Brunel University London

Site 1 and 2
Surface water drainage strategy

Doc No: P300199A-BDP-XX-XX-RP-C-0100

Rev: P01

Date: 26/07/2019

Project No.: P300199

BDP.

Document Control Sheet

	Name	Position	Date
Prepared By	Olugbenga Ajayi	Senior Civil Engineer	26/07/2019
Reviewed By	Agata Lo Certo	Associate	26/07/2019
Approved By			

Revision	Description	Date
P01	Issued for comments	26/07/2019

Contents

1 Introduction

1.1 Appointment and brief

Building Design Partnership (BDP) has been appointed by Brunel University London to produce a surface water drainage strategy for Site 1 and 2.

This report has been prepared to assess the existing surface water network, identify the causes of surface water flooding and provide suitable solutions to improve the existing conditions. This study also includes a comprehensive strategy for retrofitting SuDS into the existing drainage where possible and for implementing SuDS into future developments to alleviate historic surface water and improve resilience of the network to climate change.

1.2 Liability

BDP accepts no liability for any use of this document other than for the purposes for which it was prepared and provided. Any advice, opinions or recommendations within this document should be read and relied upon only in the context of this document as a whole.

BDP has endeavoured to assess all information provided to them during this appraisal. The report summarises from a number of external sources and cannot offer any guarantees or warranties for the completeness or accuracy of information relied upon.

2 Policy context

This document has been prepared in accordance with the relevant national, regional and local planning policy and statutory authority guidance as follows:

- National Planning Policy Framework (NPPF) dated February 2019, with reference to Section 14 “Meeting the challenge of climate change, flooding and coastal change”;
- The NPPF Planning Practice Guidance (PPG) last update in March 2019, with reference to “Climate change” section
- The London Plan issued in March 2016, with reference to. Policy 5.12 (Flood Risk Management) and Policy 5.13 (Sustainable Drainage);
- Sustainable Design and Construction Supplementary Planning Guidance issued in April 2014, that provides guidance on the implementation of London Plan Policy 5.3; and,
- The London Borough of Hillingdon “Sustainable Drainage, Design and Evaluation Guide” issued in 2018.

The NPPF states that when determining any planning applications, local planning authorities should ensure that flood risk is not increased elsewhere. Where appropriate, applications should be supported by a site-specific flood-risk assessment. Development should only be allowed in areas at risk of flooding where, in the light of this assessment (and the sequential and exception tests, as applicable) it can be demonstrated that:

a) within the site, the most vulnerable development is located in areas of lowest flood risk, unless there are overriding reasons to prefer a different location;
b) the development is appropriately flood resistant and resilient;
c) it incorporates sustainable drainage systems, unless there is clear evidence that this would be inappropriate;
d) any residual risk can be safely managed; and
e) safe access and escape routes are included where appropriate, as part of an agreed emergency plan.

The NPPF PPG identifies many opportunities to integrate climate change mitigation and adaptation objectives into the Local Plan. Considering the impact of and promoting design responses to flood risk and coastal change for the lifetime of the development is highlighted as an example of adaptation to climate change.

The NPPG encourages the use of multi-functional green infrastructure, which can reduce urban heat islands, manage flooding and help species adapt to climate change – as well as contributing to a pleasant environment which encourages people to walk and cycle. It also stresses the importance of building in flexibility to allow future adaptation if it is needed, such as setting back new development from rivers so that it does not make it harder to improve flood defences in future.

In accordance with the London Plan 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.

The guidance provides in the London Borough of Hillingdon "Sustainable Drainage, Design and Evaluation Guide" promotes the idea of integrating SuDS into the fabric of the development using the available landscape spaces as well as the construction profile of buildings. The main objectives of the Design and Evaluation Guide are:

- To create a shared vision around SuDS for all involved in design and evaluation;
- To enable the design and evaluation of SuDS to meet agreed standards;
- To ensure SuDS are maintainable now and in the future.

As highlighted in the Guide, SuDS became a statutory requirement on all major development in 2015 and therefore proposals are now required as part of the planning process. Planning Authorities can also ask for SuDS on other types of development, including smaller developments and regeneration projects.

3 Site Context

3.1 Site description

Site 1 and 2 are part of Brunel University London located in Uxbridge, in the London Borough of Hillingdon, UB8 3PH. The approximate site boundaries are shown in Figure 3.1.

Site 1 is approximately 13.8 hectares comprised mostly of buildings and associated roads, parking facilities and landscaped areas. The site is bounded by residential developments on the western side and Cleveland Road on the eastern side. The northern part, approximately 5.5 hectares, is exclusively occupies by soft landscaping. There is a gated vehicular access and a pedestrian access on Station Road and also a pedestrian access on Cowley Road. There is another gated vehicular access on Cleveland Road in proximity of the Maria Jahoda building.

Site 2 is approximately 26.8 hectares and is mainly occupied by buildings and associated roads, parking facilities and landscaped areas. The site is bounded by Cleveland Road on the western side and Kingston Lane on the eastern side. The main vehicular entrance is located on Kingston Lane. There are two pedestrian access on Cleveland Road.

The River Pinn flows in a southerly direction approximately in the middle of Site 2. It is designated as “main river” and therefore the Environment Agency is responsible to carry out maintenance, improvement or construction work to manage flood risk. It flows through the London Boroughs of Harrow and Hillingdon before joining the Frays River in Uxbridge. It is joined by several smaller rivers along its length, including the Cannon Brook in Ruislip. It is also fed by numerous drainage outfalls which carry rainwater to the river. Generally the water flows in open earth channels, regularly passing through various bridges and culverts.

Figure 3.1 - Approximate site boundary

3.2 Site topography

The analysis of the topography is based on the historic topographical survey enclosed in Appendix A. The University Campus has been developed since and the survey doesn't include the redevelopment of the Isambard Complex, the Bishop Hall, Kilmorey Hall, Lacy Hall, St Margaret's Hall, the Indoor Athletic Centre, the Netball Courts, the Eastern Gateway, Mary Seacole, the Advanced Metals Processing Centre and the Advanced Metals Casting Centre. Therefore the information below are just an indication of the topography and an approximation of the existing situation. As shown in Figure 3.2, the elevations across Site 1 range from 32.9m AOD to 36.5m AOD with a mean level of 35.6m AOD and an average slope of about 3%. The elevation range on Site 2 is much wider and varies from 29.4m AOD in proximity of the River Pinn bank to 45.2m AOD at the south east corner of the site. Most of Site 2 is predominantly sloping towards River Pinn.

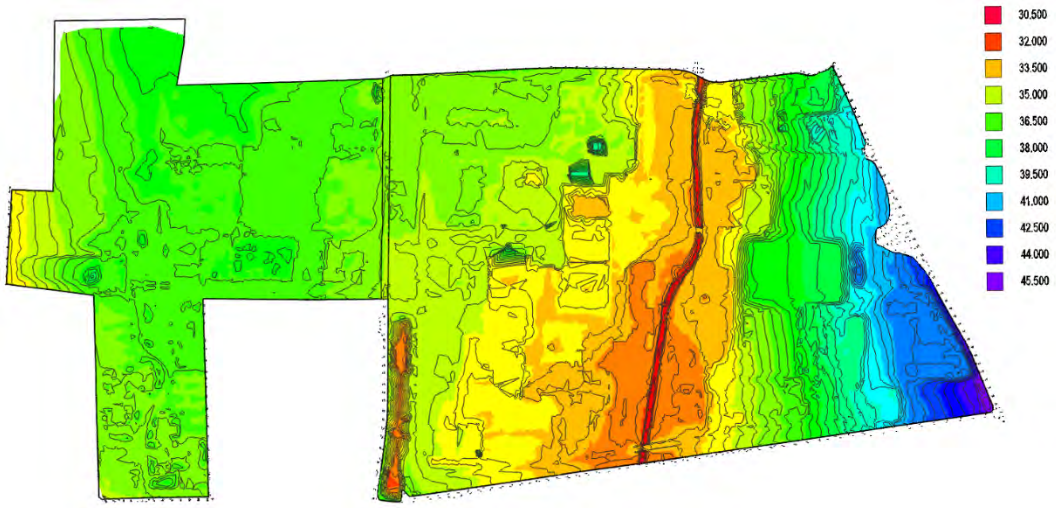


Figure 3.2 - Site 1 and 2 contours map

3.3 Geology and hydrology

The British Geological Survey map in Figure 3.3 shows that the superficial geology is predominantly Langley Silt Member that is mainly a cohesive soil and is therefore expected to have a low permeability. The eastern part of Site 2 is underlain by Boyn Hill Gravel Formation, poorly sorted, stratified gravel and locally tabular cross-bedded sand beds. The areas in proximity of the River Pinn banks are characterised by Alluvium that normally consists of soft to firm consolidated, compressible silty clay, but can contain layers of silt, sand, peat and basal gravel. The bedrock geology across both sites as shown in Figure 3.4 is London Clay Formation.

Although a predominant clay geology results in much lower infiltration rate, this does not prevent the use of SuDS within a development. Appropriate tests should be undertaken to understand site specific infiltration rates.

Based on the map in Figure 3.5 extracted from the London Borough of Hillingdon "Surface Water Management Plan Evidence Base" (SWMP), the only locations subject to increased potential of elevated ground water in permeable superficial deposit are in proximity of the River Pinn banks.

To create the SWMP, modelling was undertaken to pinpoint key flow paths, velocities and areas where water is likely to pond. Seventeen Critical Drainage Areas have been identified within the Borough, The Brunel University Campus is not within a Critical Drainage Area.

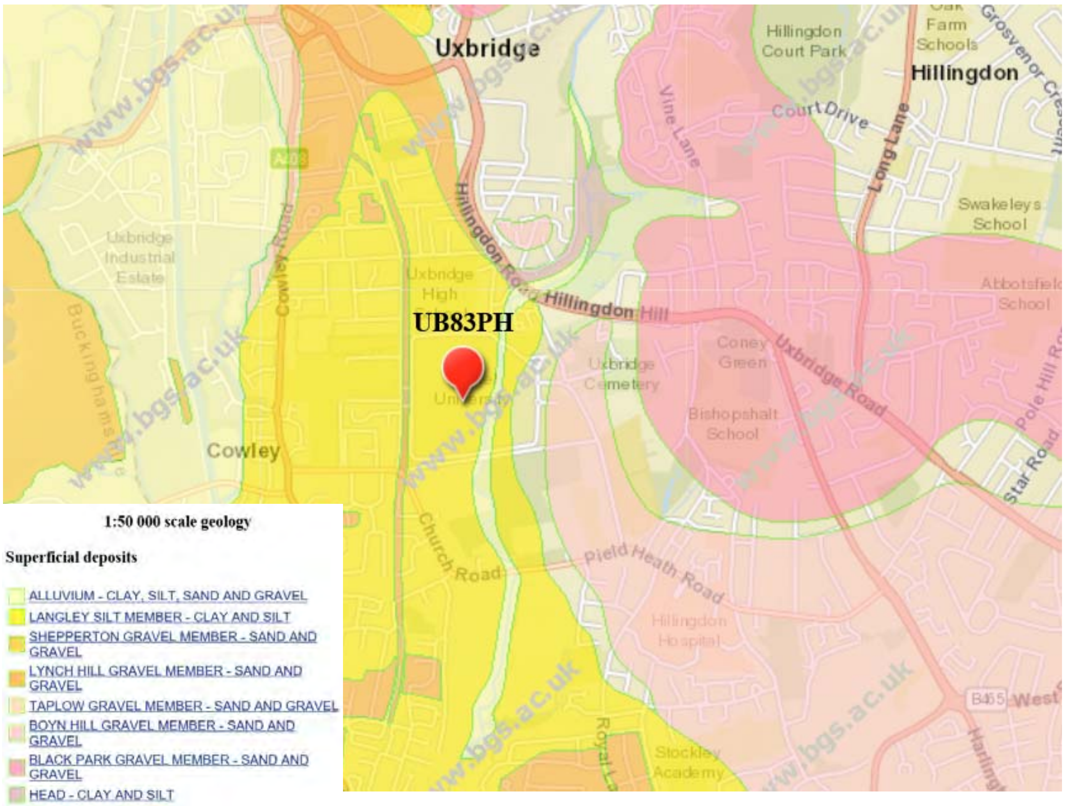


Figure 3.3 - Superficial geology
(Source: British Geological Survey map)

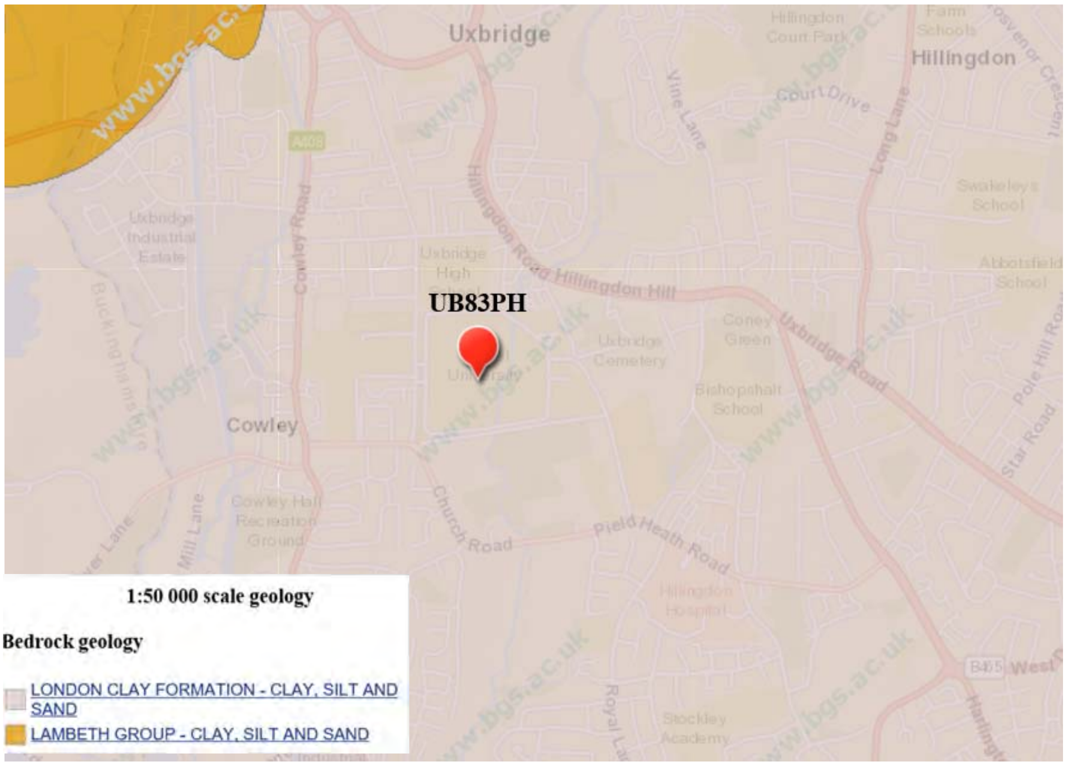


Figure 3.4 - Bedrock geology
(Source: British Geological Survey map)

