RUGBY FOOTBALL UNION

Flood Risk Assessment

Twickenham Stadium – East Stand Extension

June 2016

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Flood Risk Assessment

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Executive Summary

01

1 Executive Summary

AECOM has been commissioned to prepare a site-specific Flood Risk Assessment (FRA), to accompany a detailed planning application for the extension of the Rugby Football Union's Twickenham Stadium East Stand, which is situated to the south of the Mogden Sewage Treatment Works at 200 Whitton Road, Twickenham, Middlesex, TW2 7BA. The RFU is applying directly for detailed planning submission.

The application for which this FRA has been prepared comprises of a six storey extension to the east stand, which will provide additional floor space.

The proposed development is located within NPPF Flood Zone 2 and is therefore considered to be at risk of flooding from rivers between the 1 in 100 year (1% annual probability) and 1 in 1000 year (0.1% annual probability) events. The proposed development would be considered as "Less Vulnerable" according to the NPPF and is considered to be acceptable within Flood Zone 2. Further application of the Sequential Test or Exception test is not required.

An assessment of the existing fluvial and tidal flood risk has been made using information available from the Environment Agency Product 4 data, Environment Agency online flood maps, the London Borough of Richmond Upon Thames Strategic Flood Risk Assessment (SFRA), existing site topographical survey, development proposals and records of historical flood events. This report has concluded that the application site lies within Flood Zone 2 in accordance with the NPPF. The risk of fluvial flooding is considered to be medium.

Flooding of the site from the Duke of Northumberland's River is predicted in the 1 in 100 year plus 20% climate change event and the 1 in 1000 year event. Flood depths during these events are thought to be up to 0.1m and 0.3m respectively. These depths are not considered to give rise to significant hazard to users of the stadium facilities.

Climate change predications suggest that the site may become located in Flood Zone 3 in the future. Ground levels are not being altered and within the extension on ground level, the new footprint has limited occupied space, consisting of small lobby areas, a lift and turnstiles. Currently the site does not flood in the 1 in 100 flood event (1% AEP). When considering future climate change (at 20%) flooding is predicted to occur in the 1 in 100 year flood event, however this will be to an approximate maximum depth of 100mm. The nature of the development proposals will not create a significant loss of floodplain storage during this event. It is therefore considered that the extension will not increase flood risk to other sites.

Other sources of flood risk have been considered including public sewers, pluvial, groundwater and reservoirs. The flood risk to the site from these sources is considered to be low.

This report has shown that the surface water drainage strategy ensures that all of the surface water runoff from the roof will be discharged to the site's existing surface water network. The current site is comprised entirely of an area of hard standing. The proposed development will not, therefore, lead to an increase in impermeable area. Although the interception of rainwater will occur at a higher level post development, the impact on drainage will not be significant and the existing regime will be maintained.

Although the proposed development will not increase the flood risk any further than the current level, the RFU must take into consideration repair and long term maintenance of existing flood defences they have responsibility for as riparian owners to protect the whole site from flooding in the future.

Consideration of residual flood risks is required in accordance with the NPPF. There is a residual risk of flooding occurring from the following circumstances:

- Failure of existing flood defences resulting in fluvial flooding;
- Overtopping of flood defences in events in excess of the 1 in 100 year return period;
- An on-site rainfall event in excess of the relevant design standards resulting in flooding from the proposed surface water drainage system;
- Poor maintenance of the proposed drainage systems, which could lead to blockage.

Mitigation of these residual risks can be managed by:

- Providing safe access and egress to Whitton Road to the south west of the stadium;
- Arranging finished surface levels such that designed storm exceedance flows do not cause flooding of the site, access road, buildings in the vicinity of the site or other sensitive areas;
- Repair and long term maintenance of the flood defences;
- Long term maintenance of the private drainage systems.

Introduction

02

2 Introduction

2.1 Introduction

AECOM has been commissioned to prepare a site-specific Flood Risk Assessment (FRA), to accompany a detailed planning application for the extension of the Rugby Football Union's Twickenham Stadium East Stand, which is situated to the south of the Mogden Sewage Treatment Works at 200 Whitton Road, Twickenham, Middlesex, TW2 7BA. The RFU is applying directly for detailed planning submission.

The application for which this FRA has been prepared comprises of a six storey extension to the east stand, which will provide additional floor space for hospitality use for the levels 1, 2, 3, 4, 4a and 5.

This Flood Risk Assessment (FRA) has been prepared to the requirements of the National Planning Policy Framework, 2012 (NPPF). This FRA is considered to be a Level 2 Scoping Study as defined by *CIRIA 624 Development and Flood Risk*.

The Local Planning Authority, Environment Agency and Local Lead Flooding Authority (LLFA) need to be satisfied that the granting of planning permission will address the risk of flooding to the development site and that the proposals will not in turn increase the risk of flooding to neighbouring land and property.

This report will, in accordance with the NPPF (and the accompanying Technical Guidance document), propose preventative measures to mitigate against flooding from any source, if found necessary.

The report will also look at a surface water drainage strategy for the scheme to establish constraints and design requirements and if applicable, to promote the use of Sustainable Drainage Systems (SuDS).

This Flood Risk Assessment has therefore been prepared in order to identify and evaluate the various possible sources of flood risk to which the site might be subjected to and identify any mitigation, protection or compensation measures deemed necessary or feasible.

Review of the Environment Agency Flood Map for the site indicates that the site lies within Flood Zone 2.

Any site larger than 1 ha, or that falls within Flood Zones 2 and 3 requires an FRA to be submitted with a planning application (NPPF).

2.2 Summary of Requirements of NPPF

NPPF requires the FRA to consider all potential forms of flooding, including river, sea, estuary, land drainage, groundwater, surface water run-off, flooding from sewer systems, flooding from reservoirs and canals, etc and should consider the impact of flooding on both the development and off site parties and land. Appendix 1 contains further information on its requirements.

2.2.1 Flood Risk and Vulnerability

Flood risk takes account of both the probability and the consequences of flooding (i.e. vulnerability of the development etc.). Flood frequency is usually interpreted in terms of the return period e.g. 1 in 50 and 1 in 100-year event etc. In betting terms, there is a 50/1 (2%) chance of one or more 1 in 50-year floods occurring in a given year. Similarly, there is a 100/1 (1%) chance of one or more 1 in 100-year floods occurring in a given year.

Vulnerability classifications, as defined in the NPPF Technical Guidance document, are Essential Infrastructure, Highly Vulnerable, More Vulnerable, Less Vulnerable and Water Compatible Development.

Appendix 1 contains a detailed description of which types of development fall into each vulnerability classification.

2.2.2 Flood Zones

There are four classifications for flood zones, as defined in the NPPF:

- Zone 1: Low probability (less than 1 in 1000 annual probability of river or sea flooding in any year);
- Zone 2: Medium probability (between 1 in 100 and 1 in 1000 annual probability of river flooding or between 1 in 200 and 1 in 1000 annual probability of sea flooding in any year);

- Zone 3a: High probability (1 in 100 or greater annual probability of river flooding in any year or 1 in 200 or greater annual probability of sea flooding in any given year);
- Zone 3b: High probability (functional flood plain. Essentially the 1 in 20 or greater annual probability of flooding in any given year).

2.3 The Sequential Test and Exception Test

The Sequential Test is a risk-based test that should be applied at all stages of development and aims to steer new development to areas with the lowest probability of flooding (Zone 1). This is applied by the Local Authority by means of a Strategic Flood Risk Assessment (SFRA).

Furthermore, large sites partially affected by Flood Zones 2 and 3 should be developed sequentially, placing the most vulnerable land uses in the areas with lowest risk of flooding. Further details of the Sequential Test are provided in Appendix 1.

The SFRA may require the Exception Test to be applied to certain forms of new development. The test considers the vulnerability of the new development to flood risk and, to be passed, must demonstrate:

- There are sustainability benefits that outweigh flood risk.
- It is on previously developed land or there are no other reasonably developable sites.
- The new development is safe without increasing flood risk elsewhere.

Further details of the Exception Test are provided in Appendix 1.

2.3.1 Climate Change

The NPPF makes it a planning requirement to account for climate change in a proposed development's design. The recommended allowances have recently been updated with new advice published by the Environment Agency on 19th February 2016. Making allowances for climate change helps to minimise vulnerability and provide resilience to flooding and coastal change in the future. The climate change allowances are predictions of anticipated change for:

- Peak river flow by river basin district;
- Peak rainfall intensity;
- Sea level rise;
- Offshore wind speed and extreme wave height.

They are each based on climate change projections and different scenarios of CO_2 emissions to the atmosphere. There are different allowances for different epochs or periods of time over the next century.

2.3.2 Sustainable Drainage

The key planning objectives in the NPPF are to appraise, manage and where possible, reduce flood risk. The NPPF (and covered by Part H of the Building Regulations (DTLR, 2002)), directs developers toward the use of Sustainable Drainage Systems (SuDS) wherever possible.

2.4 Local Policy Requirements

The London Borough of Richmond Upon Thames has a statutory duty to guide development within the borough and use a number of policies to do so. The Local Plan is a guide to development in Richmond Upon Thames up to 2024 and it is used to assess planning applications. Guidance and policies from these documents that are relevant to flood risk, drainage and SuDS include:

2.4.1 *'Core Strategy'*, Richmond Upon Thames Local Plan – The Core Strategy (Adopted April 2009)

Note: The local plan refers to 'PPS25 Practice Guide' which has been superseded by the National Policy Planning Framework (NPPF). This has been summarised in the previous section 2.2.

Key policies from the Core Strategy include:

4.4.9 Climate Change

"4.4.11 Hotter, drier summers, warmer wetter winters and more extreme weather events are all predicted for South East England, as a result of climate change. In this Borough one of the most significant impacts will be the increased likelihood of flooding from the River Thames and its tributaries."

5.1.3 A Sustainable Future – Key Issues

"4. Increasing potential fir the River Thames and its tributaries to flood with related risk to personal safety and property, and other potential impacts of climate change in the borough leading to possible water shortages, hotter summers and increased rate of subsidence (due to drying out of underlying clay)."

8.1.3 CP3 Climate Change – Adapting to the Effects

"3.B Development in areas of high flood risk will be restricted, in accordance with PPS25, and using the Environment Agency's Catchment Flood Management Plan, the Borough's Strategic Flood Risk Assessment and the site level assessments to determine risk.

8.1.3.1 Justification

Although there are some localised drainage issues, the main risk in the Borough is from both fluvial and tidal flooding from the River Thames and its tributaries (the River Crane and the Beverley Brook). In accordance with PPS25 the Council will apply the Sequential Test and Exception Test to any Site Allocations and when dealing with applications in areas of flood risk. The Council's Strategic Flood Risk Assessment and advice from the Environment Agency can be used to identify the strategic flood risk, which will then need to be assessed at site level when development is proposed.

Developers should undertake site specific flood risk assessments (FRAs) as set out in chapter 3 of PPS 25 Practice Guide and relevant CIRIA guidance. The FRA will need to demonstrate to the satisfaction of the Council that any flood risks to the development, or additional risk arising from the proposal will be successfully managed with the minimum environmental effect, and that necessary flood risk management measures are sufficiently funded to ensure that the site can be developed and occupied safely throughout its proposed lifetime.

The Council will in principle support measures proposed by Thames Water, the Environment Agency, the Emergency Services and others to reduce flood risk, including increasing the quality of the floodplain, defend areas at risk and mitigate the effects of flooding through sustainable drainage and other measures."

8.1.3.6 Implementation

"Objective

8.1.3.8 With respect to flooding specifically, community management measures will be taken forward through the Council's Emergency Planning measures, in conjunction with others such as Thames Water, TLS, the Environment Agency and the Emergency Services. Consideration will be given to the proposals by the Environment Agency to expand the flood plain."

2.4.2 London Borough of Richmond upon Thames Adopted Development Management Plan (November 2011)

Policy DM SD 6 Flood Risk

"Development will be guided to areas of lower risk by applying the Sequential Test. Unacceptable developments and land uses will be restricted in line with PPS25 and as outlined in the table below. Developments and Flood Risk Assessments must consider all sources of flooding and the likely impacts of climate change. Note that new guidance on climate change allowances was published by the EA in February 2016.

Where a Flood Risk Assessment is required and in addition to the Environment Agency's normal floodplain compensation requirement, attenuation areas to alleviate fluvial and/or surface water flooding must be considered where there is an opportunity. The onus is on the applicant/developer for proposals on sites of 10 dwellings or 1000sqm of non-residential development or more to provide evidence and justification if attenuation areas cannot be used.

In areas at risk of flooding, all proposals on sites of 10 dwellings or 1000sqm of non-residential development or more are required to submit a Flood Warning and Evacuation Plan."

Policy DM SD 7 Sustainable Drainage

"All development proposals are required to follow the drainage hierarchy (see below) when disposing of surface water and must utilise Sustainable Drainage Systems (SuDS) wherever practical. Any discharge should be reduced to greenfield run-off rates wherever feasible."

When discharging surface water to a public sewer, developers will be required to provide evidence that capacity exists in the public sewerage network to serve their development.

Policy DM SD 9 Protecting Water Resources and Infrastructure

"The Borough's water resources and supplies will be protected by resisting development proposals that would pose an unacceptable threat to surface water and groundwater quantity and quality. This includes pollution caused by water run-off from developments into nearby waterways."

Policy DM SD 10 Water and Sewerage Provision

"New development will need to ensure that there is adequate water supply, surface water, foul drainage and sewerage treatment capacity to serve the development."

2.4.3 The Mayor's London Plan (2011) – Consistency with the NPPF (2012)

Policies 5.12 and 5.13 of the Mayor's London Plan address the issues of flood risk management and sustainable drainage systems (SUDS).

Policy 5.12 Flood Risk Management

"A The Mayor will work with all relevant agencies including the Environment Agency to address current and future flood issues and minimise risks in a sustainable and cost effective way.

B Development proposals must comply with the flood risk assessment and management requirements set out in the NPPF and associated Technical Guidance on flood risk over the lifetime of the development and have regard to measures proposed in Thames Estuary 2100 (TE2100 ...) and Catchment Flood Management Plans."

Policy 5.13 Sustainable Drainage

"A Development should utilise sustainable urban drainage systems (SUDS) unless there are practical reasons for not doing so, and should aim to achieve Greenfield run-off rates and ensure that surface water run-off 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;*
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".

Further policy regarding maximum runoff discharge rates is available in the London Plan 2011 Sustainable Design and Construction Supplementary Planning Guidance.

"3.4.5 London Plan policy 5.13 states that developers should aim for a greenfield runoff rate from their developments. Greenfield runoff rates are defined as the runoff rates from a site, in its natural state, prior to any development. Typically this is between 2 and 8 litres per second per hectare. The CIRIA SuDS Manual generally recommends the institute of Hydrology Report 124 methodology for calculating greenfield runoff rates.

3.4.6 Achieving a greenfield runoff rate is of particular importance where the development is located in a catchment that contributes to combined sewers with known and/or modelled capacity or flooding issues. Information to determine whether capacity/flooding issues exist is available from borough SWMPs and Strategic Flood Risk Assessments (SFRAs) as well as other historic data.

3.4.7 If greenfield runoff rates are not proposed, developers will be expected to clearly demonstrate how all opportunities to minimise final site runoff, as close to greenfield rate as practical, have been taken. This should be done using calculations and drawings appropriate to the scale of the application. In order to achieve this, applicants should:

- *consider the permeability of all existing and proposed surfaces on the application site;*
- *assess the existing surface water and foul drainage networks and their discharges; and*
- *assess a range of return periods (the probability of a rainfall event of a particular size occurring and resulting in flooding) up to and including the 1 in 100 year plus climate change critical storms (an additional 20-30%).*

3.4.8 Most developments referred to the Mayor have been able to achieve at least 50% attenuation of the site's (prior to re-development) surface water runoff at peak times. This is the minimum expectation from development proposals.

3.4.9 There may be situations where it is not appropriate to discharge at greenfield runoff rates. These include, for example, sites where the calculated greenfield runoff rate is extremely low and the final outfall of a piped system required to achieve this would be prone to blockage. An appropriate minimum discharge rate would be 5 litres per second per outfall.

3.4.10 All developments on greenfield sites must maintain greenfield runoff rates. On previously developed sites, runoff rates should not be more than three times the calculated greenfield rate. The only exceptions to this, where greater discharge rates may be acceptable, are where a pumped discharge would be required to meet the standards or where surface water drainage is to tidal waters and therefore would be able to discharge at unrestricted rates provided unacceptable scour would not result."

2.5 Objectives

The objectives of the assessment are to:

- Identify potential forms of flooding including rivers, watercourses, surface water flooding, groundwater flooding, flooding from sewer systems and other forms of flooding;
- Establish the risk of flooding;
- Determine the effects of the development on flooding elsewhere either through displacement of floodwaters or increased runoff;
- Suggest appropriate flood mitigation measures, including a strategy for disposal of surface water run-off following the principles of SuDS.

