risk of flooding or is compatible with the residual risk;*
- *not increase flood risk elsewhere, taking into account the impacts of climate change;*
- *not increase surface water peak flow rates or runoff volumes above green field levels including an allowance for climate change, as this would result in an increased flood risk to the receiving catchments;*
- *not increase the risk of groundwater flooding elsewhere or change the hydrogeological regime of the area;*

- *the location of basement development should be carefully considered within the LB of Haringey and attention should be paid to all sources of flood risk early within the planning process for new development (including the impact of potential future subterranean works that fall under permitted development);*
- *wherever possible use the opportunities offered by new development to reduce flood risk within the site and elsewhere; and*
- *ensure that where new development is necessary in areas of flood risk (in exceptional circumstances); it is made safe from flooding for the lifetime of the development, taking into account the impacts of climate change. This includes consideration of the potential effect of residual risks."*

2.2.2 Finished Floor Levels

There are no recommendations for finished floor levels in either the SFRA or SWMP. As discussed above 3, surface water flooding is the governing flood risk to the site. However, as guidelines for surface water are not mentioned in the standing advice, finished levels have been based on providing freeboard to the 1 in 100 year + 40% climate change.

2.2.3 Sustainable Drainage Systems (SuDS)

Further requirements are that:

- Surface water discharge from proposed development sites should mimic that of a present day green field site, up to and including a 1:100 AEP critical storm event including an allowance for climate change. Green field runoff rates should be maintained irrespective of whether the site falls within an area designated as being effected by flood risk from any source.
- It is critical that the onsite drainage models should demonstrate that there is no increased flood risk to third parties.
- Use SuDS measures wherever practical and achieve 50% attenuation of undeveloped site's surface water runoff at peak times.

The SFRA also contains recommendation applicable to the development sites in the form of "Green infrastructure", which would be covered by suitable SuDS measures Figure 2.1.

HDA01	Highgate School, Highgate Wood, St Luke's Hospital	• Green Infrastructure at Highgate School • Habitat creation in Highgate Wood • Green Infrastructure at St Lukes Hospital, green roofs
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Figure 2.1: SFRA Recommendation for Highgate School

3 Flood Risk

3.1 Flood Zone Classification

Figures 3.1 and 3.2 show the flood zone classification for the Bishopswood Road and Senior School campus. The mapping has been extracted from the UK Government's flood map for planning¹ and confirms that the development is within Flood Zone 1.

