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FLOOD RISK ASSESSMENT

PHOENIX CLUB, FIFIELD, BERKSHIRE

Report Reference: 2051/FRA
Final: Version F1
January 2016

Report prepared for:

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GENERAL NOTES

Title of report: Flood Risk Assessment

Site: Phoenix Club, Fifield, Berkshire

Report ref: 2051/FRA

Date: January 2015

Version	Date	Issued to
Draft version D1	6th November 2015	Pleydell Smithyman Ltd
Final version F1	15th January 2015	Pleydell Smithyman Ltd

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1 INTRODUCTION

1.1 Background

A Planning Application has been prepared for the construction of the Phoenix Gymnastics Club, including a new gym building, car parking, landscaping and Sustainable Drainage System (SuDS). The Application Area comprises approximately 1.8 hectares (ha) of land located within Flood Zone 1 on the Environment Agency's Flood Map. Flood Zone 1 land is assessed as having a less than a 1 in 1000 annual probability of river flooding (<1%). As the development is larger than 1 ha, a Flood Risk Assessment (FRA) is required in accordance with the National Planning Policy Framework (NPPF).

Hafren Water has been commissioned to undertake this Flood Risk Assessment (FRA) for the proposed development.

1.2 Data sources

The following data sources were used in this assessment:

Pleydell Smithyman Ltd

- Topographic survey
- Layout plan for proposed development
- Sustainable drainage layout

Ordnance Survey (OS)(e-map website for digital maps)

- 1:25,000 series mapping, Sheet 160, Windsor, Weybridge & Bracknell
- 1:50,000 series mapping, Sheet 175, Reading & Windsor

British Geological Survey (BGS)

- Geological map, 1:50,000 (England & Wales), Sheet 269, Windsor
- Soils map (UK Soils Observatory website)

Environment Agency (EA)

- Flood risk maps (from the 'What's in your backyard' website) for flooding from rivers and surface water and flood zones for planning
- LiDAR data (DTM at 1 m resolution)

Royal Borough of Windsor and Maidenhead (RBWM)

- Borough Local Plan: Preferred Options Consultation (Jan 2014)
- Preliminary Flood Risk Assessment (PFRA) – May 2011
- Strategic Flood Risk Assessment (SFRA) (Level 1) – January 2014

Oakley Green, Fifield and District Community Association (OGAFCA)

- 9 Wet Spots – Drainage Report 04 (June 2010)
- 9 Wet Spots 2015 – Drainage Report 05 (September 2015)

1.3 National Planning Policy Framework and Planning Practice Guidance

This FRA has been undertaken with due regard to the statutory requirements of the NPPF and with reference to the Planning Practice Guidance (PPG) in relation to development and flood risk, to ensure that flood risk is taken into account at all stages of the planning process and to avoid inappropriate development in areas potentially at risk of flooding.

PPG classifies the flood risk vulnerability of sites used for leisure purposes as `less vulnerable' development.

1.4 Local policy

The Royal Borough of Windsor and Maidenhead (RBWM) Council is the Lead Local Flood Authority (LLFA) and Local Planning Authority (LPA) for the site. The Borough Local Plan (BLP), preferred options consultation January 2014, includes `*Preferred Policy Option NR 10*', which states:

"Managing Flood Risk and Waterways

The preferred policy approach is to support appropriate comprehensive flood risk management measures with land associated with strategic flood relief measures as shown on the policies map and safeguarded.

Development that facilitates the improvement and integration of waterways in Maidenhead, including the implementation of the Maidenhead Waterway Project, will be supported.

The preferred policy approach is to only support water compatible uses and essential infrastructure development in the functional floodplain. In other areas at risk of flooding, development over 50 m^2 (including buildings or structures erected under permitted development rights) will not be permitted.

A sequential test will guide development to areas of lowest flood risk, and evidence in the form of a flood risk assessment will be required. In applying this test regard will be had to a number of factors:

1. *The availability of suitable alternative sites in areas of lower flood risk;*
2. *The vulnerability of the proposed use;*
3. *The present and future flood risk;*
4. *The scale of potential consequences.*

In all cases, the development must not itself, or cumulatively with other development, materially:

1. *Impede the flow of flood water;*
2. *Reduce the capacity of the floodplain to store water;*
3. *Increase the number of people, property or infrastructure at risk of flooding;*
4. *Cause new or exacerbate existing flooding problems, either at the site or elsewhere.*

Proposals must incorporate Sustainable Drainage Systems, should increase the storage capacity of the floodplain and should aim to reduce flood risk. All new development should be constructed with adequate flood resilient and resistant measures suitable for the lifetime of the development. "

RBWM's SFRA, PFRA and the policies outlined above, have been reviewed and the FRA has been compiled in accordance with the relevant objectives.

1.5 Regulatory requirement for this assessment

The site is located within the Environment Agency's indicative Flood Zone 1, where the probability of fluvial flooding in any one year is <0.1% Annual Exceedance Probability (AEP). Due to the size of the development (>1 ha) a Flood Risk Assessment (FRA) is required in accordance with the Planning Practice Guidance (PPG) and the Environment Agency's Flood Risk Standing Advice for Local Planning Authorities (Version 3.1).

2 BACKGROUND INFORMATION

2.1 Site and surrounding area

2.1.1 Location, extent and surroundings

The site is located on agricultural land north of the property "Longlea", east of Fifield Road, Fifield, Maidenhead and is centred upon National Grid Reference (NGR) SU 910 772 (*Drawing 2051/FRA/01*). The site lies approximately 400 m northeast from the centre of Fifield and approximately 4.5 km west from the centre of Windsor.

The site is currently used for arable farming. There is currently no access into the site from Fifield Road. The site located in the southwestern corner of a larger agricultural field, which extends 600 to 700 m to the north and east. A public footpath located adjacent to the property "Longlea" forms the southern boundary, and Fifield Road forms the western boundary of the site.

The land surrounding the site comprises agricultural land use to the east and west, with residential properties, associated with Fifield Road, further to the north and south.

2.1.2 Topography

The topographic survey indicates that the site generally slopes gently northwards. More specifically, the site is split into two catchments with the eastern half draining to the northeast, and the western half draining to the northwest. Elevations range from a high point of 27.6 metres Above Ordnance Datum (mAOD) along the southern boundary, to 25.8 mAOD at the base of the drainage ditch along the western boundary (Section 2.1.5).

Immediately west of the site Fifield Road has an elevation of approximately 26.8 mAOD.

A topographical drawing of the site is included in *Appendix 2051/FRA/A1*.

2.1.3 Watercourses

There are no watercourses within the site.

The site lies within the catchment of the River Thames, which flows broadly southeastwards, approximately 1.2 km northeast of the site, as shown on *Drawing 2051/FRA/02*.

2.1.4 Waterbodies

There are no waterbodies within the site.

2.1.5 Drainage ditches

Surface water from the western half of the site is conveyed directly into a drainage ditch along the eastern side of Fifield Road (*Drawing 2051/FRA/02 – labelled D1*). There is also a smaller drainage ditch located along the western side of Fifield Road (*Drawing 2051/FRA/02 – labelled D2*). The eastern drainage ditch flows northwards through Fifield and past the site before discharging into the River Thames further north.