2.5.1 Scope of Work

In preparing the flood risk assessment AECOM has:

- Obtained data and information from statutory and other authorities;
- Considered the existing flood alleviation arrangements;
- Considered the potential sources of flooding;
- Assessed the risk of flooding to the site;
- Assessed the impact of off-site flooding (displaced water) on third parties;
- Considered the impact of climate change;
- Considered likely mitigation requirements;
- Considered the existing and proposed surface water drainage/sewerage arrangements for the site, including the use of SUDS;
- Assessed the impact of surface water run-off from the development.

2.6 Parties Involved

The various parties and information sources, and their responsibilities, are:

- Rugby Football Union (Client)
- Mace (Project Manager):
  - Infrastructure Layout.
- London Borough of Richmond Upon Thames:
  - Adopted Development Management Plan;
  - Strategic Flood Risk Assessment (SFRA);
  - Surface Water Management Plan (SWMP);
  - Preliminary Flood Risk Assessment (PFRA);
  - Local Flood Risk Management Strategy (LFRMS).
- KSS Group:
  - Development Proposals;
  - Landscape Proposals.
- Mott MacDonald:
  - Drainage Information.
- Gerald Eve LLP (Planning):
  - Screening Request.

- M&E (Mechanical and Electrical Engineering)
- PPS Group (Communications Consultant):
  - Public Consultation.
- Environment Agency:
  - Advice on the procedures required to be undertaken to support the planning application and on the scope of this report;
  - Flood maps (i.e. Product 4 Data);
  - Guidance of specific requirements to ensure successful planning application.
- Thames Water:
  - Sewer flooding history;
  - Details of existing public sewerage, water and surface water networks;
  - Guidance of specific requirements for foul and surface water drainage to ensure successful planning application.

Supporting Information

03

3 Supporting Information

During the course of the flood risk assessment, contact was made with the parties identified in Section 2.6. Information from these parties and other sources to support the flood risk assessment is documented within this section.

3.1 Location and Description

The proposed stadium extension, comprising of the East Stand is to be situated within an area of land located between the A316 and the Duke of Northumberland's River at 200 Whitton Road, Twickenham, Middlesex, TW2 7BA. The proposed site is to the south of the Mogden Sewage Treatment Works. The site can be located by the approximate National Grid Reference: 515325, 174317.

Location plans are shown in Figure 1 and Figure 2.

The proposed site area is bounded by:

- North Car Park to the north;
- Rugby Road and Twickenham Trading Estate to the east;
- Whitton Road and the A316 (Chertsey Road) to the south;
- The Duke of Northumberland's River to the west.

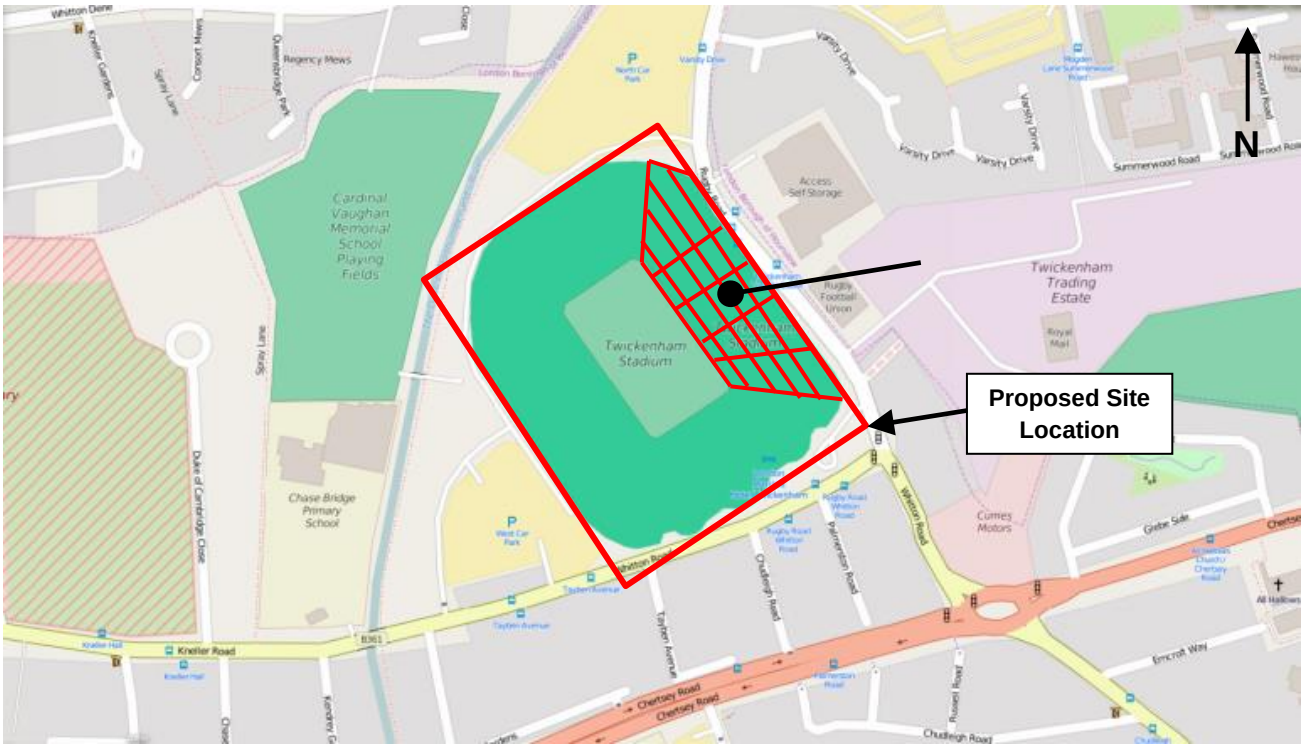


Figure 1: Location Plan - Map

The proposed current development site is comprised entirely of an area of hard standing. The proposed development will not, therefore, lead to an increase in impermeable area. The wider topography slopes in the south eastern direction towards the River Thames.

Figure 2: Location Plan - Aerial Photograph

3.2 Site and Surrounding Levels

The north side, west side and north west corner levels of the stadium are approximately 9.3 to 9.6m AOD and there is an upwards slope towards the river at a level of approximately 9.75m. Beyond the river the land slopes downwards to the River Thames.

The west side of the stadium is approximately 9.5m AOD and the south at approximately 8.8m AOD. The four residential blocks of housing to the south of the stadium have levels from 9.1 to 8.5m AOD, for the northern most side of the residential blocks.

The topography of the general area between the northern extent of the residential area (on the southern border of the stadium) up to the roundabout just south of the Mogden Sewage Treatment Works, is relatively flat with the lowest level being approximately 8.3m AOD and the highest level being 10.5m AOD. There is an overall slope towards the south east corner of the site. In regard to the wider area it also slopes in the same direction which leads to the River Thames.

3.3 Watercourses

There are a number of watercourses surrounding the site. The closest watercourse is the Duke of Northumberland's River, which is an artificial watercourse, a tributary of the River Crane and a distributary of the River Thames. The next closest watercourse is the Whitton Brook, which is also a tributary of the River Crane. The River Crane itself is a tributary of the River Thames.

The River Thames is approximately 1.9km to the east and 1.4km to the south east of the site, as it curves around the site. In the River Thames extreme high water levels due to tidal variations may occur as a result of a combination of factors, including high fluvial flows, high tide, and storm surge. The latter two, collectively referred to as 'tidal flood risk', are the governing factors for flood risk for this site.

3.4 Ground Conditions

The Environment Agency website[1] accessed on 20/05/16 shows that the site does not lie in a groundwater protection zone. The site superficial deposits are designated as a Principal aquifer and the bedrock is unknown. As the site is underlain by a principal aquifer, it should be ensured that pollutants do not infiltrate into the ground. Drainage systems should be designed to protect groundwater quality, and only clean uncontaminated surface water should be able to drain to the surface water drainage system. The British Geological Society (BGS) 'Surface Geology' maps give further details showing that the bedrock geology is the London Clay Formation (Clay and Silt) and the superficial deposit is the Kempton Park Gravel Formation (Sand and Gravel).

[1] https://www.gov.uk/government/organisations/environment-agency

Interrogation of the British Geological Society (BGS) 'Borehole Scans' map reveals there are no available borehole investigations within the site area. The nearest borehole investigation record is located 130m north of the stadium and indicates that this area is overlain by made ground (sandy topsoil, brick rubble), underlain by sand, clay, gravel then silty clay. This BGS borehole record is included in Appendix 4.

3.5 Proposed Development

The proposed development site plan is shown in Appendix 3.

The application for which this FRA has been prepared comprises of a six storey extension to the east stand, which will provide additional floor space for hospitality use for the levels 1, 2, 3, 4, 4a and 5.

As this is an extension to the stadium, the access and egress to the site will be exactly the same. There will be minimal changes to the existing infrastructure. Some services may need to be diverted around the foundations for the extension and there will be a limited extent of drainage constructed. This drainage encompasses the internal drainage of the building, the surface water downpipes from the roof and the underground water drains and manholes.

3.6 Vulnerability

The proposed leisure facilities are classified as "Less Vulnerable" in accordance with NPPF Technical Guidance document, Table 2 (Appendix 1). The proposed development is therefore compatible with Flood Zones 1, 2 and 3a (3a subject to Exception Test). The development is not compatible however within Flood Zone 3b. Refer to NPPF Technical Guidance document, Table 3 (Appendix 1).

3.7 Environment Agency Flood Maps

The Flood Map for Planning (Rivers and Sea) from the Environment Agency website shows that the whole of the proposed site is located within an area considered to be in Flood Zone 2. It is important to note that this map assumes no defences. *Contains Environment Agency information © Environment Agency and database right.*

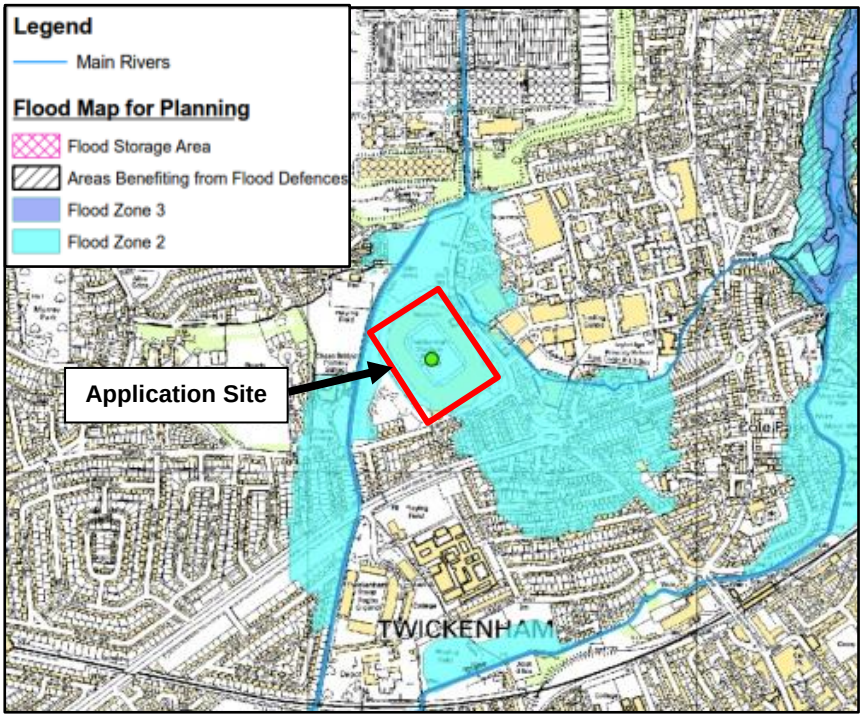


Figure 3: Flood Map for Planning (11/04/2016)

The site is in Flood Zone 2 meaning that each year, there is a chance of flooding from rivers is between 1 in 1000 year (0.1% annual probability) and 1 in 100 (1% annual probability). The nearest extents of Flood Zone 3 are the watercourses themselves (i.e. Duke of Northumberland's River, Whitton Brook and the River Crane), but importantly there is no land close to the site that is classified as Flood Zone 3.

Taken from the Environment Agency Online Flood Maps (accessed on 20/05/16):

- Risk of flooding from rivers & sea: Low
- Risk of flooding from reservoirs: None
- Risk of surface water flooding: Small and dilute area of low and medium chance of flooding
- Flood Map for Planners: Flood Zone 2

3.8 Strategic Flood Risk Assessment

A Strategic Flood Risk Assessment (SFRA) for the London Borough of Richmond Upon Thames was published in August 2010.

The SFRA contains information relating to other sources of flooding, as well as recommendations for the production of site-specific FRA's. With regards to the proposed development, the following information contained within the SFRA is deemed of relevance:

- *"A considerable proportion of the London Borough of Richmond upon Thames is at risk of flooding. The risk of flooding posed to properties within the Borough arises from a number of sources including river flooding, localised runoff, sewer and groundwater flooding.*
- *The Borough is characterised by a number of major river systems including the River Thames, the River Crane (and tributaries) and Beverley Brook. Collectively, these represent a major source of flood risk to properties within the Borough.*
- *A large proportion of Richmond Borough is situated in proximity to the River Thames and its tributaries; it is the only Borough to span both sides of the River Thames. Therefore, a relatively large number of properties within the Borough are potentially at risk of flooding from rivers.*
- *The River Thames within this Borough extends from Barnes to Hampton Court (upstream of Teddington Weir). Teddington Weir represents the upper tidal extent of the River Thames, and the Borough is at risk from both fluvial (river) and tidal (sea) flooding.*
- *Downstream of Teddington Weir, the Borough is protected against flooding from the River Thames by the Thames Tidal Defence (TTD) system. The TTD system provides protection against tidal flooding through a combination of raised flood defences, flood proofing to riverside properties and the Thames Barrier. A 'combined' event can be observed when an unusually high tide happens to coincide with particularly high river levels due to prolonged rainfall in the upper catchment.*
- *It should be remembered that the risk of fluvial and tidal flooding can be expected to increase as a result of climate change. Within the London Borough of Richmond upon Thames, the current understanding of the flooding regime appears to indicate that the increase in the number of properties potentially at risk of flooding in 2010 as a result of climate change is relatively small. Rather, those properties that are currently at risk can expect to be affected by flooding more frequently and to a greater severity.*
- *In addition to fluvial and tidal flooding, properties and infrastructure within the London Borough of Richmond upon Thames are also at risk of flooding from other, more localised, sources caused by surface water. Surface water flooding is caused where the existing drainage systems are unable to deal with demand, where the topography has changed affecting the flow paths or due to blockages of culverts and gullies.*