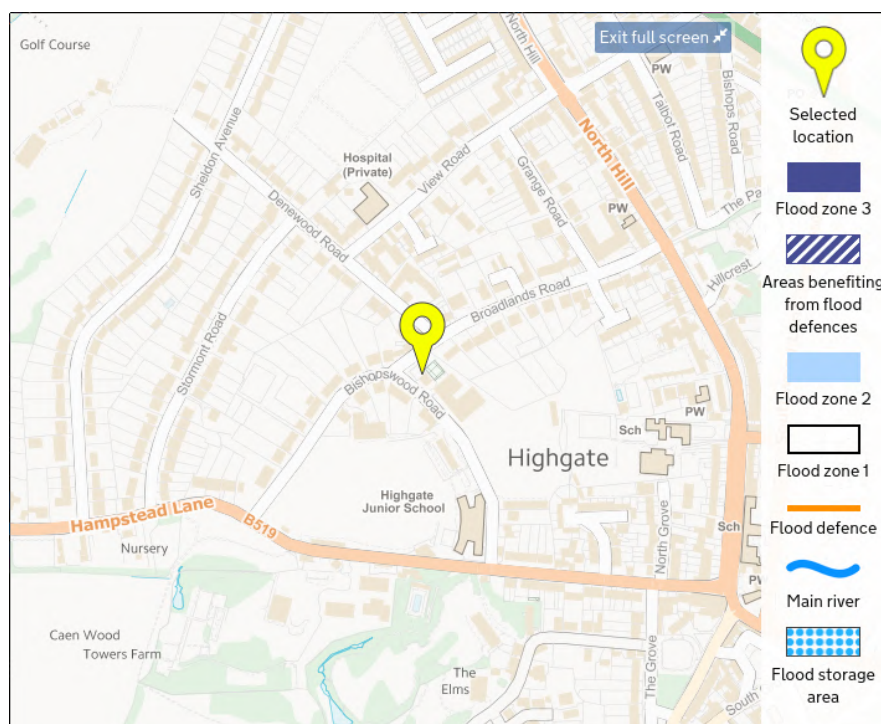


Figure 3.1: Flood Risk for Planning: Bishopswood road campus

¹<https://flood-map-for-planning.service.gov.uk/>

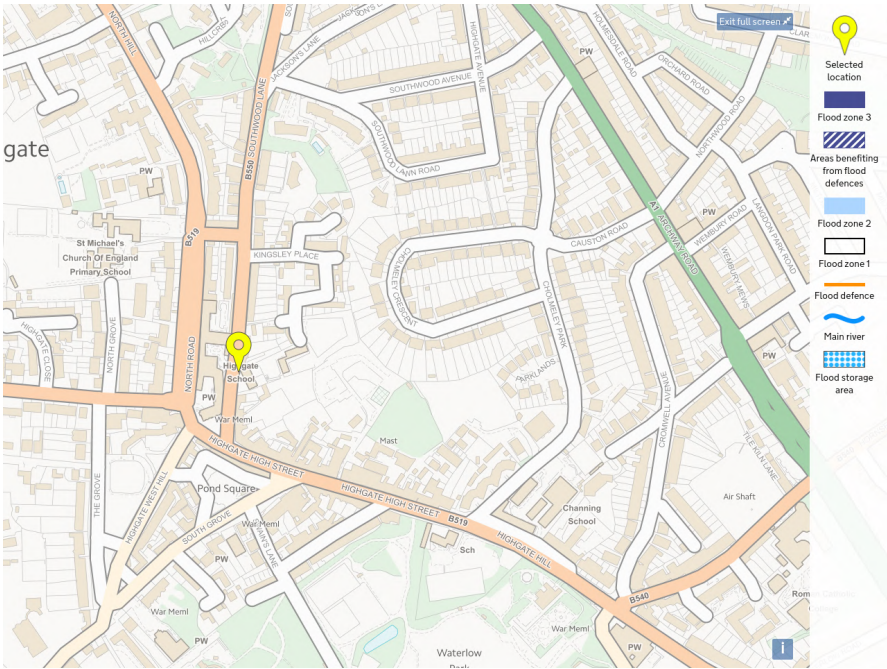


Figure 3.2: Flood Risk for Planning: Senior school campus

3.2 Sources of Flood Risk

3.2.1 Introduction

Flooding has many potential sources and all of these sources must be considered in a flood risk assessment. These sources are:

- Fluvial flooding.
- Coastal/Tidal flooding.
- Pluvial flooding.
- Sewer flooding.
- Groundwater flooding.
- Flooding from infrastructure failure.

Each of these potential sources of flooding are discussed with reference to both development sites. Sources of flood risk are outlined in more detail on a per project level in the individual FRA's.

3.2.2 Surface Water Flood Risk

Surface water flooding occurs following intense rainfall events, when water is unable to infiltrate the ground or cannot discharge to a watercourse. The Environment Agency mapping shows that the site is not at significant risk of surface water flooding. Accordingly it is considered that surface water flood risk is not an issue. It should also be noted that the drainage design for the development is reported elsewhere.

Bishopswood Road Campus

Figures 3.3 to 3.5 show the surface water flood risk to the Bishopswood Road Campus site. The mapping gives flood depths on the site for high, medium and low risks. Importantly it should be recognised that the depths shown on the figures reflect the existing surface water flood risk and not surface water flood risk to the proposed sports facilities. The predicted depth of surface water is considered to present a flood risk to the sports facilities which will be raised above the maximum surface water level.

The mapping indicates that in all risk scenarios there are flood depths of over 900mm within the Bishopswood Road Campus extent. Surface water flooding only affects Mallinson sports centre out of the five planned developments for the high risk scenario.

The low risk scenario shows a clear flow route from the south-east and from the east which flow across the campus, where water then appears to pond behind Broadlands Road, before spilling over. This low risk scenario demonstrates that the temporary accommodation, the Orchard synthetic pitch and Tatham's Field synthetic pitch are at risk of surface water flooding in addition to Mallinson sports centre.