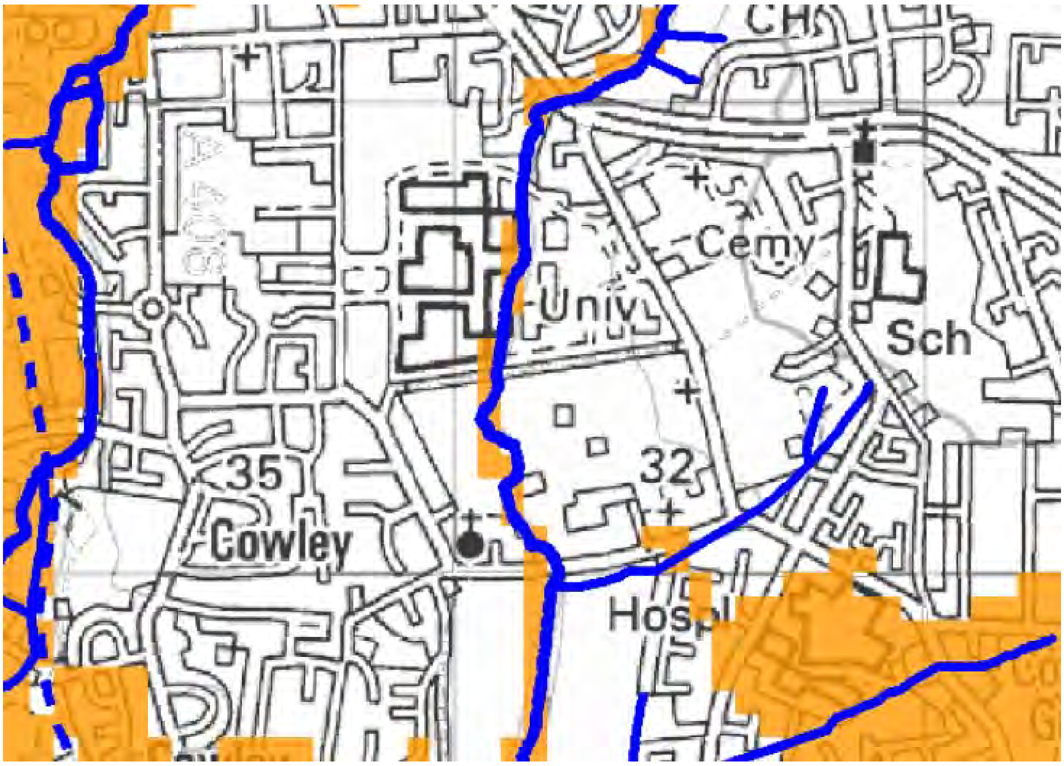


Figure 3.5 - Increased potential for elevated groundwater map
(Source: London Borough of Hillingdon Surface Water Management Plan, Appendix D, January 2013)

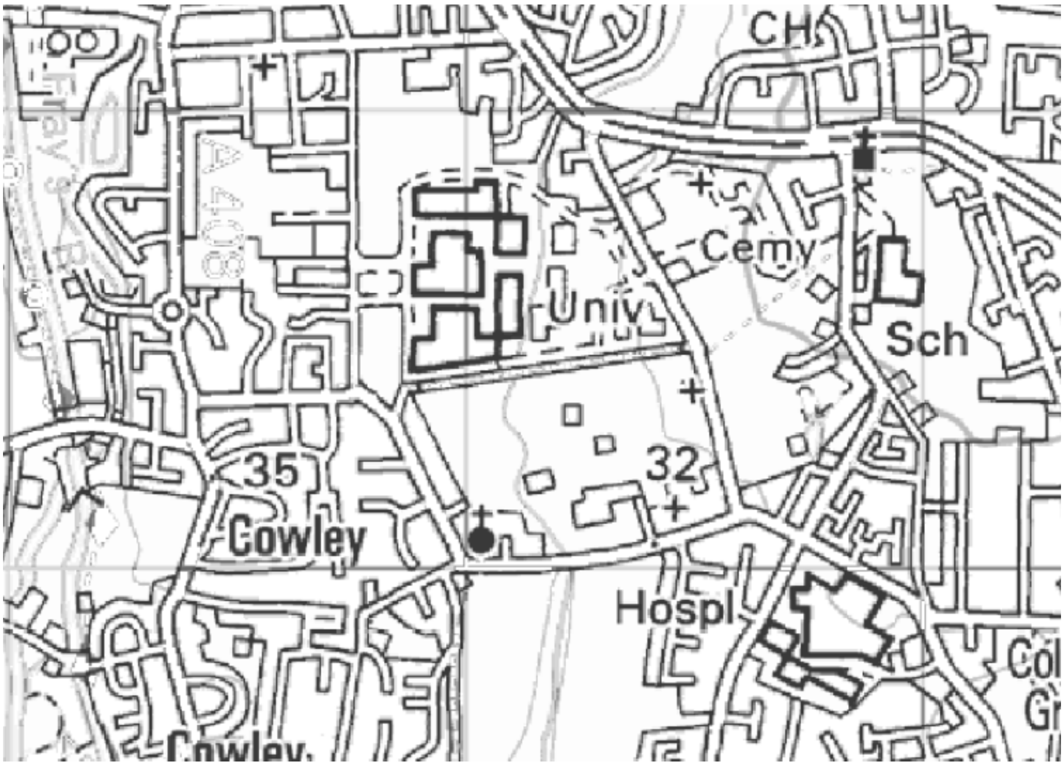


Figure 3.6 – Critical drainage area index map
(Source: London Borough of Hillingdon Surface Water Management Plan, Appendix D, January 2013)

4 Existing drainage

4.1 Surface water drainage

The map in Figure 4.1, extracted from the SWMP, shows Thames Water sewer asset records in proximity of the University Campus. With reference to Site 1 and 2, there is a surface water sewer on the eastern side of Site 1 that runs southbound underneath Cleveland Road and a surface water sewer on the eastern side of Site 2 that runs southbound underneath North Loop Road and Kingstone Lane.

Based on the available information it is unclear where these public sewers connect but it believed that they both discharge into the River Pinn.

The map in Figure 4.2 is based on the data provided by Thames Water as part of the SWMP and shows an overview of the number of properties that are known to have experienced sewer flooding prior to June 2010. Site 1 and 2 lay in sector UB8 2 and UB8 3 where 12 to 21 properties have been affected by sewer flooding.

The University private drainage network shown in Appendix C consists of a separate foul water and surface water drainage. The drawing included the most recent drainage records for the following developments:

- AMCC3, December 2018
- Heinz Wolff Rear, January 2016
- Bishop Green, March 2015
- Sports Centre, August 2012
- North to South Loop Road, January 2017.

Figure 4.1 – Thames Water surface water sewer
(Source: London Borough of Hillingdon Surface Water Management Plan, Appendix D, January 2013)

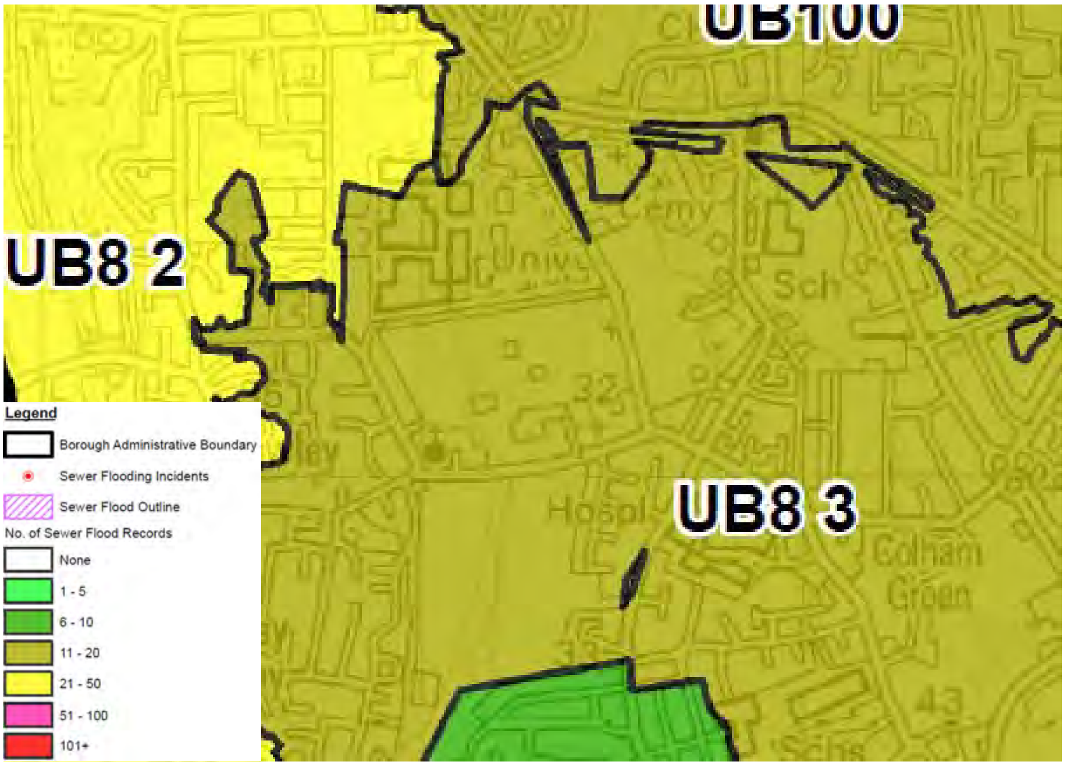


Figure 4.2 – Recorded incidents of sewer flooding
(Source: London Borough of Hillingdon Surface Water Management Plan, Appendix D, January 2013)

4.2 Watercourses

The River Pinn flows in an open channel through the middle of Site 2 and is the only watercourse within the site.

The historic flood map in Figure 4.3 shows that the outlines of historic data events. The Site 1 and the majority of Site 2 have not been affected by flooding from the River Pinn.

Figure 4.3 - Historic flood event outlines
(Source: Environment Agency Product 4 Data)

Detailed Flood Risk Assessment Maps (Product 4) have been obtained from the Environment Agency and are enclosed in Appendix B for reference. This information include the results of a detailed hydraulic model for the River Pinn such as:

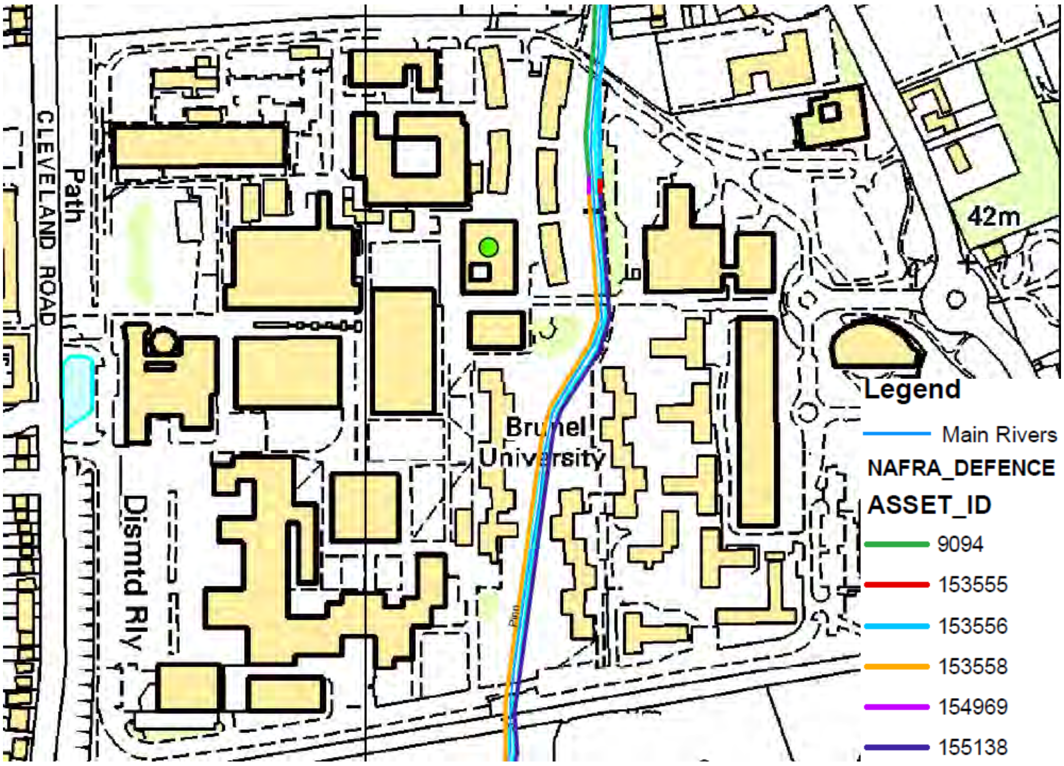
- Flood map for planning;
- Defended flood outlines for different return periods;
- Relevant model node locations and flood level;
- Model extents showing defended scenarios;
- Flood defence locations;
- Historic flood events outlines.