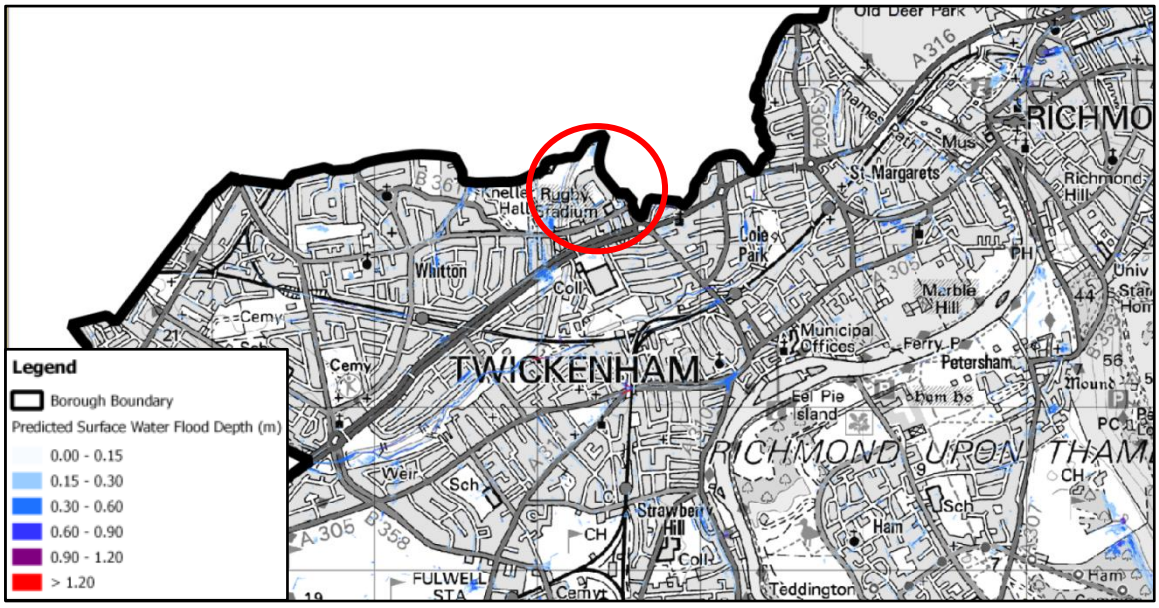


Figure 4: Updated Flood Map for Surface Water

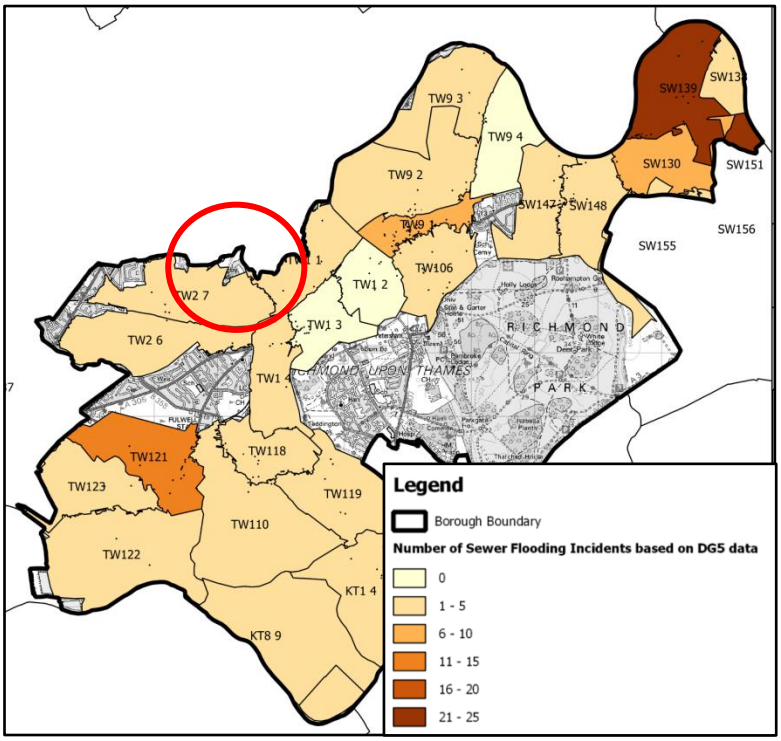


Figure 5: Sewer Flooding Incidents

- *Evidence of historical flooding of this nature has been captured through discussions with the Environment Agency, the Borough and local residents. Note that not every occasion would have been reported and documented and the information displayed may not incorporate all occurrences of surface water flooding.*
- *Work has been done within the Borough to keep a better record of blocked gullies and problematic locations which are repeatedly flagged up. This is partly in conjunction with the requirement of a Lead Local Flood Authority to develop an Asset Register (Flood and Water Management Act, 2010) and partly as a method to prioritise and repair problem locations.*
- *Along with surface water flooding, other localised flooding issues include groundwater flooding and the surcharging of the underground sewer system (which results in overland flow). Evidence of historical flooding of this nature has been captured through discussions with the Environment Agency, the Borough and local residents.*

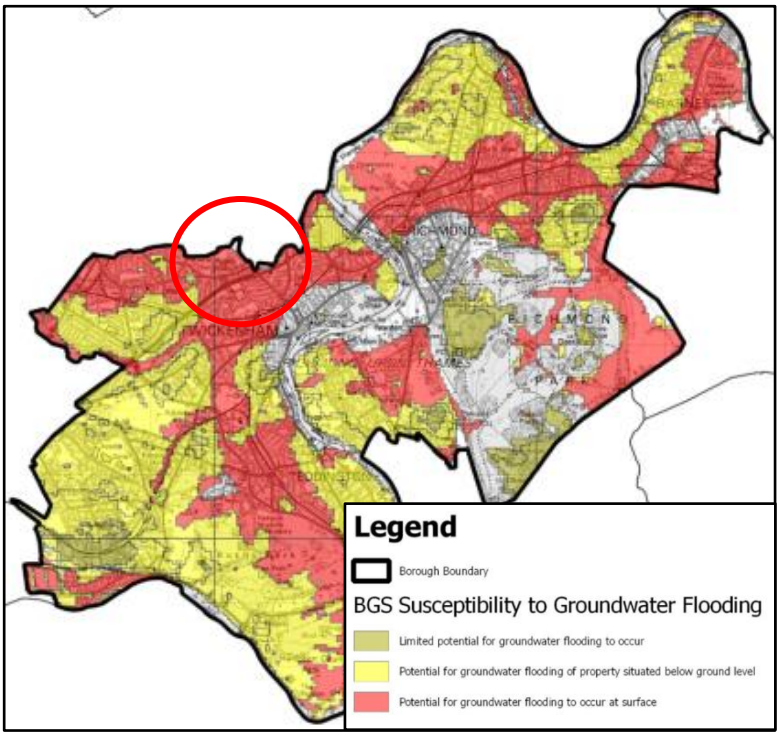


Figure 6: BGS Susceptibility to Groundwater Flooding

- *The River Thames has a considerable history of flooding with significant events (resulting in property flooding) occurring no less than ten times within the past 100 years. The most recent River Thames flood occurred in January 2014 in which a number of areas to the west of London were severely affected, resulting in damage to homes and businesses within low lying Boroughs (including Spelthorne, Windsor and Maidenhead) along the Thames corridor. Several Thames gauges showed record levels since they were installed in the 1980s and 90s."*

3.9 Local Flood Risk Management Strategy

A Local Flood Risk Management Strategy for the London Borough of Richmond Upon Thames was published in August 2015.

The LFRMS has five key objectives*:*

- Encourage direct involvement in decision making through the establishment of and maintain partnerships with key organisations, including the Environment Agency and Thames Water
- Improve our knowledge and understanding of the interactions between different sources of flooding in LBRuT
- Encourage residents, businesses and local landowners to take action and contribute to the management and reduction of flood risk
- Target resources where they have the greatest effect by adopting a risk-based approach
- Contribute to wider social, economic and environmental outcomes by encouraging sustainable multi-benefit solutions for the management of local flood risk

The SFRA contains information relating to other sources of flooding, as well as recommendations for the production of site-specific FRA's. With regards to the proposed development, the following information contained within the SFRA is deemed of relevance:

- *"In England, 5.2 million properties are at risk of flooding. Of these, 1.4 million are at risk from rivers or the sea, 2.8 million are at risk from surface water and 1 million are at risk from both. This risk was realised in many parts of the country during the summer floods of 2007, which resulted in 55,000 properties flooding, 7,000 rescues by emergency services, 13 deaths and an estimated £3billion of damages. The severity of this event generated changes in the way flooding should be managed by local and national organisations.*
- *Across South West London there are risks of flooding from a range of sources, including surface water runoff and ponding, groundwater, sewer surcharging and flooding from main rivers and ordinary watercourses, and reservoirs. In some cases more than one of these sources of flooding can combine to cause a flood event.*
- *Risks from tidal and fluvial flooding associated with the River Thames, Hogsmill, Beverley Brook, and Whitton Brook are relatively well understood and have been managed at a national scale for many years by the Environment Agency The risks and opportunities for flooding along the Lower Crane are not currently fully understood; the Environment Agency is undertaking flow analysis of the Lower Crane in order to consider naturalisation measures. Flood risk from more local sources, including surface water runoff and ponding, groundwater and small ditches and land drains are less well understood; these are typically very localised events which are often difficult to predict, and with sparse historical records available to provide supporting evidence.*
- *Parts of South West London have a particular susceptibility to surface water and sewer flooding due to the pressures from increasing urbanisation and climate change. Over recent years, severe surface water flooding has been experienced across the area causing damage to property and disruption to businesses and services.*
- *Modelling undertaken as part of the London Borough of Richmond upon Thames (LBRuT) Surface Water Management Plan (SWMP) in 2012 shows that the risk of surface water flooding to properties within LBRuT is considerable; up to 30,000 residential properties and 3,000 non-residential properties are modelled to be at risk of flooding during a rainfall event that has a 1 in 100 chance of occurring in any given year (1% Annual Exceedance Probability (AEP)).*
- *Both the Crane and the Duke of Northumberland's rivers flow into the tidal reaches of the Thames, contributing to overall flood risk of the tidal reaches.*
- *Current predictions of future rainfall indicate that we should expect increasing numbers of severe and extreme weather events in the future. Intense storms are the main cause of surface water flooding, which would also increase in frequency. It is predicted that the frequency of heavy rainfall events could double by the 2080s according to the UK Climate Projections 2009*[17]*. By the 2080s, it is predicted that there could be around three times as many days in winter with heavy rainfall (defined as more than 25mm in a day) and that the amount of rain in extreme storms (with a 1 in 5 annual chance or rarer) could increase locally by 40%. Consequently, the number of properties, business and critical infrastructure at risk will also increase.*
- *Current applications for Environment Agency Levy funding to carry out surface water investigations include:*

Mogden Lane – concerns have been raised over the capacity of storm drains in the Mogden Lane area, servicing the large wastewater treatment facility. It is perceived that subsequent storms in close succession may rapidly overload the system resulting in localised flooding."

There were seven Critical Drainage Areas (CDAs) identified as a result of the SWMP modelling, which are shown in Figure 7. Historical sources of flooding and the types of flooding are shown in Figure 8.

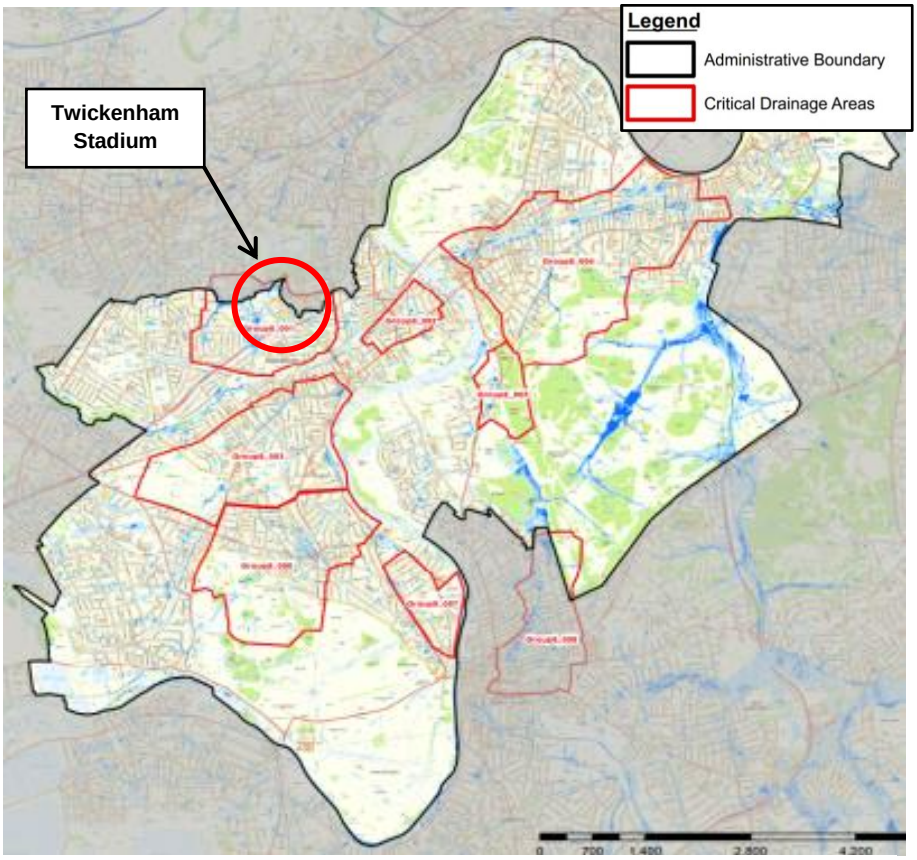


Figure 7: Critical Drainage Areas

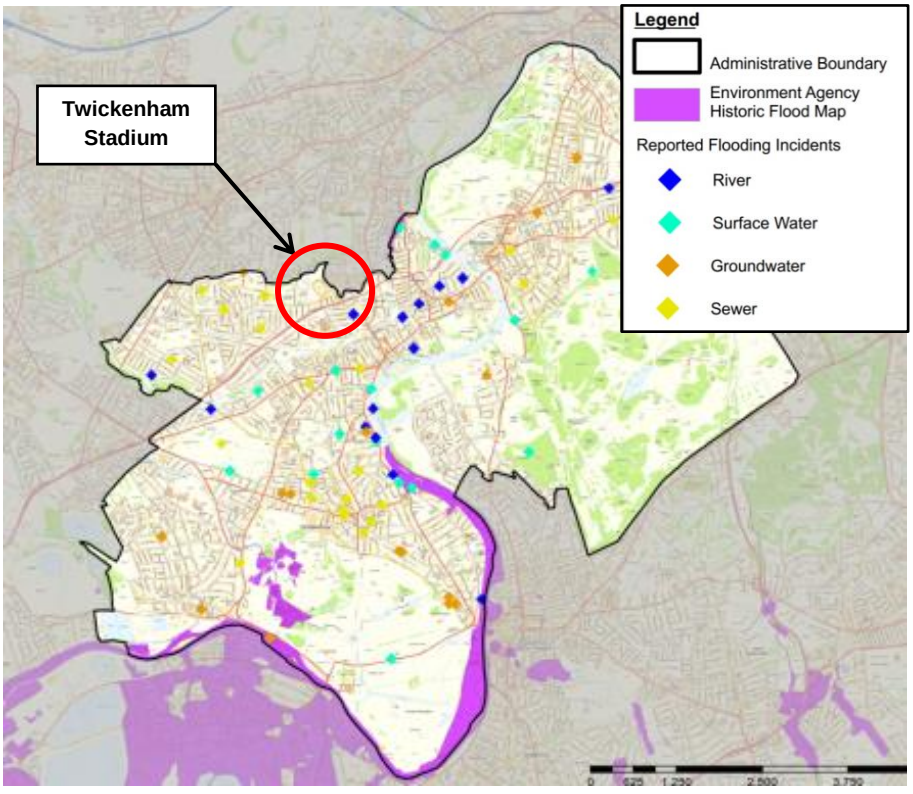


Figure 8: Historical Sources of Flooding Incidents

3.10 Preliminary Flood Risk Assessment

A Preliminary Flood Risk Assessment (PFRA) for the London Borough of Richmond Upon Thames was published in March 2011.

The PFRA is a high level study which covers all the types of flooding in Richmond Upon Thames and includes a summary of historic significant floods and information regarding future flood risk based on Environment Agency data. With regards to the proposed development, the following information contained within the PFRA is deemed of relevance:

- *"No data providers were able to provide comprehensive details of the consequences of specific past flood events, which made accurately assessing the consequences of historic flooding difficult.*
- *According to readily available datasets, the London Borough of Richmond has experienced a number of past surface water flooding events, however they have not been deemed to have had significant consequences for human health, economic activity, the environment and cultural heritage."*

3.11 Surface Water Management Plan (Final Draft)

A Surface Water Management Plan (SWMP) for the London Borough of Richmond Upon Thames was published in July 2011.

The SWMP looks at the flood risk across Richmond Upon Thames and can be used as information to support the policies and site allocations in the Borough's planning documents to minimize future flood risk. It identifies Local Flood Risk Hazard Zones (LFRZs) and Critical Drainage Areas (CDAs), and outlines the preferred surface water management strategy for Richmond Upon Thames, which is based upon surface water modelling developed specifically for this purpose.

Refer to Figure 7 for the updated CDAs. The surface water flood maps from this study are not included as they are now superseded by the plans available in the Strategic Flood Risk Assessment dated March 2016, refer to Figure 4.

Of note is the definition of a Critical Drainage Area (CDA) is defined as:

'a discrete geographic area (usually a hydrological catchment) where multiple and interlinked sources of flood risk (surface water, groundwater, sewer, main river and/or tidal) cause flooding in one or more Local Flood Risk Zones during severe weather thereby affecting people, property or local infrastructure.'

3.12 Consultation with the Environment Agency

Product 4 Data (Detailed Flood Risk) has been received from the Environment Agency. This contains various information including Flood Map for Planning (Figure 3), Historic Flood Map and the Defended Flood Events Outlines Map. The report is contained within Appendix 2. Extracts from Product 4 are shown in Figures 9 to 14 below.

