ATKINS

CITY OF LONDON

Hampstead Heath Ponds Project

FLOOD RISK ASSESSMENT

July 2014

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List of Abbreviations

For ease of reference, the following terminology has been used throughout this Transport Statement:

AEP	Annual Exceedance Probability
CDA	Critical Drainage Area
EIA	Environmental Impact Assessment
FRA	Flood Risk Assessment
FRMS	Flood Risk Management Strategy
NPPF	National Planning Policy Framework
PFRA	Preliminary Flood Risk Assessment
PMF	Probable Maximum Flood
RARS	Risk Assessment for Reservoir Safety
SFRA	Strategic Flood Risk Assessment
SoP	Standard of Protection
SUDS	Sustainable Drainage Systems
SWMP	Surface Water Management Plan

Terminology

Throughout this document, flood events are defined according to their likelihood of occurrence. The term “annual chance” is used, meaning the chance of a particular flood occurring in any one year. This is directly linked to the probability of a flood.

For example, a flood with an annual chance of 1 in 100 (a 1 in 100 chance of occurring in any one year), has an Annual Exceedance Probability (AEP) of 1% and a return period of 1 in 100 years.

Definitions

For ease of reference, the following terminology has been used throughout this Flood Risk Assessment:

Term	Definition
The Proposed Development	As specified in The Application which is the subject of this Flood Risk Assessment
The Site	Land area of the Proposed Development
The Application	Proposed engineering works to the Hampstead and Highgate chains of ponds comprising dam raising at Model Boating Pond (2.5m) and Mixed Bathing Pond (1m), new walls along dam crest to increase the height of the dams at Men's Bathing Pond (1m) and Highgate No.1 Pond (1.25m), a 190mm kerb along part of the crest at Hampstead No.2 Pond, a new flood storage dam (5.6m) in the catchpit area, grass-lined spillways at most ponds, dam crest restoration, pond enlargement at Model Boating Pond, a replacement changing room building at Ladies Bathing Pond and associated landscaping, habitat creation and de-silting.
The Applicant	The City of London Corporation

1. Introduction

Atkins Services

1.1 Atkins Limited has been commissioned by the City of London Corporation (CoL) to complete a Flood Risk Assessment (FRA) to accompany a Planning Application for works to the Highgate and Hampstead chains of ponds on Hampstead Heath, for the purpose of reducing the risk of dam failure at any of these ponds.

1.2 The purpose of this FRA is to review the risk of all forms of flooding to the Site and from the Proposed Development, in order to satisfy the requirements of the National Planning Policy Framework (NPPF) (Communities and Local Government, 2012). This FRA then provides recommendations for mitigation measures to ensure that the Proposed Development will be safe and has no adverse impacts on flood risk.

Sources of Data

1.3 To inform this FRA, data and information has been obtained from the following sources:

- details of the Proposed Development from the Atkins design team;
- results of the hydraulic modelling undertaken by Atkins (2013/14) including simulations of the existing and proposed situation and breach modelling;
- publicly available information on the Environment Agency 'What's in Your Backyard' website http://maps.environment-agency.gov.uk;
- soil and geology information from the British Geological Society (BGS);
- the North London Strategic Flood Risk Assessment (SFRA) (Mouchel 2008);
- the London Borough of Camden Surface Water Management Plan (SWMP) (Halcrow 2011a);
- the London Borough of Camden Flood Risk Management Strategy (FRMS) (London Borough of Camden 2013); and
- the London Borough of Camden Preliminary Flood Risk Assessment (PFRA) (Halcrow 2011b).

Site Description

Location and Land Use

1.4 Hampstead Heath is the largest area of open space in north-west London (c300 hectares) and attracts in excess of 7 million visits per annum, including walkers, cyclists and swimmers. The City of London Corporation is responsible for the management and protection of the Heath, and for making it available as open space. The Hampstead Heath Act 1871 requires The City of London to comply with the following obligations:

- Forever to keep the Heath open, unenclosed, un-built upon and by all lawful means to prevent, resist and abate all encroachment on the Heath and attempted encroachment and to protect the Heath and preserve it as an open space.
- At all times to preserve as far as may be the natural aspect of the Heath and to that end to protect the turf, gorse, heather, timber and other trees, scrubs and brushwood thereon.
- Not to sell, lease, grant or in any manner dispose of any part of the Heath.
- To drain, level and improve the Heath, as far only as may be from time to time requisite, with a view to its use for the purposes of health and unrestricted exercise and recreation.

1.5 The Highgate chain of ponds is located on the eastern part of the Heath, to the west of the urban area of Highgate and includes Stock Pond, Ladies Bathing Pond, Bird Sanctuary Pond, Model Boating Pond, Men's Bathing Pond and Highgate No. 1 Pond. The Hampstead chain of ponds is located on the south-western part of the Heath, to the north of the urban area of Hampstead and includes Vale of

Health Pond, Viaduct Pond, Mixed Bathing Pond, Hampstead No. 2 Pond and Hampstead No. 1 Pond. The location of the ponds is illustrated on Figure 1-1.

Figure 1-1: Location of the Hampstead Heath ponds

Geology

1.6 The Heath Geology is composed mainly of Bagshot Beds, underlain by Claygate Members, in turn underlain by London Clay. Bagshot Beds are present on the ridge to the north between the north east and south west flowing streams of the Heath. London Clay is exposed at the lower elevations within the Heath and is the dominant geology over which most of the ponds are built.

1.7 The sand in the Bagshot formation and Claygate Members make them permeable compared to London Clay, allowing water to flow through them readily. The water within these strata is recharged at the surface from precipitation which, owing to the relatively high porosity of the deposits, is stored within the matrix of the strata and forms a local aquifer. At the junctions of the Bagshot formation with the Claygate Member, and the Claygate Members with the London Clay, spring lines form at the ground surface. Areas overlaying Terrace Deposits and the Claygate Members / Bagshot formation are designated as 'Secondary A' aquifers by the Environment Agency, meaning permeable layers capable of supporting water supplies at a local rather than strategic scale, and in some cases forming an important source of baseflow to rivers.

Topography

1.8 Hampstead Heath comprises of two main valleys, within which the two chains of ponds are located, separated by a ridge of high ground which includes Parliament Hill (Kite Hill). The highest ground (around or in excess of 100m AOD) is along this central ridge and in the northern part of the Heath. Ground levels fall to 60 - 70m AOD in the south of the Heath at the downstream end of the two pond chains.

Watercourses and Drainage

1.9 The Highgate chain consists of six ponds, from upstream to downstream: Stock Pond, Ladies Bathing Pond, Bird Sanctuary Pond, Model Boating Pond, Men's Bathing Pond and Highgate No. 1 Pond. The Hampstead chain consists of five ponds, from upstream to downstream: Vale of Health, Viaduct Pond, Mixed Bathing Pond, Hampstead No. 2 Pond and Hampstead No. 1 Pond. These ponds are under the custodianship of the City of London. The ponds were constructed by the Hampstead Heath Water Company in the late 18th Century for the supply of water to north London.

1.10 The adjacent 45 hectare Kenwood Estate, including Kenwood House, Wood Pond and Thousand Pounds Pond is owned and managed by English Heritage. There are two other chains of ponds on Hampstead Heath: to the north is Golders Hill Park chain in the designed landscape of the former Golders Hill mansion, and the Heath Expansion chain (also known as the Seven Sisters chain). These two chains are not included in the scope of the proposed works, and therefore are not discussed further.

1.11 The Hampstead and Highgate chains of ponds are fed by a series of small streams (classified as Ordinary Watercourses) which drain a majority of Hampstead Heath to the south and east of the B519 (Spaniards Road / Hampstead Lane), in addition to a small urban area to the south of Highgate Village. Rain falling on the Heath either infiltrates into the ground, lies on the ground surface, or runs off over the ground surface, following the natural topography. The majority of this surface runoff ends up in the two chains of ponds.