Product 4 Data should be taken into consideration for development in Flood Zone 3, other than non-domestic extensions less than 250m^2, and all domestic extensions, and all applications with a site area greater than 1 ha" in Flood Zone 2.

It is recommended that future developments are kept at a suitable distance and level from the River Pinn flood plain to minimise the risk of flooding.

4.2.1 Flood defences

The Environment Agency Asset Information Management system shows the River Pinn flood defences, shown in Figure 4.4, consist mainly of natural embankments that are generally considered in good conditions.



Asset ID	Asset Type	Asset Protection	Asset Comment	Asset Description	Design Standard of protection (years)	Downstream Crest Level	Upstream Crest Level	Condition of Defences (1=Good, 5 = Poor)
9094	high_ground	fluvial	Natural Vegetated Bank	Natural Bank	5	32.70	33.30	3
153558	high_ground	fluvial	Natural vegetated Channel	Natural Bank	2	30.50	32.70	3
155138	high_ground	fluvial	Natural vegetated channel	Natural Channel	2	30.40	33.10	3
154969	high_ground	fluvial	Precast concrete channel lining forming flume for possible gauging / telemetry station	Bank protection.	20	32.60	32.60	3
153556	high_ground	fluvial	Natural Vegetated Bank	Bank protection.	2	33.10	33.30	3
153555	high_ground	fluvial	Concrete blockwork channel sides forming flume for possible gauging/telemetry station	Bank protection.	100	33.10	32.60	3

Figure 4.4 – Existing flood defences
(Source: Environment Agency Product 4 Data)

According to “River Pinn catchment flood reduction proposals” issued in March 2018, communities in the River Pinn catchment have experienced flooding several times, most recently in June 2016. The report is the result of collaboration between the Environment Agency and Hillingdon and Harrow Councils as well as Thames Water to understand the causes of this flooding and identify actions that could reduce the risk in the future.

The study area has been split into six areas and as shown in Figure 4.5 Brunel University London catchment lies within study area 5. Hillingdon and Uxbridge flood reduction options, shown in Figure 4.6, have been proposed for study area 5 and have undergone public consultation:

- 5A) Construction of an embankment to reduce the risk of flooding to properties locally.
- 5B) Construction of an embankment to reduce the risk of flooding to Brunel University.

- 5C) Utilising open space to the south of Brunel University to store flood water during high river flows.
- 5D) Construction of an embankment to reduce the risk of flooding to properties locally.

From the result of consultation, option 5C is amongst the favoured options for Hillingdon and Uxbridge area.

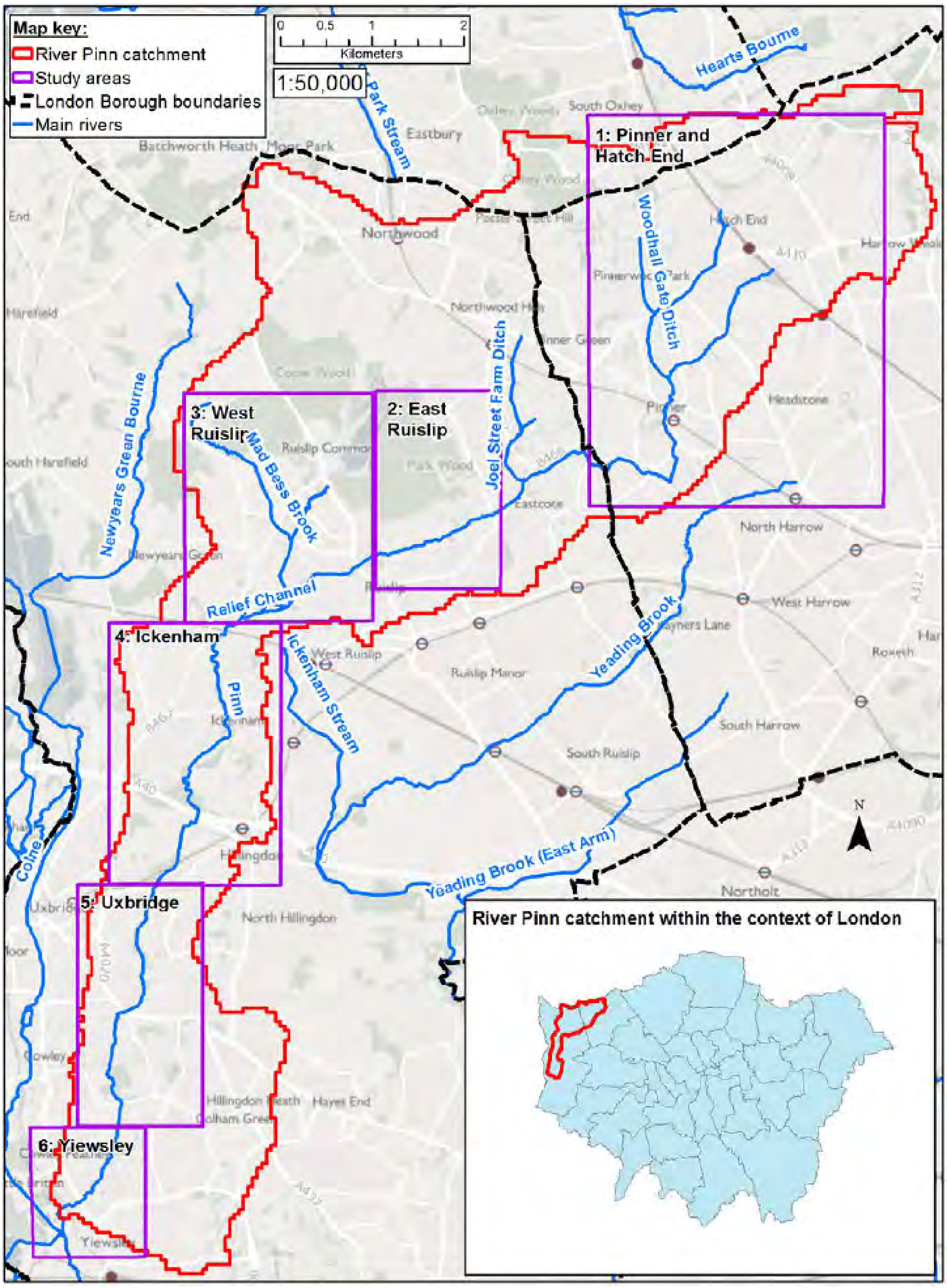


Figure 4.5 - Overview of River Pinn Catchment area
(Extracted from "River Pinn catchment flood reduction project – Consultation response report, March 2018")

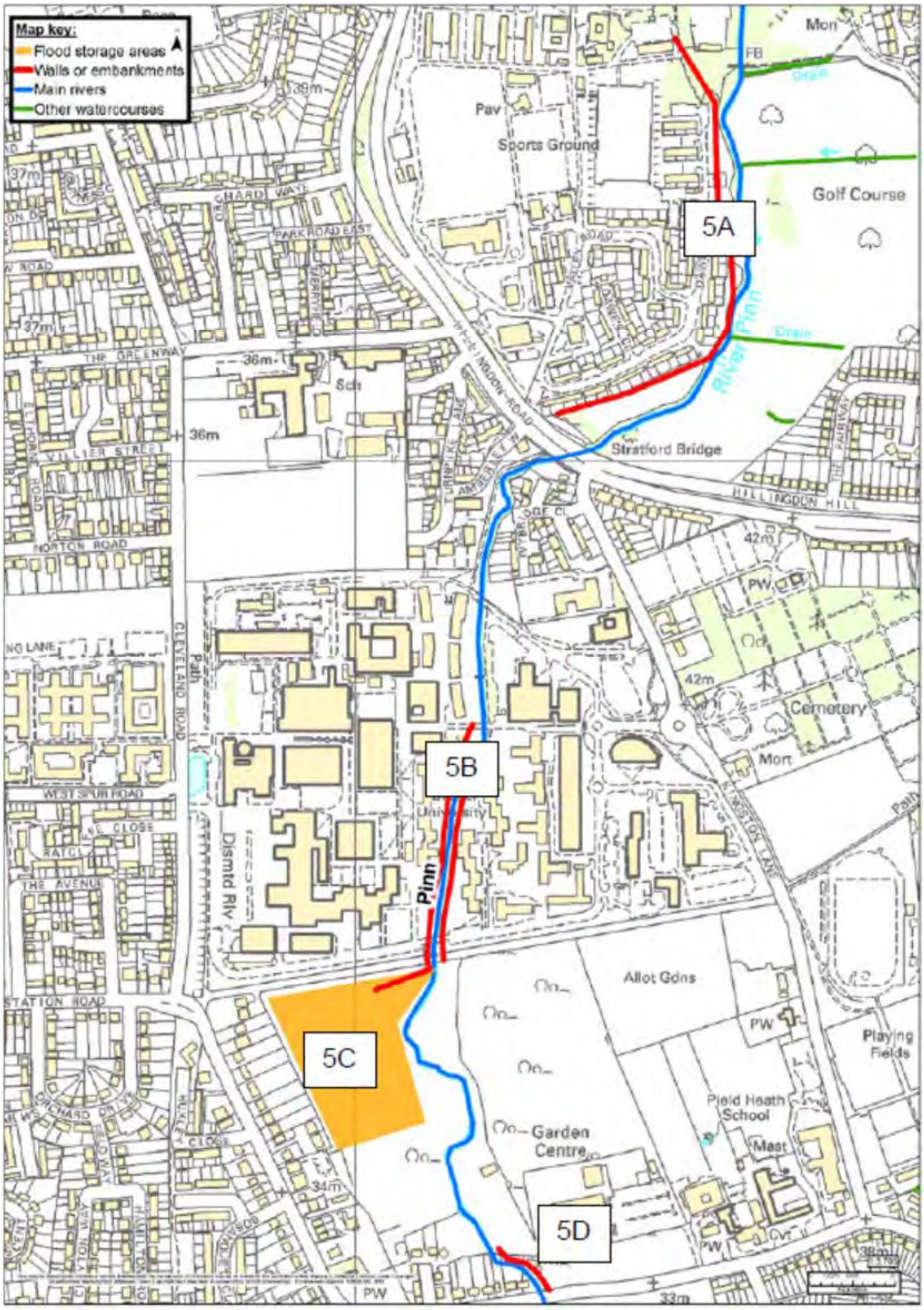


Figure 4.6 - Hillingdon and Uxbridge flood reduction options
(Extracted from "River Pinn and Cannon Brook flood reduction proposals – Consultation document March 2018")

4.3 Existing catchment areas

In order to identifying the existing catchment areas, the estate Department Team has provided a comprehensive map of the Campus showing the most up to date information on the existing drainage. The University Campus is subdivided in six different sites. For the purpose of this report only Site 1 and 2 catchment areas have been analysed in details. The available survey information are incomplete and present some inconsistencies and therefore the assessment of the existing catchment areas is indicative only and should be verified by further surveys. Based on the available information provided by the University, the following paragraphs describe the catchment areas identified for Site 1 and 2 and demarcated on Drawing No. P300199-BDP-ZZ-ZZ-SK-C-001 in Appendix D.

4.3.1 Site 1

From the available information, it appears that the surface water drainage network for Site 1 can be divided in the following sub-catchments:

- Sub-catchment (1A) includes the Isambard Complex and associated external landscaped areas, roads and parking facilities on the western side of Site 1. The surface water run-off from these areas discharges predominantly to soakaways which are scarred across the site.
- Sub-catchment (1B) consists of the Galbraith Hall, Fleming Hall and Mill Hall and associated external landscaped areas, roads and parking facilities on the north-east side of Site 1. Based on the available information, it appears that the surface water run-off from these areas is collected through a surface water drain running to the north of Site 1 and that eventually discharges without any form of attenuation and/or treatment into the surface water sewer on Cleveland Road.
- Sub-catchment (1C) consists of the Chadwick, Gaskell and Maria Jahoda buildings and associated external landscaped areas, roads and parking facilities at the south-east of Site 1. Based on the available information, it appears that the surface water run-off from these areas is collected through a surface water drain running to the south of Site 1 and that eventually discharges without any form of attenuation and/or treatment into the surface water sewer on Cleveland Road.

4.3.2 Site 2

From the available information, it appears that the surface water drainage network for Site 2 predominantly discharges into the River Pinn and can be divided in the following sub-catchments located to the west and to the east of the River Pinn:

- Sub-catchment (2W1) includes the Bragg building and part of Heinz Wolff and Halsbury building and associated external landscaped areas, roads and parking facilities. Based on the available information, it appears that the surface water run-off from these areas is collected through a surface water drain running underneath the North Loop Road that eventually discharges without any form of attenuation through a 600mm diameter outfall (O1) into the River Pinn. A petrol interceptor collects the surface water run-off from the car park adjacent to the Biology Annex.
- Sub-catchment (2W2) includes the Borough Road Hall, Lancaster Hall, Maria Grey Hall, Southwark Hall and Stockwell Hall and associated external landscaped areas, roads and parking facilities. Based on the available information, it appears that the surface water run-off from these areas discharges through a 150mm diameter outfall (O2) into the River Pinn. A below ground attenuation tank is located

between the Maria Grey Hall and the Southwark Hall. The dimensions of the tank and the location and characteristics of the flow control device are unknown.