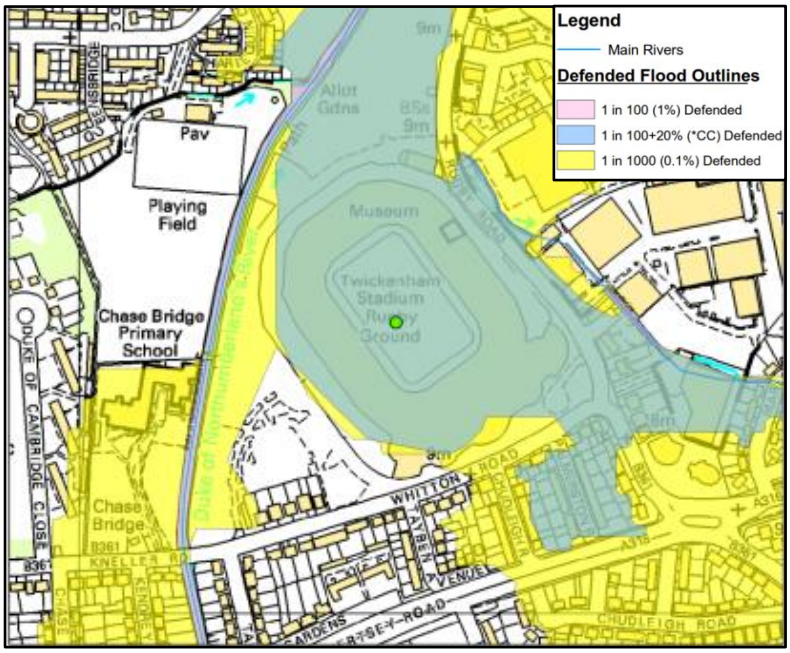


Figure 9: Flood Defence Levels

Figure 9 shows that in the 1 in 100 year event no flooding will occur. However flooding of the site from the Duke of Northumberland's River is expected in the In the 1 in 100 year plus climate change event and the 1 in 1000 year event.

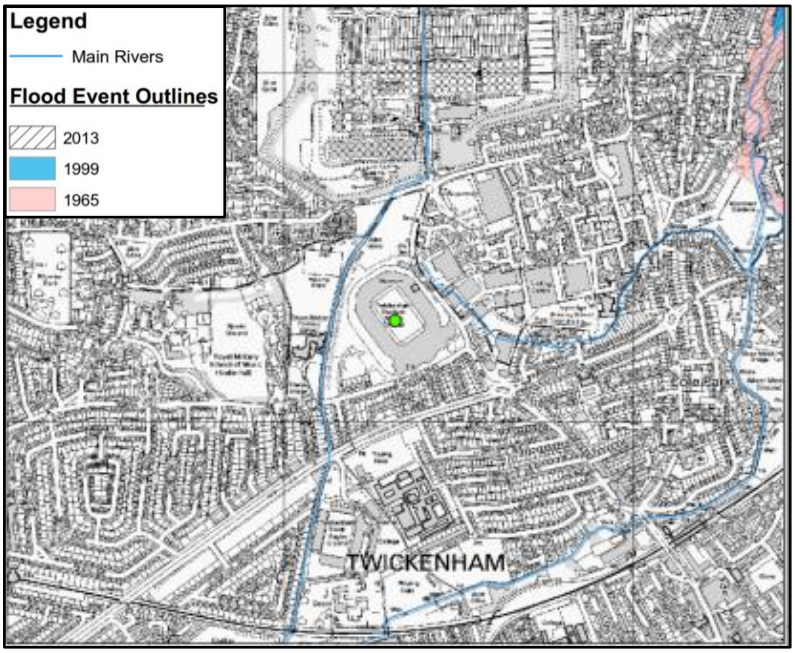


Figure 10: Flood Event History

Figure 10 shows that there have been no fluvial flood incidents within the site.

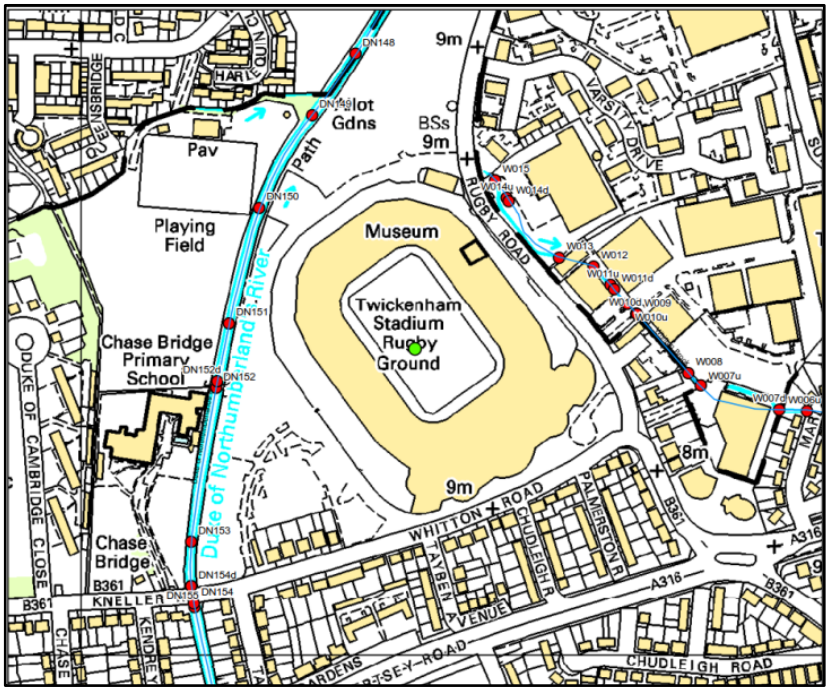


Figure 11: 1D Modelling

Node Label	100yr + 20%	1000yr
W015	8.440	9.377
W014u	8.329	9.344
W014d	8.326	9.311
W013	8.031	9.303
W012	7.948	9.281
W011u	7.888	9.277
W011d	7.817	9.144
W010u	7.781	9.143
W010d	7.778	9.011
W009	7.743	9.003
W008	7.456	8.959
W007u	7.364	8.950
W007d	7.073	8.146
W006u	6.916	8.149
DN155	9.871	10.246
DN154	9.864	10.241
DN154d	9.864	10.241
DN153	9.838	10.190
DN152	9.778	10.067
DN152d	9.778	10.067
DN151	9.748	10.006
DN150	9.707	9.874
DN149	9.685	9.830
DN148	9.681	9.861

Figure 12: 1D Modelling Results

Figure 11 and 12 show the 1D modelling.

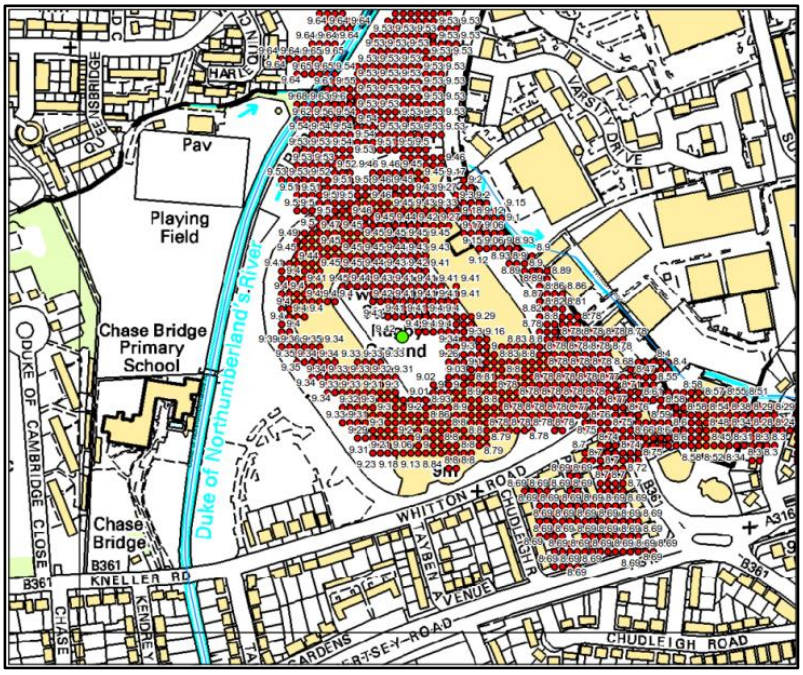


Figure 13: 1 in 100 year + 20% 2D Modelling

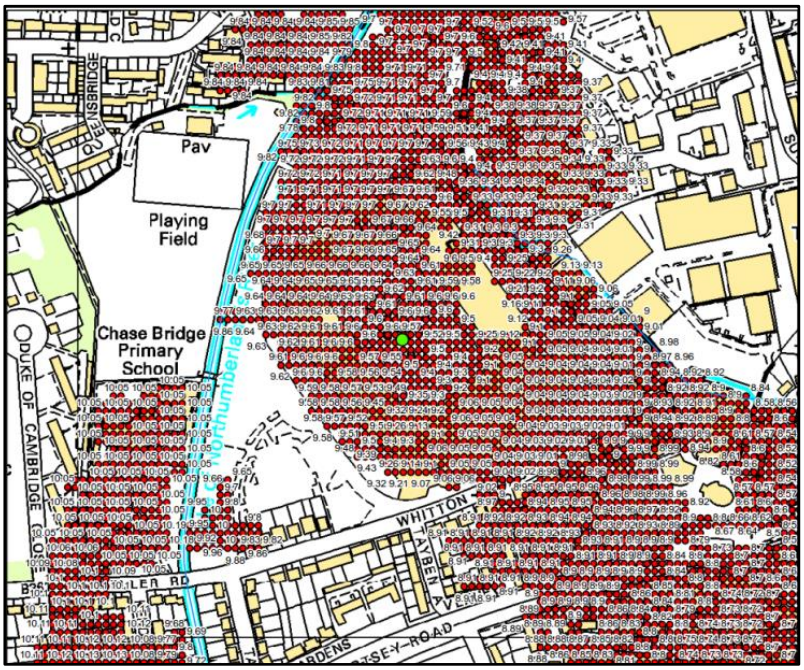


Figure 14: 1 in 1000 year 2D Modelling

Figure 13 and 14 show the 2D modelling for both of the flood events. Each node shows the flood depth. Larger versions can be seen in Appendix 2.

3.13 Consultation with Thames Water

Thames Water Sewer Flooding History Enquiry

On the 30st March 2016 AECOM received an email from Thames Water (refer to Appendix 5) which stated that there have been no instances of flooding in the requested area as a result of surcharging public sewers.

Assessment of Flood Risk

04

4 Assessment of Flood Risk

In accordance with the NPPF, flood risk must be assessed for all sources of flooding and development of the site should be carried out in such a way as to mitigate any potential flood risk to both the site and third parties and their property. This section identifies all possible sources of flooding and suggests appropriate methods to mitigate flood risk.

4.1 The Sequential Test

As the development comprises of an extension to the existing stadium facility, consideration of other locations for the development is not practical. The whole stadium site lies in Flood Zone 2 and therefore alternative sites at lower flood risk are not available.

4.2 The Exception Test

The proposed scheme is classed as “Less Vulnerable” (refer to Section 3.7) and is considered appropriate within Flood Zone 2. Application of the Exception Test is not required.

4.3 Sources of Potential Flooding

Flood risk from the following sources has been considered:

4.3.1 Tidal Flooding

Tidal flooding causes high tides, due to the moon’s gravitational pull, and/or a storm surge, which is when areas of pressure can build up between the north east and east regions of the UK and Norway, Denmark and Netherlands which can be funnel into the Thames Estuary, and travel all the way to the upper tidal extents located in Teddington in the London Borough of Richmond Upon Thames, which is upstream of the proposed site location, hence within the tidal range of the Thames.

Although for this particular site, there are no sources of tidal flooding directly from the River Thames as the proposed site is outside of its flood extents.

There are no other sources of tidal flooding; both the Duke of Northumberland’s River and the River Crane / Whitton Brook are non-tidal in this location due to a number of flow control structures which isolate flows from the tidal Thames.

4.3.2 Fluvial Flooding

The main sources of fluvial flooding are from the Duke of Northumberland’s River and the Whitton Brook.

Fluvial flooding from the River Thames is negligible, due to the relatively far distance and the dense level of infrastructure in between the river and the proposed development.

4.3.3 Pluvial Flooding

'Pluvial' flooding is that which results from rainfall generated overland flow before the runoff enters any watercourse, drain or sewer. It is more often linked to high intensity rainfall events (typically in excess of 30mm per hour). However it can also result from lower intensity rainfall or melting snow where the ground is saturated, frozen, developed or has low permeability. This results in overland flow and ponding in depressions in the topography. In urban areas ‘pluvial’ flows are likely to follow the routes of highways and other surface connectivity to low spots where flooding can occur. In some cases it can deviate from this route into adjacent developments via dropped kerbs (either for access to driveways or disability access).

The current surface water drainage network takes the majority of flows from the development footprint to the north discharging into the underground water tank located to the north of the stadium. A small area also drains to the south, to the attenuation feature south of the stadium.

A potential source of surface water flooding could come from surface water runoff from the surrounding area, especially the north car park.

4.3.4 Groundwater Flooding

Groundwater flooding is caused by the emergence of water from sub-surface permeable strata. Fluctuations in the groundwater table can cause flooding should the table rise above the existing ground level. Groundwater flooding events tend to have long durations, lasting days or weeks.

4.3.5 Flooding from Drains Sewers and Water Mains

Thames Water asset plans show that foul and surface water sewer are present in Rugby Road to the east of the stadium, Whitton Road to the south of the stadium and adjacent to the Duke of Northumberland's River to the west and north of the stadium.

There are a series of private foul and surface water drains that serve the existing stadium. Further details of the existing site drainage arrangements for the East Stand Development are discussed in Section 5.

4.3.6 Canals, Reservoirs and Other Artificial Sources

There are a group of large reservoirs to the south east of the site, with the first one located 4.5km south west of the proposed site.

There are no canals or other artificial sources of flooding within the vicinity of the proposed scheme.

4.4 Probability and Trends of Flooding

4.4.1 Watercourses

The Duke of Northumberland's River

The Environment Agency Product 4 data identifies that the site has not been affected by flooding in the past, refer to 'Flood Event History' (Figure 10). The Local Flood Risk Management Plan 'Historical Sources of Flooding Incidents' (Figure 8) shows no flooding occurring in the area of the site in the 1965, 1999 and 2013 flood events.

The Environment Agency's Flood Map for Planning (Rivers and Sea), refer to Figure 3 or Appendix 2, shows that the application site is located within Flood Zone 2 in accordance with the NPPF and therefore is subject to a flood risk of between 1% (1 in 100 years) and 0.1% (1 in 1000 years) AEP.

Figure 9 shows that the stadium and subsequent extension will be protected in a 1 in 100 year event, but not protected in the 1 in 100 year plus 20% climate change or the 1 in 1000 year event. It is therefore noted that at some stage in the future the stadium including extension will be located within Flood Zone 3a. However as the development is classified as "less vulnerable" it would still be compatible with Flood Zone 3a. In addition, ground levels are not being altered and the new extension on ground level comprises infill between the existing stadium structure, specifically supporting columns, facades and turnstiles which will not result in significant displacement of flood storage. Refer to Figure 15 for a section through the East Stand.

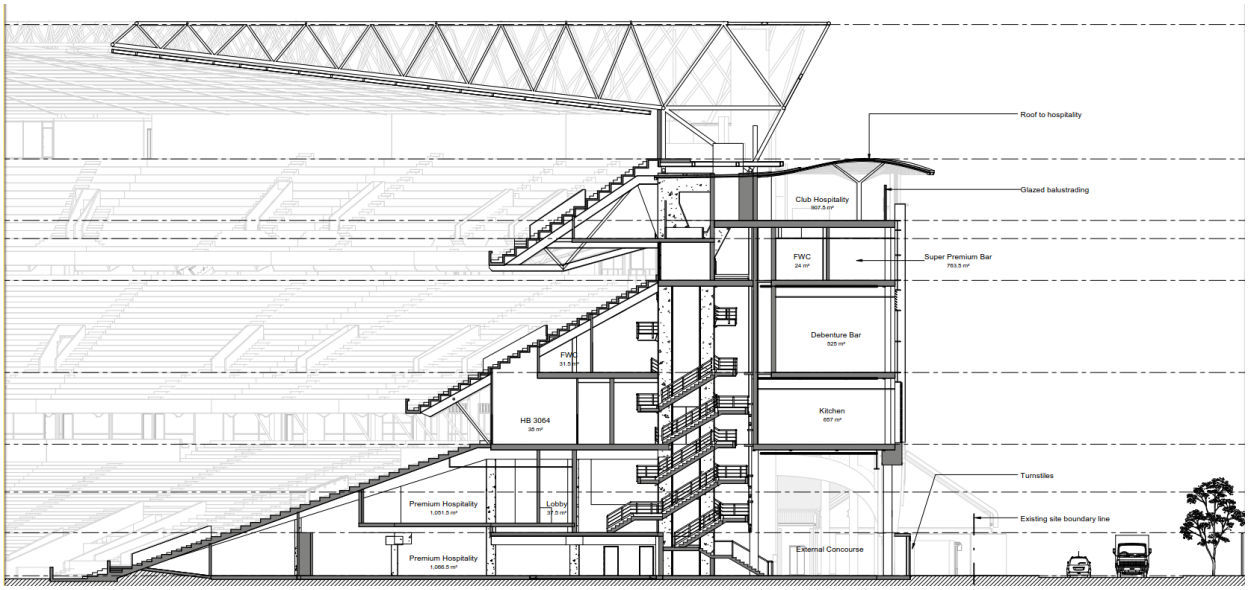


Figure 15: Section through East Stand Extension

In the vicinity of the east stand development expected flood depths are approximately up to 0.1m for the 1 in 100 year + climate change event and up to 0.3m in the extreme 1 in 1000 year flood event. These depths are not considered to give rise to significant hazard to users of the stadium facilities.