The eastern drainage ditch (D1) is approximately 2.0 m wide from bank to bank and has a depth of approximately 0.8 m to the top of the western bank. The eastern bank of ditch D1 is approximately 400 mm higher than the western bank, for a length of approximately 25 m, in the southwestern corner of the site.

A small isolated ditch is also located along the southern boundary of the site, just northeast of "Longlea" (*Drawing 2051/FRA/02 – labelled D3*).

2.1.6 Ground conditions

The solid geology beneath the site comprises the London Clay Formation. The London Clay Formation is classified by the Environment Agency as 'Unproductive Strata'; *"these are rock layers or drift deposits with low permeability that have negligible significance for water supply or river base flow."*

There are no superficial deposits on-site, however borehole records (*Appendix 2051/FRA/A3*) indicate that clays, sands and gravels may be present beneath the site and immediate surrounding area.

The soils on-site are classified as being slowly permeable, loamy and clayey.

2.1.7 Flood zones

The site is located within Flood Zone 1 according to the Environment Agency flood map for planning, where the probability of fluvial flooding in any one year is less than 0.1% (Annual Exceedance Probability, AEP, <0.1%).

The areas immediately surrounding the site also lie within Flood Zone 1. The flood zoning within the site and its vicinity, extracted from the Environment Agency's 'Flood Map for Planning', is shown on *Drawing 2051/FRA/03*.

3 PROPOSED DEVELOPMENT

Full details of the proposals are included elsewhere in the Planning Application, however a summary of the development is provided below as it forms the basis of the Flood Risk Assessment.

The proposed development comprises the construction of the Phoenix Gymnastics Club. The development will include a new gym building, car parking, landscaping and access from Fifield Road.

The development will also include construction of a Sustainable Drainage System (SuDS). The scheme includes the construction of ephemeral retention pools along the eastern and western boundaries, and a water attenuation area along the northern boundary. The pools and attenuation area will provide a maximum storage capacity of 1,798 m^3.

A permeable sub-base will be constructed beneath the car parking area, to provide additional attenuation storage for surface waters. The permeable sub-base will provide a maximum storage capacity of 314 m^3, assuming a storage void of 32%.

The proposed SuDS scheme will provide a total surface water storage capacity of 2,112 m^3.

Details of the proposed site layout and SuDS scheme are shown in *Appendix 2051/FRA/A2.*

4 APPROACH TO THE FLOOD RISK ASSESSMENT

4.1 'Flood risk'

Using a mixture of quantitative and qualitative methods, the FRA considers the likelihood of flooding, the associated hazards and the vulnerability of the flood receptor. These factors are combined to produce the single measure, 'flood risk'.

4.2 Climate change

Within the UK, projections of future climate change indicate that there will be more frequent, short duration, high intensity rainfall events and periods of long duration rainfall. The National Planning Policy Framework (NPPF) recommends that the effects of climate change are incorporated into Flood Risk Assessments. Recommended precautionary sensitivity ranges for peak rainfall intensities and peak river flows are outlined in the Environment Agency document, 'Climate change allowances for planners' (September 2013) and are summarised in *Table 2051/FRA/T2*, below.

2051/FRA/T1: Recommended increases in parameters due to climate change				
Increment in peak:	Years			
	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
Rainfall intensity	+5%	+10%	+20%	+30%
River flow	+10%	+20%		

4.3 Flood receptors

4.3.1 Receptors internal to the site

The Application Area is to be used for leisure; therefore the flood vulnerability class of this area is defined in the Planning Practice Guidance, as 'less vulnerable'.

4.3.2 Receptors external to the site

The closest receptors to the site are the public footpath immediately south of the site, Fifield Road immediately to the west, and the residential properties of "Longlea" and "Little Ridge" approximately 15 m south of the site.

Further to the north and west of Fifield Road, the properties of Wayside Riding Stables and Deeds House are located approximately 300 and 400 m north of the site.

The residential properties, road, and public footpath form the 'highly vulnerable' receptors within the locality of the site. This level of vulnerability increases the potential severity of the

consequences of flooding for these receptors. The overall degree of flood risk may thus be higher for such receptors for a given severity of flood event.

Other receptors outside the site, comprising roads and agricultural fields, are all classed as 'less vulnerable'.

4.4 Design events and flooding pathways

As required by the Planning Practice Guidance, the return period to be considered for fluvial and rainfall events is 100 years and the effects of climate change will be factored in as described in Section 4.2 of this report. This design event will be referred to as the climate-changed, 1% AEP event where 'AEP' means 'Annual Exceedance Probability'.

This FRA considers the following hydrological components:

- Fluvial flow
- Surface water run-off
- Groundwater
- Sewer and/or water mains leakage

Pathways for flooding may involve two or more such components in sequence, such that the type of flow at the source is not the same as that delivering flooding to the receptor.

Within this FRA, flood risk to both internal and external receptors is assessed with reference to interactions between the development site and the hydrological components itemised above. For internal receptors this furnishes information on the degree of flood hazard and hence the degree of flood risk. In the case of external receptors, flood hazard, and hence flood risk during the design events, is not evaluated. Instead the potential for the development to qualitatively increase or decrease flood risk at external receptors is assessed so that targeted measures to ensure a qualitative reduction can subsequently be taken, if necessary.

5 FLOOD RISK TO THE SITE

5.1 Background

The risk of flooding at the site has been assessed by examining the likelihood of flooding, the hazard caused if the site were to flood and its vulnerability. This has been undertaken for a range of likely mechanisms using both quantitative and qualitative methods. In terms of NPPF Flood Risk Vulnerability Classification, the proposed site use for leisure comprises a 'less vulnerable' flood classification.

5.2 Fluvial flooding

The site is located within Flood Zone 1 on the Environment Agency's indicative flood map, which is classified as 'very low' flood risk with a 1 in 1000-year or less (<0.1%) annual probability of fluvial flooding (*Drawing 2051/FRA/03*).

The overall risk of fluvial flooding is considered to be 'very low'. Under Table 3 of the NPPF Technical Guidance, this style of development is appropriate for this flood classification and it is considered that mitigation is not required.

5.3 Surface water flooding

Historic incidents of surface water flooding have not been reported on the site according to the SFRA.

The Environment Agency's 'Risk of Flooding from Surface Water' map indicates the western part of the site is at a 'low' to 'high' risk from surface water flooding, as shown on *Drawing 2051/FRA/04*. 'Low' risk areas have between 0.1% - 1% AEP chance of flooding, 'medium' risk areas have between 1% - 3.3% chance of flooding and 'high' risk areas have 3.3 % AEP or greater chance of flooding.

The 'low to high' risk area can be attributed to the topography of the site and surrounding area. However, the EA's surface water model is subject to a number of assumptions and will not have accounted for the presence of site-specific topographic elevations, floor levels, construction characteristics or field drains.

Within the locality of the site, Fifield Road is flanked to the east (D1) and west (D2) by drainage ditches. The eastern ditch (D1) is larger than the western ditch (D2) and measures approximately 2.0 m wide by 0.8 m depth (*Drawing 2051/FRA/02*).