1.12 Each pond is linked to the next by overflow pipes of small (300 – 450mm) diameter. The bottom pond on each chain, namely Highgate No.1 Pond on the Highgate chain and Hampstead No.1 Pond on the Hampstead chain, has an overflow pipe which discharges directly into the culverted River Fleet system. These discharges from the ponds are combined with the local surface water drainage in the culverted River Fleet, which then flow southwards, through central London and into the River Thames near Blackfriars Bridge. Each pond also has a low-level scour pipe with a control valve which is normally closed. These scour pipes discharge to the surface water drainage system. The City of London cannot discharge water from the ponds through these scour pipes without the permission of Thames Water, and so they are rarely used.

1.13 The Model Boating, Men's Bathing and Hampstead No.1 ponds on the Heath are classified as large raised reservoirs under the Reservoirs Act of 1975 and amended by the Flood and Water Management Act of 2010. This Act provides the legal framework for ensuring the safety of reservoirs.

1.14 The nearest foul drainage pipes are located to the east of the Highgate chain ponds, taking foul flow from both the Ladies and Men's Bathing Pond changing facilities. There is also a foul drainage pipe taking foul flow from the Mixed Bathing Pond changing facilities. This pipe runs along the eastern side of the pond, under the dam embankment and westwards, to East Heath Road.

Indicative Flood Risk

1.15 No Environment Agency Flood Zone mapping is available for Hampstead Heath as the minor watercourses are not classified as Main Rivers and detailed modelling has not been undertaken for the purpose of deriving Flood Zones in this area, The Environment Agency Flood Mapping for Surface Water (see Section 3.2) does however illustrate the site to be at risk of surface water flooding. The risk of flooding from all sources has been assessed and is documented in Section 3 of this FRA.

Development Proposal

1.16 The purpose of the Proposed Development is to significantly reduce the risk of dam failure at any of the ponds in the Highgate and Hampstead chains of ponds that could result in severe flooding and the consequential risk of loss of life and damage to property. In broad terms the key elements of the Proposed Development are as follows:

- increase flood storage capacity by raising some of the dams and constructing a new dam in the Catchpit area;
- reinforce existing dams where required;
- construct spillways to prevent any overtopping which would erode the dams;
- replacement of the swimming facilities at the Ladies Bathing Pond;
- mitigate ecological and landscape impacts by softening pond edges and improving marginal habitat; and
- dredging of Stock Pond, Ladies Bathing Pond, Men's Bathing Pond, Viaduct Pond and Mixed Bathing Pond to improve the water quality of the ponds.

1.17 Each chain of ponds is considered as a whole system so that significant increases in storage capacity are located in the least sensitive locations, limiting tree loss around ponds and reducing works required elsewhere.

1.18 Temporary works are required in order to construct the Proposed Development, and can be summarised as follows:

- A main works compound located at the site of Kenwood House nursery at the northern extent of East Heath. This works compound will be used to store stockpiled materials and plant, and also be the location of welfare facilities and the site office.
- A series of small worksites to be established by each of the Ponds, where construction works are due to take place.
- Four borrow pits are required; two for each chain of ponds, from which the fill material required to raise the dams will be obtained from.

Consultation

1.19 This section outlines the consultation responses received specifically in relation to the Proposed Development, and the risk of flooding.

Environment Agency

1.20 A consultation response was received from Nick Beyer, a Major Projects Officer at the Environment Agency, dated 21 March 2014. This response confirmed that:

- there should be no increase in surface water flood risk as a result of the Proposed Development;
- the requirements of the London Plan (Policy 5.13) and its Supplementary Planning Guidance on Sustainable Design and Construction should be appropriately accounted for within the designs;
- the surface water strategy for the works should be carried out in accordance with the NPPF and associated Technical Guidance; and
- the requirements of the Reservoirs Act 1975 (as amended by the Water and Flood Bill 2010) will need to be met, including the provision of Reservoir Flood Plans (on-site plans) and updated inundation maps based on dam breach analysis.

City of London Corporation

1.21 In response to the Environmental Impact Assessment (EIA) Scoping Report, CoL requested information detailing benefits of the proposed works to the dams in reducing the risk of sewer overflows elsewhere in the catchment.

1.22 The Proposed Development will reduce the risk of failure of the Hampstead Heath dams and, in doing so, reduce the risk of flooding posed by the ponds to downstream areas. There will be no impact on the risk of sewer overflows in these downstream areas.

The Heath and Hampstead Society

1.23 In response to the EIA Scoping Report, The Heath and Hampstead Society raised concerns to the London Borough of Camden regarding the proposed scope of the assessment of flood risk. The Society requested an assessment of all flood risks arising from severe storms in the local area, and not just an assessment of flooding on the Heath itself. This was to recognise that in the event of an extreme flood, residents downstream of the ponds would already be subject to severe flooding.

1.24 The purpose of this FRA and the Environmental Statement (ES) is not to justify the requirement for the Proposed Development. The scope of this document is therefore limited to an assessment of the existing risk of flooding on Hampstead Heath and the impacts of the Proposed Development on the risk of flooding both to the Site and adjacent areas. There is no planning requirement for a detailed assessment of the existing risk of flooding from all sources to areas adjacent to the Heath.

London Borough of Camden

1.25 In the initial Scoping Opinion provided by the London Borough of Camden, dated 8 April 2014, no additional requirements relating to flood risk work were identified. Meetings were subsequently held with the Council and discussions recorded in a planning pre-application advice meeting note, dated 8 May 2014. This note identified the following requirements in relation to flood risk:

- Confirmation that there will be no change in local surface water flood risk. This should be demonstrated by comparing the volume and rate of water discharged from the ponds into the Thames Water sewer network, under a range of rainfall events, for the existing situation and the future situation following completion of the proposed works.
- Confirmation that the drainage systems on the Heath will not be altered to feed directly into the flood relief sewer, supported by plans as necessary. The flood relief sewer runs across the Heath to the north of the running track and conveys flow when water levels in the main sewer system on Highgate Road are such that it reaches capacity.
- Correspondence with Thames Water to confirm that they are happy with the proposals.
- Submission of an assessment of spillway operation and the resulting risk of flooding following completion of the Proposed Development.
- Provision of a future maintenance plan for the dams, a risk management plan and an emergency response plan.

1.26 Where possible and appropriate, these requests for information are incorporated into this FRA. This includes an assessment and discussion on surface water flood risk and spillway operation. CoL is undertaking discussions with Thames Water at present. The Heath Management Plan and Emergency Plan will be updated, but not as part of this FRA.

Document Objectives and Structure

1.27 An FRA should consider all types of flooding to satisfy the following three key objectives:

- To assess flood risk to the Proposed Development and to demonstrate that any residual risks to the development and its users would be acceptable. This assessment should take into account climate change over the lifetime of the development.
- To assess the potential impact of the Proposed Development on flood risk elsewhere and to demonstrate that the development would not increase flood risk elsewhere.
- To satisfy the requirements of the NPPF, including application of the Sequential Test and where necessary, the Exception Test.

1.28 CIRIA C624 provides guidance on the implementation and good practice in assessing flood risks throughout the development process. The document recommends that an FRA should be undertaken in phases so that the detail provided corresponds with the type of development and the level of design detail available at the time of writing.

1.29 There are three levels of assessment:

- **Level 1 FRA (Screening Study):** To identify if there are any flooding issues related to a development site which may warrant further consideration. The screening study will ascertain whether a Level 2 or Level 3 FRA is required;
- **Level 2 FRA (Scoping Study):** Undertaken if a Level 1 study indicates that the site may lie within an area which is prone to flooding or that the site may increase flood risk due to increased runoff; and to confirm the possible sources of flooding which may affect the site. The Scoping Study will identify any residual risks that cannot easily be controlled and, if necessary will recommend that a Level 3 FRA is undertaken; and
- **Level 3 FRA (Detailed Study):** Undertaken if the Level 2 study concludes that quantitative analysis is required to assess flood risk issues related to the development site. This may include detailed hydraulic modelling of rivers or drainage systems.

1.30 This report forms a Level 3 FRA (Detailed Study) and is structured as follows:

- Section 2 discusses the planning context of the Proposed Development;
- Section 3 describes and assesses the risk of flooding from all sources, and
- Section 4 provides the summary and conclusions of this FRA.