The surface water flood maps presented below are very broad scale and do not represent the details of the five developments within the campus. Therefore, site specific modelling has been carried out and is further discussed in the Highgate School MSC 4-Phase FRA as well as the hydraulic modelling report. The hydraulic modelling report outlines proposed flood mitigation options which include: an amphitheatre in the Orchard synthetic pitch which doubles as a flood storage attenuation area, a bund set to 110.00mAOD, ground levels of the most northerly buildings set to 106.00mAOD with an additional gully to drain this area as well as the diversion of an existing swale through the Orchard synthetic pitch area.

The modelling demonstrates that the modelled options are effective at mitigating internal flooding of the school for the 1% AEP plus 20% climate change allowance design event as well as a benefit downstream of the school. The astro turf pitch does not have flood depths greater than 210mm as shown by hydraulic modelling therefore temporary accommodation could be placed within the pitch. The modelling also demonstrates that there is no adverse impact off site, with flood levels reduced by 100mm at the northern end of the site (See Figure 3.6).

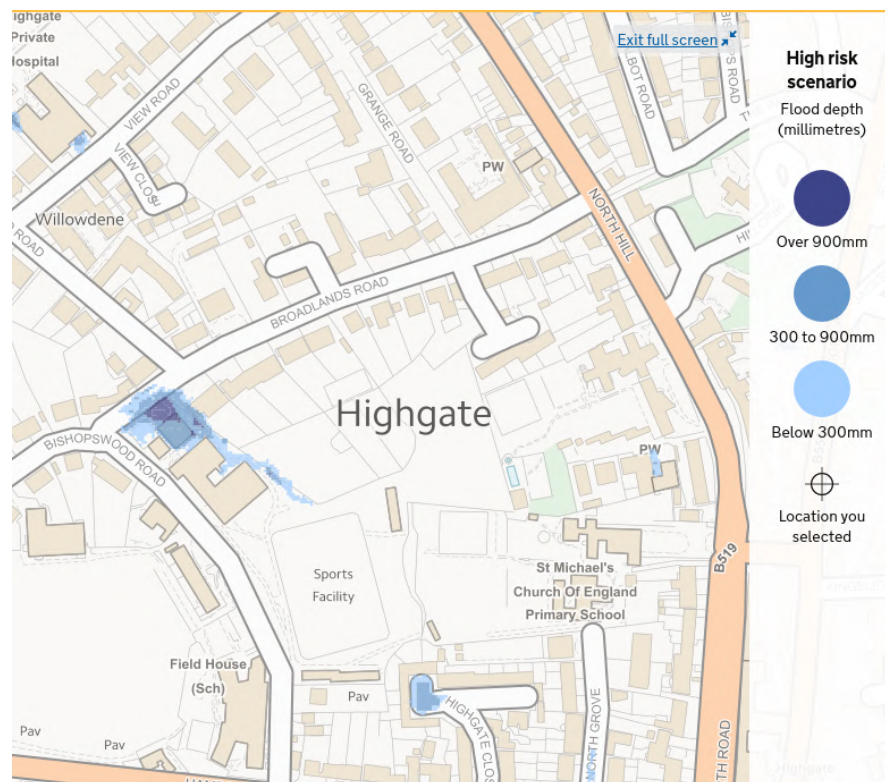


Figure 3.3: Surface Water Flood Risk (High <3.3%) Bishopswood campus

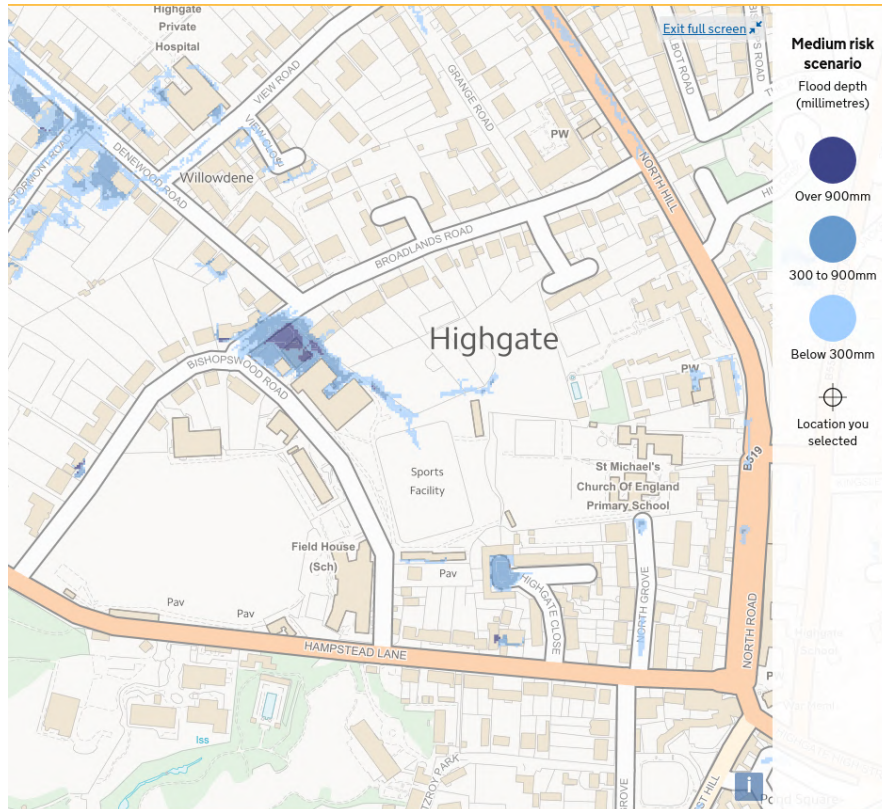


Figure 3.4: Surface Water Flood Risk (Medium 3.3% to 1%) Bishopswood campus

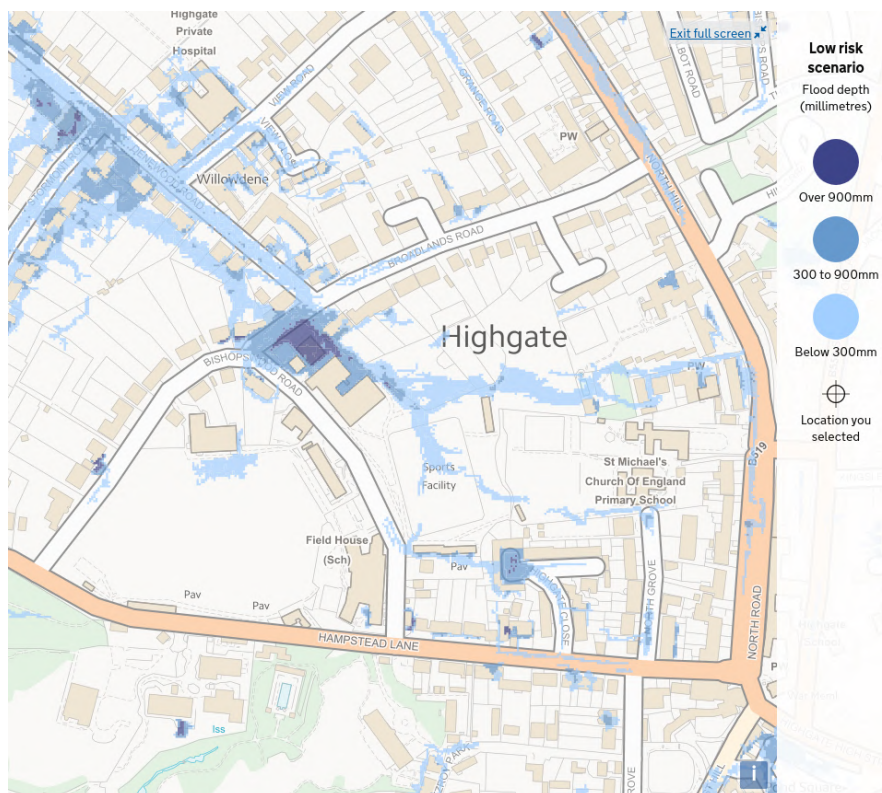


Figure 3.5: Surface Water Flood Risk (Low 0.1% to 1%) Bishopswood campus