The Duke of Northumberland's River has fluvial flood defences which comprise of natural vegetated channel (design standard of protection 25 years), concrete bank protection (100 years), timber piling bank protection (25 years), timber piling bank protection with section of concrete lining (200 years) and concrete lined channels (200 years). It is noted that the condition of these defences are poor, hence it is recommended that the repair and long term maintenance of these defences would reduce the residual risk. The full table of defences can be seen in the Product 4 Data (Appendix 2).

In conclusion we would suggest that the risk of fluvial flooding from the Duke of Northumberland's River is low to medium, this can be mitigated by the future maintenance of flood defences in the area and upgrade to ensure the impacts of future climate change do not degrade the standard of protection. The proposed development does not increase fluvial flood risk to the site or elsewhere and the hazard to users of the stadium facilities is also not increased from current levels.

Safe access and egress to higher ground within Flood Zone 1 is available towards Whitton Road on the south-west side of the stadium.

Whitton Brook

The Product 4 'Flood Map for Planning' shows that in the 1 in 1000 and 1 in 100+ 20% Climate Change flood events, the Duke of Northumberland's River will be the cause of the flooding, but the overland flow may travel into the Whitton Brook and cause that to flood.

The Whitton Brook has fluvial flood defences which comprise of natural vegetated channel / banks and timber bank protection. Refer to Appendix 2 to view this map and table. The design standard of protection for all these is assessed as being 200 years. The banks / channel due to their nature are not condition graded. The bank protection has been assessed as condition grade 3 – fair.

River Crane

Figure 3 indicates that the flood plain associated with the River Crane is remote from the site. On the 'Historical Sources of Flooding Incidents' map (Figure 8) the closest recorded flood event to the proposed site was 'river' flooding, in this case the River Crane, which occurred near Twickenham Railway Station. It is therefore unlikely that flooding from the River Crane will affect the site.

4.4.2 Flooding from Drains and Sewers

Public sewers that serve the surrounding residential and commercial areas are not known to flood. From the flooding history given by Thames Water (refer to Appendix 5), there are no historical records of flooding from the foul and surface water sewers.

The area of the proposed site is in a Critical Drainage Area, as shown in Figure 7. The 'Historical Sources of Flooding Incidents' map (Figure 8) illustrates that there has been sewer flooding within the CDA, but it is not within close proximity to the proposed site.

Referring to the 'Sewer Flooding Incidents' Map (Figure 5), the area TW2 7 which the proposed site is within, has a low number of sewer flooding incidents (1 to 5 events).

The site topography means that should flooding occur in the vicinity of the site, overland flows would typically be directed towards the Whitton Brook and Duke of Northumberland's River to the east and west and away from the stadium itself.

An assessment of the drainage system to serve the proposed extension is detailed in Section 5.

The proposed foul drainage will be designed in accordance with relevant guidance such as Sewers for Adoption (7th Edition) and Building Regulations Approved Document H. It is within the interests of RFU and Thames Water to exercise a good maintenance regime on their assets which should reduce the likelihood of flooding from existing on site drains and sewers.

The risk of flooding from public and private sewers is therefore considered to be low.

4.4.3 Pluvial Flooding

From the SFRA it was found that there are no recorded instances of surface water flooding in the vicinity of the application site, however the report warns that this does not mean that no such flooding has occurred, or there is no future flood risk. Whilst pluvial flooding could occur, this would likely result in localised ponding which would then discharge into the proposed on-site drainage system.

The 'Updated Flood Map for Surface Water' (Figure 4) from the SFRA shows no major source of pluvial flooding. The site topography means that should flooding occur in the vicinity of the site, overland flows would typically be directed away

from the stadium towards the Whitton Brook and Duke of Northumberland's River to the east and west as is the case presently.

Pluvial flooding is not considered a significant issue for this site, and the risk is therefore considered to be low.

4.4.4 Groundwater Flooding

The stadium is located within an area assessed to have a high level of susceptibility to groundwater flooding, refer to Figure 6. However, the SFRA shows that there has been no recorded groundwater flooding incidents within the area of the site.

The closest British Geological Survey borehole records are located approximately 130m north of the site. These records show water levels to be 2 - 2.5m below ground level, refer to Appendix 4. This relates to a level of approximately 7 – 7.5m AOD based on topographical survey results, compared to the ground levels on site of 9 – 9.5m AOD. In addition there are no basements in the proposed extension works.

The risk from groundwater flooding to the proposed development site is therefore considered to be low.

4.4.5 Canals, Reservoirs and Other Artificial Sources

There are a group of large reservoirs, with the first one being located 4.5km south west of the proposed site. The Environment Agency reservoir flood maps show no flood extents of these reservoirs within the proposed site location.

The risk of flooding to the site of flooding from canals, reservoirs and other artificial sources is low.

4.4.6 Combination of Sources

As identified in Figure 7 the stadium is located within a Critical Drainage Area (CDA), and as discussed in section 3.12, this means that multiple and *interlinked* sources of flood risk cause flooding during severe weather, which affects people, property or local infrastructure. However as discussed in section 4.4.2, 4.4.3 and 4.4.4 within the area around the stadium, the risk of flooding from sources other than watercourses is considered to be low.

The site does not have a known history of flooding from any source. The site topography means that should flooding occur the in the vicinity of the site, overland flows would typically be directed towards the Whitton Brook and Duke of Northumberland's River to the east and west and away from the stadium itself.

Drainage Assessment

05

5 Drainage Assessment

This section demonstrates the application site is able to discharge surface water without risk to on-site and off-site parties. The drainage strategy will consider the following:

a) Existing site layout and discharge arrangements
b) Existing impermeable and permeable area arrangements
c) Proposed impermeable and permeable area arrangements
d) Proposed site layout and discharge arrangements

5.1 Existing Drainage Arrangements

The existing site has a surface and foul drainage network which is in active use, due to the activities and events held at the stadium.

5.1.1 Surface Water Drainage

The application site is currently covered by hardstanding and is effectively 100% impermeable. There is therefore no or limited infiltration into the ground. Any infiltration would be heavily limited by the clayey ground conditions.

The current surface water drainage network takes the majority of flows from the development footprint to the north discharging into the underground water tank located to the north of the stadium. This tank allows attenuation before pumping of water along a surface water rising main offsite. It is assumed that this discharges into the Thames Water surface water network within Rugby Road to the east. One rainwater pipe at the south end of the East Stand is connected into the southern surface water network. This network gathers runoff from the south stand and hardstanding areas, routing it through a storage tank comprised of side by side elliptical pipes. Flows then discharge to the Thames Water surface water drainage network located within Rugby Road to the east.

5.1.2 Foul Drainage

The current foul water drainage that serves the East Stand is discharged to the public foul sewerage network in Rugby Road.

5.2 Proposed Surface Water Drainage Strategy

The proposed current development site is comprised entirely of an area of impermeable hardstanding. The proposed east stand development is largely contained beneath the overhang of the existing east stand, though a small footprint extends beyond the overhang over the existing concourse area surrounding the stadium. The proposed development will not, therefore, lead to any increase in impermeable area.

Although the interception of rainwater will occur at a higher level post development, the impact on drainage will not be significant and the existing regime will be maintained. Ground levels are not being altered and within the extension on ground level, the new footprint has limited occupied space, consisting of small lobby areas, a lift and turnstiles. Currently the site does not flood in the 1 in 100 flood event (1% AEP). When considering future climate change (at 20%) flooding is predicted to occur in the 1 in 100 year flood event, however this will be to an approximate maximum depth of 100mm. The nature of the development proposals will not create a significant loss of floodplain storage during this event. It is therefore considered that the extension will not increase flood risk to other sites.

5.2.1 Details of Proposed Surface Water Management

The proposed drainage strategy (refer to Appendix 3) shows that the proposed foul water sewerage from the East Stand development will connect into the existing public foul sewer in Rugby Road.

As discussed in section 5.2 there are limited changes to the existing surface water drainage network proposed. The proposed rain water pipes will connect into the existing private surface water drainage network within the site. Minor modifications are required to this network to divert around foundations etc.

5.2.2 Sustainable Drainage Systems (SuDS)

The proposed development will not lead to any increase in impermeable area and there are limited alterations to the existing surface water drainage network. Existing attenuation tanks are present in both the drainage networks connected into to the north and south which. No further attenuation is proposed.

Residual Risks & Mitigation

06

6 Residual Risks and Mitigation

Consideration of residual flood risks is required in accordance with the NPPF. There is a residual risk of flooding occurring from the following circumstances:

- Failure of existing flood defences resulting in fluvial flooding;
- Overtopping of flood defences in events in excess of the 1 in 100 year return period;
- An on-site rainfall event in excess of the relevant design standards resulting in flooding from the proposed surface water drainage system;
- Poor maintenance of the proposed drainage systems, which could lead to blockage.

Mitigation of these residual risks can be managed by:

- Providing safe access and egress to Whitton Road to the south west of the stadium;
- Arranging finished surface levels such that designed storm exceedance flows do not cause flooding of the site, access road, buildings in the vicinity of the site or other sensitive areas;
- Repair and long term maintenance of the flood defences;
- Long term maintenance of the private drainage systems.

Conclusion

07

7 Conclusion

This Flood Risk Assessment has considered all potential sources of flooding and has identified that the existing application site is at low risk from flooding.

An assessment of the existing fluvial and tidal flood risk has been made using information available from the Environment Agency Product 4 data, online map resource, in addition to Environment Agency flood maps, the London Borough of Richmond Upon Thames Strategic Flood Risk Assessment (SFRA), existing site topographical survey, development proposals and records of historical flood events. This report has concluded that the application site lies within Flood Zone 2 in accordance with the NPPF. The risk of fluvial flooding is considered to be medium.

The proposed development would be considered as “Less Vulnerable” according to the NPPF and is considered to be acceptable within Flood Zone 2. Further application of the Sequential Test or Exception test is not required.

The proposed development is not considered to impact upon the fluvial flood risk to the site or elsewhere and the current anticipated flood depths are not considered to give rise to significant hazard to users of the stadium facilities. Through future climate change, the site is predicted to become located within Flood Zone 3a. The nature of development would still be compatible with Flood Zone 3a should this occur. Anticipated flood depths not considered significant. The nature of the development proposals will not create a significant loss of floodplain storage during this event.

Safe access and egress to higher ground is available to wards Whitton Road to the south west.

Other sources of flood risk have been considered including public sewers, pluvial, groundwater and reservoirs. The flood risk to the site from these sources is considered to be low.

The current site is comprised entirely of an area of hard standing. The proposed development will not, therefore, lead to an increase in impermeable area. Although the interception of rainwater will occur at a higher level post development, the impact on drainage will not be significant and the existing regime will be maintained.

Based on the findings of this Flood Risk Assessment, it is concluded that the flood risk to the existing site is acceptable in relation to the proposed scheme, and furthermore that the proposed scheme will not increase flood risk to other sites. In light of this it can be concluded that there are no flood risk or surface water drainage grounds on which to refuse this application.

Appendices

08

Appendix 1: Extract from Technical Guidance to the NPPF

Flood risk

As set out in the National Planning Policy Framework, inappropriate development in areas at risk of flooding should be avoided by directing development away from areas at highest risk, but where development is necessary, making it safe without increasing flood risk elsewhere. For these purposes:

- "areas at risk of flooding" means land within Flood Zones 2 and 3; or land within Flood Zone 1 which has critical drainage problems and which has been notified to the local planning authority by the Environment Agency;
- "flood risk" means risk from all sources of flooding - including from rivers and the sea, directly from rainfall on the ground surface and rising groundwater, overwhelmed sewers and drainage systems, and from reservoirs, canals and lakes and other artificial sources.

The Sequential and Exception Tests

As set out in the National Planning Policy Framework, the aim of the Sequential Test is to steer new development to areas with the lowest probability of flooding. The flood zones (see table 1) are the starting point for this sequential approach. Zones 2 and 3 are shown on the flood map[1] with Flood Zone 1 being all the land falling outside Zones 2 and 3. These flood zones refer to the probability of sea and river flooding only, ignoring the presence of existing defences.

Strategic Flood Risk Assessments (see paragraphs 7-8) refine information on the probability of flooding, taking other sources of flooding and the impacts of climate change (see paragraphs 11-15) into account. They provide the basis for applying the Sequential Test, on the basis of the flood zones in table 1. Where table 1 indicates the need to apply the Exception Test (as set out in the National Planning Policy Framework), the scope of a Strategic Flood Risk Assessment will be widened to consider the impact of the flood risk management infrastructure on the frequency, impact, speed of onset, depth and velocity of flooding within the flood zones considering a range of flood risk management maintenance scenarios. Where a Strategic Flood Risk Assessment is not available, the Sequential Test will be based on the Environment Agency flood zones.

The overall aim should be to steer new development to Flood Zone 1. Where there are no reasonably available sites in Flood Zone 1, local planning authorities allocating land in local plans or determining planning applications for development at any particular location should take into account the flood risk vulnerability of land uses (see table 2) and consider reasonably available sites in Flood Zone 2, applying the Exception Test if required (see table 3). Only where there are no reasonably available sites in Flood Zones 1 or 2 should the suitability of sites in Flood Zone 3 be considered, taking into account the flood risk vulnerability of land uses and applying the Exception Test if required.

1 To access the flood map, see the Environment Agency's website at:
http://www.environment-agency.gov.uk/homeandleisure/floods/default.aspx3

Table 1: Flood zones

(Note: These flood zones refer to the probability of river and sea flooding, ignoring the presence of defences)

Zone 1 - low probability **Definition** This zone comprises land assessed as having a less than 1 in 1,000 annual probability of river or sea flooding (<0.1%). **Appropriate uses** All uses of land are appropriate in this zone. **Flood risk assessment requirements** For development proposals on sites comprising one hectare or above the vulnerability to flooding from other sources as well as from river and sea flooding, and the potential to increase flood risk elsewhere through the addition of hard surfaces and the effect of the new development on surface water run-off, should be incorporated in a flood risk assessment. This need only be brief unless the factors above or other local considerations require particular attention. **Policy aims** In this zone, developers and local authorities should seek opportunities to reduce the overall level of flood risk in the area and beyond through the layout and form of the development, and the appropriate application of sustainable drainage systems[2].
Zone 2 - medium probability **Definition** This zone comprises land assessed as having between a 1 in 100 and 1 in 1,000 annual probability of river flooding (1% – 0.1%), or between a 1 in 200 and 1 in 1,000 annual probability of sea flooding (0.5% – 0.1%) in any year. **Appropriate uses** Essential infrastructure and the water-compatible, less vulnerable and more vulnerable uses, as set out in table 2, are appropriate in this zone. The highly vulnerable uses are *only* appropriate in this zone if the Exception Test is passed. **Flood risk assessment requirements** All development proposals in this zone should be accompanied by a flood risk assessment. **Policy aims** In this zone, developers and local authorities should seek opportunities to reduce the overall level of flood risk in the area through the layout and form of the development, and the appropriate application of sustainable drainage systems.

1.1 [2]Sustainable drainage systems cover the whole range of sustainable approaches to surface drainage management. They are designed to control surface water run off close to where it falls and mimic natural drainage as closely as possible.

Zone 3a - high probability

Definition

This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%), or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.

Appropriate uses

The water-compatible and less vulnerable uses of land (table 2) are appropriate in this zone. The highly vulnerable uses should not be permitted in this zone.

The more vulnerable uses and essential infrastructure should only be permitted in this zone if the Exception Test is passed. Essential infrastructure permitted in this zone should be designed and constructed to remain operational and safe for users in times of flood.

Flood risk assessment requirements

All development proposals in this zone should be accompanied by a flood risk assessment.

Policy aims

In this zone, developers and local authorities should seek opportunities to:

- reduce the overall level of flood risk in the area through the layout and form of the development and the appropriate application of sustainable drainage systems;
- relocate existing development to land in zones with a lower probability of flooding; and
- create space for flooding to occur by restoring functional floodplain and flood flow pathways and by identifying, allocating and safeguarding open space for flood storage.

Zone 3b - the functional floodplain

Definition

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. The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. But land which would flood with an annual probability of 1 in 20 (5%) or greater in any year, or is designed to flood in an extreme (0.1%) flood, should provide a starting point for consideration and discussions to identify the functional floodplain.