2. Planning Context

National Planning Policy Framework

2.1 The NPPF (Communities and Local Government, 2012) and accompanying Technical Guidance sets out Government policy on development and flood risk. The aim of the Framework is to ensure that flood risk is taken into account at all stages of the planning process, to avoid inappropriate development in areas at risk of flooding and to direct development away from areas of highest risk. Where new development is deemed necessary in areas of flood risk, the NPPF aims to make it safe, without increasing flood risk elsewhere and where possible, reduce flood risk overall.

2.2 The NPPF requires that, for all development proposals of 1 hectare or greater in Flood Zone 1 and all proposals for development located in Flood Zones 2 and 3, a FRA must be submitted to the Local Planning Authority. The area proposed for development is greater than 1 hectare; the purpose of this report is therefore to document an assessment of flood risk associated with the development proposal in accordance with the requirements of NPPF.

The Sequential Test

2.3 The NPPF sets out the details of a Sequential Test, which gives preference to locating new developments wherever possible in Flood Zone 1 and states that the vulnerability of the Proposed Development to flooding should be taken into account when considering locations in Flood Zone 2 and then Flood Zone 3. Table 2-1 summarises the vulnerability classification of appropriate land uses for each Flood Zone, as included in the Technical Guidance to the NPPF.

Table 2-1: Fluvial Flood Zone definition and appropriate land use

Flood Zone	Annual probability of fluvial flooding	Vulnerability classification of appropriate land uses		
		Appropriate	Exception test required	Not appropriate
Flood Zone 1	< 1 in 1000 (0.1%) annual chance	All land Uses	-	-
Flood Zone 2	1 in 100 (1%) – 1 in 1000 (0.1%) annual chance	Essential Infrastructure Water Compatible More Vulnerable Less Vulnerable	Highly Vulnerable	-
Flood Zone 3a	> 1 in 100 (1%) annual chance	Water Compatible Less Vulnerable	Essential Infrastructure More Vulnerable	Highly Vulnerable
Flood Zone 3b	Land where water has to flow or be stored in times of flooding. The Functional Floodplain (Flood Zone 3b) is generally defined as land which floods with a >1 in 20 annual chance.	Water Compatible	Essential Infrastructure	Highly Vulnerable More Vulnerable Less Vulnerable

2.4 In accordance with Table 2 of the NPPF Technical Guidance, a majority of the Proposed Development is classified as 'Water Compatible'. This includes "flood control infrastructure" (the raised dams, new spillways and culverts / pipes) and "amenity open space, outdoor sports and recreation and essential facilities such as changing rooms". The temporary Kenwood House nursery works compound is classified as "Less Vulnerable". Water Compatible land uses are considered appropriate in all Flood Zones and therefore for all parts of the site. The Proposed Development meets the requirements of the Sequential Test, with no requirement to fulfil the Exception Test.

Review of Existing Studies

Strategic Flood Risk Assessment

2.5 The North London SFRA (Mouchel 2008) presents a collation of information on all known sources of flooding in the area to use as an evidence base to inform planning policy and decision making. This included mapping of areas at risk of flooding using previous flood modelling studies. The main source of flooding identified for the site in the SFRA is from surface water, with a low risk identified for fluvial, tidal and groundwater flooding. The ponds on Hampstead Heath were highlighted as presenting a risk of reservoir flooding to downstream properties, although this risk was considered low.

2.6 There are no records of groundwater or fluvial flooding within the London Borough of Camden. There are seven records of sewer flooding documented in the SFRA, however the locations of these have not been specified and therefore it is not possible to identify how close the incidents were to Hampstead Heath.

Surface Water Management Plan

2.7 The London Borough of Camden undertook a specific SWMP (Halcrow 2011a) which has superseded the North London SFRA (2008). The SWMP highlights evidence of historic flooding from surface water, the most recent of which was in 2002 when a high intensity rainfall event resulted in extensive flooding and damage to properties, public services and facilities. The ponds on Hampstead Heath are highlighted as being located within a Critical Drainage Area (CDA), which can be defined as an area where multiple interlinked sources of flood risk cause flooding to a Local Flood Risk Zone (LFRZ). The LFRZ to which the Hampstead Heath CDA drains is at risk from two sources of flooding: surface water and the residual risk of inundation following overtopping or breaching of the pond embankments.

Flood Risk Management Strategy

2.8 The London Borough of Camden FRMS (London Borough of Camden 2013) aims to inform local residents and businesses about the risk of flooding, and provide an action plan to manage flooding in the areas of highest risk. This is a requirement of the Flood and Water Management Act 2010. The FRMS focuses on the risk of surface water flooding, which is highlighted as a particular issue in the Borough. In the FRMS, Hampstead Heath is identified as an area at high risk of surface water flooding, with anticipated flood depths of greater than 30cm. The area is also identified as being vulnerable to groundwater flooding, especially those locations with basement properties.

Preliminary Flood Risk Assessment

2.9 The Flood Risk Regulations (2009) require all Lead Local Flood Authorities to prepare a PFRA. The London Borough of Camden PFRA (Halcrow 2011b) provides a high level overview of all sources of flooding within the Borough, excluding flooding from Main Rivers. The PFRA highlights two sources of past flood risk in the local area: surface water flooding and sewer flooding. The location is highlighted as within the Hampstead area, with properties and roads affected. There are no other sources of past flood risk recorded within the PFRA.

Review of Existing Policies

Local Development Framework

2.10 The Site lies wholly within the London Borough of Camden administrative area. The London Borough of Camden's Local Development Framework (LDF) was adopted in November 2010. This comprises of a set of planning documents including:

- Camden Core Strategy 2010 – 2025 (November 2010); and
- Camden Development Policies 2010 – 2025 (November 2010).

2.11 Table 2-2 details the policies that are relevant in terms of flood risk.

Table 2-2: Camden Local Development Framework Core Policies

Document	Core Policy Number	Policy Name	Policy Summary
Camden Core Strategy	CS13	Tackling climate change through promoting higher environmental standards	All development should take measures to minimise the effects of, and adapt to, climate change. Development is encouraged to meet the highest feasible environmental standards that are financially viable during construction. In terms of water and surface water flooding, the policy requires the protection of reservoirs and requires development to avoid harm to the water environment, water quality or drainage and to prevent or mitigate local surface water and downstream flooding.
Camden Development Policies	DP23	Water	Requires developments to reduce the risk of flooding. All sites over one hectare are required by national planning policy contained within the NPPF to produce a site specific FRAs. In Camden these assessments should focus on the management of surface water run-off and should address the amount of impermeable surfaces resulting from development and the potential for increased flood risk both on site and elsewhere within the catchment.

London Plan 2011

2.12 The London Plan is the overall strategic plan for London, and it sets out a fully integrated economic, environmental, transport and social framework for the development of the capital to 2031. It forms part of the development plan for Greater London; the local plans written by London Boroughs need to be in general conformity with the London Plan, and its policies guide Council decision making on planning applications. Table 2-3 details the policies from the London Plan that are relevant in terms of flood risk.

Table 2-3: London Plan Core Policies

Core Policy Number	Policy Name	Policy Summary
5.12	Flood Risk Management	Outlines the requirement for Boroughs and developers to carry out FRAs and states that developments must comply with national planning policy on flood risk assessment and management to ensure they are designed and built to be resilient to flooding.
5.13	Sustainable drainage	Promotes the inclusion of sustainable urban drainage systems in developments and sets out a drainage hierarchy that developers should follow when designing their schemes.

Greater London Authority Sustainable Design & Construction Supplementary Planning Guidance 2014

2.13 The London Mayor published the Supplementary Planning Guidance (SPG) on Sustainable Design and Construction in 2014. The SPG provides guidance on the implementation of a range of policies that relate to environmental sustainability. The Mayor has set out priority areas (which are closely linked to the London Plan 2011), of which those relevant to flood risk can be summarised as follows:

- Developers should maximise all opportunities to achieve greenfield runoff rates in their developments.
- When designing their schemes developers should follow the drainage hierarchy set out in London Plan policy 5.13.