The eastern bank of ditch D1 is approximately 400 mm higher than the western bank, for a length of approximately 25 m, where the site is indicated to be at a 'high' risk from flooding.

Ditches D1, D2, and the freeboard provided by the eastern bank of D1, would prevent surface waters from entering the western part of the site. Surface water flooding in the locality of the site would be restricted to Fifield Road itself, with waters flowing downslope to the north.

A small ditch (D3) is located along part of the southern site boundary, with a hedge marking the boundary of the site and field. The ditch and vegetation will restrict surface water flows that may enter from off-site to the south.

Therefore, the risk of surface water flooding to the site is 'very low' and mitigation measures are not proposed.

5.4 Groundwater flooding

Historic incidents of groundwater flooding have not been reported on the site according to the SFRA.

The London Clay bedrock formation below the site and the immediate surrounding area is designated as an 'Unproductive' aquifer. The soils on-site are slowly permeable, loamy and clayey.

As such it is unlikely that these strata will yield large volumes of groundwater, therefore the overall risk of groundwater flooding is considered to be 'very low'.

Borehole records for the site do not show any shallow watertables.

Mitigation measures are not considered necessary.

5.5 Flooding from sewers and water mains

Historic incidents of sewer and/or water main flooding have not been reported on the site according to the SFRA.

South East Water are responsible for a 1200 mm water main located along the eastern side of Fifield Road. The SFRA indicates that sewers may also be associated with Fifield Road. Any leakage from sewers or water mains would be captured by the existing drainage ditches along Fifield Road. Utility organisations would subsequently repair the broken service pipe.

Flood risk posed by site interaction with mains leakage is not considered significant for any receptor.

6 FLOOD RISK FROM THE SITE TO THE SURROUNDING AREA

6.1 Fluvial flooding

The area surrounding the site is located within Flood Zone 1, which is classified as 'very low' flood risk (less than 1 in 1000-year (<0.1%) annual probability of fluvial flooding). It is not proposed to discharge surface water off-site. Drainage features will be designed for infiltration and attenuation; hence the flood risk to neighbouring land due to the proposed development is considered 'very low'.

6.2 Surface water flooding

As noted in Section 5.3, there have been no historic incidents of surface water flooding onsite, however there have been a number of incidents in Fifield as stated in the PFRA.

The proposed development will cause some changes to run-off characteristics of the site due to the proposed increase in impermeable surfaces. Surface water run-off from the proposed site will drain to the proposed sustainable drainage system outlined in Section 3 and shown in *Appendix 2051/FRA/A2*. In order to prevent impact on external receptors it will be necessary to ensure that these features are sized to accommodate the required volume generated in a significant rainfall event. 'Greenfield' run-off rates have been calculated together with run-off rates for the existing site and the proposed development which are provided in *Appendix 2051/FRA/A4.* Location and sizing of proposed attenuation features is discussed under mitigation measures in Section 7 below.

There is currently an overall 'very low' risk of surface water flooding across the Application Area (Section 5.3) and this is not expected to change as a result of the development. It is considered therefore that with appropriately sized sustainable drainage the development will not increase the risk of flooding to the surrounding area.

The new access from Fifield Road will be constructed over an existing drainage ditch (D1), therefore measures will need to demonstrate that flows within the ditch are not restricted.

Mitigation measures and the outline drainage scheme for reducing surface water flooding are discussed in Section 7 of this report.

6.3 Interaction with other hydrological components

The degree of flood risk associated with the site's hydrological interaction with the surrounding area is unlikely to be significant. Therefore mitigation measures are not considered necessary.

7 MITIGATION MEASURES

7.1 Background

Table 2051/FRA/T2 shows which combinations of flooding sources and receptors require mitigation.

2051/FRA/T2: Flooding pathways requiring mitigation		
Flood mechanism	PROPOSED SITE	
	Internal receptor	External receptor
Fluvial	Not required	Not required
Surface water	Not required	**Required**
Groundwater	Not required	Not required
Sewer and/or mains-Derived	Not required	Not required

7.2 Methodology for calculation of run-off and storage volume

7.2.1 Greenfield run-off rates

The peak run-off rate from the greenfield site has been estimated using the IH124 method (equation 7.1, Institute for Hydrology Report No 124, 1994). The IH124 method to give mean annual peak flow (Q_{BAR}) is of the form:

$$Q_{BAR(rural)} = 0.00108AREA^{0.89}SAAR^{1.17}SOIL^{2.17}$$

Where:
- Q_{BAR} (rural) mean annual flood, with a return period of 2.3 years (m^3/s)
- AREA catchment area (km^2)
- SAAR (4170) Standard Average Annual Rainfall (1941 to 1970) (mm)
- SOIL soil index

This method does not account for slope or storm duration and provides a conservative (low) estimate of the peak greenfield run-off rate. $Q_{BAR(rural)}$ can be multiplied using the UK Flood Studies Report regional growth curves to produce peak flood flows for any return period.

7.2.2 Run-off rates from post-development surfaces

The peak run-off rates for the post-development site, for the 1 in 100-year event and a storm duration of 6 hours, have been estimated using the Rational Method. The Rational Method to give peak flows (Q_p) is of the form:

$$Q_p = 2.78\ CiA$$

Where: C = run-off co-efficient (dimensionless)
i = rainfall intensity (mm/hr)
A = catchment area (ha)

The run-off coefficient, C, varies for different surfaces. The values of C used for this assessment are consistent with the 'Wallingford Procedure for design and analysis of urban storm drainage' (HR Wallingford, 1981) with a value of 0.95 for roofs, and 0.8 for hard surfaced areas (including access road and parking areas).

Rainfall intensities at the site were obtained from the FEH CD-ROM, Version 3. Rainfall intensity is dependent on storm duration, representing the likely critical duration for the receiving drainage system. The effect of climate change on rainfall intensities has been taken into account in accordance with the National Planning Policy Framework (NPPF) and RBWM Council's local policies, assuming that the development lifetime will extend to 2115 and possibly beyond.

Estimates of the proposed areas have been completed and are tabulated below. It is assumed that run-off from external source areas will not enter the site.

2051/FRA/T3: Site surface areas	
Zone	**Area (m^2)**
	Proposed development
Roofs	1,160
Hard surfacing	4,160
Soft landscaping	12,680
Total	18,000

Sheets in *Appendix 2051/FRA/A4* provide estimates of the greenfield and post-development run-off values from the site, using the IH124 and Rational Method. Key information from these calculations is summarised in *Table 2051/FRA/T4*.

2051/FRA/T4: Run-off volumes and attenuation storage				
Phase of development	**Method**	**Return period**	**Run-off rate (l/s)**	**Run-off volume (m^3)**
Greenfield	IH124	1 in 2 years	6.6	-
Post-development	Rational	1 in 100 years (+CC 30%)	*32	***692**
Total post-development attenuation storage required (m^3)				**692**
*For a critical storm duration of 6 hours.				

As summarised above, the rate of run-off in the design event will increase over the lifetime of the development. Measures to mitigate this are proposed in Section 7.3 below.