Appropriate uses

Only the water-compatible uses and the essential infrastructure listed in table 2 that has to be there should be permitted in this zone. It should be designed and constructed to:

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

Essential infrastructure in this zone should pass the Exception Test.

Flood risk assessment requirements

All development proposals in this zone should be accompanied by a flood risk assessment.

Policy aims

In this zone, developers and local authorities should seek opportunities to:

- reduce the overall level of flood risk in the area through the layout and form of the development and the appropriate application of sustainable drainage systems;
- relocate existing development to land with a lower probability of flooding.

Table 2: Flood risk vulnerability classification

Essential infrastructure • Essential transport infrastructure (including mass evacuation routes) which has to cross the area at risk. • Essential utility infrastructure which has to be located in a flood risk area for operational reasons, including electricity generating power stations and grid and primary substations; and water treatment works that need to remain operational in times of flood. • Wind turbines.
Highly vulnerable • Police stations, ambulance stations and fire stations and command centres and telecommunications installations required to be operational during flooding. • Emergency dispersal points. • Basement dwellings. • Caravans, mobile homes and park homes intended for permanent residential use[3]. • Installations requiring hazardous substances consent[4]. (Where there is a demonstrable need to locate such installations for bulk storage of materials with port or other similar facilities, or such installations with energy infrastructure or carbon capture and storage installations, that require coastal or water-side locations, or need to be located in other high flood risk areas, in these instances the facilities should be classified as "essential infrastructure")[5].
More vulnerable • Hospitals. • Residential institutions such as residential care homes, children's homes, social services homes, prisons and hostels. • Buildings used for dwelling houses, student halls of residence, drinking establishments, nightclubs and hotels. • Non–residential uses for health services, nurseries and educational establishments. • Landfill and sites used for waste management facilities for hazardous waste[6]. • Sites used for holiday or short-let caravans and camping, subject to a specific warning and evacuation plan.[7]

[3] For any proposal involving a change of use of land to a caravan, camping or chalet site, or to a mobile home site or park home site, the Sequential and Exception Tests should be applied.
[4] See Circular 04/00: *Planning controls for hazardous substances* (paragraph 18) at: www.communities.gov.uk/publications/planningandbuilding/circularplanningcontrols
[5] In considering any development proposal for such an installation, local planning authorities should have regard to planning policy on pollution in the National Planning Policy Framework.
[6] For definition, see *Planning for Sustainable Waste Management: Companion Guide to Planning Policy Statement 10* at www.communities.gov.uk/publications/planningandbuilding/planningsustainable
[7] See footnote 3.

Less vulnerable

- Police, ambulance and fire stations which are not required to be operational during flooding.
- Buildings used for shops, financial, professional and other services, restaurants and cafes, hot food takeaways, offices, general industry, storage and distribution, non–residential institutions not included in “more vulnerable”, and assembly and leisure.
- Land and buildings used for agriculture and forestry.
- Waste treatment (except landfill and hazardous waste facilities).
- Minerals working and processing (except for sand and gravel working).
- Water treatment works which do not need to remain operational during times of flood.
- Sewage treatment works (if adequate measures to control pollution and manage sewage during flooding events are in place).

Water-compatible development

- Flood control infrastructure.
- Water transmission infrastructure and pumping stations.
- Sewage transmission infrastructure and pumping stations.
- Sand and gravel working.
- Docks, marinas and wharves.
- Navigation facilities.
- Ministry of Defence defence installations.
- Ship building, repairing and dismantling, dockside fish processing and refrigeration and compatible activities requiring a waterside location.
- Water-based recreation (excluding sleeping accommodation).
- Lifeguard and coastguard stations.
- Amenity open space, nature conservation and biodiversity, outdoor sports and recreation and essential facilities such as changing rooms.
- Essential ancillary sleeping or residential accommodation for staff required by uses in this category, *subject to a specific warning and evacuation plan*.

Notes to Table 2:

a. This classification is based partly on Department for Environment, Food and Rural Affairs and Environment Agency research on *Flood Risks to People* (*FD2321/TR2*)[8] and also on the need of some uses to keep functioning during flooding.

b. Buildings that combine a mixture of uses should be placed into the higher of the relevant classes of flood risk sensitivity. Developments that allow uses to be distributed over the site may fall within several classes of flood risk sensitivity.

c. The impact of a flood on the particular uses identified within this flood risk vulnerability classification will vary within each vulnerability class. Therefore, the flood risk management infrastructure and other risk mitigation measures needed to ensure the development is safe may differ between uses within a particular vulnerability classification.

[8] See website for further details. www.defra.gov.uk/science/Project_Data/DocumentLibrary/FD2320_3364_TRP.pdf

Table 3: Flood risk vulnerability and flood zone 'compatibility'

Flood Risk Vulnerability classification (see Table 2)		Essential Infrastructure	Water compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone (see Table 1)	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	✓	Exception Test required	✓	✓
	Zone 3a	Exception Test required	✓	×	Exception Test required	✓
	Zone 3b 'Functional Floodplain'	Exception Test required	✓	×	×	×

Key: ✓ Development is appropriate.
× Development should not be permitted.

Notes to Table 3:
This table does not show:

a. the application of the Sequential Test which guides development to Flood Zone 1 first, then Zone 2, and then Zone 3;
b. flood risk assessment requirements; or
c. the policy aims for each flood zone.

Flood risk assessment

Properly prepared assessments of flood risk will inform the decision-making process at all stages of development planning. A Strategic Flood Risk Assessment is a study carried out by one or more local planning authorities to assess the risk to an area from flooding from all sources, now and in the future, taking account of the impacts of climate change, and to assess the impact that changes or development in the area will have on flood risk. It may also identify, particularly at more local levels, how to manage those changes to ensure that flood risk is not increased. A site-specific flood risk assessment is carried out by, or on behalf of, a developer to assess the risk to a development site and demonstrate how flood risk from all sources of flooding to the development itself and flood risk to others will be managed now, and taking climate change into account. There should be iteration between the different levels of flood risk assessment.

Strategic Flood Risk Assessment

As set out in the National Planning Policy Framework, Local Plans should be supported by Strategic Flood Risk Assessment. The Strategic Flood Risk Assessment should be prepared in consultation with the Environment Agency, local planning authorities' own functions of emergency response and drainage authority under the Land Drainage Act 1991, and where appropriate, internal drainage boards. Initially the Strategic Flood Risk Assessment will be used to refine information on the areas that may flood, taking into account other sources of flooding and the impacts of climate change, in addition to the information on the flood map. Local planning authorities should use the Strategic Flood Risk Assessment to inform their knowledge of flooding, refine the information on the flood map and determine the variations in flood risk from all sources of flooding across and from their area. These should form the basis for preparing appropriate policies for flood risk management for these areas. The Strategic Flood Risk Assessment should be used to inform the sustainability appraisal (incorporating the Strategic Environmental Assessment Directive) of local development documents, and will provide the basis from which to apply the Sequential Test and Exception Test in the development allocation and development control process.

Where local planning authorities have been unable to allocate all proposed development and infrastructure in accordance with the Sequential Test, taking account of the flood vulnerability category of the intended use, it will be necessary to increase the scope of the Strategic Flood Risk Assessment to provide the information necessary for application of the Exception Test. This should, additionally, consider the beneficial effects of flood risk management infrastructure in generally reducing the extent and severity of flooding when compared to the flood zones on the flood map. The increased scope of the Strategic Flood Risk Assessment will enable the production of mapping showing flood outlines for different probabilities, impact, speed of onset, depth and velocity variance of flooding taking account of the presence and likely performance of flood risk management infrastructure.

Site-specific flood risk assessment

As set out in the National Planning Policy Framework, local planning authorities should only consider development in flood risk areas appropriate where informed by a site-specific flood risk assessment. This should identify and assess the risks of all forms of flooding to and from the development and demonstrate how these flood risks will be managed so that the development remains safe throughout its lifetime, taking climate change into account. Those proposing developments should take advice from the emergency services when producing an evacuation plan for the development as part of the flood risk assessment.

Minor developments[10] are unlikely to raise significant flood risk issues unless they would:

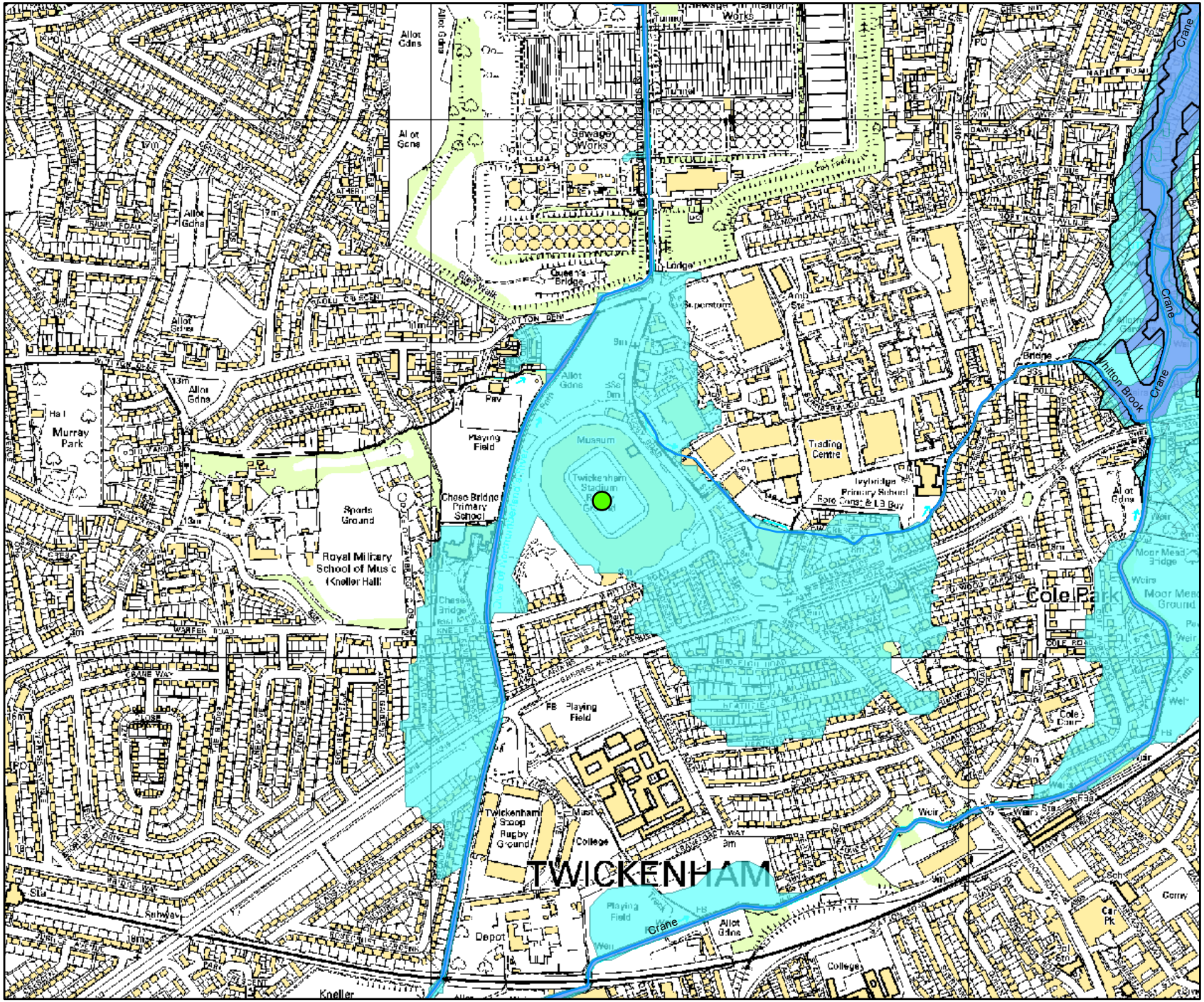
- have an adverse effect on a watercourse, floodplain or its flood defences;
- would impede access to flood defence and management facilities; or
- where the cumulative impact of such developments would have a significant effect on local flood storage capacity or flood flows.

[9] The Environment Agency provides 'standing advice' on flood risk – see the Agency's website at: http://www.environment-agency.gov.uk/research/planning/82584.aspx . Applicants for planning permission will find this advice helpful when preparing a site-specific flood risk assessment for, and before designing, a lower risk development (and for ensuring extensions or alterations are designed and constructed to conform to any flood protection already incorporated in the property and include flood resilience measures in the design). The Agency also provides standing advice to enable local planning authorities to clearly identify the type of planning applications on which they should consult the Agency, and to make decisions on low risk applications where flood risk is an issue, without directly consulting the Agency for an individual response.

[10] Minor development means: - Minor non-residential extensions: industrial/commercial/leisure etc. extensions with a footprint less than 250sqm.
- Alterations: development that does not increase the size of buildings e.g. alterations to external appearance. - Householder development: e.g. sheds, garages, games rooms etc. within the curtilage of the existing dwelling in addition to physical extensions to the existing dwelling itself. This definition excludes any proposed development that would create a separate dwelling within the curtilage of the existing dwelling e.g. subdivision of houses into flats.

Appendix 2: Environment Agency Product 4

Flood Map for Planning centred on Twickenham Stadium - 11/04/2016 - HNL/7561/MS



Environment Agency
2 Bishops Square Business Park
St Albans Road West
Hatfield
Hertfordshire
AL10 9EX

0 130 260 520
Metres

Legend

Main Rivers

Flood Map for Planning

- Flood Storage Area
- Areas Benefiting from Flood Defences
- Flood Zone 3
- Flood Zone 2

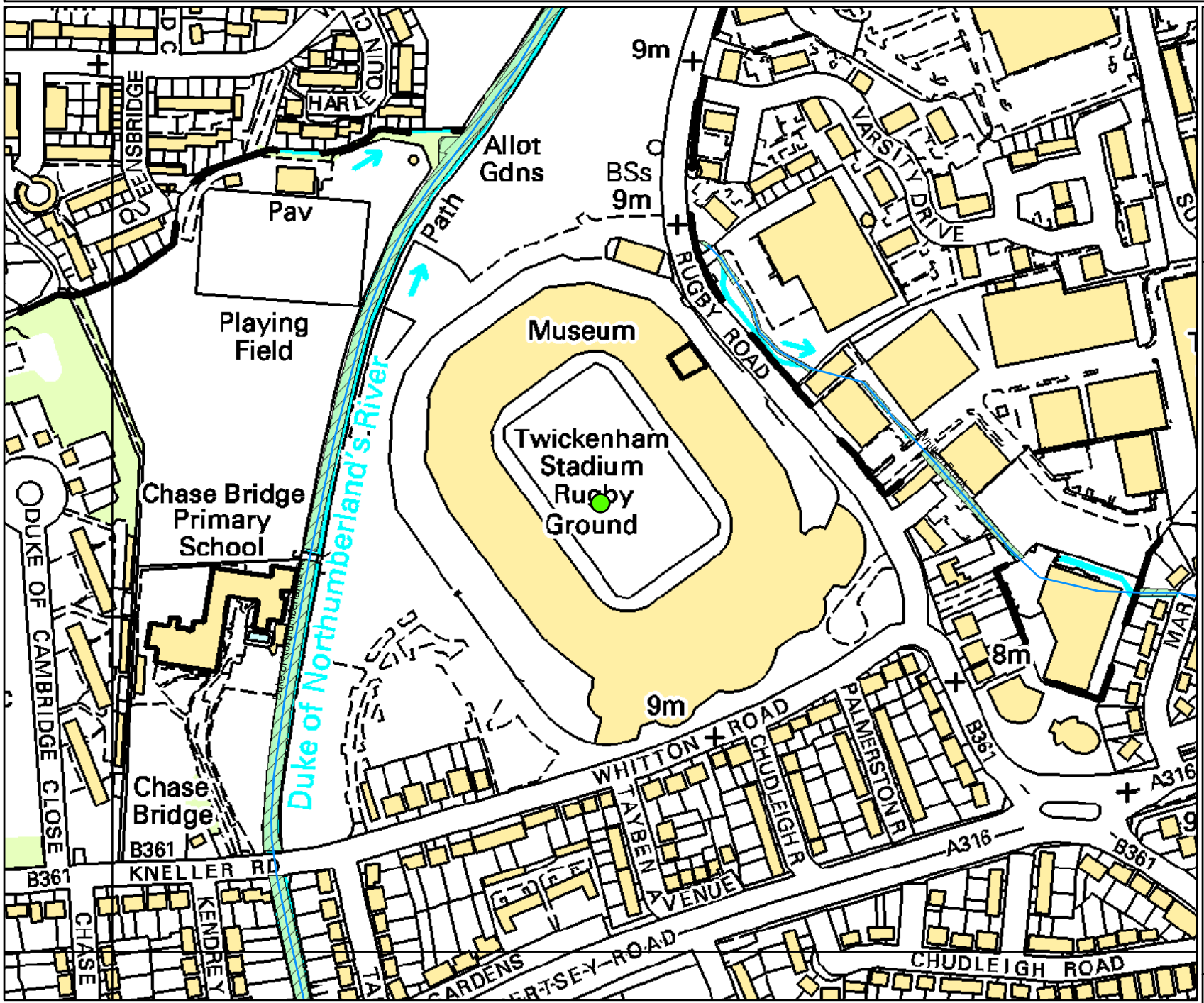
Flood Map for Planning (assuming no defences)

Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 1 in 200 or greater chance of happening each year
- or from a river with a 1 in 100 or greater chance of happening each year.