- Developers should design Sustainable Drainage Systems (SuDS) into their schemes that incorporate attenuation for surface water runoff as well as habitat, water quality and amenity benefits.
- Development in areas at risk from any form of flooding should include flood resistance and resilience measures in line with industry best practice.
- Developments should be designed to be flexible and capable of being adapted to and mitigating the potential increase in flood risk as a result of climate change. All sources of flooding need to be considered when designing and constructing developments.

3. Assessment of Flood Risk

Summary Assessment of all Sources of Flooding

3.1 The NPPF states that all sources of flooding should be considered within the development framework. The extent to which these sources are assessed will vary and depends on whether they are considered significant in the context of the site and Proposed Development. Table 3-1 defines the various sources of flooding and the risk of this section provides an initial assessment of each of these sources, identifying those that require further consideration. Those identified as a 'key risk' are then assessed in more detail in the remainder of Section 3.

Table 3-1: Definitions of all Sources of Flooding

Source	Definition	Key Risk
Fluvial flooding	Exceedance of the flow capacity of river channels, leading to overtopping of the river banks and inundation of the surrounding land. Climate change is expected to increase the risk of fluvial flooding in the future.	**No**
Tidal flooding	Flooding from the sea as a result of high tide levels and / or wave action. Alternatively, propagation of high tides and storm surges up tidal river channels, leading to overtopping of the river banks and inundation of the surrounding land.	**No**
Surface water (pluvial) flooding	Intense rainfall exceeds the available infiltration capacity and / or the drainage capacity (of both minor surface watercourses and surface water sewers) leading to overland flows and surface water flooding. Climate change is expected to increase the risk of surface water flooding in the future.	**Yes**
Groundwater flooding	Emergence of groundwater at the surface (and subsequent overland flows) or into subsurface voids as a result of abnormally high groundwater flows, the introduction of an obstruction to groundwater flow and / or the rebound of previously depressed groundwater levels.	**No**
Foul Sewer flooding	Flooding by water contaminated with sewerage in areas with a combined sewer network. This is caused by exceedance of sewer capacity and / or a blockage in the sewer network.	**No**
Other sources of flood risk including ponds and reservoirs	Flooding from canals, reservoirs (breach or overtopping) and failure of flood defences.	**Yes**

Fluvial Flooding

3.2 There are no rivers on or in the vicinity of Hampstead Heath. The streams on Hampstead Heath are classified as minor watercourses. For the purpose of this assessment therefore, channel exceedance is considered as a surface water flood risk. The ponds discharge into the culverted River Fleet. Flooding from this source is also considered as a surface water drainage issue. No further consideration of fluvial flooding is required as part of this FRA.

Tidal Flooding

3.3 Hampstead Heath is located on higher ground over 50m higher than, and over 5km from, the closest tidal reach of the River Thames. There are no other tidal open channels near the site. No further consideration of tidal flooding is required as part of this FRA.

Surface Water (pluvial) flooding

3.4 The Environment Agency flood mapping, SFRA, PFRA and SFRM have all identified the Site as an area with a high risk of surface water flooding. Furthermore, the SWMP highlights the Hampstead Heath ponds as being located within a Critical Drainage Area.

3.5 The Proposed Development has the potential to change the risk of surface water flooding by introducing new impermeable areas, disrupting surface water flow paths and affecting the rate and volume of water discharging from the last ponds in each chain, directly into the surface water sewer system.

3.6 A more detailed assessment of the existing risk of surface water flooding and the potential impact of the Proposed Development will be undertaken as part of this FRA.

Groundwater flooding

3.7 The higher parts of the Heath are underlain by the permeable Bagshot Beds and Claygate Members. At the lower elevations however, most of the ponds are underlain by impermeable London Clay. At the junctions of these bedrock geologies, spring lines form at the ground surface. These springs feed the streams which drain into the pond chains. Flood risk from these streams has been classified as surface water flooding.

3.8 A majority of the Heath is undeveloped and the Proposed Development is “Water Compatible” and therefore not sensitive to groundwater flooding. There are no historical records of groundwater flooding at or in the vicinity of the Site.

3.9 There is potential for any proposed below-ground works (for example, building foundations) to disrupt groundwater flow paths. The underlying London Clay will however contain very little mobile groundwater and any below-ground structures near the ponds will therefore have a negligible impact on groundwater flood risk.

3.10 No further consideration of groundwater flooding is required as part of this FRA.

Foul sewer flooding

3.11 A majority of the Heath is undeveloped and therefore has a low existing risk of flooding from foul sewers. The existing foul water system will not be affected by the proposed works and no new sewer connections are proposed. As part of the works at Ladies Bathing Pond, the existing changing rooms will be demolished and replaced with new facilities built in the same location. The replacement changing rooms will offer the same facilities and capacity and therefore there is no anticipated increase in foul sewer flows. The new system will be designed to ensure that there is no risk of foul sewer flooding.

3.12 No further consideration of foul sewer flooding is required as part of this FRA.

Other sources of flood risk including ponds and reservoirs

3.13 The closest canal is Regents canal, which is approximately 3.5km from the Site. This is however located at a lower elevation and so the Site would not be at risk should a breach from this canal occur. There are no raised flood defences in the vicinity of the site which would pose a risk of flooding if failure occurred. No further consideration of flooding from canals or failure of flood defences is required as part of this FRA.

3.14 The following other sources of flooding are however directly applicable to Hampstead Heath:

- The actual risk of flooding to the site and downstream receptors arising from the exceedance of pond capacity and the subsequent overtopping at one or more pond locations.
- The residual risk of flooding to the site and downstream receptors arising from the event of dam failure (breach).

3.15 Industry standard best practice, as laid out in ‘Floods and reservoir safety’, (Institution of Civil Engineers, 3rd edition 1996), is intended to ensure that where a community could be endangered by the breach of a dam, the risk of any breach caused by a flood is virtually eliminated. A community is defined as at least 10 people, and because of their proximity to densely populated areas, the dams are all category A as given in Table 1 of ‘Floods and reservoir safety’. This table states that the minimum standard for a design flood inflow at a Category A dam would be a 1:10,000 year flood if overtopping is tolerable, and the PMF if overtopping is not tolerable. As all the dams are earth embankment dams, with poor grass cover and trees on crests and slopes which would increase risk

of erosion due to eddying, overtopping of the dams is not tolerable. The hydraulic model indicated that, during a PMF event, the dams would be overtopped by depths of up to 550mm on the Highgate chain (at Highgate No. 1 Pond) and up to 410mm on the Hampstead chain (at Mixed Bathing Pond). These depths of flows in the PMF would present an unacceptable risk of dam failure. The dams would also be overtopped in smaller floods, as low as a 1:5 year flood in some locations, and could therefore fail individually or in a cascade. The key objective of the Proposed Development is to reduce the risk of dam failure, and thereby reduce the residual risk of flooding from this source. An assessment of the existing risk of reservoir flooding and the potential impact of the Proposed Development will be undertaken as part of this FRA.

3.16 The direct risk of flooding from Wood Pond and Thousand Pound Pond (which are owned and managed by English Heritage) is not assessed in this FRA. Works have recently been carried out on the dams at these ponds to make them resilient during a storm event. These ponds are therefore not thought to present a flood risk, as large floods will pass safely around these dams through their new spillways.

Flooding from Surface Water

Existing Flood Risk

3.17 The information provided in the SFRA, FRMS and PFRA described in Section 0, indicates there is a high risk of surface water flooding at the Site. The ponds are also located within a Critical Drainage Area as a result of the risk of flooding from both surface water and reservoir inundation. The locations at highest risk from surface water flooding are illustrated on the Environment Agency Flood Mapping for Surface Water (FMfSW), an extract from which is provided in Figure 3-1. The areas at risk consist of the lowest lying land around and between the two chains of ponds and along the lines of the minor watercourses and overland flow routes which feed them.