- Sub-catchment (2W3) includes part of Heinz Wolff and Halsbury building, the Hamilton Centre, the Wilfred Brown, the Michael Sterling, the John Crank, the Gordon Hall, the Lecture Centre, the Bannerman Centre and associated external landscaped areas, roads and parking facilities. Based on the available information, it appears that the surface water run-off from these areas discharges through a 525mm diameter outfall (O6) into the River Pinn. A below ground attenuation tank is located at the south-east corner of the Gordon Hall. The dimensions of the tank and the location and the characteristics of the flow control device are unknown.
- Sub-catchment (2W4) includes only the Saltash Hall and associated external landscaped areas. Based on the available information, it appears that the surface water run-off from these areas discharges without any form of attenuation and/or treatment into the River Pinn. The dimension of this outfall (O7) is unknown.
- Sub-catchment (2W5) includes Tower A-D, the Medical Centre, the Howell, the Antonin Artaud, and the Joseph Lowe building and associated external landscaped areas, roads and parking facilities. Based on the available information, it appears that the surface water run-off from these areas discharges through a 450mm diameter outfall (O8) into the River Pinn. It is unclear whether attenuation is provided in this area. It is also unclear whether the surface water run-off from the large parking lot discharges through soakaways. A series of petrol interceptors collect surface water run-off from the car park areas.
- Sub-catchment (2E1) includes the St John building and associated external landscaped areas, roads and parking facilities. Based on the available information, it appears that the surface water run-off from these areas discharges through a 450mm diameter outfall (O2) into the River Pinn. A petrol interceptor collects surface water run-off from the car park areas. However, it is unclear whether the majority of the cark park discharges into a soakaway.
- Sub-catchment (2E2) includes the Eastern Gateway, the Sports Hall, the Bishop Hall and the Maria Seacole building and associated external landscaped areas, roads and parking facilities. Based on the available information, it has not been possible to establish which parts of this sub-catchment discharge into outfall (O4, 150mm diameter) and to outfall (O5, 450mm diameter) and therefore this area has been grouped in one sub-catchment. There are three attenuation tanks scattered across this area. However, the location and the characteristics of the flow control device are unknown.
- Sub-catchment (2E3) consists of the Clifton Hall, the Kilmorey Hall, the Lacy Hall, the Chepstow Hall, the Faraday Hall 1-7, the St. Magarets Hall, the Russell building, the Elliott Jacques, the Gardiner Building, the Advanced Metals Processing Centre, the Advanced Metals Casting Centre and associated external landscaped areas, roads and parking facilities. Based on the available information, it appears that the surface water run-off from these areas discharges through a 600mm diameter outfall (O9) into the River Pinn. It is unclear whether there any means of surface water run-off treatment in the car park areas. There are four attenuation tanks scattered across this area. However, the location and the characteristics of the flow control device are unknown. It also appears that access road and associated car park along the Cleveland Road and South Loop Road discharge without any form of attenuation into outfall (O9) into the River Pinn. The parking bays at the southern end have been surfaced with a gravel reinforcement surface.

4.4 Existing SuDS

SuDS have been extensively implemented across the University Campus. Although a comprehensive plan recording all SuDS locations and characteristics is not available, the drawing in Appendix C provided by the Estate Department Team shows the location of attenuation tanks and petrol interceptors. It is recommended that all SuDS are surveyed and that their location and characteristics are recoded in the University drainage network map.

Some examples of the existing SuDS already implemented cross the campus are provided below.

The roof areas from the buildings of the Isambard Complex discharge into perimetral filter drains that eventually discharges into soakaway. The construction drawings in Appendix G show the locations and dimensions of the soakaways. However, as-built information are not available.

The access road into the Isambard Complex discharges into a swale as shown in Figure 4.8.

Existing car park areas have been surfaced with gravel permeable paving grid system and permeable block paving as shown in Figure 4.9 to Figure 4.11.

Figure 4.7 – Existing filter drains (Isambard Complex)

Figure 4.8 – Existing swale (Isambard Complex)

Figure 4.9 – Existing car park with gravel permeable paving grid system (South Loop Road)

Figure 4.10 – Existing overspill car park with loose self-bind gravel surface (St John)

Figure 4.11 – Existing car park with permeable block paving surface (Eastern Gateway)

4.5 Historic flooding incidents

The Estate Department has provided a map of the Campus enclosed in Appendix E showing historic flooding incidents. Site visits have been carried out on the 11th June 2019 after heavy rain and on the 11th July 2019 with the Estate Department team to inspect those areas and discuss the causes of flooding and the remedial works already implemented or to be implemented.

The access road into the Isambard Complex had been subject to flooding incidents that have been resolved since a gully has been introduced in proximity of the gated access that allows surface water run-off to flows towards the existing swale. This area was inspected after heavy rain and the pictures in Figure 4.13 shows that there is no longer water ponding at this location.

Figure 4.12 – Additional drainage outlets into the existing swale (Isambard Complex access road)

Figure 4.13 – No water ponding after heavy rain at the Isambard Complex access road gate

The pedestrian path between the Galbraith Hall and the Gaskell building is generally subject to water ponding due to the fact that it is a low point. The Estate Department has planned remedial works which will involve the relaying of the paving and the provision of a channel drain that will discharge into a soakaway.

Figure 4.14 –Water ponding on the pedestrian path between the Galbraith Hall and the Gaskell building

The car park between the Gaskell Building and the Maria Jahoda Building had been subject to historic flooding due to blocked gullies and pipes. Since the drains have been unblocked, there have been no longer issues with water ponding as shown in Figure 4.15.

Figure 4.15 – No water ponding after heavy rain at the car park between the Gaskell Building and the Maria Jahoda Building

The pedestrian crossing in proximity of the Wilfred Brown building had been subject to historic flooding due to blocked gullies and pipes. Since the drains have been unblocked, there have been no longer issues with water ponding as shown in Figure 4.16.

Figure 4.16 – No water ponding after heavy rain at the pedestrian crossing in proximity of the Wilfred Brown building

The car park north of the Antonin Artaud building had been subject to historic flooding due to blocked gullies and pipes. Since the drains have been unblocked, there have been no longer issues with water ponding as shown in Figure 4.17.

Figure 4.17 – No water ponding after heavy rain at the car park north of the Antonin Artaud building

The pedestrian path between the Bannerman Centre and the Hamilton Centre had been subject to historic flooding due to blocked channels and pipes. Since the drains have been unblocked, there have been no longer issues with water ponding as shown in Figure 4.18.

Figure 4.18 – No water ponding after heavy rain on the pedestrian path between the Bannerman Centre and the Hamilton Centre

The entrance to the Sports Hall car park had been subject to historic flooding due to the outfall into the river been blocked. Since the river outfall has been cleared, there have been no longer issues with water ponding in Figure 4.19.

Figure 4.19 – No water ponding after heavy rain at the entrance to the Sports Hall car park

The entrance to the Netball Courts had been subject to historic flooding due to the fact that it is a low point. Since a permanent barrier and a channel have been installed, there have been no longer issues with water ponding.

Figure 4.20 – Permanent barrier installed at the entrance to the Sports Hall car park

The majority of the recorded flooding incidents are due to low entity surface water flooding and have not caused significant disruptions to the University Campus. They have been resolved with regular maintenance of the drainage system.

The only recorded incidents of flooding to the buildings occurred sporadically in the past years in proximity of the river bank and affected the Saltash Hall. The flooding is due to the rive level There are no details available of the frequency and the entity of these incidents.

5 Proposed drainage strategy

5.1 Proposed SuDS Strategy

They key aim of sustainable drainage systems (SuDS) is to mimic natural drainage process through a variety of techniques that can be used independently or as a series of complementary measures. In accordance with the CIRIA SuDS Manual and the London Borough of Hillingdon "Sustainable Drainage, Design and Evaluation Guide", SuDS are generally broadly divided in three types according to their function:

- **Source Controls**: green and blue roofs, permeable surfaces, filter strips, protected filter drains, together with some swales and basins, provide the first stage of treatment, intercepting primary pollution and reducing runoff flow rates.
- **Site Controls**: these features will normally be preceded by source controls, and meet remaining storage requirements.
- **Regional Controls**: where it is difficult to store all the runoff within a development boundary, clean water can be conveyed to the open storage features within the public open space or other parts of the development to contribute to open space amenity.

The preferred method of discharge should follow the following hierarchy:

1) Re-use on site
2) Infiltration into the ground
3) A natural watercourse
4) Surface water sewer
5) Combined sewer.

Although there is limited information on the existing site drainage and on future developments, the aim of the proposed strategy is to provide a comprehensive appraisal, highlight opportunities for introducing SuDS into the existing network and future development in order to:

- Alleviate existing drainage issues and where possible eliminate them;
- Improve the water quality;
- Reduce the surface water run-off discharging into the River Pinn.

It is also important to prevent discharge to the receiving watercourses from the first 5mm of any rainfall event ensuring that the initial flush of pollutants is contained within the SuDS feature. It is generally recommended that two minimum treatment stages are provided through different SuDS techniques prior to reaching the final outfalls in order to help enhancing the existing water quality and ecology in the receiving watercourses.

Based on the above guidelines, a review of the existing drainage has been carried out and a series of opportunities have been identified to introduce SuDS across Site 1 and 2:

- **Rainwater harvesting**: although rainwater harvesting tanks could be difficult to be retrofitted into existing buildings to be refurbished, they should be considered in proposed new developments where possible. Where rainwater harvesting tanks are not a feasible, water butts could be introduced to harvest water for watering plants. Alternatively rainwater pipes could be disconnected from the traditional piped drainage system and discharge into adjacent soft landscape and/or permeable surfaces.

- **Green/blue roofs**: although green roofs cannot be retrofitted into existing buildings to be refurbished, they should be considered in proposed new developments where possible.
- **Infiltration systems**: although infiltration rates are relatively low in the majority of the site, partial infiltration will contribute to improve the water quality and attenuated discharge rates into the receiving watercourse. Soakaways have been widely used on Site1 where infiltration rates are considerably higher.
- **Filter Strips /Drains**: they have been already widely used across the campus especially on Site 1. Filter strips/drains can be introduced around hardstanding surfaces to reduce pollutant levels and encourage absorption and biodegradation process.
- **Swales**: there are limited opportunities to introduce swales on Site 1 and 2 due to the fact that these features generally require a considerable land intake and redesign of the topography.
- **Bio-retention systems**: they can be implemented in the landscape to reduce runoff rates and volumes. These systems do not require a significant land intake but they are effective in delivering interception and provide environmental benefits.
- **Trees**: there are opportunities to introduce tree pits especially in car park areas in order to reduce pollutant levels.
- **Permeable paving**: the existing car park areas could be resurfaced with permeable block paving or with reinforced grass or gravel crates depending on the expected traffic load. Even though infiltration rates are relatively low in the majority of the site, partial infiltration will contribute to improve the water quality and attenuated discharge rates into the receiving watercourse. Possible locations where permeable paving can be introduced are shown in Figure 5.1.
- **Attenuation storage tanks**: they are an effective way to create belowground attenuation storage where a high storage volume is required and there is not sufficient space in the landscape. Attenuation tanks have been widely used across the site especially on Site 2.
- **Detention basins**: there are limited opportunities to introduce detention basins on Site 1 and 2. The Zone D car park and associated access road appear in poor condition and considering that there is an existing dismantled railway embankment in proximity of the car park as shown in Figure 5.1, the surface water runoff from the car park could be collected into the basin. Further investigation will be required to verify the feasibility of this option.
- **Ponds and wetlands:** there are limited opportunities to introduce ponds and wetlands on Site 1 and 2 due to the fact that these features generally require a considerable land intake and redesign of the topography.

As highlighted in the London Borough of Hillingdon “Sustainable Drainage, Design and Evaluation Guide”, there are four critical objectives that SuDS seek to meet:

- **Quantity**: managing flows and volumes to match rainfall characteristics before development, in order to prevent flooding from outside the development, with the site and downstream of the development.

- **Amenity**; enhancing people's quality of life through an integrated design that provides useful and attractive multi-functional spaces.
- **Quality**: preventing and treating pollution to ensure that clean water is available as soon as possible to provide amenity and biodiversity benefits within the development, as well as protecting watercourses, groundwater and sea.
- **Biodiversity**: maximising the potential for wildlife thought design and management of SuDS.

Each SuDS technique has been ranked in terms of feasibility, performance in achieving the above objectives, capital and maintenance costs as shown in Table 1.

Figure 5.1 – Possible location for permeable paving and detention basin

Table 1 - Proposed SuDS feasibility and performance

SuDS	Quantity	Amenity	Quality	Bio-diversity	Capital cost	Maintenan-ce cost
Rainwater harvesting	Good	Low	Low	Low	High	Medium
Green/blue roofs	Medium	Medium	Medium	Medium	High	Medium
Infiltration systems	Medium	Medium	Medium	Medium	Low	Medium
Filter Strips	Low	Low	Medium	Low	Low	Low
Filter Drain	Low	Low	Medium	Low	Low	Low
Swales	Medium	Medium	Medium	Medium	Low	Medium
Bio-retention systems	Medium	Medium	Medium	Medium	Low	Medium
Permeable pavements	Good	Poor	Good	Low	Medium	Medium
Trees	Low	Good	Medium	Good	Low	Low
Attenuation tanks	Good	Poor	Good	Low	Medium	Medium
Detention basins	Good	Good	Good	Good	Low	Low
Ponds and wetlands	Good	Good	Good	Good	High	Medium

Legend (cell colours in the SuDS column):
- Feasible (green): Green/blue roofs, Infiltration systems, Filter Strips, Filter Drain, Bio-retention systems, Permeable pavements, Trees, Attenuation tanks
- Less feasible (yellow): Rainwater harvesting, Swales, Detention basins
- Not feasible (orange): Ponds and wetlands

5.2 SuDS maintenance plan

The Estate Department Team has provided the maintenance regime for the existing drainage on site and this consists of regular cleaning and/or jetting of the drains, gullies, channels, interceptors every six or twelve months depending on the location as shown on the drawing in Appendix F.

The London Borough of Hillingdon "Sustainable Drainage, Design and Evaluation Guide" suggests a passive maintenance approach for SuDS which should be included as part of the site management rather than dedicated to SuDS.