7.3 Surface water – external receptors

7.3.1 Run-off

Run-off characteristics for the site will be altered as a result of the proposed development. In accordance with RBWM Council's policies, Sustainable Drainage Systems (SuDS) should be used in order to mitigate flood risk to external receptors.

Run-off calculations have been completed for the 1 in 100-year event, for a storm duration of 6 hours, in accordance with the NPPF and CIRIA SuDS Manual (C697). The total post-development attenuation storage required for the 1 in 100-year event, and a critical storm duration of 6 hours, is 692 m^3.

To reduce the risk of surface water flooding as a result of run-off from the proposed development, the proposed SuDS system will include ephemeral retention pools and a water attenuation area providing a maximum storage capacity of 1,798 m^3. A permeable sub-base will also be constructed beneath the car parking area, to provide additional water attenuation storage of 314 m^3, assuming a storage void of 32%.

The SuDS system will provide run-off management at the source and close to the surface; providing a total surface water storage capacity of 2,112 m^3. All SuDS features are located outside any areas of flood risk. The site occupier will be responsible for future maintenance of the SuDS system.

In the pre-development site, run-off from the western part of the site discharged directly into the eastern drainage ditch (D1). However, all run-off post-development will be directed into the SuDS system, reducing the risk of flooding to external receptors and increasing the capacity of drainage ditch D1. The SuDS system will also provide more than triple the required run-off attenuation storage, offering a significant betterment to external receptors.

Although the ground conditions vary, evidence from boreholes (*Appendix 2051/FRA/A3*) completed on-site, indicate the presence of some sands and gravels below the site. Final locations, dimensions and infiltration testing will be completed before construction commences on-site.

7.3.2 New access

The new access into the site from Fifield Road will involve crossing the existing drainage ditch along the eastern side of Fifield Road (D1). The access crossing will be achieved through the installation of an oversized, free flowing culvert, under permission of the Environment Agency and RBWM Council. The culvert will be designed so as to not restrict flows within the drainage ditch, reducing the risk of flooding to external receptors.

8 SUMMARY AND CONCLUSIONS

A Planning Application has been prepared for the construction of the Phoenix Gymnastics Club, including a new gym building, car parking, landscaping and Sustainable Drainage system (SuDS). The Application Area is located within Flood Zone 1 on the Environment Agency's Flood Map. Flood Zone 1 land is assessed as having a less than 1 in 1000 annual probability of river flooding (<1%).

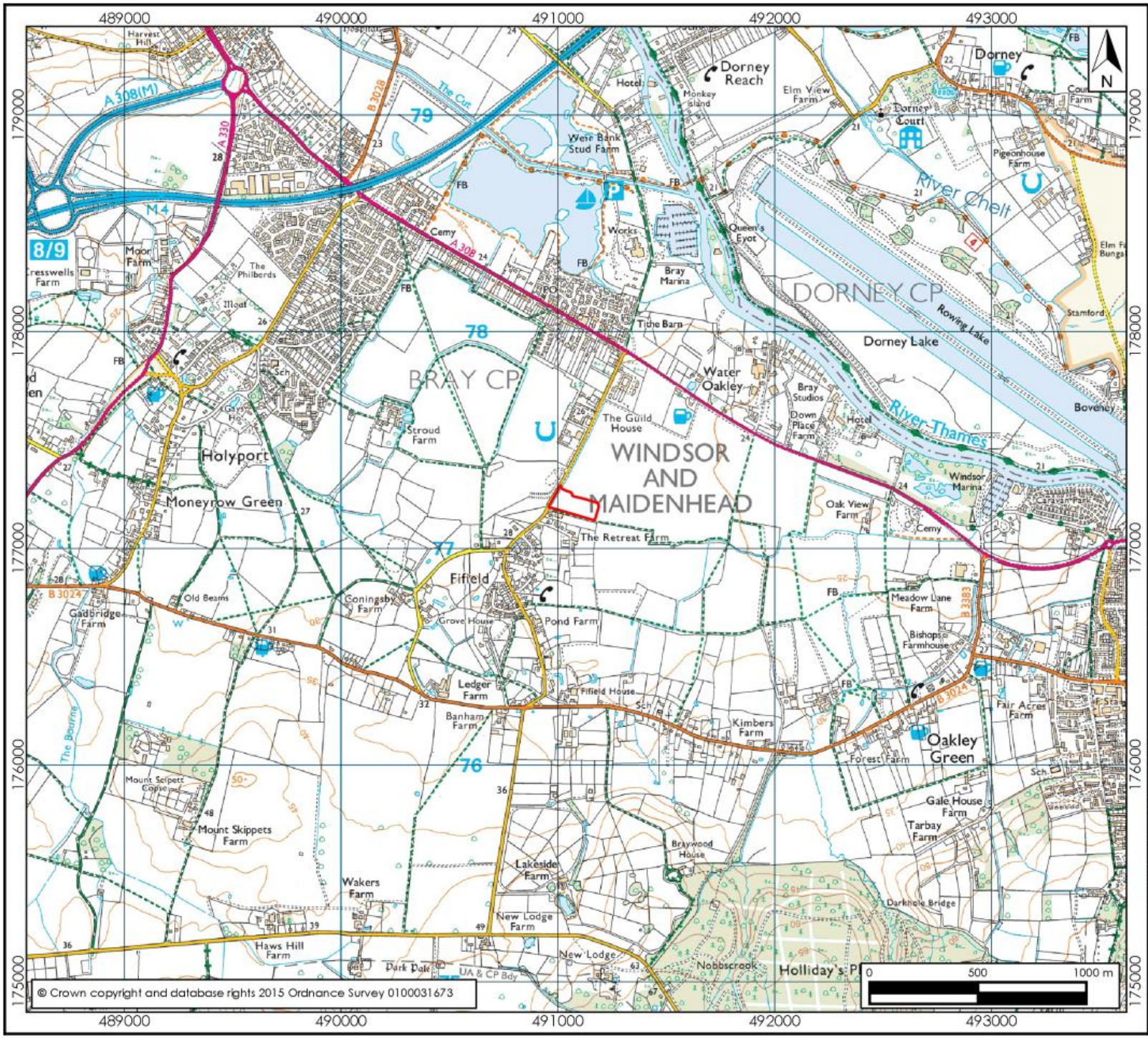
Risks of flooding have been considered for fluvial, surface water, groundwater and sewers/mains. Risks from fluvial, groundwater and sewers/mains flooding are 'very low' (see Sections 4 and 5) for the site and surrounding area. There is a risk of surface water flooding to the surrounding area as a result of the development. Mitigation measures in terms of surface water storage (attenuation features) have been proposed.

The total post-development attenuation storage capacity for the 1 in 100-year event (plus climate change) is 692 m^3. The proposed SuDS scheme will significantly reduce surface water flood risk to external receptors, more than doubling the required attenuation storage by providing a total storage of 2,112 m^3. Drainage features will be designed for infiltration and attenuation, hence the flood risk to external receptors will be significantly reduced.

The existing drainage ditches and banks associated with Fifield Road will not be altered as a result of the development, hence there will be no increased surface water flood risk to the site. The new access crossing will be achieved through the installation of an oversized, free flowing culvert, under permission of the Environment Agency and RBWM Council. The culvert will be designed so as to not restrict flows within the drainage ditch, reducing the risk of flooding to external receptors.