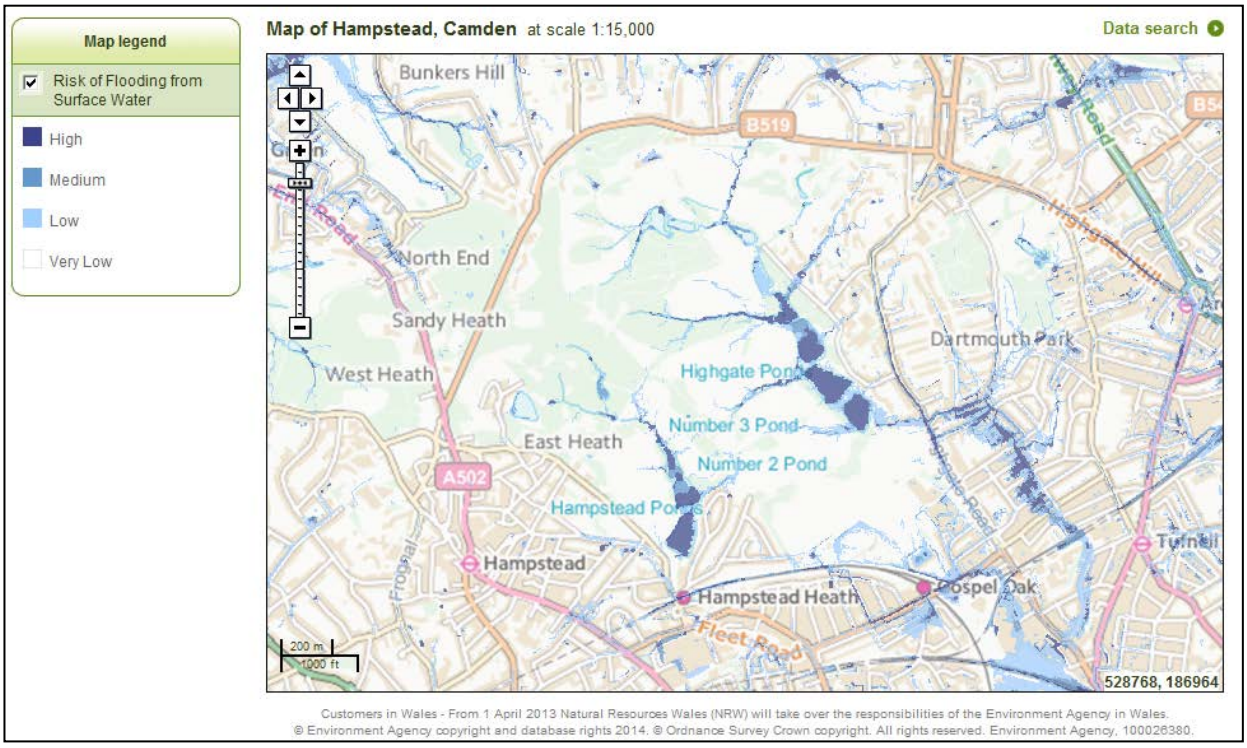

Figure 3-1: Extract from the Environment Agency FMfSW (last accessed April 2014)

3.18 Surface water flooding on and around Hampstead Heath can result from the following:

- exceedance of infiltration capacity (on both permeable greenfield and impermeable developed land);
- exceedance of minor surface watercourse capacity; and

- exceedance of the piped surface water drainage capacity including surface water sewers and the discharge of water into the culverted River Fleet.

Risk to the Proposed Development

Temporary Works

3.19 The Kenwood House nursery works compound is located on high ground, immediately south of Hampstead Lane. This is outside of the areas identified as being at risk from surface water flooding.

3.20 The locations of the smaller worksites have not been confirmed, but a map has been provided to the contractor, BAM Nuttall, which recommends that the lowest lying areas at risk of flooding are, where possible, to be avoided when siting the worksites. The nature of the Proposed Development, however, means that works will be required in the areas identified as being at risk of flooding. Only plant and materials being used at the time will be located at the worksites, with no storage of any unused plant or materials in these areas, reducing the risk of damage should any of the worksites be affected by surface water ponding. A 'just in time' approach to materials delivery will be used to minimise stockpiling or material storage on site. BAM Nuttall is currently developing methods which will be put in place during the construction phase to prevent inundation of the construction works. This includes the use of solid hoardings at each of the worksites, to reduce the risk of flooding and also to reduce the risk of contamination of surface water from loose materials.

3.21 A majority of the fill material required for the Proposed Development will be sourced from borrow pits located on the Heath. The risk of inundation of the borrow pits is minimised by avoiding the lowest lying areas at risk of flooding. Any inundation of the borrow pits will be managed by de-watering on site to drain the ground or surface water. This will be undertaken in accordance with the Environment Agency Pollution Prevention Guidelines and the receipt of any relevant permits.

Permanent Development

3.22 A majority of the Proposed Development has been identified as "Water Compatible" using the vulnerability classifications in Table 2 of the NPPF Technical Guidance (Communities and Local Government 2012). The raised dams, new spillways and culverts / pipes will be designed to convey water and therefore will not be damaged should surface water flooding occur. The replacement changing facility at Ladies Bathing Pond will be raised above the level of the pond to reduce the risk of internal flooding.

Impact of the Proposed Development

3.23 New developments have the potential to alter the pathway, speed, quantity and quality of surface water runoff and therefore the risk of surface water flooding to the site and neighbouring areas. This can be through the introduction of new areas of impermeable surfaces, disruption of surface water flow paths and changes to the rate and volume of water discharged in the surface water sewer system.

3.24 The impact of the Proposed Development has been assessed both with respect to the temporary works and the permanent development.

Temporary Works

3.25 The contractor, BAM Nuttall, has confirmed that no temporary impermeable areas are envisaged as part of the works. The works compound will be located on existing areas of hardstanding at the Kenwood House nursery. Plant and materials will be transported from the works compound to the worksites using designated access routes across the Heath, all of which are existing hard standing paths and roads. The only exception to this is the temporary access route which will be required to access Stock Pond and Ladies Bathing Pond from the west, as use of Millfield Lane is not permitted. This may entail a small temporary increase in impermeable area, the drainage from which will be managed by the contractors.

3.26 Surface water runoff assessments will be produced by BAM Nuttall for each of the works areas. These will indicate the route of any surface water runoff and will be used to ensure that major flow paths are not disrupted during the construction period. The worksites will be optimised to minimise the construction footprint, thereby reducing the likely impacts on flood flow routes. Any impacts which do

result from the worksites will be limited to the local diversion of surface water runoff, with a negligible impact on the risk of surface water flooding.

3.27 At Model Boating Pond, a portable dam will be installed in front of the existing dam. The space between the two dams will then be dewatered to provide the necessary working area. Dewatering and the subsequent controlled discharge of this water will be undertaken in accordance with the Environment Agency Pollution Prevention Guidelines and the issue of any relevant permits to ensure no increase in downstream flood risk. The use of a portable dam will avoid the need to completely dewater the whole pond.

3.28 Several of the ponds are to be de-silted using suction pump dredgers. The sediment will be discharged into silt bags where it will be left to settle and dewater, with the water passing through the walls of the bags. This water will either infiltrate into the ground or runoff overland back into the pond following the local topography. No further treatment of the water will be required because sufficient cleaning will be provided by the filtration of the silt bags and the added flocculent. It is anticipated that the silt will have a high water content (up to 90%). The bags will be located close to the ponds, such that any surface water runoff will only occur over a short distance. Given that the water will have originated from the ponds, the discharge of this same water back into the pond will not cause any increase in pond water levels and flood risk. It is recommended that the silt bags are orientated to minimise the impact they could have on existing surface water flow paths. As with the worksites, any impacts which do result from the silt bags will be limited to the local diversion of surface water runoff, with a negligible impact on the risk of surface water flooding.

Permanent Development

3.29 The Proposed Development will not result in any permanent increase in impermeable area on the site. The new facilities at the Ladies Bathing Pond are to replace the current facilities. While there is a proposed 90 – 121m2 increase in the building footprint, this increase will be over the existing pond, and therefore will not result in any change in the impermeable area on the Site. The raised dam embankments, the new dam in the Catchpit area and the new spillways will be overlaid with topsoil and grass, with no change in the rate or volume of surface water runoff from these areas.