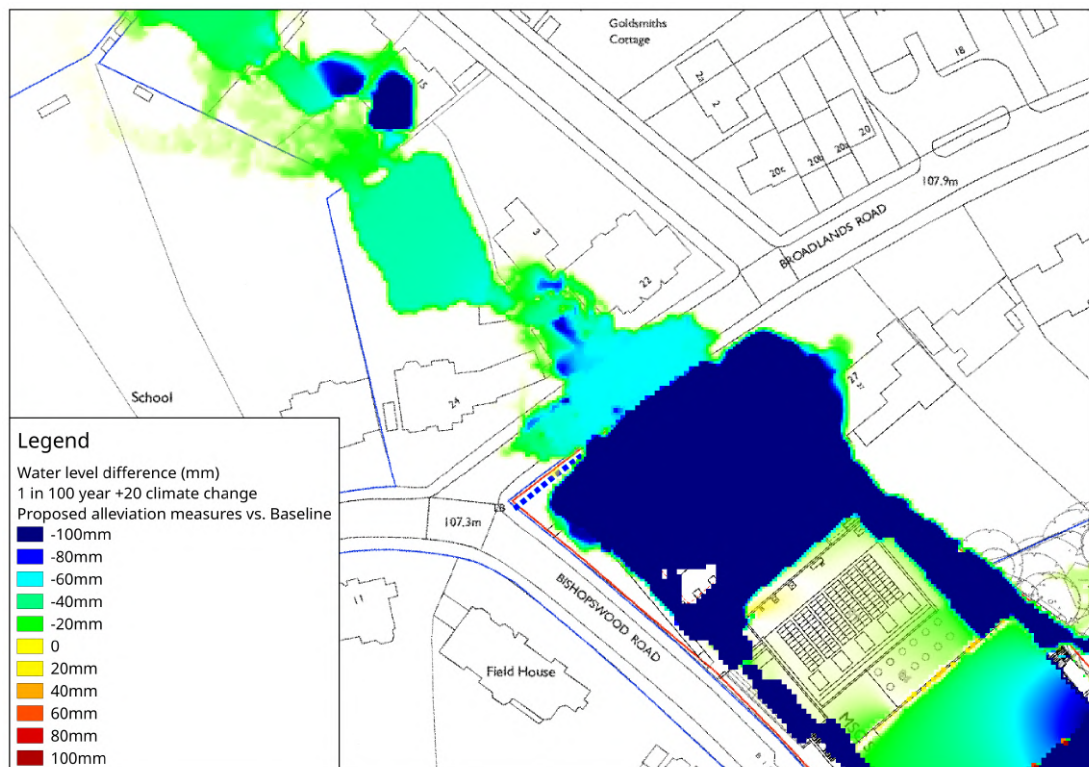


Figure 3.6: Water level difference mapping between the proposed post development scenario and existing case: Bishopswood campus

Senior School campus

Figures 3.7 to 3.9 show the surface water flood risk to the Senior school campus site. The high risk flooding scenario indicates that there is no significant surface water flood risk to the Senior school campus. The low risk scenario shows a small areas of surface water flooding up to 900mm. There is not a clear flow route through this campus area. This low risk scenario demonstrates that part of the RMC Science block is at risk of surface water flooding between 300 to 900mm. The Science block FRA (see Appendix A) concludes that “flood risk from surface water and overland flows is considered low”.