In light of the above, the Application Area is considered to satisfy the flood risk requirements of the NPPF and associated technical guidance.

DRAWINGS



Scale correct at A4

Client	Pleydell Smithyman Ltd 20a The Wharfage Ironbridge TELFORD TF8 7NH
Title	Site location plan
Project	Phoenix Club, Fifield
Drawing	2051/FRA/01
Version	1
Date	January 2016
Scale	1:25,000

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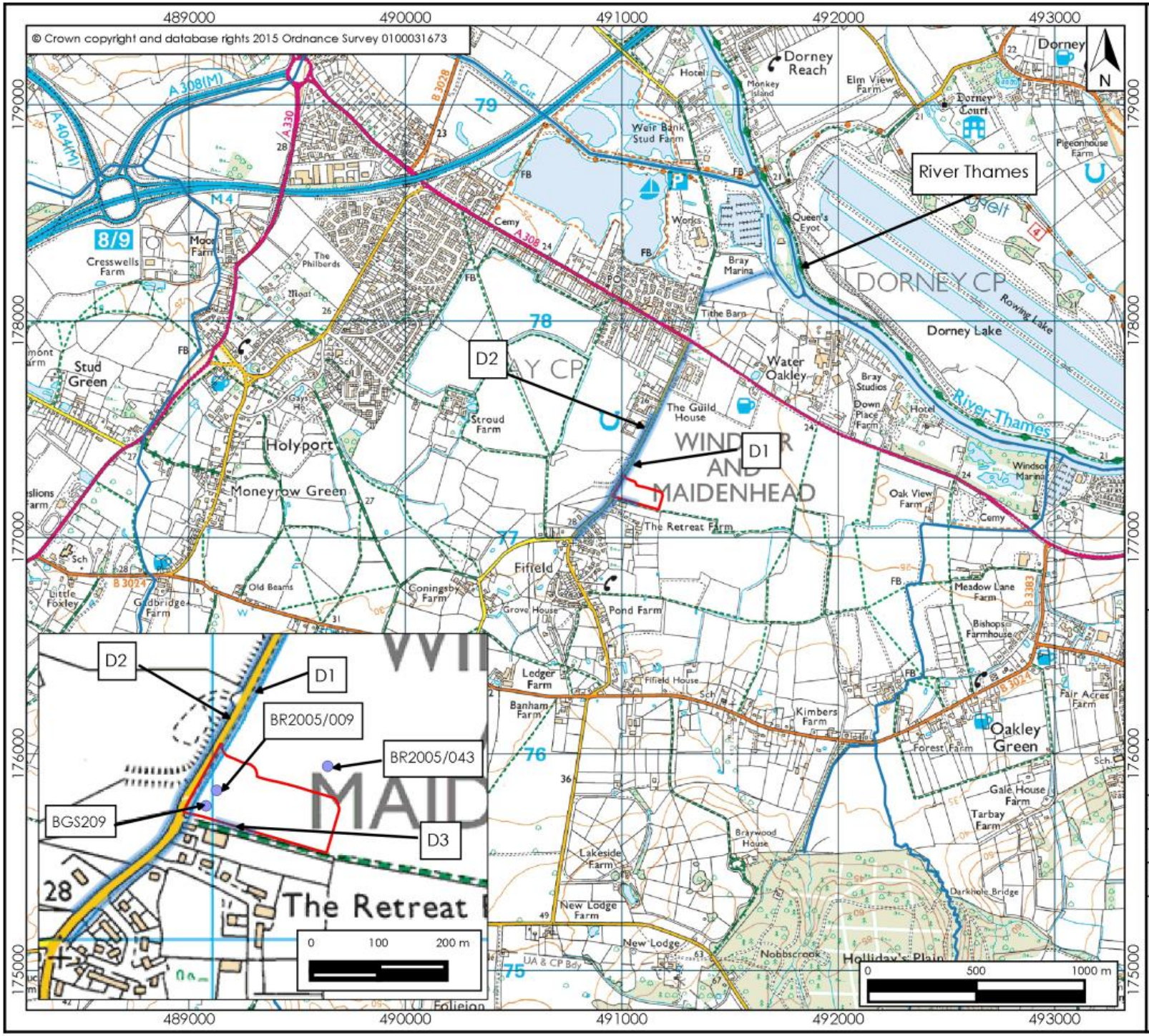

Legend

- Application Area
- Watercourses
- Drainage Ditches (D1-D3)
- Boreholes

Scale correct at A4

Client	Pleydell Smithyman Ltd 20a The Wharfage Ironbridge TELFORD TF8 7NH
Title	Water features
Project	Phoenix Club, Fifield
Drawing	2051/FRA/02
Version	1
Date	January 2016
Scale	As shown

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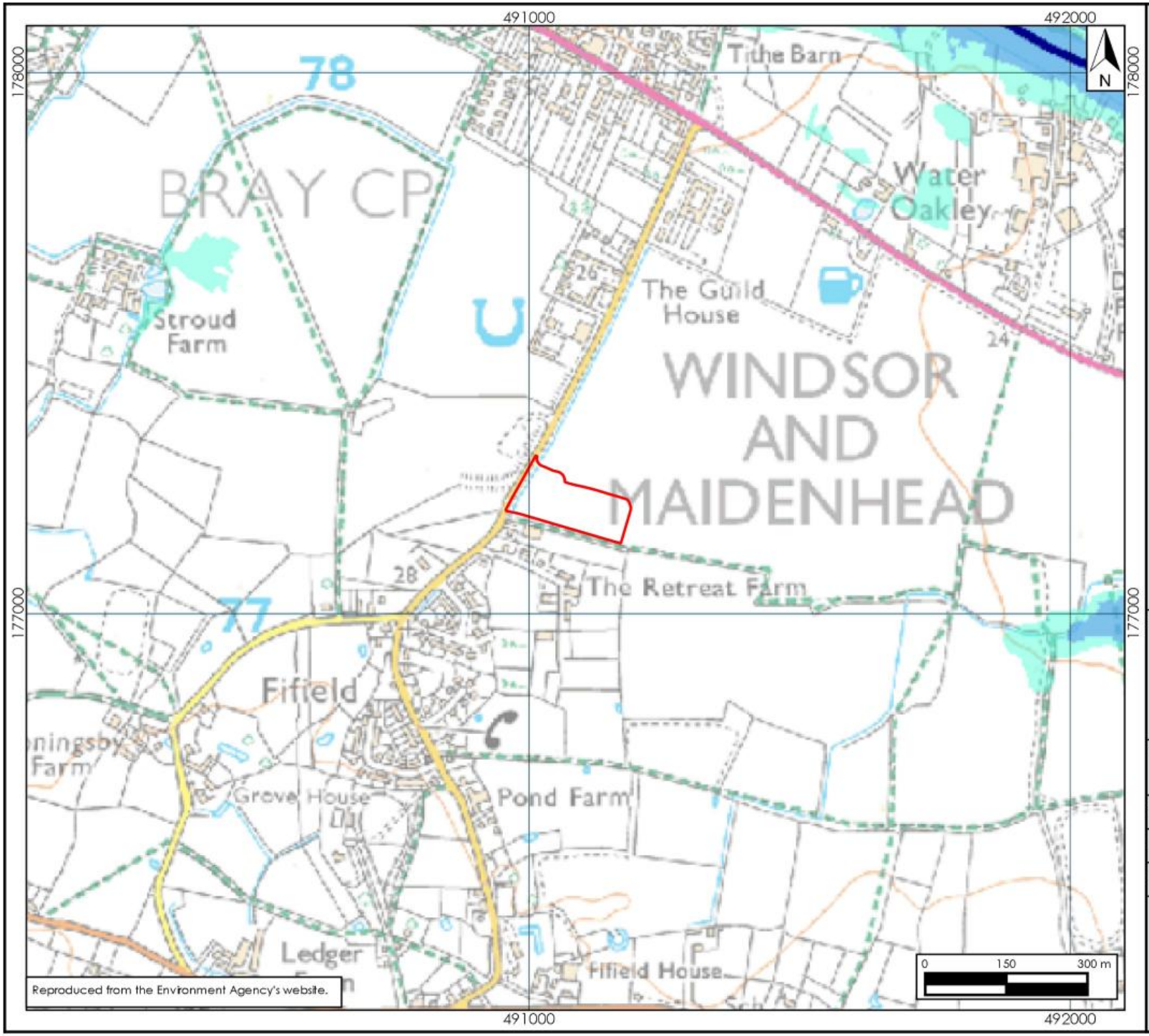