3.30 A new dam is to be constructed in the Catchpit area at the lowest point of the valley. This has been designed to deliberately retain water in the upstream part of the Hampstead pond catchment during flood events. A pipe in the dam will allow the stream to flow unimpeded during normal conditions.

3.31 Currently, Highgate No.1 Pond and Hampstead No.1 Pond both have overflow pipes which discharge directly into the culverted River Fleet system. These overflow pipes will not be changed as part of the Proposed Development. The rate at which water is discharged through these pipes depends on the head of water at the upstream end (i.e. in the pond) and the water levels in the downstream end (i.e. in the connecting pipe). The pipes were included in the hydraulic modelling study (Atkins, 2013/14) which simulated the flow of water through the pond chains, including over the dams / spillways, through the pipes and over the surrounding land for both the existing and the Proposed Development scenarios. Water that spills over the dam embankments in the existing scenario or over the spillway / through the box culvert in the proposed scenario will flow overland towards the urban areas. This water will then enter the surface water sewer system though road gullies.

3.32 Table 3-2 and Table 3-3 list the peak flows of water discharged from Highgate No. 1 Pond and Hampstead No. 1 Pond for both the existing and proposed scenarios, for a range of flood events, up to and including the Probable Maximum Flood (PMF). Table 3-4 and Table 3-5 list the volume of water discharged in a 14-hour model run period.

Table 3-2: Peak flow of water discharged from Highgate No. 1 Pond

Flood Event (AEP)	Peak flow of water discharged from Highgate No. 1 Pond (m^3/s)			
	Through Pipe		Over dam / pond edges (existing) and over spillway (proposed)	
	Existing	Proposed	Existing	Proposed
1 in 100 (1%)	0.5	0.7	0.4	No overtopping
1 in 1,000 (0.1%)	0.6	0.7	13.6	0.6

1 in 10,000 (0.01%)	0.6	0.7	15.9	4.9
PMF	0.7	0.7	34.8	30.8

Table 3-3: Peak flow of water discharged from Hampstead No. 1 Pond

Flood Event (AEP)	Peak flow of water discharged from Hampstead No. 1 Pond (m^3/s)			
	Through Pipe		Over dam / pond edges (existing) and through box culvert (proposed)	
	Existing	Proposed	Existing	Proposed
1 in 100 (1%)	0.4	0.4	No overtopping	No flow
1 in 1,000 (0.1%)	0.5	0.5	4.1	2.5
1 in 10,000 (0.01%)	0.5	0.5	5.2	3.3
PMF	0.5	0.5	14.3	11.1

Table 3-4: Volume of water discharged from Highgate No. 1 Pond

Flood Event (AEP)	Volume of water discharged from Highgate No. 1 Pond (m^3) in 14 hours					
	Through Pipe		Over dam / spillway / pond edges		Total	
	Existing	Proposed	Existing	Proposed	Existing	Proposed
1 in 100 (1%)	17,800	2,100	6,700	0	24,500	2,100
1 in 1,000 (0.1%)	22,600	21,300	65,400	0	88,000	21,300
1 in 10,000 (0.01%)	22,900	21,500	82,000	26,800	104,900	48,300
PMF	18,100	19,800	199,300	157,500	217,400	177,300

Table 3-5: Volume of water discharged from Hampstead No. 1 Pond

Flood Event (AEP)	Volume of water discharged from Hampstead No. 1 Pond (m^3) in 14 hours					
	Through Pipe		Over dam / spillway / pond edges		Total	
	Existing	Proposed	Existing	Proposed	Existing	Proposed
1 in 100 (1%)	18,000	14,500	0	0	18,000	14,500
1 in 1,000 (0.1%)	22,000	20,300	17,300	12,700	39,300	33,000
1 in 10,000 (0.01%)	21,900	20,200	23,100	18,300	45,000	38,500
PMF	18,100	17,000	75,700	71,600	93,800	88,600

3.33 The model results demonstrate that for any flood event there will be a reduction in both peak rate and volume of water that is passed downstream from Highgate No. 1 Pond and Hampstead No. 1 Pond. At Hampstead No.1 Pond, the frequency of flooding of areas downstream will be less than existing, and the return period of the flood causing flow through the box culvert will be closer to 1 in 1,000 than in the existing scenario.

3.34 The peak flow in the Highgate No. 1 Pond outlet pipe is marginally higher following the Proposed Development because the dam raising work accommodates higher flood levels in the pond and therefore a higher head of water at the upstream end of the pipe. This peak flow is still very small in the context of the overall flows through the pond chain in these flood events. It is also more than compensated for by the reduction in peak flow over the new Highgate No. 1 Pond spillway compared with over the existing dam crest. Figure 3-2 and Figure 3-3 illustrate the existing and proposed PMF flows from the two downstream ponds.

3.35 Furthermore, the additional storage capacity means that there will be a delay in the discharge of water from Highgate No. 1 Pond and Hampstead No. 1 Pond, providing more time during a flood event for the peak flows in the surface water sewer to pass further downstream. The delay in discharge is illustrated on Figure 3-2 and Figure 3-3. It is however noted, that should such an extreme event occur, widespread surface water flooding would be likely and so the benefits of the increased attenuation provided by the ponds to people, property and infrastructure, would be negligible.