Flood Zone 2 shows the extent of an extreme flood from rivers or the sea with up to a 1 in 1000 chance of occurring each year.

Produced by:
Partnerships & Strategic Overview,
Hertfordshire & North London

Detailed FRA centred on Twickenham Stadium - 11/04/2016 - HNL/7561/MS



Environment Agency
2 Bishops Square Business Park
St Albans Road West
Hatfield
Hertfordshire
AL10 9EX

0 45 90 180
Metres

Legend

Main Rivers

Defended Flood Outlines

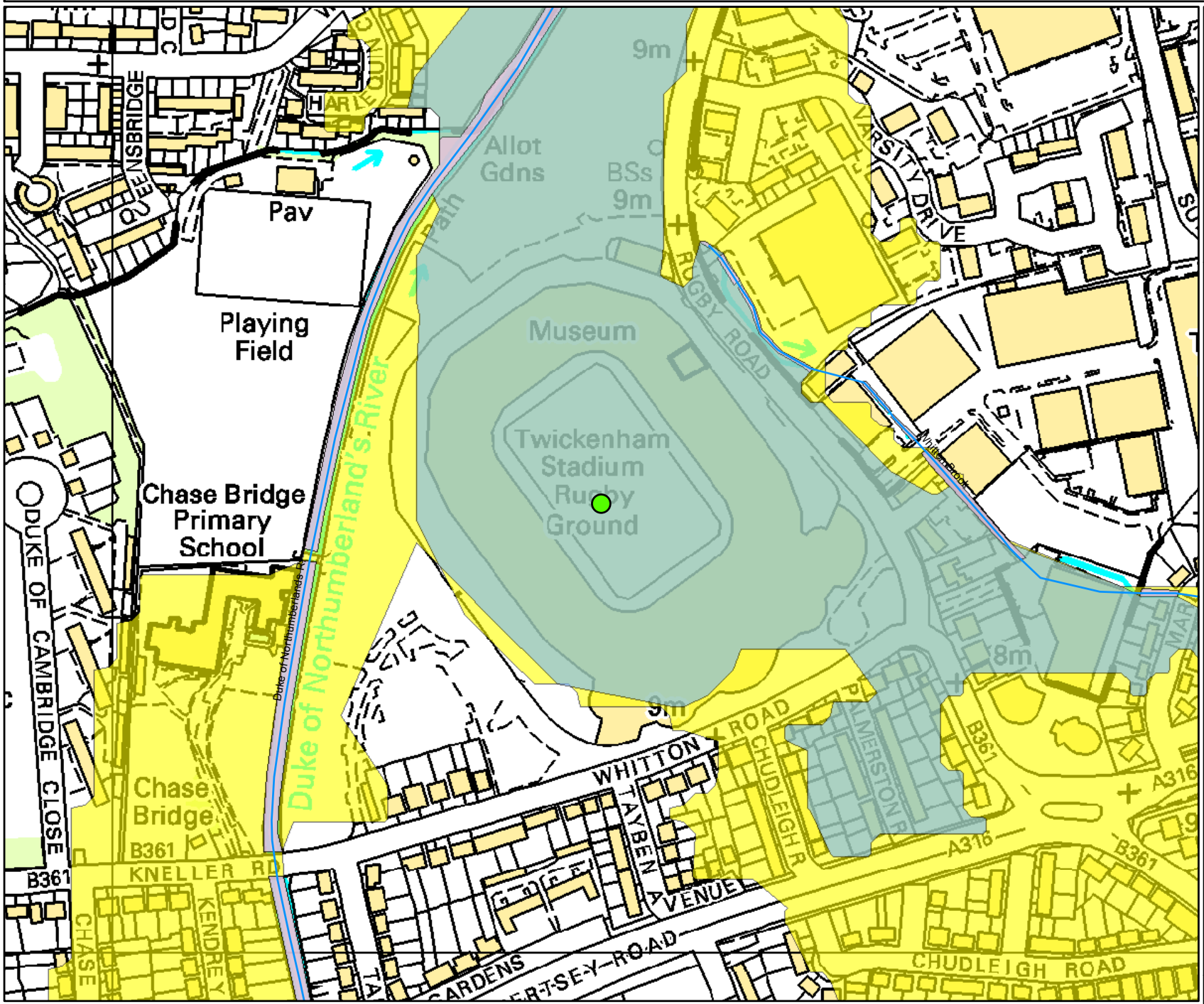
- 1 in 5 (20%) Defended
- 1 in 10 (10%) Defended
- 1 in 20 (5%) Defended
- 1 in 50 (2%) Defended

The data in this map has been extracted from the River Crane Mapping Study (Halcrow 2008).
This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites withinthe catchment.
Modelled outlines take into account catchment wide defences.

Flood risk data requests including an allowance for climate change will be based on the 1 in 100 flood plus 20% allowance for climate change, unless otherwise stated. You should refer to 'Flood risk assessments: climate change allowances' to check if this allowance is still appropriate for the type of development you are proposing and its location. You may need to undertake further assessment of future flood risk using different allowances to ensure your assessment of future flood risk is based on best available evidence.
https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Produced by:
Partnerships & Strategic Overview,
Hertfordshire & North London

Detailed FRA centred on Twickenham Stadium - 11/04/2016 - HNL/7561/MS



Environment Agency

Environment Agency
2 Bishops Square Business Park
St Albans Road West
Hatfield
Hertfordshire
AL10 9EX

0 45 90 180
Metres

Legend

Main Rivers

Defended Flood Outlines

- 1 in 100 (1%) Defended
- 1 in 100+20% (*CC) Defended
- 1 in 1000 (0.1%) Defended

The data in this map has been extracted from the River Crane Mapping Study (Halcrow 2008).
This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites withinthe catchment.
Modelled outlines take into account catchment wide defences.
Flood risk data requests including an allowance for climate change will be based on the 1 in 100 flood plus 20% allowance for climate change, unless otherwise stated. You should refer to 'Flood risk assessments: climate change allowances' to check if this allowance is still appropriate for the type of development you are proposing and its location. You may need to undertake further assessment of future flood risk using different allowances to ensure your assessment of future flood risk is based on best available evidence.
https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

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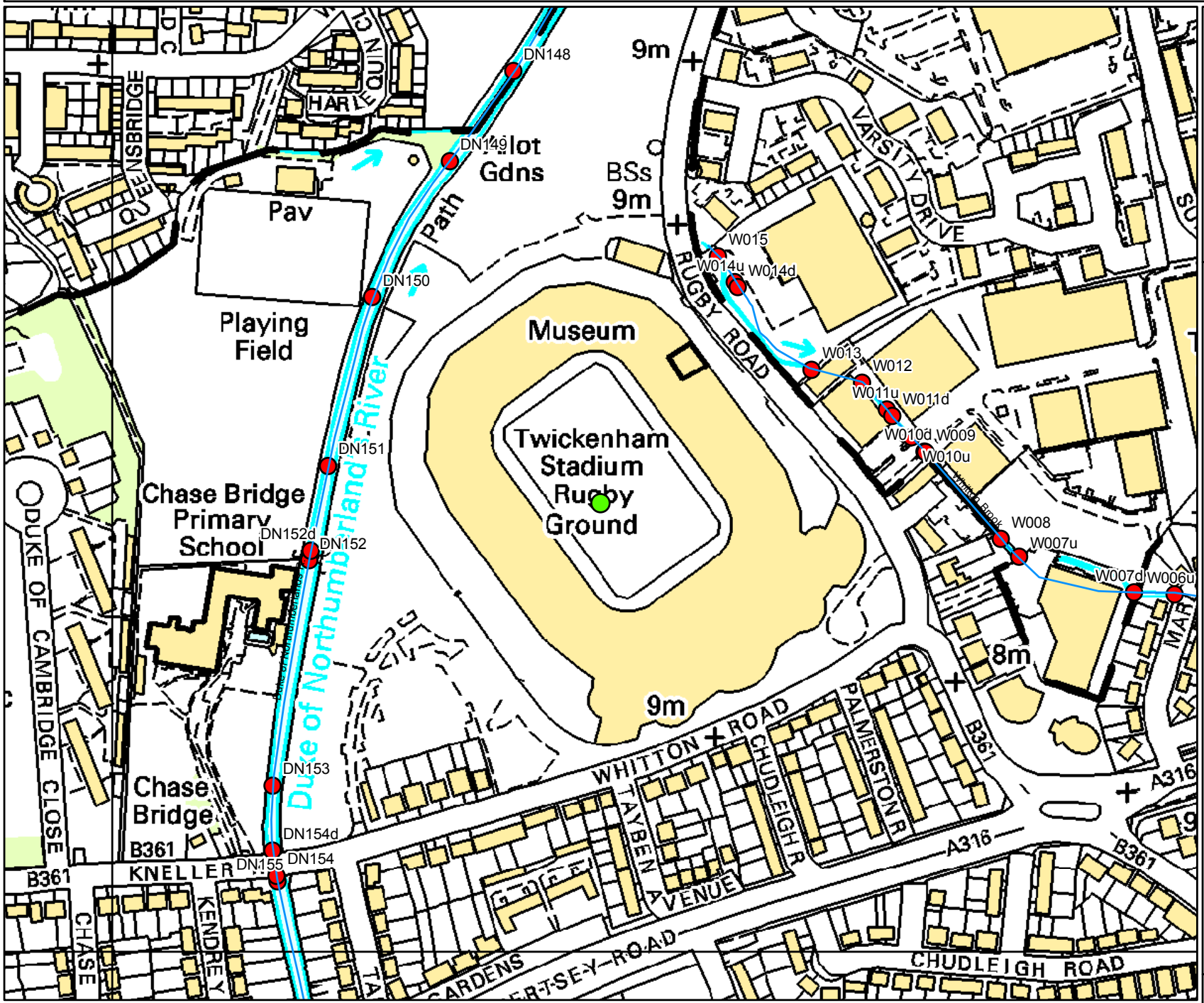
Detailed FRA centred on Twickenham Stadium - 11/04/2016 - HNL/7561/MS



Environment Agency

Environment Agency
2 Bishops Square Business Park
St Albans Road West
Hatfield
Hertfordshire
AL10 9EX

0 45 90 180
Metres

Legend

Main Rivers

1D Node Results

Node Results

The data in this map has been extracted from the River Crane Mapping Study (Halcrow 2008).
This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites withinthe catchment.
Modelled outlines take into account catchment wide defences.
Flood risk data requests including an allowance for climate change will be based on the 1 in 100 flood plus 20% allowance for climate change, unless otherwise stated. You should refer to 'Flood risk assessments: climate change allowances' to check if this allowance is still appropriate for the type of development you are proposing and its location. You may need to undertake further assessment of future flood risk using different allowances to ensure your assessment of future flood risk is based on best available evidence.
https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Produced by:
Partnerships & Strategic Overview,
Hertfordshire & North London

Environment Agency ref: HNL/7561/MS

Flood risk data requests including an allowance for climate change will be based on the 1 in 100 flood plus 20% allowance for climate change, unless otherwise stated. You should refer to 'Flood risk assessments: climate change allowances' to check if this allowance is still appropriate for the type of development you are proposing and its location. You may need to undertake further assessment of future flood risk using different allowances to ensure your assessment of future flood risk is based on best available evidence.

https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

The following information has been extracted from the River Crane Mapping Study (Halcrow 2008)

Caution:
The modelled flood levels and extents are appropriate for catchment wide strategic flood risk mapping. However, for more detailed flood risk assessment it is recommended that each of the underlying flood mapping, hydraulic modelling and hydrological assumptions are re-evaluated to determine the appropriateness in a more detailed analysis.

All flood levels are given in metres Above Ordnance Datum (mAOD)
All flows are given in cubic metres per second (cumecs)

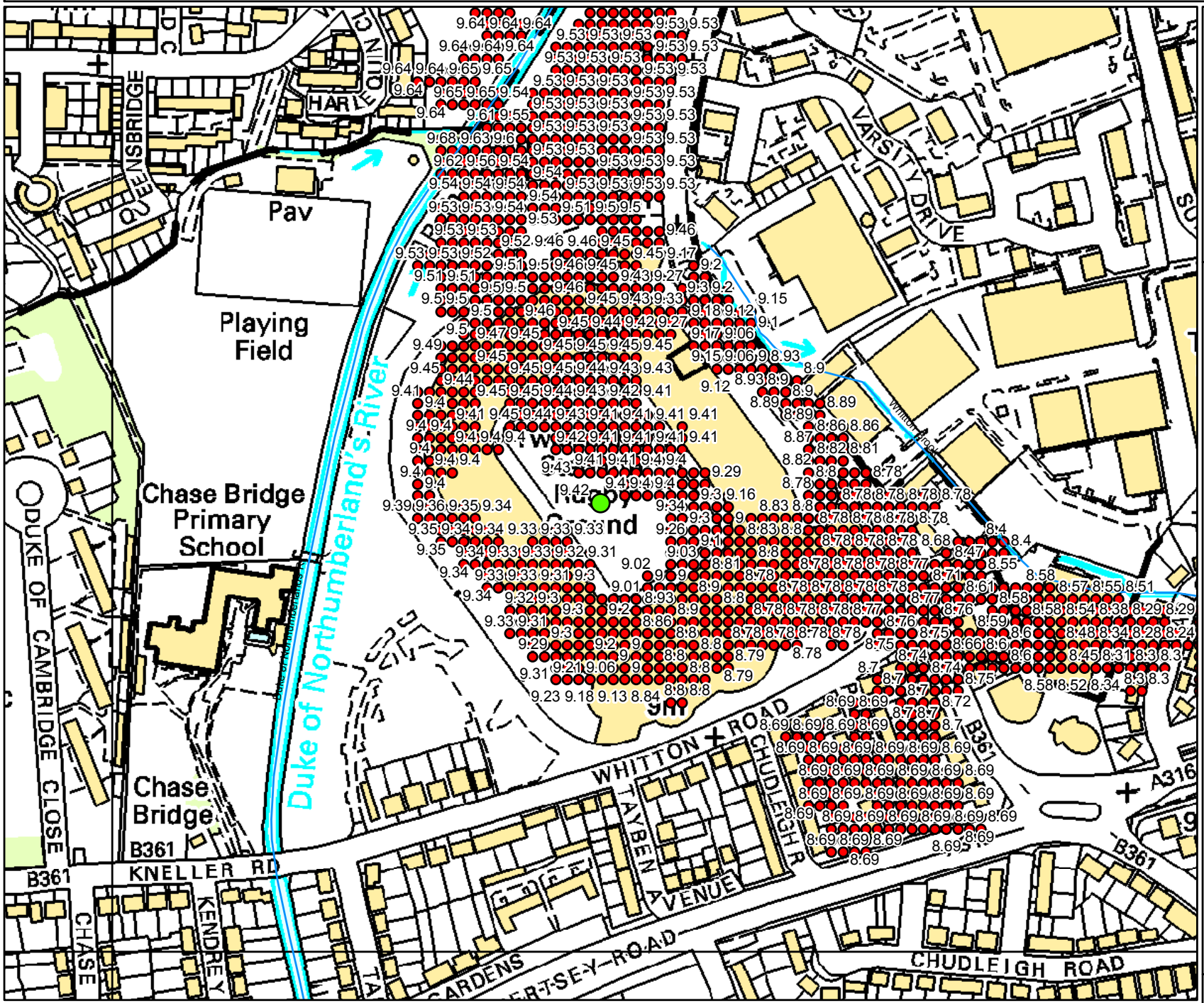
MODELLED FLOOD LEVEL

			Return Period					
Node Label	**Easting**	**Northing**	**5 yr**	**20 yr**	**50 yr**	**100 yr**	**100yr + 20%**	**1000yr**
W015	515395.3	174451.7	8.370	8.380	8.403	8.415	8.440	9.377
W014u	515405.6	174435.2	8.260	8.273	8.294	8.305	8.329	9.344
W014d	515405.6	174435.2	8.256	8.269	8.290	8.302	8.326	9.311
W013	515456.1	174377.5	7.907	7.928	7.970	7.991	8.031	9.303
W012	515489.5	174370.2	7.842	7.860	7.896	7.914	7.948	9.281
W011u	515505.7	174352.2	7.782	7.799	7.835	7.853	7.888	9.277
W011d	515505.7	174352.2	7.709	7.728	7.761	7.780	7.817	9.144
W010u	515522.1	174334.3	7.654	7.675	7.716	7.739	7.781	9.143
W010d	515522.1	174334.3	7.653	7.673	7.714	7.736	7.778	9.011
W009	515530.8	174324.0	7.618	7.638	7.679	7.702	7.743	9.003
W008	515580.4	174267.6	7.352	7.370	7.404	7.422	7.456	8.959
W007u	515592.1	174255.7	7.263	7.280	7.313	7.331	7.364	8.950
W007d	515592.1	174255.7	7.003	7.017	7.043	7.054	7.073	8.146
W006u	515693.3	174232.1	6.854	6.864	6.885	6.896	6.916	8.149
DN155	515106.3	174044.1	9.611	9.726	9.779	9.809	9.871	10.246
DN154	515104.1	174047.7	9.607	9.720	9.773	9.802	9.864	10.241
DN154d	515104.1	174047.7	9.607	9.720	9.773	9.802	9.864	10.241
DN153	515104.3	174106.6	9.588	9.698	9.751	9.779	9.838	10.190
DN152	515128.7	174254.4	9.541	9.645	9.696	9.723	9.778	10.067
DN152d	515128.7	174254.4	9.541	9.645	9.696	9.723	9.778	10.067
DN151	515139.8	174315.7	9.512	9.614	9.666	9.692	9.748	10.006
DN150	515170.0	174425.6	9.464	9.563	9.615	9.641	9.707	9.874
DN149	515220.8	174514.2	9.433	9.531	9.584	9.612	9.685	9.830
DN148	515263.0	174572.5	9.420	9.515	9.568	9.604	9.681	9.861