Legend

- Application Area
- Flood Zone 3
- Flood Zone 2
- Flood defences
- Areas benefiting from flood defences
- Main Rivers

Client	Pleydell Smithyman Ltd 20a The Wharfage Ironbridge TELFORD TF8 7NH
Title	EA Flood Planning Map
Project	Phoenix Club, Fifield
Drawing	2051/FRA/03
Version	1
Date	January 2016
Scale	1:10,000

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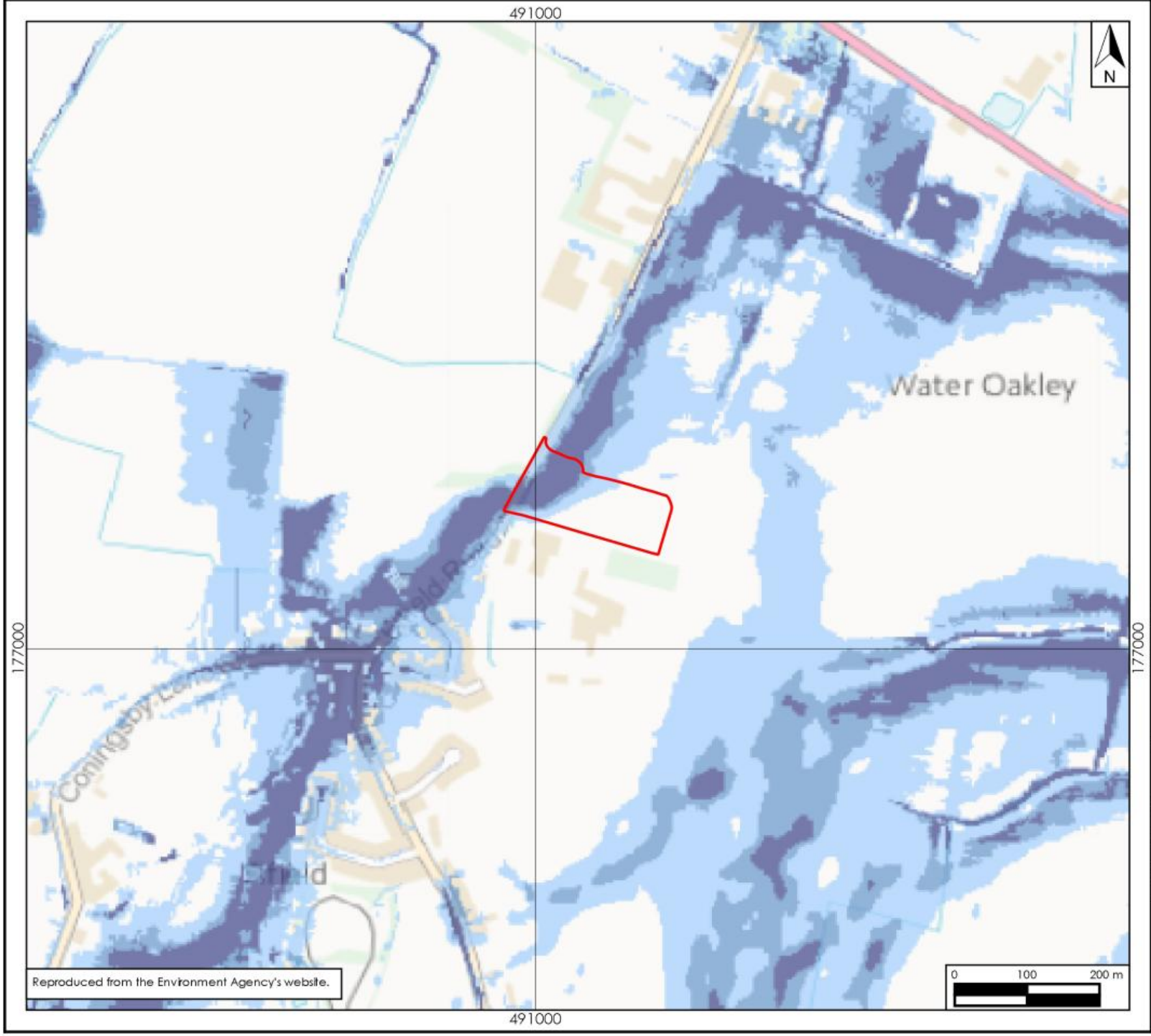

Legend

- Application Area
- High Risk
- Medium Risk
- Low Risk
- Very Low Risk

Client	Pleydell Smithyman Ltd 20a The Wharfage Ironbridge TELFORD TF8 7NH
Title	EA Surface Water Flood Map
Project	Phoenix Club, Fifield
Drawing	2051/FRA/04
Version	1
Date	January 2016
Scale	1:7,500