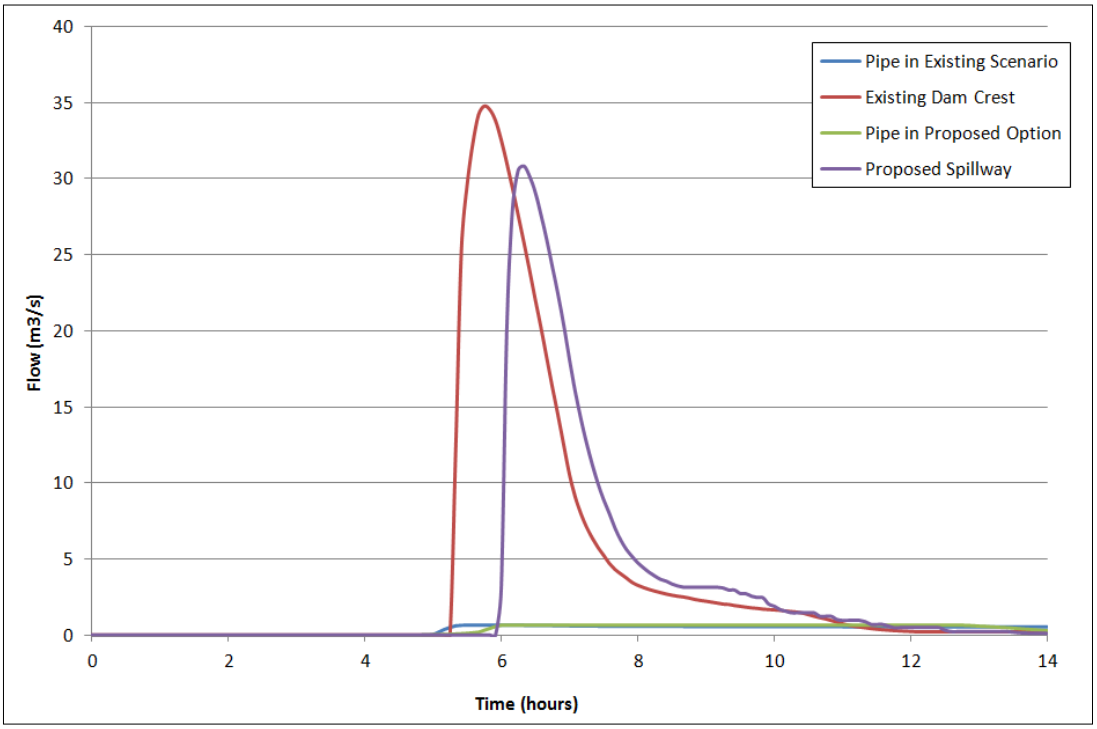

Figure 3-2: Existing and proposed PMF flows from Highgate No. 1 Pond

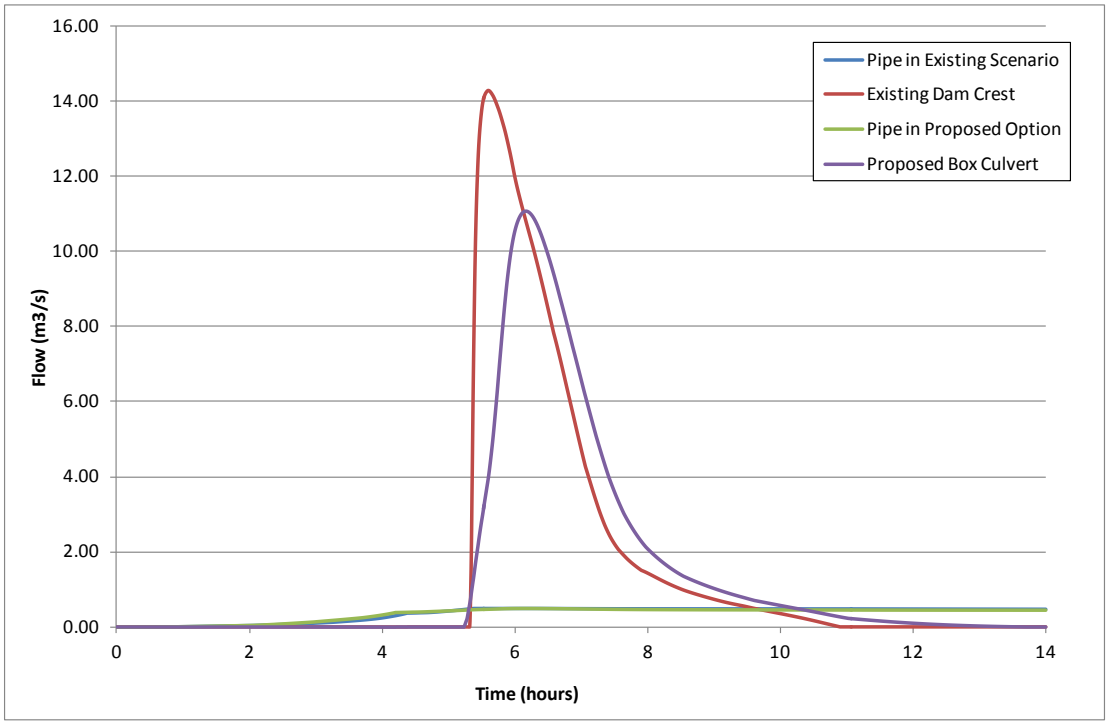

Figure 3-3: Existing and proposed PMF flows from Hampstead No. 1 Pond

Flooding from Reservoirs

3.36 This section considers the two risks of flooding posed by the Hampstead Heath ponds, both to the Heath and to downstream receptors. These are:

1. the actual risk of flooding arising from the exceedance of pond capacity and the subsequent overtopping at one of more pond locations; and
2. the residual risk of flooding arising from the unlikely event of dam failure (breach).

3.37 The assessment makes use of the outputs from the Hampstead Heath Ponds Project hydraulic modelling studies (Atkins, 2013/14) undertaken to simulate the risk of overtopping for both the existing and the Proposed Development scenarios; and the impacts of dam breaching (failure).

Risk of Overtopping

3.38 The existing and post-works Standard of Protection (SoP) (which describes estimated frequency of pond overtopping) has been modelled as part of the Hampstead Heath Pond Project. This assessment highlighted that under the existing scenario, dam overtopping first occurs in the Highgate chain at Stock Pond and in the Hampstead chain at Mixed Bathing Pond during the 1 in 5 annual chance flood event (20% AEP). The annual frequency of flood which results in overtopping of the dam crest for each of the ponds is summarised in Table 3-6.

Table 3-6: Average frequency of flood currently causing water to flow over the dam crests

Average Frequency Range	Highgate chain ponds	Hampstead chain ponds
Up to 5 years	Stock Pond	Mixed Bathing
5 years to 20 years	Ladies Bathing, Bird Sanctuary	-
20 to 50 years	Model Boating, Men's Bathing	Hampstead No. 2
50 years to 100 years	Highgate No 1	-
100 years to 1,000 years	-	Vale of Health, Viaduct, Hampstead No. 1
1000 to 10,000 years	-	-

3.39 Should a major storm occur during the construction period, there is a risk that dam overtopping will inundate the construction works. The construction approach described above is not only relevant to the risk of surface water flooding, but will also minimise the impact of inundation from pond overtopping. It is recommended that the contractors sign up to receive alerts from the UK Met Office to warn of any forecast storms in the Hampstead Heath area. This should be combined with monitoring of the pond water levels, and the information used to make worksites safe and evacuate construction workers should there be a risk of flooding.

3.40 The existing risk of flooding from the ponds in the downstream urban areas is evaluated from a hydraulic assessment of overtopping at Highgate No. 1 Pond and Hampstead No. 1 Pond. In the existing situation, these ponds have been found to overtop in the 1 in 100 (1%) flood event and the 1 in 1,000 (0.1%) flood event respectively.

3.41 Under the Proposed Development, the works have been designed to ensure that overtopping of the dam crest does not occur, for all flood events up to and including the PMF. Each of the ponds will have a spillway or box culvert which will be designed to safely convey water around or through the dam. Modelling of the Proposed Development has confirmed that the new spillway to be constructed at Highgate No. 1 Pond will not discharge water during the 1 in 100 (1%) flood event. This represents an improvement in the SoP and a reduction in the risk of flooding to downstream areas arising from overtopping of Highgate No. 1 Pond.

3.42 In the proposed scenario, the return period at which the box culvert spillway at Hampstead No.1 Pond is overtopped would be higher, and the new box culvert will discharge water less frequently than the overtopping of the dam crest in the existing scenario. The frequency of flooding downstream will therefore be reduced by the proposed works. For any return period event the volume of water discharged through the culvert, and the rate of flow, would both be lower. There will

therefore be no change to the existing risk of flooding to downstream areas arising from the overtopping of Hampstead No. 1 Pond.

3.43 The modelling evidence for this assessment is provided in Table 3-7.

Table 3-7: Downstream SoP under the existing and proposed scenarios

Pond	Flood Event (AEP)	Existing		Proposed	
		Maximum water level (m AOD)	Uncontrolled overtopping?*	Maximum water level (m AOD)	Controlled overtopping?
Highgate No. 1	1 in 50 (2%)	63.20	No	62.61	No
	1 in 100 (1%)	63.89	Yes	62.77	No
	1 in 1,000 (0.1%)	64.15	Yes	64.48	No
Hampstead No. 1	1 in 100 (1%)	70.29	No	69.77	No
	1 in 1,000 (0.1%)	71.04	Yes	70.46	Yes
	1 in 10,000 (0.01%)	71.05	Yes	70.51	Yes

* Uncontrolled overtopping assessment based on a comparison of the maximum pond water level with the existing minimum dam crest level of 63.77m AOD at Highgate No. 1 Pond and 70.91m AOD at Hampstead No. 1 Pond.

Risk of Dam Failure

3.44 As explained above, the dams are vulnerable to erosion due to overtopping in a range of flood events. As all the dams are risk category A as described in Table 1 of 'Floods and reservoir safety' (Institution of Civil Engineers, 3rd edition 1996), and overtopping is not tolerable, the design standard flood inflow is the PMF. During a PMF, the dams would be overtopped for several hours by depths of up to 550mm, which presents an unacceptably high risk of erosion leading to dam failure. Smaller floods will also cause overtopping of dams, most of which do not have the minimum level of resilience that a good grass cover would provide, due to the covering of trees on the dams. Dam failure would lead to the uncontrolled release of stored water and extensive flooding in the downstream areas of Gospel Oak, Dartmouth Park and Kentish Town.