MODELLED FLOWS

			Return Period					
Node Label	**Easting**	**Northing**	**5 yr**	**20 yr**	**50 yr**	**100 yr**	**100yr + 20%**	**1000yr**
W015	515395.3	174451.7	0.050	0.050	0.050	0.050	0.050	0.050
W014u	515405.6	174435.2	0.198	0.217	0.261	0.285	0.332	1.424
W014d	515405.6	174435.2	0.198	0.217	0.261	0.285	0.332	1.424
W013	515456.1	174377.5	0.196	0.217	0.260	0.285	0.332	1.804
W012	515489.5	174370.2	0.196	0.217	0.260	0.285	0.332	1.804
W011u	515505.7	174352.2	0.196	0.217	0.260	0.285	0.332	1.793
W011d	515505.7	174352.2	0.196	0.217	0.260	0.285	0.332	1.793
W010u	515522.1	174334.3	0.196	0.217	0.260	0.285	0.332	1.787
W010d	515522.1	174334.3	0.196	0.217	0.260	0.285	0.332	1.787
W009	515530.8	174324.0	0.196	0.217	0.260	0.285	0.332	1.784
W008	515580.4	174267.6	0.196	0.217	0.260	0.285	0.332	1.866
W007u	515592.1	174255.7	0.196	0.217	0.260	0.285	0.332	2.270
W007d	515592.1	174255.7	0.195	0.217	0.260	0.285	0.332	2.270
W006u	515693.3	174232.1	0.195	0.217	0.260	0.285	0.332	2.266
DN155	515106.3	174044.1	2.743	3.569	3.861	4.133	4.571	6.200
DN154	515104.1	174047.7	2.743	3.569	3.861	4.134	4.571	6.200
DN154d	515104.1	174047.7	2.894	3.649	3.993	4.211	4.745	9.900
DN153	515104.3	174106.6	2.894	3.649	3.992	4.212	4.746	9.900
DN152	515128.7	174254.4	2.892	3.648	3.989	4.213	4.746	9.900
DN152d	515128.7	174254.4	2.892	3.648	3.989	4.213	4.746	9.900
DN151	515139.8	174315.7	2.892	3.649	3.988	4.214	4.747	9.900
DN150	515170.0	174425.6	2.892	3.650	3.985	4.216	4.747	9.800
DN149	515220.8	174514.2	2.893	3.652	3.983	4.218	4.748	8.700
DN148	515263.0	174572.5	2.894	3.654	3.983	4.219	4.514	5.200

Detailed FRA centred on Twickenham Stadium - 11/04/2016 - HNL/7561/MS



Environment Agency
2 Bishops Square Business Park
St Albans Road West
Hatfield
Hertfordshire
AL10 9EX

0 45 90 180
Metres

Legend

Main Rivers

2D Node Results: Heights

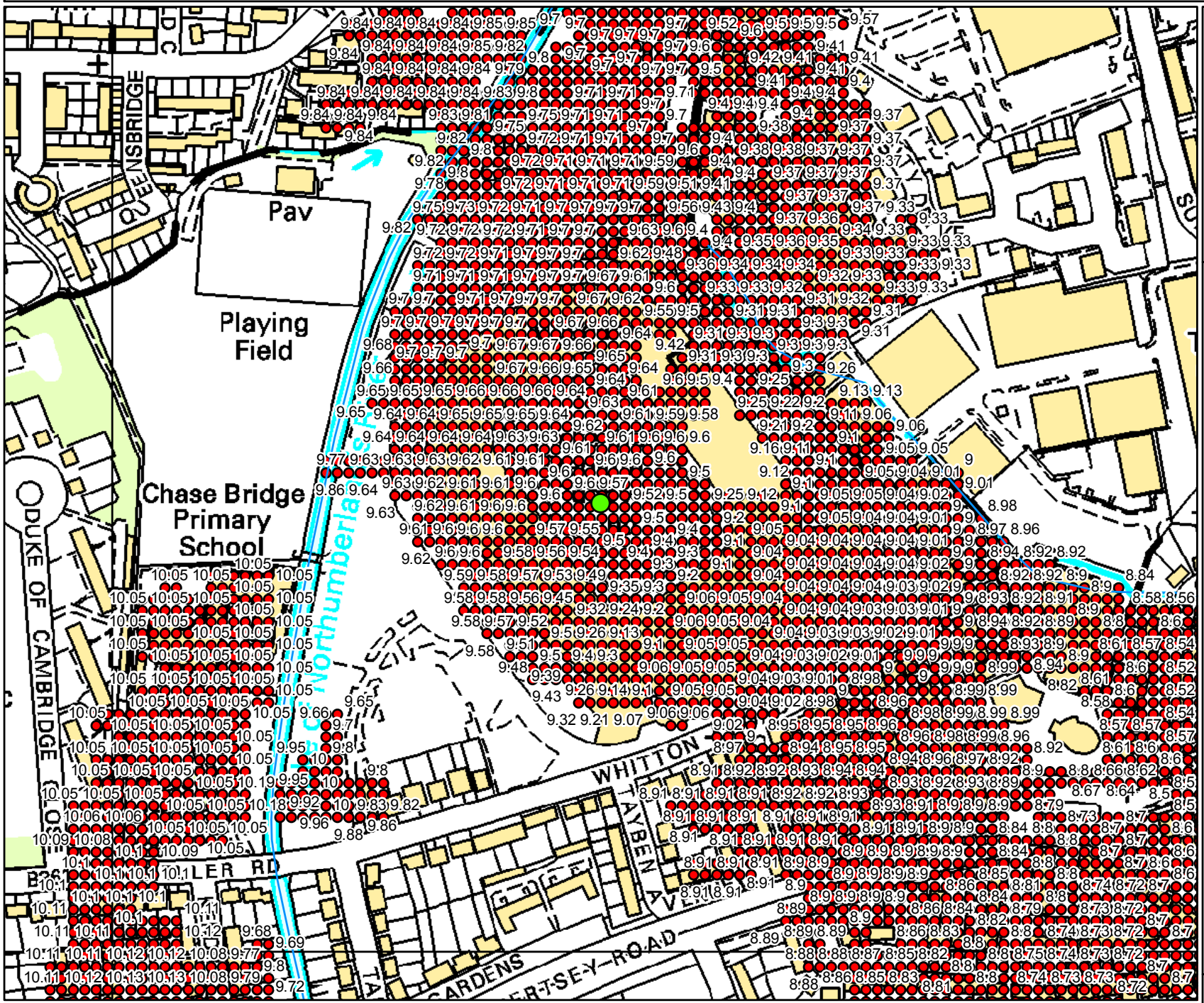
1 in 100+20% (*CC) Defended

The data in this map has been extracted from the River Crane Mapping Study (Halcrow 2008).
This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites withinthe catchment.
Modelled outlines take into account catchment wide defences.

Flood risk data requests including an allowance for climate change will be based on the 1 in 100 flood plus 20% allowance for climate change, unless otherwise stated. You should refer to 'Flood risk assessments: climate change allowances' to check if this allowance is still appropriate for the type of development you are proposing and its location. You may need to undertake further assessment of future flood risk using different allowances to ensure your assessment of future flood risk is based on best available evidence.
https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

Produced by:
Partnerships & Strategic Overview,
Hertfordshire & North London

Detailed FRA centred on Twickenham Stadium - 11/04/2016 - HNL/7561/MS



Environment Agency
2 Bishops Square Business Park
St Albans Road West
Hatfield
Hertfordshire
AL10 9EX

0 45 90 180
Metres

Legend

Main Rivers

2D Node Results: Heights

1 in 1000 (0.1%) Defended

The data in this map has been extracted from the River Crane Mapping Study (Halcrow 2008).
This model has been designed for catchment wide flood risk mapping. It should be noted that it was not created to produce flood levels for specific development sites withinthe catchment.
Modelled outlines take into account catchment wide defences.

Flood risk data requests including an allowance for climate change will be based on the 1 in 100 flood plus 20% allowance for climate change, unless otherwise stated. You should refer to 'Flood risk assessments: climate change allowances' to check if this allowance is still appropriate for the type of development you are proposing and its location. You may need to undertake further assessment of future flood risk using different allowances to ensure your assessment of future flood risk is based on best available evidence. https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances

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Historic Flood Map centred on Twickenham Stadium - 11/04/2016 - HNL/7561/MS

Environment Agency
2 Bishops Square Business Park
St Albans Road West
Hatfield
Hertfordshire
AL10 9EX

0 130 260 520
Metres

Legend

Main Rivers

Flood Event Outlines

2013
1999
1965

The historic flood event outlines are based on a combination of anecdotal evidence, Environment Agency staff observations and survey.
Our historic flood event outlines do not provide a definitive record of flooding.
It is possible that there will be an absence of datain places where we have not been able to record the extent of flooding.
It is also possible for errors occur in the digitisation of historic records of flooding.

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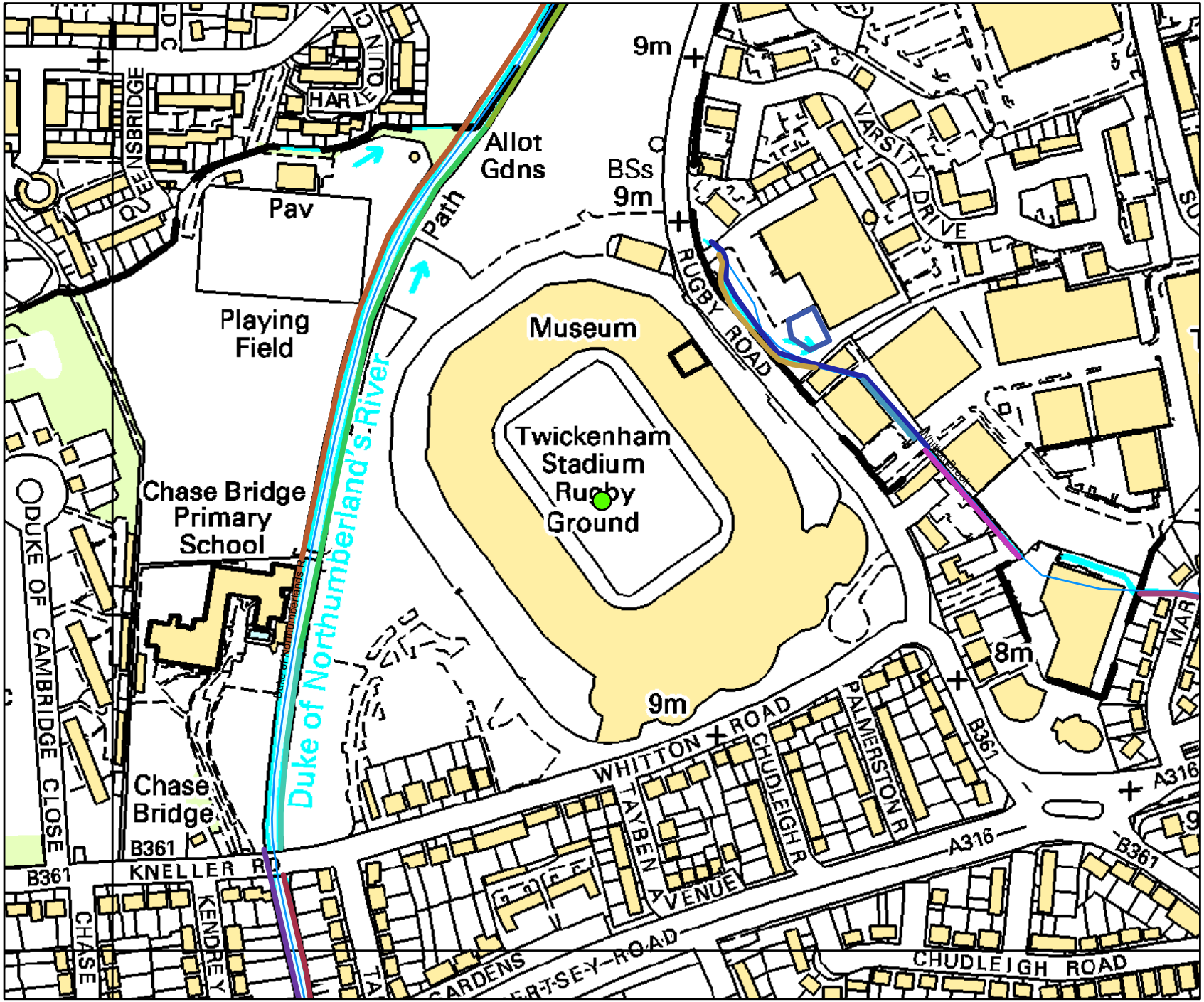
Detailed FRA centred on Twickenham Stadium - 11/04/2016 - HNL/7561/MS



Environment Agency
2 Bishops Square Business Park
St Albans Road West
Hatfield
Hertfordshire
AL10 9EX

0 45 90 180
Metres

Legend

Main Rivers

DEFENCE ASSET_ID	
45866	126259
45867	143306
45868	143309
90787	143310
126257	145737
	147163
	147365

The following information on defences has been extracted from the Asset Information Management System (AIMS)

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Environment Agency ref: HNL/7561/MS

The following information on defences has been extracted from the Asset Information Management System (AIMS)

Defences

Asset ID	Asset Type	Asset Protection	Asset Comment	Asset Description	Design Standard of protection (years)	Upstream Crest Level	Downstream Crest Level	Condition of Defences (1=Good, 5 = Poor)
143310	defence	fluvial	Bank protection.	Timber piling bank protection	25	10.82	9.6	4
90787	defence	fluvial	Natural Bank	Natural vegetated channel	25	10.37	9.81	3
147163	defence	fluvial	Embankment.	RAISED EARTH EMBANKMENT CREATING THE FLOOD STORAGE AREA.	50	8.68	8.68	3
143309	defence	fluvial	Bank protection.	Concrete block bank protection	100	No information available	No information available	4
145737	defence	fluvial	Bank protection.	HORIZONTAL TIMBER PLANKS LAID AGAINST BANK AS BANK PROTECTION.	200	9.05	8.86	3
147365	defence	fluvial	Wall.	POURED CONCRETE WALL ACTING AS BANK PROTECTION.	200	8.01	8.08	3
143306	defence	fluvial	Bank protection.	Timber piling bank protection with section of Concrete lining at U/S extent.	200	No information available	No information available	5
126259	defence	fluvial	Lined Channel	Cast insitu concrete channel lining.	200	10.47	10.27	5
126257	defence	fluvial	Lined Channel	Cast insitu concrete channel lining	200	10.37	10.21	4
45868	defence	fluvial	Natural bank	Natural vegetated channel	200	9.21	8.9	No information available
45867	defence	fluvial	Natural Bank	Natural vegetated channel	200	No information available	No information available	No information available
45866	defence	fluvial	Natural Bank	Natural vegetated bank	200	9.22	9.05	No information available