Type	Activity	Normal site care (Site) or SuDS-specific maintenance (SuDS)	Suggested frequency
Regular Maintenance			
Litter	Pick up all litter in SUDS Landscape areas along with remainder of the site – remove from site	Site	1 visit monthly
Grass	Mow all grass verges, paths and amenity grass at 35-50mm with 75mm max. Leaving cuttings in situ	Site	As required or 1 visit monthly
Grass	Mow all dry swales, dry SUDS basins and margins to low flow channels and other SUDS features at 100mm with 150mm max. Cut wet swales or basins annually as wildflower areas – 1st and last cuts to be collected	Site	4-8 visits per year or as required
Grass	Wildflower areas strimmed to 100mm in Sept or at end of school holidays – all cuttings removed Or Wildflower areas strimmed to 100mm on 3 year rotation – 30% each year – all cuttings removed	Site	1 visit annually 1 visit annually
Inlets & outlets	Inspect monthly, remove silt from slab aprons and debris. Strim 1m round for access	SuDS	1 visit monthly
Permeable paving	Sweep all paving regularly to keep surface tidy	Site	1 visit annually or as required
Occasional Tasks			
Permeable paving	Sweep and suction brush permeable paving when ponding occurs	SuDS	As required - estimate 10-15 year intervals
Flow controls	Annual inspection of control chambers - remove silt and check free flow	SuDS	1 visit annually
Wetland & pond	Wetland vegetation to be cut at 100mm on 3 - 5 year rotation or 30% each year. All cuttings to be removed to wildlife piles or from site.	Site	As required

Figure 5.2 – Example of SuDS and site maintenance
(Source: "Sustainable Drainage, Design and Evaluation Guide", London Borough of Hillingdon, in 2018)

Intervention maintenance can also be required for SuDS as well as conventional pipe drainage. A suitable maintenance schedule must be developed, maintained, followed and updated as required by the University, in accordance with CIRIA Publication C753, The SuDS Manual. The following tables give some guidance on the essential maintenance activities to be carried out for each component.

Table 2 - Essential maintenance regime for the below ground drainage pipework, manholes and channels

Maintenance schedule	Required action	Recorded frequency
Regular maintenance	Inspect and identify areas that are not operating correctly. If required, take remedial action. Remove sediment from pre-treatment structures (e. g. gullies, channels, silt traps).	Monthly for the first three months then six-monthly Six-monthly or as required
Occasional maintenance	Debris removal from catchment surface where this may cause risks to performance.	Monthly
Remedial actions	Repair / rehabilitation of inlets, outlets, overflows and vents.	As required

Table 3 - Essential maintenance regime for infiltration systems and attenuation tanks

Maintenance schedule	Required action	Recorded frequency
Regular maintenance	Litter and debris removal. Manage other vegetation and remove nuisance plants.	Monthly or as required
Occasional maintenance	Cut back adjacent vegetation where possible.	Annually
Remedial actions	Remove build up of sediment on surfaces.	As required
Monitoring	Inspect all inlets, outlets and overflows for blockages and clear as necessary. Inspect infiltration surfaces for ponding, compaction or silt accumulation. Record areas where water is ponding for more than 48 hours. Inspect inlets and facility for silt accumulation. Establish appropriate silt removal frequencies.	Monthly and after large storms Monthly or as required Six-monthly and after large storms

6 Conclusions and recommendations

An assessment of the existing surface water network has been carried out to identify the causes of surface water flooding and provide suitable solutions to improve the existing conditions. A comprehensive strategy has been prepared for retrofitting SuDS into the existing drainage where possible and for implementing SuDS into future developments to alleviate historic surface water and improve resilience of the network to climate change.

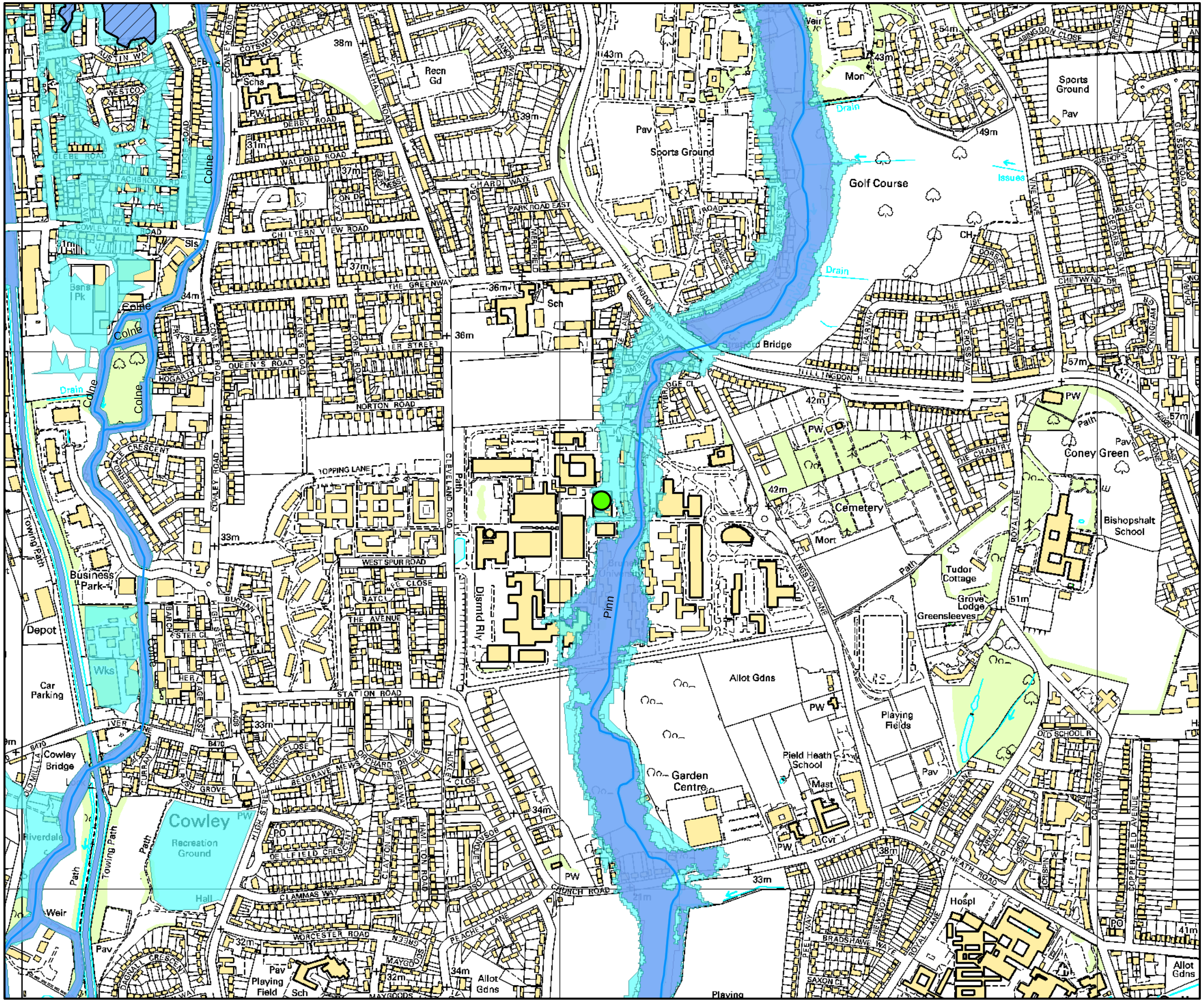
It is recommended that the University:

- Keeps updated records of the drainage network across the Campus. The records should include location and characteristics of all existing forms of SuDS.
- Keeps updated records of all flood incidents including location, entity and frequency. The caused and suitable solution should be identified and recorded.
- Keeps a comprehensive approach which considers the implications and benefits in the wider drainage network when re-developing parts of the campus.
- Considers the options presented in paragraph 5.1 for introducing SuDS in the existing network and for future developments.
- Continues to operate their drainage maintenance regime and introduces a passive maintenance approach to SuDS as described in paragraph 5.2.

Appendix A – Topographical survey

Appendix B – Environment Agency Product 4 Data

Flood Map for Planning centred on Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR



Environment Agency

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

0 125 250 500
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)

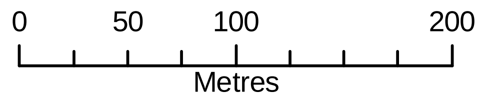
Flood Zone 3 shows the area that could be affected by flooding:
- from the sea with a 1 in 200 or greater chance of happening each year
- or from a river with a 1 in 100 or greater chance of happening each year.

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 Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE



Legend

Main Rivers

Defended Flood Outlines

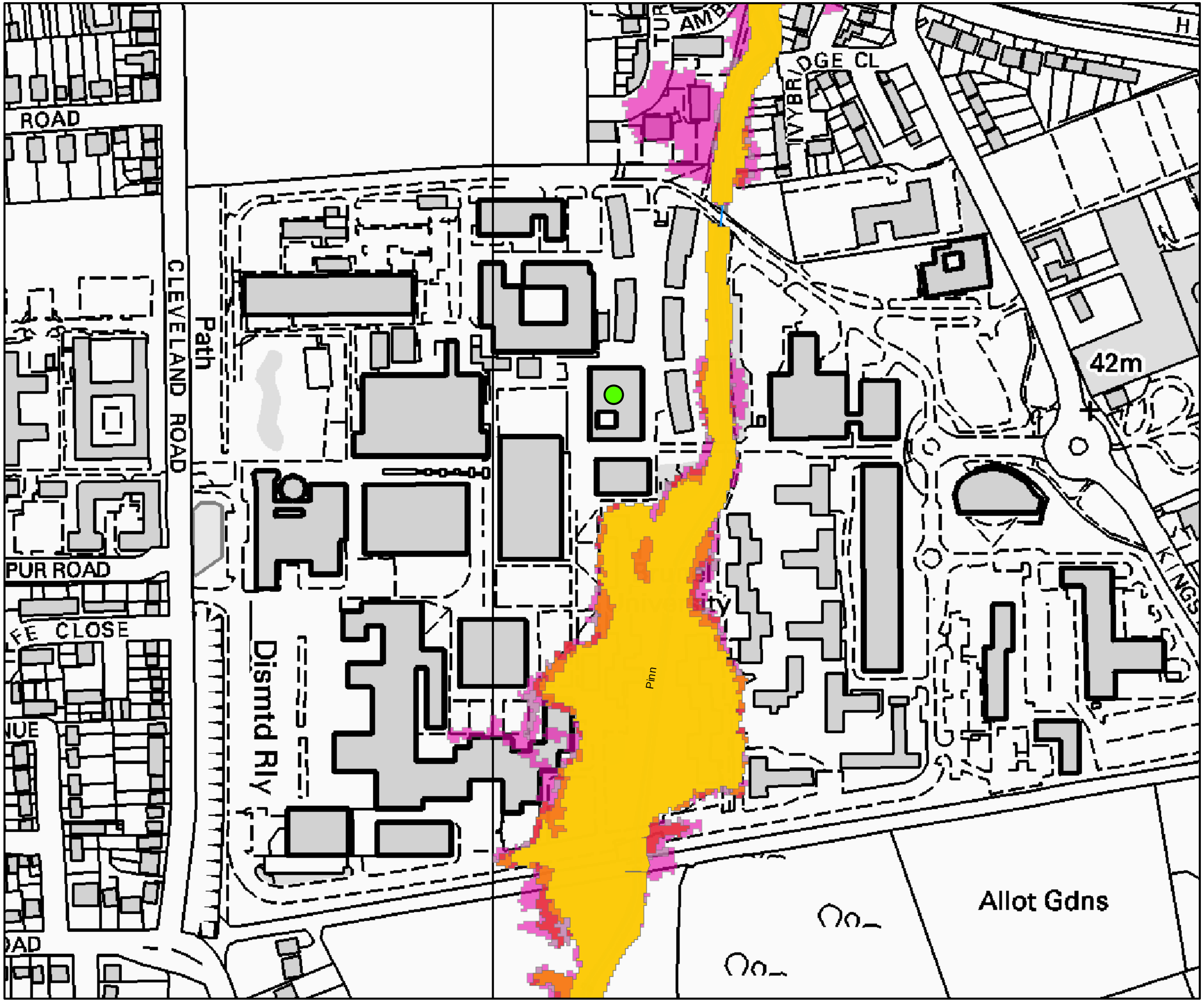
- 1 in 2 year (50%) Defended
- 1 in 5 year (20%) Defended
- 1 in 10 year (10%) Defended
- 1 in 20 year (5%) Defended

The data in this map has been extracted from the River Pinn Mapping Study (JBA, 2015).
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 within the 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 Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR



Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

0 50 100 200
Metres

Legend

Main Rivers

Defended Flood Outlines

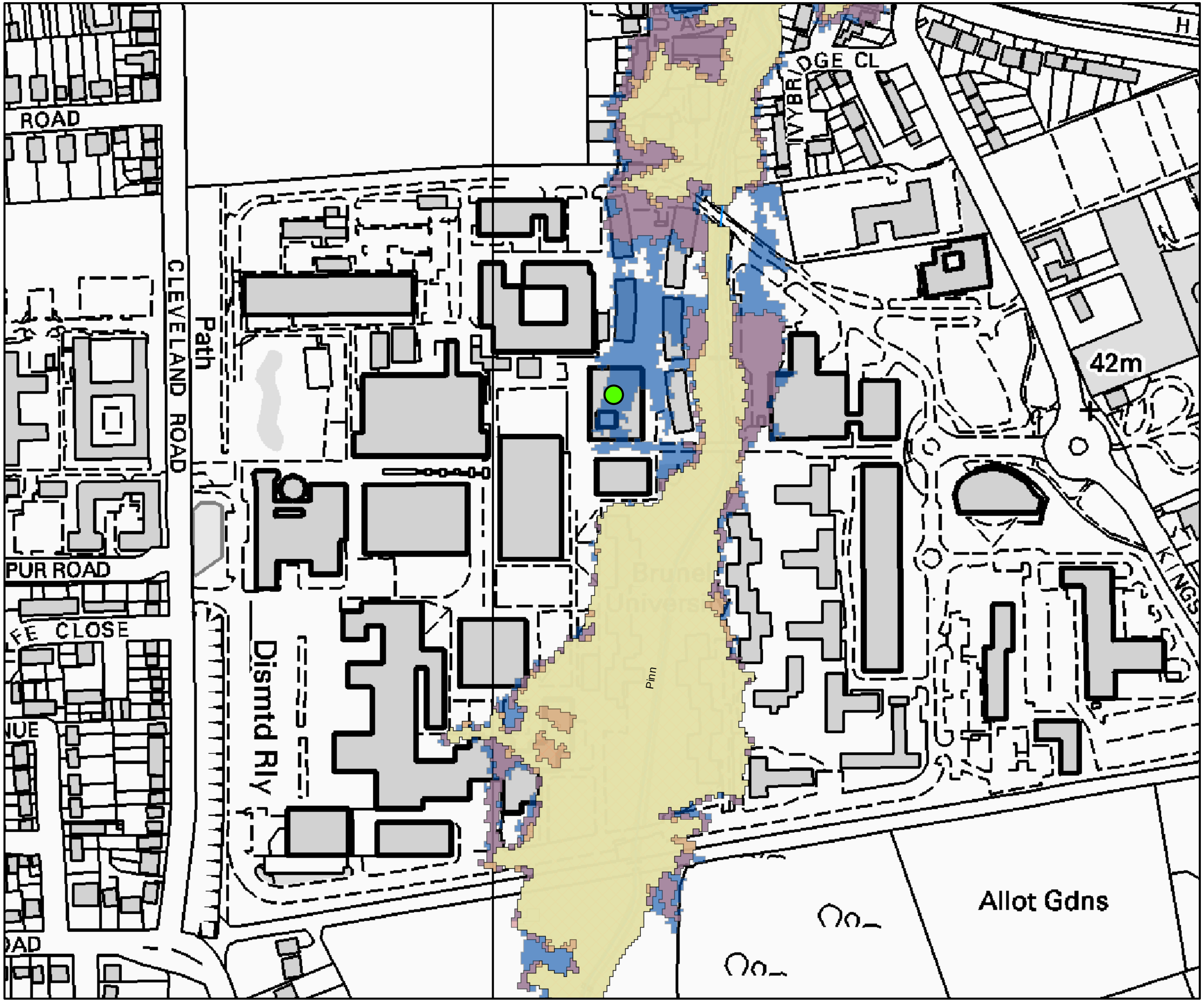
- 1 in 30 year (3.33%) Defended
- 1 in 50 year (2%) Defended
- 1 in 75 year (1.33%) Defended
- 1 in 100 year (1%) Defended
- 1 in 100 year + 20% (*CC) Defended

The data in this map has been extracted from the River Pinn Mapping Study (JBA, 2015).
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 within the 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 Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR



Environment Agency

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

0 50 100 200
Metres

Legend

Main Rivers

Defended Flood Outlines

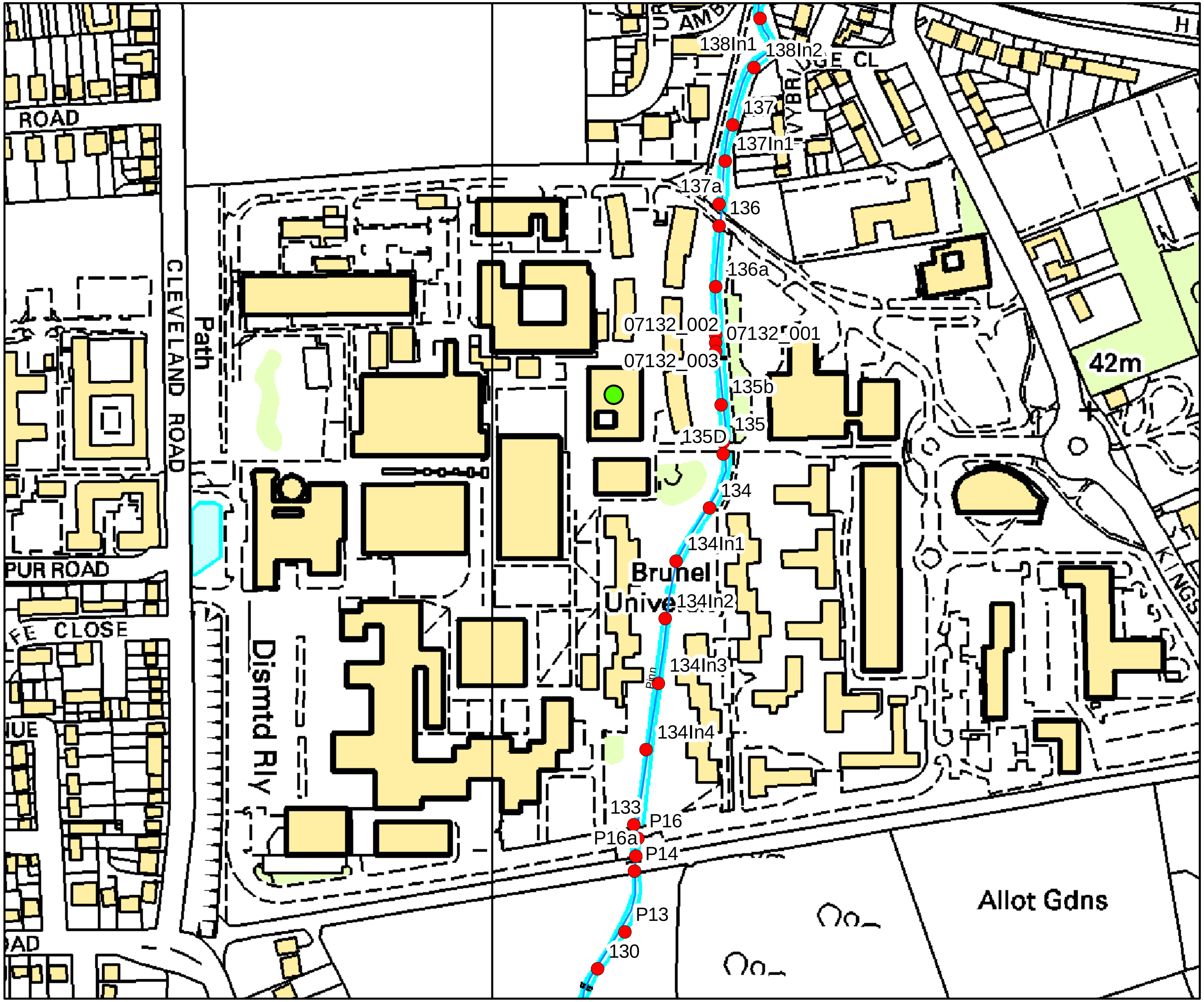
- 1 in 100 year + 25% (*CC) Defended
- 1 in 100 year + 35% (*CC) Defended
- 1 in 100 year + 35% (*CC) Defended
- 1 in 250 year (0.4%) Defended
- 1 in 1000 year (0.1%) Defended

The data in this map has been extracted from the River Pinn Mapping Study (JBA, 2015).
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 within the 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 Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR



Environment Agency

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

0 50 100 200
Metres

Legend

Main Rivers

1D Node Results

Nodes

The data in this map has been extracted from the River Pinn Mapping Study (JBA, 2015).
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 within the 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: HNL77356NR

The following information has been extracted from the River Pinn Mapping Study (JBA, 2015)

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

Caution:
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 across the entire catchment.

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

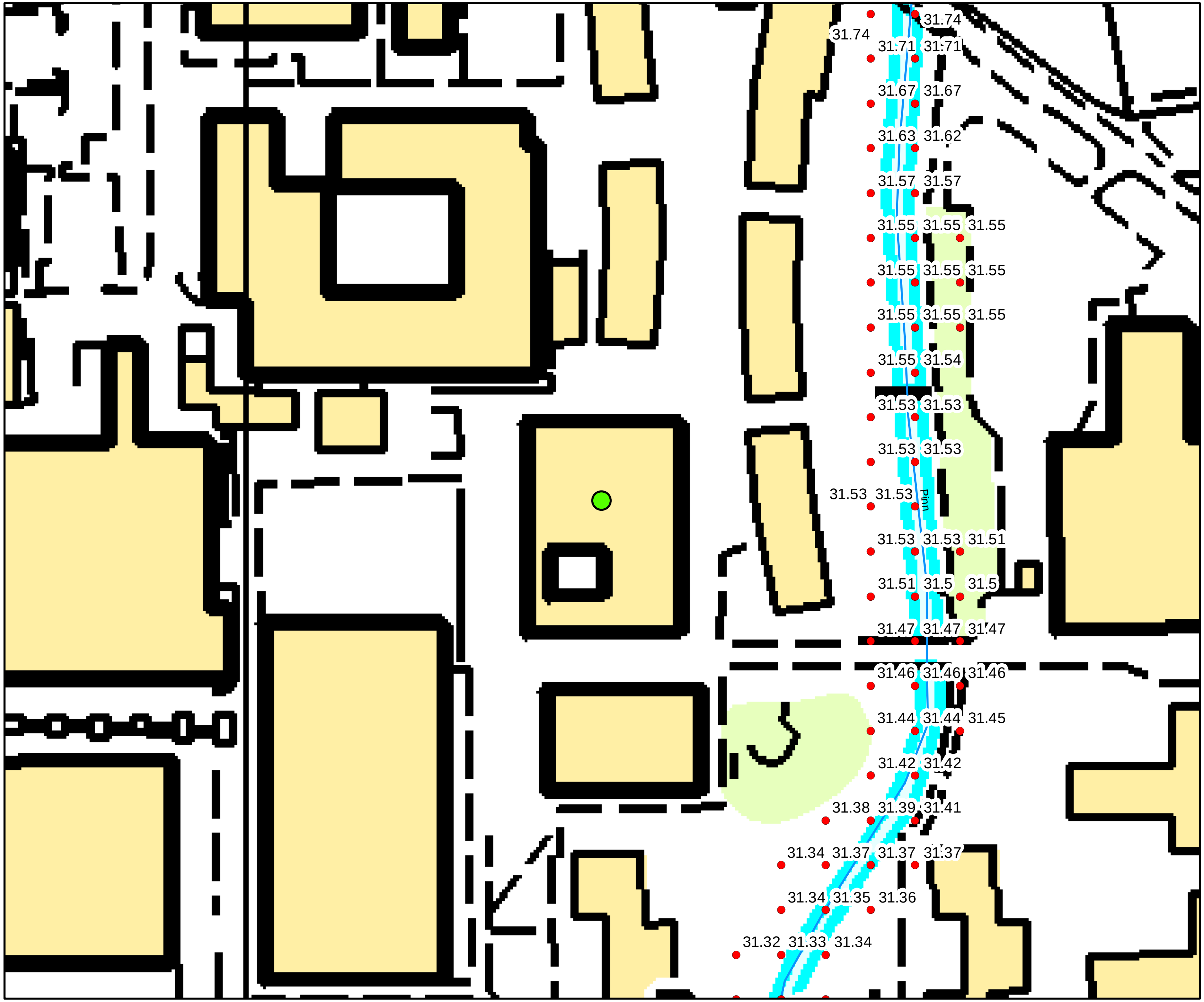
MODELLED FLOOD LEVEL

				Return Period												
Node Label	**Easting**	**Northing**	**2 yr**	**5 yr**	**10 yr**	**20 yr**	**30 yr**	**50 yr**	**75 yr**	**100 yr**	**100yr + 20%**	**100yr + 25%**	**100yr + 35%**	**100yr + 70%**	**200 yr**	**1000yr**
138In1	506174	182967	32.00	32.15	32.24	32.40	32.55	32.66	32.74	32.79	32.93	32.96	33.01	33.19	32.98	33.33
138In2	506170	182935	31.93	32.07	32.17	32.33	32.50	32.62	32.70	32.75	32.89	32.92	32.98	33.17	32.95	33.32
137	506156	182898	31.84	31.99	32.09	32.26	32.46	32.57	32.65	32.71	32.86	32.89	32.95	33.16	32.92	33.31
137In1	506151	182874	31.80	31.95	32.06	32.24	32.44	32.56	32.63	32.69	32.84	32.88	32.94	33.15	32.91	33.30
137a	506147	182846	31.78	31.93	32.04	32.23	32.43	32.54	32.62	32.68	32.83	32.86	32.92	33.12	32.89	33.26
136	506147	182832	31.74	31.90	32.00	32.18	32.38	32.47	32.52	32.55	32.64	32.66	32.70	32.81	32.68	32.90
136a	506145	182792	31.56	31.70	31.80	32.02	32.26	32.34	32.38	32.41	32.47	32.49	32.52	32.60	32.50	32.64
07132_003	506145	182761	31.54	31.70	31.81	32.03	32.27	32.35	32.39	32.42	32.49	32.51	32.54	32.63	32.52	32.69
07132_002	506145	182756	31.55	31.71	31.81	32.03	32.27	32.35	32.39	32.42	32.48	32.50	32.53	32.60	32.51	32.65
07132_001	506145	182750	31.54	31.69	31.80	32.02	32.27	32.35	32.39	32.42	32.49	32.51	32.54	32.62	32.52	32.67
135b	506149	182716	31.53	31.70	31.81	32.04	32.28	32.36	32.40	32.43	32.50	32.52	32.55	32.64	32.53	32.70
135	506150	182691	31.47	31.64	31.75	32.00	32.25	32.33	32.38	32.40	32.47	32.49	32.52	32.61	32.50	32.68
135D	506150	182683	31.47	31.64	31.75	31.99	32.23	32.31	32.35	32.37	32.42	32.43	32.45	32.51	32.44	32.56
134	506141	182648	31.38	31.58	31.70	31.96	32.22	32.30	32.34	32.36	32.41	32.42	32.44	32.50	32.43	32.54
134In1	506119	182614	31.31	31.53	31.66	31.94	32.21	32.29	32.33	32.35	32.40	32.41	32.43	32.49	32.42	32.53
134In2	506112	182576	31.25	31.49	31.63	31.92	32.20	32.28	32.32	32.34	32.38	32.39	32.41	32.46	32.40	32.49
134In3	506108	182534	31.21	31.47	31.61	31.90	32.19	32.28	32.32	32.34	32.39	32.40	32.43	32.49	32.41	32.53
134In4	506100	182491	31.18	31.44	31.59	31.90	32.19	32.27	32.31	32.33	32.36	32.37	32.39	32.42	32.38	32.44
133	506092	182442	31.16	31.43	31.57	31.88	32.18	32.27	32.31	32.34	32.40	32.41	32.43	32.50	32.42	32.55
P16	506095	182433	31.03	31.23	31.32	31.52	31.75	31.82	31.88	31.92	32.03	32.05	32.08	32.16	32.06	32.21
P16a	506093	182422	30.93	31.12	31.19	31.38	31.64	31.72	31.78	31.83	31.95	31.98	32.02	32.13	32.00	32.20
P14	506092	182412	30.93	31.11	31.18	31.23	31.28	31.35	31.40	31.43	31.54	31.57	31.63	31.77	31.60	31.87
P13	506086	182372	30.91	31.11	31.18	31.25	31.29	31.34	31.38	31.41	31.50	31.52	31.57	31.69	31.55	31.78
130	506068	182348	30.86	31.05	31.13	31.19	31.22	31.26	31.29	31.31	31.36	31.38	31.41	31.48	31.39	31.55