3.45 The key objective of the Proposed Development is, therefore, to **virtually eliminate the risk** of flooding resulting from dam failure, following the guidance in 'Floods and reservoir safety'. This will be achieved in three ways:

- Dam crest raising will reduce the volume of water overflowing the spillways compared to that overtopping the dams in the existing scenario;
- The new spillway channels and / or culverts will be designed to safely pass floodwater around instead of over the dams, reducing the risk of erosion and breach / failure; and
- The design of the new / raised embankments will be undertaken to the current high design standards for reservoirs in the UK to ensure that they are structurally sound.

3.46 This is a passive control system where no human intervention or mechanical apparatus is required to control the floodwater. Table 3-8 provides a comparison of the dam crest levels and the maximum water levels in the existing and proposed scenarios, to demonstrate the benefit that the Proposed Development has on dam crest overtopping during the PMF event. The only dam crest which is modelled to overtop is at Bird Sanctuary Pond, and this is because it has been designed to be 'drowned' by rising water levels in Model Boating Pond, immediately downstream. Under the Proposed Development, the new spillways and culverts will pass floodwater around instead of over the dam crests.

Table 3-8: Risk of dam crest overtopping in the PMF event

Pond	Existing			Proposed		
	Min. dam crest level (m AOD)	Max. water level (m AOD)	Uncontrolled overtopping depth (mm)	Min. dam crest level (m AOD)	Max. water level (m AOD)	Uncontrolled overtopping depth (mm)
Highgate Chain						
Stock	81.65	82.09	440	82.20	82.13	Dam crest does not overtop
Ladies Bathing	76.87	77.20	330	77.17	77.01	
Bird Sanctuary	72.57	73.02	450	72.65	74.13	Dam drowns
Model Boating	71.87	72.25	380	74.37	74.13	Dam crest does not overtop
Men's Bathing	68.16	68.54	380	69.16	69.05	
Highgate No. 1	63.77	64.32	550	65.02	64.91	
Hampstead Chain						
Vale of Health	105.44	105.59	150	105.82	105.76	Dam crest does not overtop
Viaduct	89.97	90.10	130	90.16	90.08	
Mixed Bathing	75.46	75.87	410	76.82	76.74	
Hampstead No. 2	74.91	75.26	350	75.15	75.07	
Hampstead No. 1	70.91	71.15	240	70.91	70.82	

3.47 Following completion of the works, the risk of a reservoir breach will be substantially reduced to 'Within the range of Tolerability' as defined in the Risk Assessment for Reservoir Safety Management (RARS) guidance (Defra 2013). The residual risk of flooding from the ponds will then be considered negligible.

3.48 Future management of the ponds and associated structures will be set out in the revised Heath Management Plan and the revised Emergency Plan, and will include statutory inspections and maintenance. This will ensure that the residual risk of flooding from the ponds remains negligible for the lifetime of the development. An updated breach assessment will also be undertaken to map the impacts of dam failure on downstream people, property and infrastructure.

4. Conclusions and Recommendations

4.1 This FRA has been undertaken in accordance with NPPF to accompany a Planning Application for works to the Highgate and Hampstead chains of ponds on Hampstead Heath. The Proposed Development is being promoted to reduce the risk of dam failure at any of these ponds.

4.2 In summary, the Proposed Development includes raising and reinforcing existing dams, constructing a new dam in the Catchpit area, constructing spillways (both open and box culverts) and reconstructing the swimming facilities at Ladies Bathing Pond. The ecological and landscape impacts will be mitigated by softening pond edges and improving marginal habitat, and dredging will be undertaken to improve the water quality of the ponds.

Flood Risk

4.3 This FRA has identified that flooding from surface water, and from the ponds, are the key flood risks to Hampstead Heath and adjacent areas. These sources of flooding were subject to more detailed assessment, the findings of which are summarised below.

Flooding from Surface Water

4.4 Surface water flood risk to the construction works will be minimised by: where possible avoiding low lying areas at highest risk; managing the storage of plant and materials; and undertaking dewatering if required. Once built, the Proposed Development is water compatible and would not be damaged by surface water flooding.

4.5 There will be no increase in impermeable area either during the construction or following completion of the works. This is possible because of the use of hardstanding at the Kenwood House nursery and existing paving access routes across the Heath during construction, and the design of the new structures overlaid with topsoil and grass. Surface water runoff assessments will be produced by the contractor BAM Nuttall. These, along with the Construction Management Plan, will outline the methods used to ensure that the construction works, including the worksites, dewatering and silt bags do not increase surface water flood risk.

4.6 The model results demonstrate that there will be a reduction in both the peak rate and volume (over a 14-hour period) of water that is passed into the downstream surface water drainage system from Highgate No. 1 Pond and Hampstead No. 1 Pond in the proposed scenario compared with the existing situation. The additional storage capacity also means that there will be a further delay in the discharge of water from these ponds, providing more time during a flood event for the peak flows in the surface water sewer to pass further downstream. The proposed works will therefore act to reduce the risk of surface water flooding downstream. Should such an extreme event occur however, widespread surface water flooding would be likely, and so the benefits of the increased attenuation provided by the ponds to people, property and infrastructure, would be negligible.

Flooding from Reservoirs

4.7 Should a major storm occur during the construction period, there is a risk that dam overtopping will inundate the construction works. The methods described for surface water flooding will also minimise the impact of inundation from dam overtopping.

4.8 The hydraulic modelling work has confirmed that the new spillway to be constructed at Highgate No. 1 Pond and the new box culvert at Hampstead No. 1 Pond will discharge water less frequently than the overtopping of the dam crest in the existing scenario. The proposed works will therefore not increase the risk of flooding to downstream areas arising from the overtopping of the ponds.

4.9 Because of the inadequate overflow pipes and lack of flood storage capacity in the ponds, overtopping of the dams is unacceptably frequent. In the existing scenario, the dams are overtopped in low return period events (around 1:100 at Highgate No.1 Pond and 1:1000 at Hampstead No.1 Pond). All of the dams would be overtopped in a PMF event, and in any overtopping there is a risk of dam failure due to erosion of the dam crest and downstream slope, due to the lack of good grass cover.

4.10 Dam failure would lead to the uncontrolled release of stored water and extensive flooding in the downstream areas of Gospel Oak, Dartmouth Park and Kentish Town. The Proposed Development will reduce the residual risk of flooding by constructing new spillway channels and / or culverts to safely pass floodwater around instead of over the dams and by ensuring that any new or raised dams meet high present-day engineering standards for structural stability.

4.11 Modelling work has demonstrated that the dam crests would not be overtopped in the PMF event following completion of the works. In the absence of overtopping, the risk of a reservoir breach will be substantially reduced and the residual risk of flooding from the ponds will be negligible.

Recommendations

4.12 There are several recommendations arising from this FRA. These are described in the relevant parts of this document and are summarised as follows:

- Work sites should be located, where possible, away from the lowest lying areas (at risk of flooding) immediately adjacent to and between the ponds.
- The current intention for no temporary increases in impermeable area during the construction phase should be realised. If this is not possible, the temporary increase in surface water runoff rates and volume will need to be managed to ensure no increase in the risk of surface water flooding.
- Partial dewatering of Model Boating Pond and the borrow pits (if required) should be undertaken in accordance with the Environment Agency Pollution Prevention Guidelines and the issue of any relevant permits.
- Surface water runoff assessments should be produced by the contractor for each of the works areas.
- The silt bags should be orientated to minimise the impact they have on local surface water flow paths.
- The contractors should sign up to receive alerts from the UK Met Office to warn of any forecast storms in the Hampstead Heath area and combined with monitoring of the pond water levels, use this information to make worksites safe and evacuate workmen should there be a risk of flooding.
- The Heath Management Plan and Emergency Plan should be updated to document the future management of the ponds and associated structures.
- An updated breach assessment should be undertaken to map the impacts of dam failure on downstream people, property and infrastructure following completion of the Proposed Development.

Conclusion

4.13 It is considered that the Proposed Development satisfies the requirements of the NPPF. It is compatible with the level of flood risk and will not increase flood risk at the site or to the surrounding area.

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