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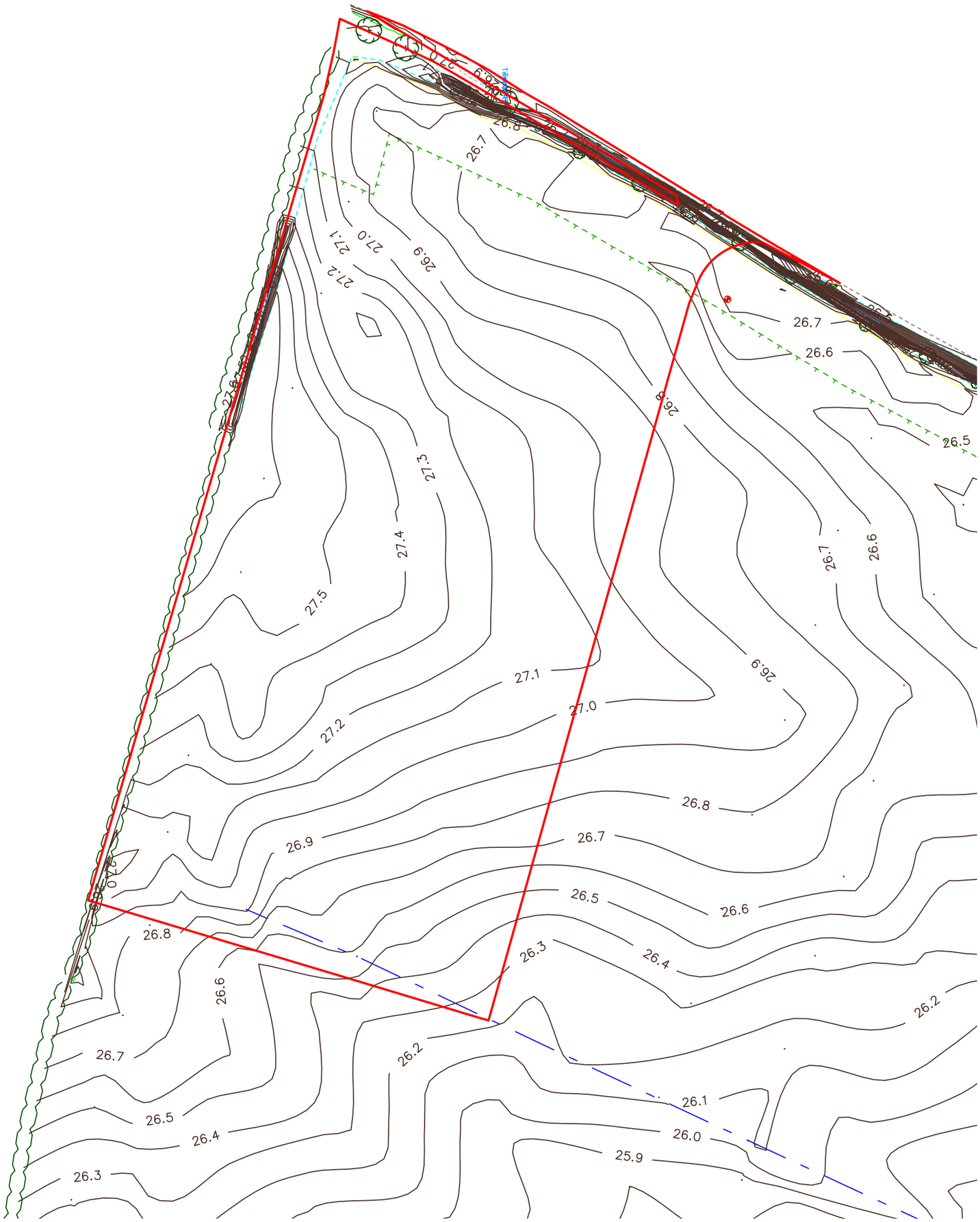
APPENDIX 2051/FRA/A1

Topographic survey


27.0
26.9
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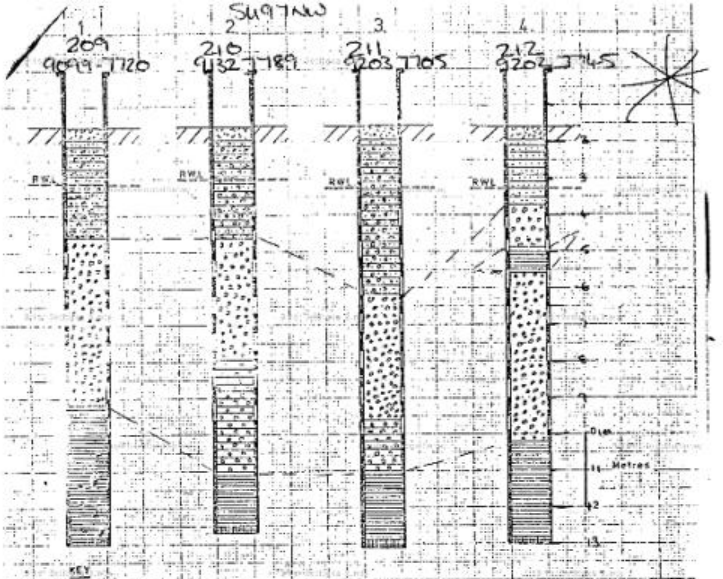
26.2
26.1
26.0
25.9
27.1
27.2
27.3
27.4
27.5

APPENDIX 2051/FRA/A2

Proposed site layout and drainage scheme

APPENDIX 2051/FRA/A3

Borehole records



Saturated thickness H = 5·3 metres for No. 1
Saturated thickness H = 5·7 metres for No. 2
Saturated thickness H = 5·6 metres for No. 3
Saturated thickness H = 5·8 metres for No. 4

SECTIONS OF BOREHOLES AT BRAY

(COMPLETED OCTOBER 1975)

Tarmac Southern Limited

BH Ref : BR 2005/043

Elevation : 26.541 **Drill Rig / Method :** HE50 Intermittent Flight Auger **Site Name :** Water Oakley

Easting : 491171 **Site Comments :** Water Oakley Farm nr Bray **Logged By :** M.Rosted

Northing : 177259 **Borehole Comments :** **Date Drilled :** Aug. 05

Geology

Depth	From	To	Level	Thick.	Legend	Wt	Class.	Field Description
	0.0	0.3	26.24	0.3			Topsoil	Topsoil. Dark brown, loose soil with only a small amount of stone present
1	0.3	1.5	25.04	1.2			Clay	Pale brown clay.
2	1.5	3.5	23.04	2.0			Gravelly Clay	Pale brown silty clay with gravel - not processable. Wet @ 2.2m.
3								
4								
5	3.5	6.3	20.24	2.8			Sand & Gravel	Pale brown, wet, slightly silty to silty, fine/medium to medium grained sand with a substantial amount of coarse, angular sand (quartz and flint mainly). Approx. 60% flint and quartzite gravel (flint is mainly sub-angular, and quartzite mainly sub-rounded to rounded). Av. gravel size = 10-20mm. Max gravel size = 150mm (mainly in form of flint - some broken fragments). Moderate amount of over sized material present (mainly in form of flint). Overall very good, clean material.
6								
7	6.3	7.5	19.04	1.2			Basal Clay	Basal Clay. Dark grey, firm to stiff clay - occasionally laminated.
8								
9								
10								
11								
12								