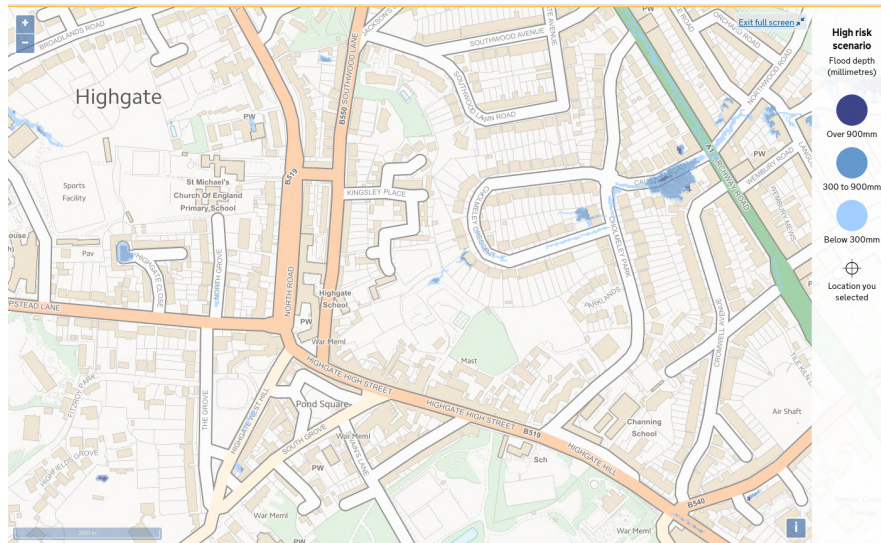


Figure 3.7: Surface Water Flood Risk (High <3.3%) Senior school campus

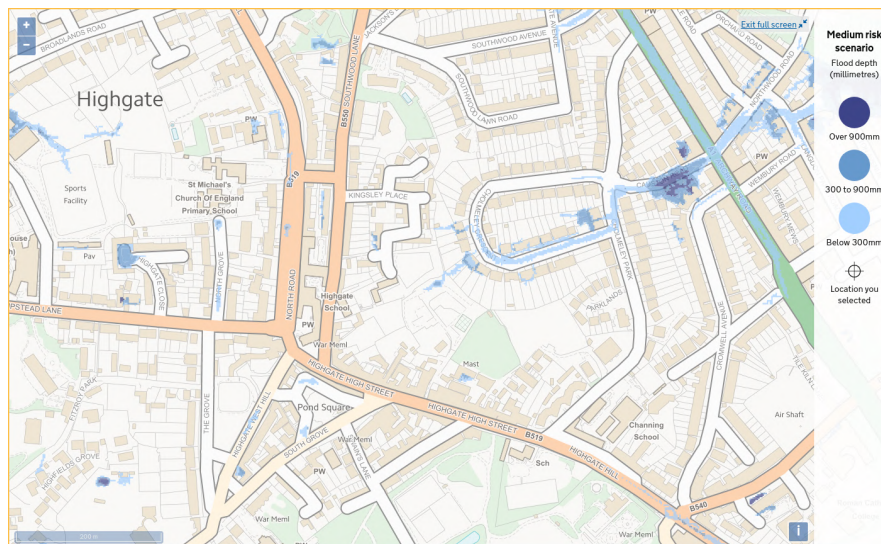


Figure 3.8: Surface Water Flood Risk (Medium 3.3% to 1%) Senior school campus

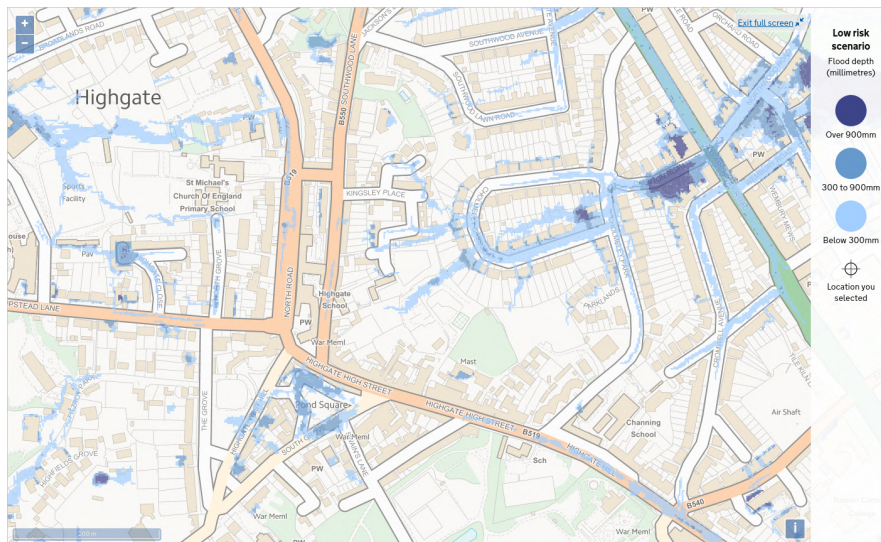


Figure 3.9: Surface Water Flood Risk (Low 0.1% to 1%) Senior school campus

3.2.3 Sewer Flooding

The SWMP mapping (Appendix C) has not identified a specific sewer flooding issue in the vicinity of either campus. The area 'N6 4', which the site is located within is recorded as having '1 to 5' sewer flooding records. Other areas within the borough are recorded as having between '21 to 50' sewer flooding records so sewer flooding incidents at our site can be considered low.