Tarmac Southern Limited

BH Ref : BR 2005/009

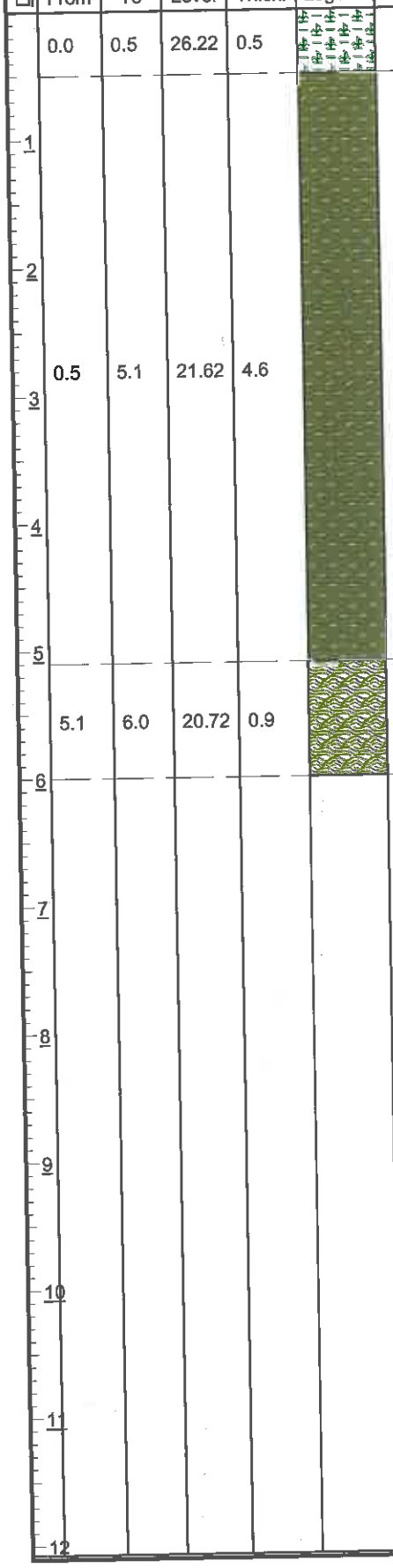
Elevation : 26.723
Easting : 491006
Northing : 177223

Drill Rig / Method : HE50 Intermittent Flight Auger
Site Comments : Water Oakley Farm nr Bray
Borehole Comments :

Site Name : Water Oakley
Logged By : M.Rosted
Date Drilled : Aug. 05

Geology

Depth From	To	Level	Thick.	Legend	Wt	Class.	Field Description
0.0	0.5	26.22	0.5			Topsoil	Topsoil. Dark brown, loose soil with only a small amount of stone present
0.5	5.1	21.62	4.6			Clay	Pale brown firm clay.
5.1	6.0	20.72	0.9			Clay	Basal Clay. Dark grey, firm to stiff clay - occasionally laminated.



APPENDIX 2051/FRA/A4

Run-off rate calculations

Greenfield Runoff Estimate for Existing Site

Institute of hydrology report no. 124 (IH124)

$$Q_{BAR(rural)} = 0.00108AREA^{0.89}SAAR^{1.17}SOIL^{2.17}$$

Where:

$Q_{BAR(rural)}$	mean annual flood (return period 2.3 years) (m^3/s)
AREA	catchment area (km^2)
SAAR(4170)	standard average rainfall for the period 1941 to 1970 (mm)
SOIL	soil index

$Q_{BAR(rural)}$ can be factored by the UK Flood Studies Report regional growth curves to produce peak flood flows for any return period.

Parameters	
Area	0.0180 km^2
SAAR	666
SOIL	0.45
FSR region	6
Return period	2
Growth curve factor	0.88

Results	
QBAR(rural)	7.5 l/s
Q (1in1yr)*	6.3 l/s
QBAR	4.1 l/s/ha
Q (1in1yr)	3.5 l/s/ha
Q (1in100yr)	13.2 l/s/ha

NB: calculation based on 0.5 km2 and then scaled down to actual catchment size. The IH124 methodology is designed for sites > 0.5 km2 but can be linearly interpolated to represent smaller catchments.

Q (1in1yr)*: approximate calculation using a ratio of 0.85 (*R&D Technical Report W5-074/A Preliminary Rainfall Runoff Management For Developments. Revision D - January 2012*)

Return period (yr)	**2**	**5**	**10**	**25**	**50**	**100**	**200**
Q (l/s/ha)	3.6	5.3	6.7	8.9	10.9	13.2	16.0
Q (l/s)	6.6	9.5	12.1	16.0	19.5	23.8	28.8

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Title:	Greenfield run-off rates from existing site, using IH124 formula		
Project:	Phoenix Club, Fifield, Berkshire		
Calc Sheet:	A4.1		Date: Jan-16

Storage Volumes vs Storm Duration (1-in-100-year storm) for post-development site

	Hard Surfacing	Roofing	Greenfield
Contribution Coefficient	0.8	0.95	0.18
Area Ha	0.416	0.116	1.268

Climate change (% rainfall increase) 30 %

The Rational Method to give peak flow Q_p is in the form:

$$Q_p = 2.78\ CiA$$

Where:

C co-efficient of run-off (dimensionless)
i rainfall intensity (mm/hr)
A catchment area (Ha)

IH124 Estimate of 50% AEP Greenfield Discharge 0.0 l/s

Groundwater Inflow Rate (-ve for Outflow) 0.0 l/s

Duration	Rainfall *2	Rainfall intensity	Accretion Rate from Hard Surfacing *3	Accretion Rate from Roofing *3	Accretion Rate from Greenfield *3	Accretion Rate from Groundwater *3	Accretion Rate from Watercourse *3	Net Accretion Rate in Storage	Net Accretion Volume in Storage
	100 year event								
hours	mm	mm/hr	l/s	l/s	l/s	l/s	l/s	l/s	m^3
0.25	50.3	201.2	242.0	80.1	166.0	0.0	0	488.1	439.3
0.5	55.5	111.1	133.6	44.2	91.6	0.0	0	269.5	485.0
1	61.3	61.3	73.8	24.4	50.6	0.0	0	148.8	535.5
2	67.7	33.9	40.7	13.5	27.9	0.0	0	82.1	591.2
4	74.7	18.7	22.5	7.4	15.4	0.0	0	45.3	652.7
6	79.2	13.2	15.9	5.3	10.9	0.0	0	32.0	691.6
8	82.5	10.3	12.4	4.1	8.5	0.0	0	25.0	720.7
12	87.4	7.3	8.8	2.9	6.0	0.0	0	17.7	763.5
16	90.7	5.7	6.8	2.3	4.7	0.0	0	13.7	791.7
20	93.2	4.7	5.6	1.9	3.8	0.0	0	11.3	814.3
24	95.4	4.0	4.8	1.6	3.3	0.0	0	9.6	833.1
28	97.3	3.5	4.2	1.4	2.9	0.0	0	8.4	849.5
32	98.9	3.1	3.7	1.2	2.5	0.0	0	7.5	863.9
36	100.4	2.8	3.4	1.1	2.3	0.0	0	6.8	876.7
40	101.7	2.5	3.1	1.0	2.1	0.0	0	6.2	888.4
44	103.0	2.3	2.8	0.9	1.9	0.0	0	5.7	899.2
48	104.1	2.2	2.6	0.9	1.8	0.0	0	5.3	909.0

*2 Obtained from FEH CD-ROM v3

*3 Climate change factored into rainfall intensity at this stage

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TF8 7NH

Title:	Runoff rates and retention volumes for post-development site		
Project:	Phoenix Club, Fifield, Berkshire		
Calc Sheet:	A4.2	Date:	Jan-16