However, as the SFRA mapping is very broad scale, it does not offer strong conclusions regarding risk of flooding from sewers.

3.2.4 Groundwater Flooding

Bishopswood Road Campus

There is limited information on flood risk from groundwater. The EA website shows no information on groundwater flooding for the site.

The British Geological Survey (BGS) possesses a record of boreholes within the UK. According to this record, boreholes (TQ28NE4111, TQ28NE412 and TQ28NE413) are available in the vicinity of the site, approx. 250m away, to the East on Bishopswood Road. The Borehole logs, from 2006, indicate the ground is all clay and remarks include 'water seepages throughout'. Groundwater flooding usually occurs in more permeable strata such as chalk, so the risk for groundwater flooding in clay is considered low.

The SWMP mapping (Appendix D) shows two potential incidents have occurred near to the site. However the disclaimer states that *"Incident records shown are generally unconfirmed and may include issues such as water main bursts or non-groundwater related problems."*

The proposed new sports hall is partly below ground level, however with suitable tanking and an entrance threshold level above the potential surface water flood level, this should mitigate some risk of development.

Given the points raised in this section, groundwater flooding at the site is considered a low risk and will not be considered further.

Senior School Campus

The SWMP mapping shows that a potential incident has occurred at the location of the RMC Science block (Appendix C). This as stated above does not mean that groundwater flooding has occurred at this site as the records are generally unconfirmed.

The BGS site does not have record of boreholes in the vicinity of this campus. The Flood Risk Assessment for the Highgate School Science building outlines results of a geotechnical site investigation.

"Groundwater was encountered during intrusive works between 8.0m and 12.5m below ground level. Investigation revealed that a layer of engineered till lies above Bagshot Formation which overlays Claygate member. However, EA maps confirm that the site is not located within any groundwater Source Protection Zones (SPZ)"

"According to the site investigation no significantly elevated concentrations of contaminants were detected in soils at this site and it is considered unlikely that significant contamination will migrate from soils into the groundwater."

Therefore groundwater flooding at the Senior school campus is considered at a greater risk of flooding than the Bishopswood campus due to the potential incident and the groundwater encountered. However, the site is considered at low risk of groundwater flooding and the proposed basements will be designed to be fully waterproof for the lifetime of the development.

The site is at low risk of contamination as outlined in the Highgate school science building FRA (Appendix A) and appropriate level of pollution prevention is provided for the Bishopswood campus using SuDS techniques (Highgate School MSC 4-Phase FRA) therefore one credit for minimising watercourse pollution can be awarded under BREEAM.

3.2.5 Flooding from Infrastructure Failure

Flooding from infrastructure failure can occur if a large reservoir were to fail and release the water it holds. The Environment Agency defines the maximum extent of flooding for these cases which have been derived using highly conservative modelling scenarios. A copy of the Reservoir Inundation mapping is shown in Figure 3.10. There are no issues associated with reservoir inundation.

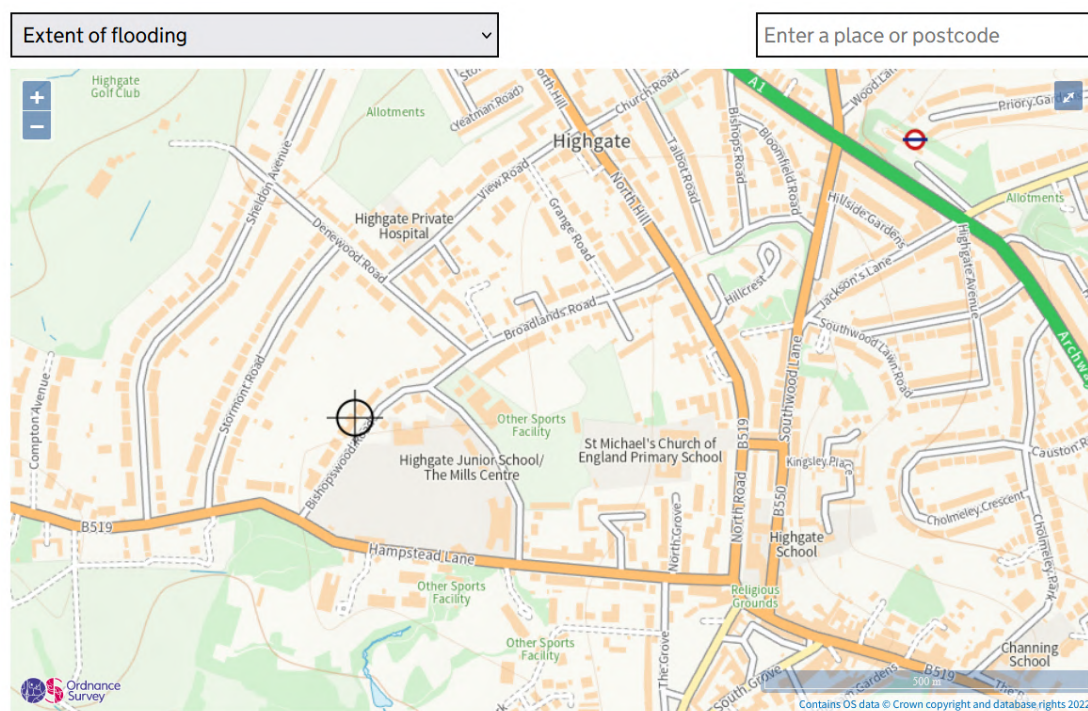


Figure 3.10: Reservoir Inundation

4 Conclusions and Recommendations

4.1 Conclusions

The following conclusions are made from the Flood Risk Assessment undertaken to assess the risk of flooding to the Mallinson Sports Centre redevelopment at Highgate school

- The proposed developments lies in Flood Zone 1.
- The main flood risk posed to the the Bishopswood road campus is surface water flooding.
- Other sources of flooding such as infrastructure flooding, surface water flooding and groundwater flooding have been reviewed but are considered low risk for both sites.
- Mitigation for groundwater flood risk for the RMC Science block assumes that the proposed basements will be designed to be waterproofed for the lifetime of the development.
- Site specific flood risk assessments have been undertaken for the Mallinson sports centre, RMC Science block and Dyne House which cover attenuation for surface water runoff. Flood risk is considered acceptable if flood mitigation measures are implemented for Mallinson sports centre.
- Hydraulic modelling has been undertaken for the Mallinson sports centre within the Bishopswood road campus to address surface water flood risk. This includes the modelling of proposed flood mitigation measures and suggest that the level of risk is considered acceptable when these measures are implemented.
- Three BREEAM credits can be awarded based on low flood risk and the site is not considered a potential source of water pollution.
- The proposed developments within the Senior school campus have an acceptable level of flood risk within the terms and requirements of NPPF.

- The proposed developments within the Bishopswood road campus are considered acceptable in terms of flood risk meeting NPPF requirements apart from the Mallinson Sports Centre. However measures such as flood mitigation options, SuDS and flood resilience measures that are outlined in the Highgate School MSC 4-Phase FRA prevent internal flooding to the school and result in no adverse impact off site, thereby meeting the terms of NPPF.

4.2 Recommendations

It is recommended that:

- Surface water flood risk for Mallinson Sports centre, flood mitigation measures should be implemented based on the site specific FRA and the Hydraulic Modelling Report.
- Threshold levels should be set at 600mm above the 1% AEP plus 20% climate change allowance for the Sports centre or 300mm above ground level for other projects.
- Groundwater flood risk for the science block the basement should be mitigated to incorporate basement waterproofing for the lifetime of the development.

A Appendix A – Basement Impact Assessment Report

B Appendix B - SWMP GP4 Haringey

Fig9 Sewer Incidents

C Appendix C - SWMP GP4 Haringey Fig10 Potential Elevated Ground Water

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