MODELLED FLOWS

				Return Period												
Node Label	**Easting**	**Northing**	**2 yr**	**5 yr**	**10 yr**	**20 yr**	**30 yr**	**50 yr**	**75 yr**	**100 yr**	**100yr + 20%**	**100yr + 25%**	**100yr + 35%**	**100yr + 70%**	**200 yr**	**1000yr**
138In1	506174	182967	7.60	9.31	10.54	12.24	13.11	14.37	15.36	16.12	18.34	18.91	19.88	22.61	19.34	24.64
138In2	506170	182935	7.60	9.31	10.54	12.24	13.11	14.37	15.36	16.12	18.29	18.86	19.84	22.50	19.30	24.28
137	506156	182898	7.60	9.31	10.54	12.24	13.10	14.37	15.36	16.12	18.26	18.77	19.61	21.83	19.13	23.57
137In1	506151	182874	7.71	9.42	10.65	12.35	13.23	14.50	15.45	16.15	18.06	18.52	19.20	21.02	18.82	22.39
137a	506147	182846	7.71	9.42	10.65	12.34	13.22	14.50	15.49	16.27	18.52	19.10	20.18	23.62	19.58	26.04
136	506147	182832	7.71	9.42	10.65	12.34	13.22	14.50	15.49	16.27	18.52	19.10	20.18	23.62	19.58	26.04
136a	506145	182792	7.71	9.42	10.65	12.34	13.22	14.49	15.49	16.27	18.52	19.10	20.18	23.68	19.59	26.51
07132_003	506145	182761	7.71	9.42	10.65	12.34	13.22	14.49	15.49	16.27	18.52	19.10	20.18	23.64	19.58	26.50
07132_002	506145	182756	7.71	9.42	10.65	12.34	13.22	14.49	15.49	16.27	18.52	19.10	20.18	23.67	19.58	26.60
07132_001	506145	182750	7.71	9.42	10.65	12.34	13.21	14.49	15.49	16.27	18.52	19.10	20.18	23.79	19.58	26.91
135b	506149	182716	7.71	9.42	10.65	12.33	13.21	14.49	15.49	16.27	18.51	19.09	20.16	23.66	19.57	26.71
135	506150	182691	7.71	9.42	10.65	12.33	13.21	14.49	15.49	16.27	18.50	19.05	20.02	22.97	19.49	25.15
135D	506150	182683	7.71	9.42	10.65	12.33	13.21	14.49	15.49	16.27	18.50	19.05	20.02	22.97	19.49	25.15
134	506141	182648	7.71	9.42	10.65	12.33	13.15	14.34	15.29	16.03	18.20	18.76	19.78	23.04	19.22	25.67
134In1	506119	182614	7.71	9.42	10.65	12.32	13.18	14.28	15.15	15.84	17.80	18.30	19.22	22.16	18.71	24.59
134In2	506112	182576	7.71	9.42	10.65	12.32	13.00	13.95	14.87	15.61	17.78	18.35	19.41	22.80	18.83	25.61
134In3	506108	182534	7.71	9.42	10.65	12.18	12.70	13.47	14.00	14.48	15.98	16.37	17.09	19.46	16.69	21.46
134In4	506100	182491	7.71	9.42	10.64	11.80	11.80	12.92	14.11	15.05	17.75	18.46	19.78	23.86	19.05	27.16
133	506092	182442	7.71	9.42	10.65	12.25	12.44	12.46	12.54	12.72	13.28	13.41	13.57	14.31	13.48	14.98
P16	506095	182433	7.71	9.42	10.65	12.25	12.44	12.46	12.54	12.72	13.28	13.41	13.57	14.31	13.48	14.98
P16a	506093	182422	7.71	9.42	10.64	12.25	12.51	12.67	12.89	13.14	13.46	13.46	13.48	13.44	13.48	13.40
P14	506092	182412	7.71	9.42	10.64	12.25	12.51	12.67	12.89	13.14	13.46	13.46	13.48	13.44	13.48	13.40
P13	506086	182372	7.71	9.42	10.65	12.25	12.94	13.88	14.50	15.05	16.32	16.54	16.92	18.02	16.67	18.41
130	506068	182348	7.71	9.42	10.64	12.25	13.16	14.52	15.51	16.27	18.46	19.01	20.01	23.21	19.45	25.48

Detailed FRA centred on Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR



Environment Agency

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

0 15 30 60
Metres

Legend

Main Rivers

2D Node Results: Heights

1 in 2 year (50%) Defended

The data in this map has been extracted from the River Pinn Mapping Study (JBA, 2015).
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 within the 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 Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR

Environment Agency

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

0 15 30 60
Metres

Legend

Main Rivers

2D Node Results: Heights

1 in 5 year (20%) Defended

The data in this map has been extracted from the River Pinn Mapping Study (JBA, 2015).
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 within the 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 Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

0 15 30 60
Metres

Legend

Main Rivers

2D Node Results: Heights

1 in 10 year (10%) Defended

The data in this map has been extracted from the River Pinn Mapping Study (JBA, 2015).
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 within the 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 Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

0 15 30 60

Metres

Legend

Main Rivers

2D Node Results: Heights

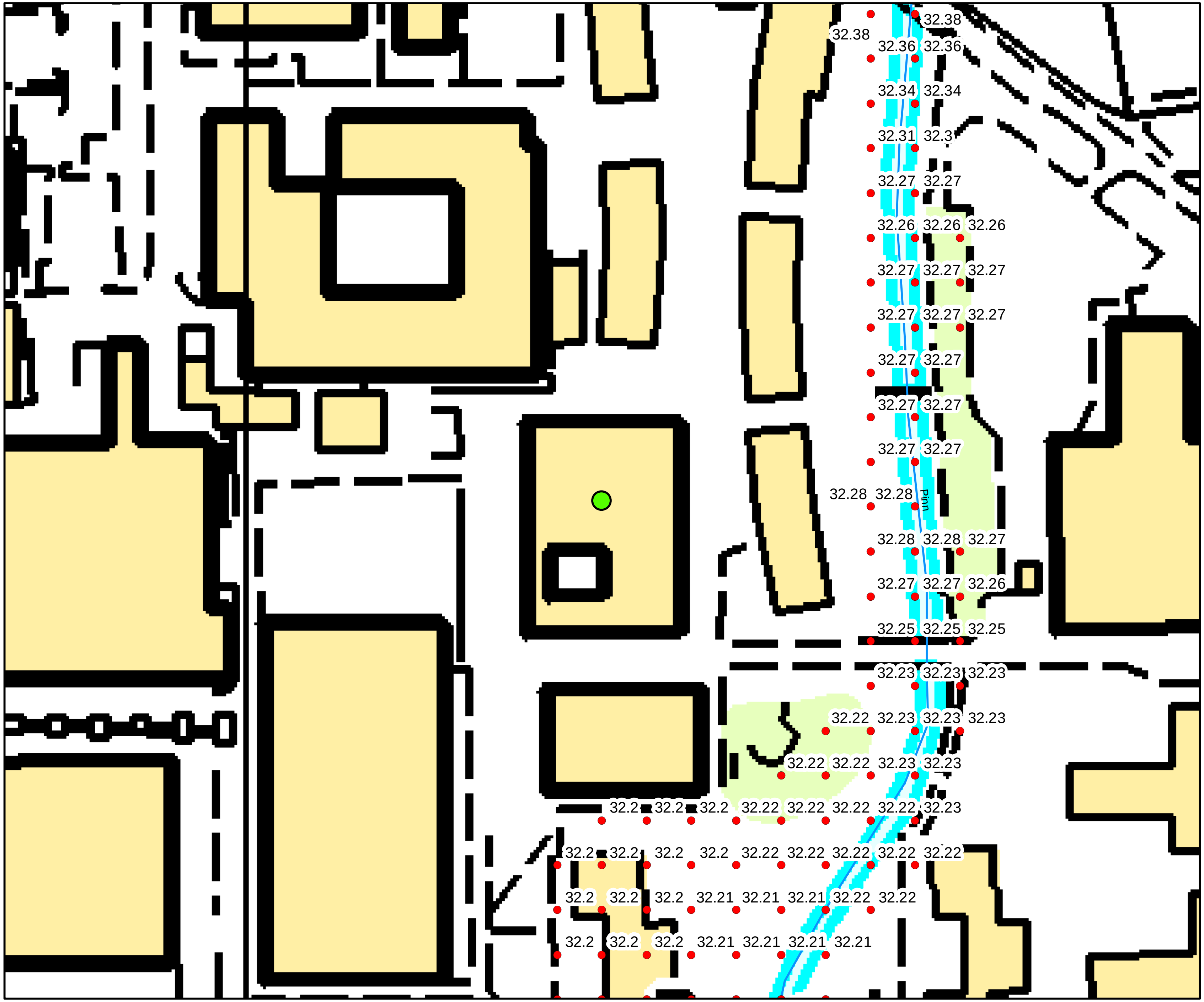
1 in 20 year (5%) Defended

The data in this map has been extracted from the River Pinn Mapping Study (JBA, 2015).
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 within the 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 Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR



Environment Agency

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

0 15 30 60
Metres

Legend

Main Rivers

2D Node Results: Heights

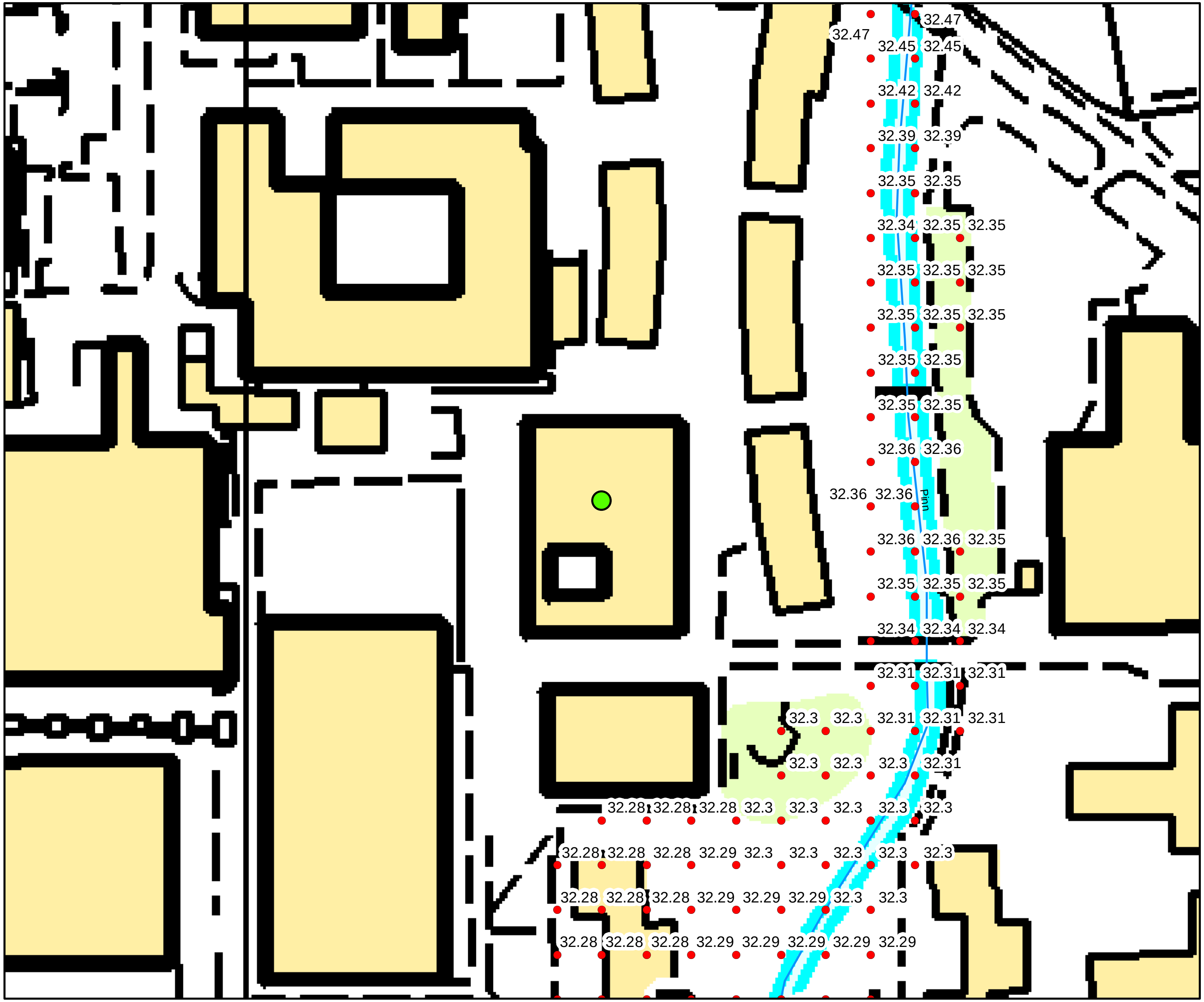
1 in 30 year (3.33%) Defended

The data in this map has been extracted from the River Pinn Mapping Study (JBA, 2015).
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 within the 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 Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR



Environment Agency

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

0 15 30 60
Metres

Legend

Main Rivers

2D Node Results: Heights

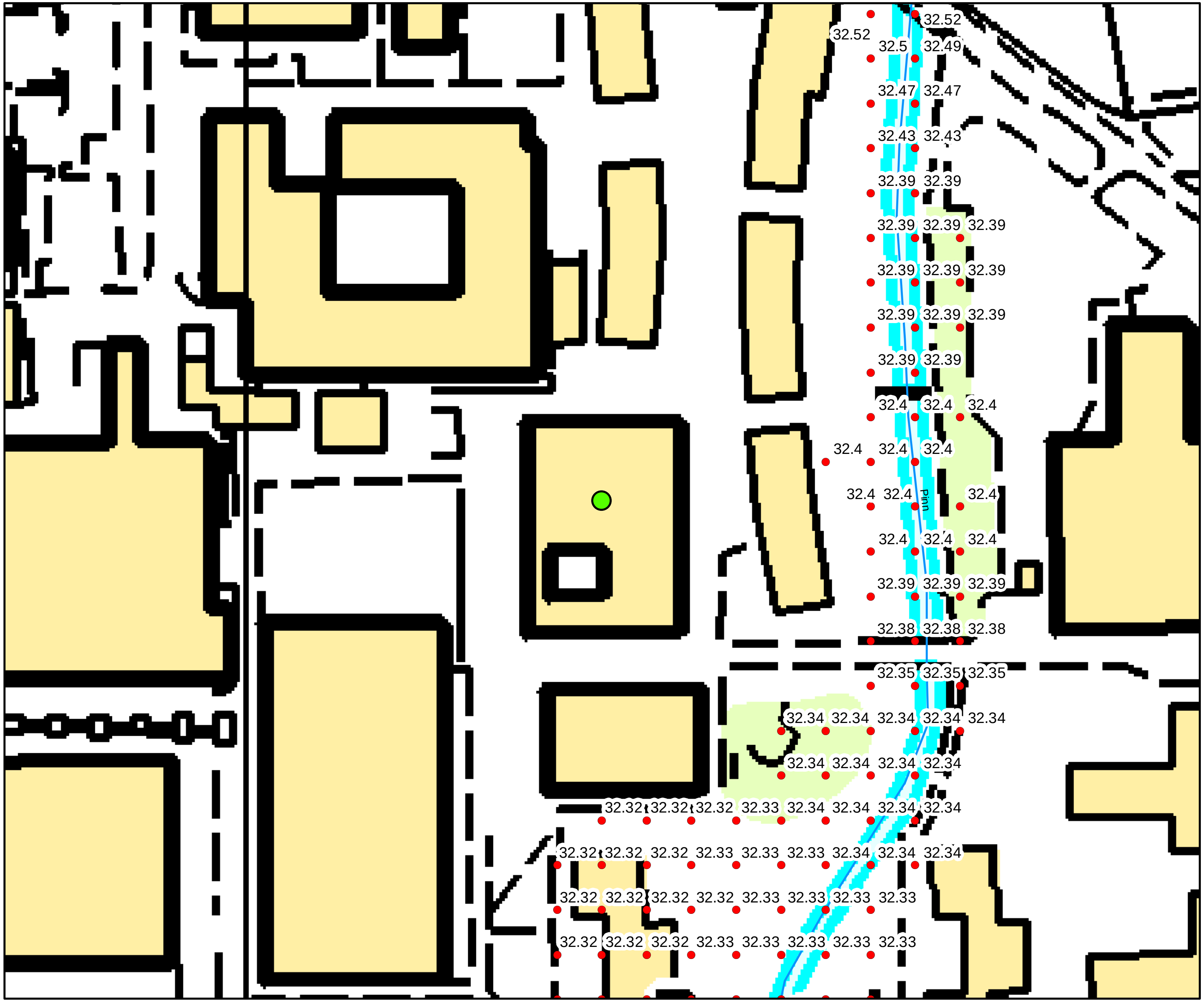
1 in 50 year (2%) Defended

The data in this map has been extracted from the River Pinn Mapping Study (JBA, 2015).
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 within the 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 Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR



Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

0 15 30 60
Metres

Legend

Main Rivers

2D Node Results: Heights

1 in 75 year (1.33%) Defended

The data in this map has been extracted from the River Pinn Mapping Study (JBA, 2015).
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 within the 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 Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

0 15 30 60
Metres

Legend

Main Rivers

2D Node Results: Heights

1 in 100 year (1%) Defended

The data in this map has been extracted from the River Pinn Mapping Study (JBA, 2015).
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 within the 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 Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

0 15 30 60
Metres

Legend

Main Rivers

2D Node Results: Heights

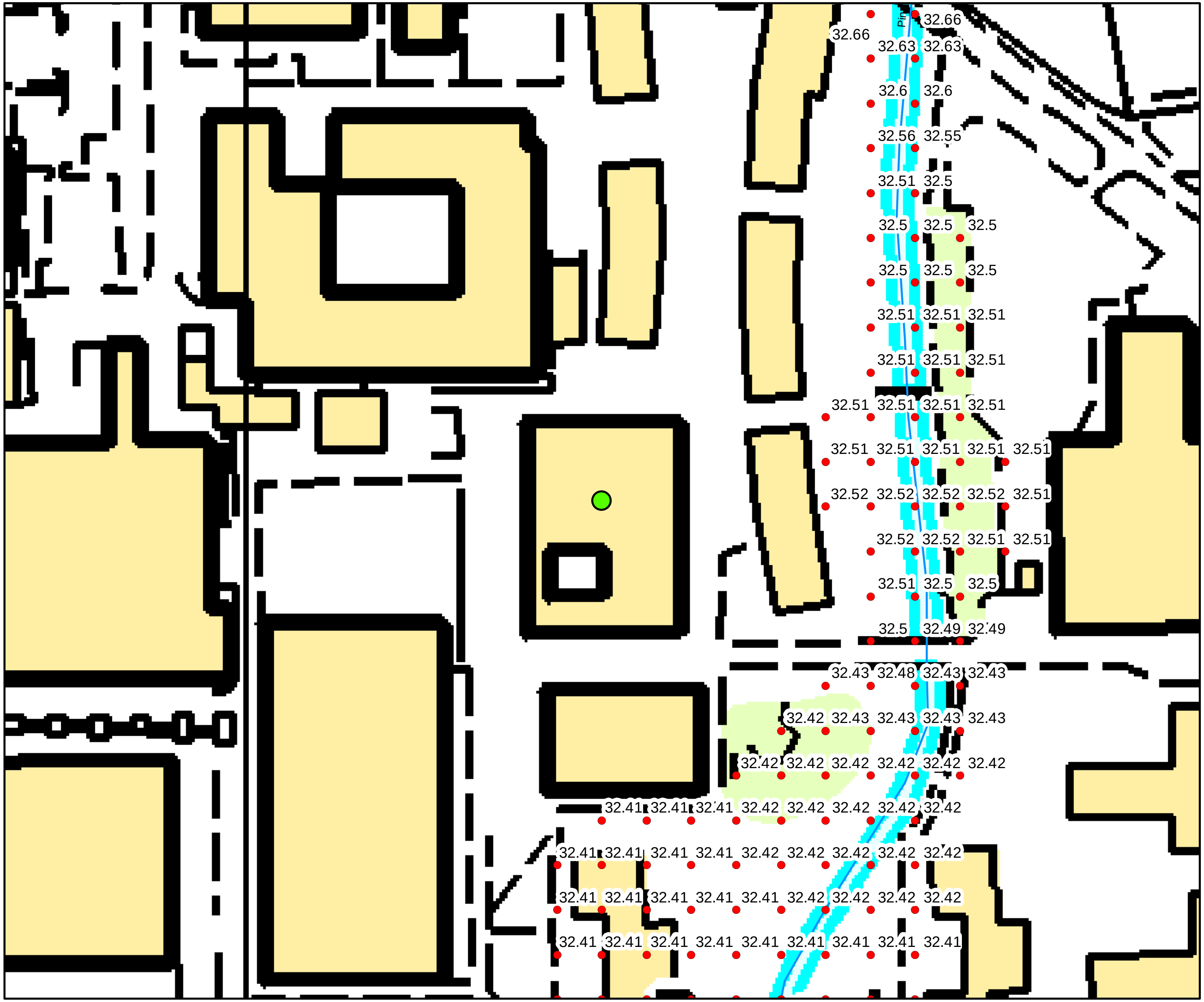
1 in 100 year + 20% (*CC) Defended

The data in this map has been extracted from the River Pinn Mapping Study (JBA, 2015).
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 within the 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 Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR



Environment Agency

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

0 15 30 60

Metres

Legend

Main Rivers

2D Node Results: Heights

1 in 100 year + 25% (*CC) Defended

The data in this map has been extracted from the River Pinn Mapping Study (JBA, 2015).
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 within the 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 Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

0 15 30 60
Metres

Legend

Main Rivers

2D Node Results: Heights

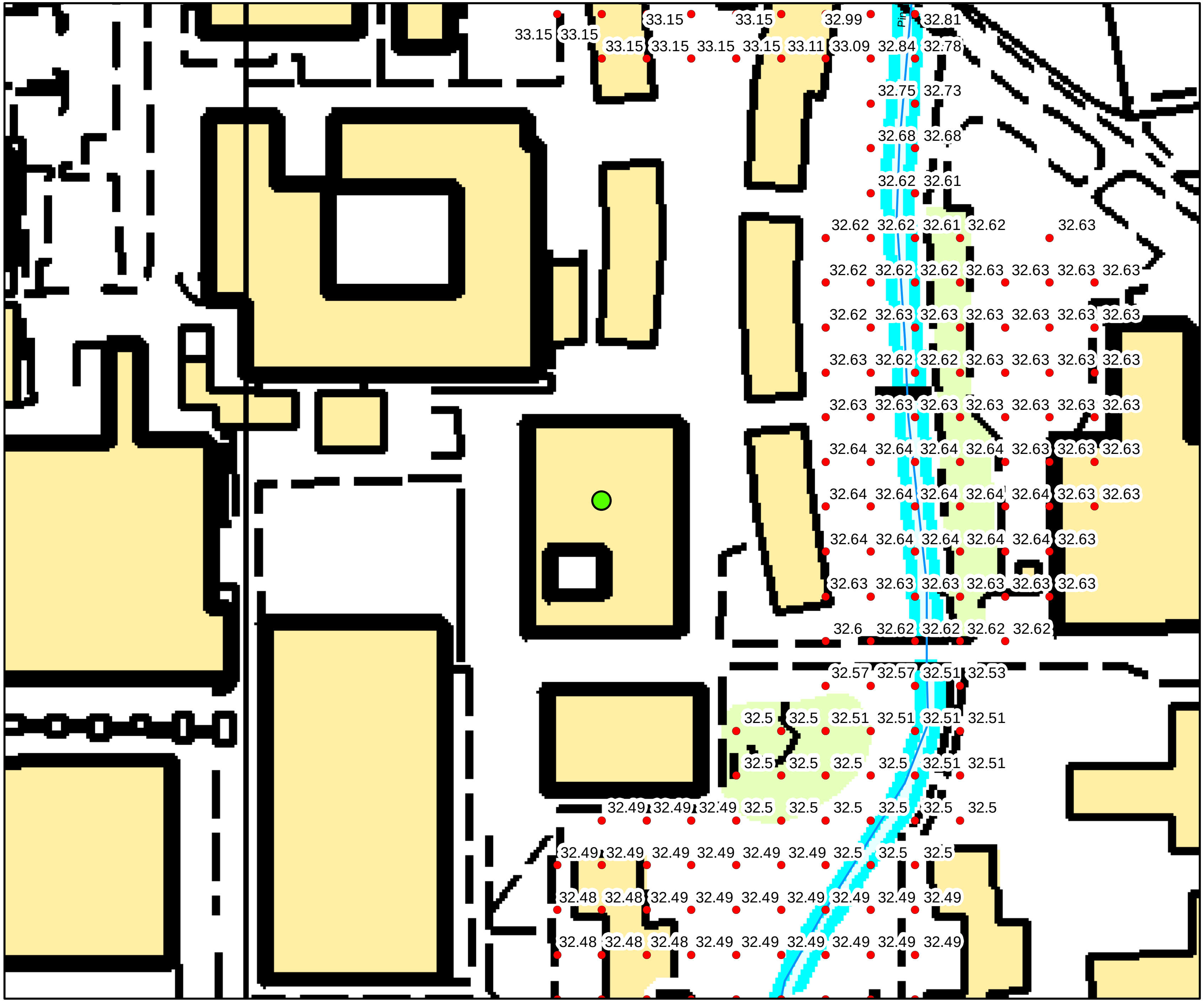
1 in 100 year + 35% (*CC) Defended

The data in this map has been extracted from the River Pinn Mapping Study (JBA, 2015).
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 within the 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 Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR



Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

0 15 30 60
Metres

Legend

Main Rivers

2D Node Results: Heights

1 in 100 year + 70% (*CC) Defended

The data in this map has been extracted from the River Pinn Mapping Study (JBA, 2015).
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 within the 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 Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR

Environment Agency

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

0 15 30 60
Metres

Legend

Main Rivers

2D Node Results: Heights

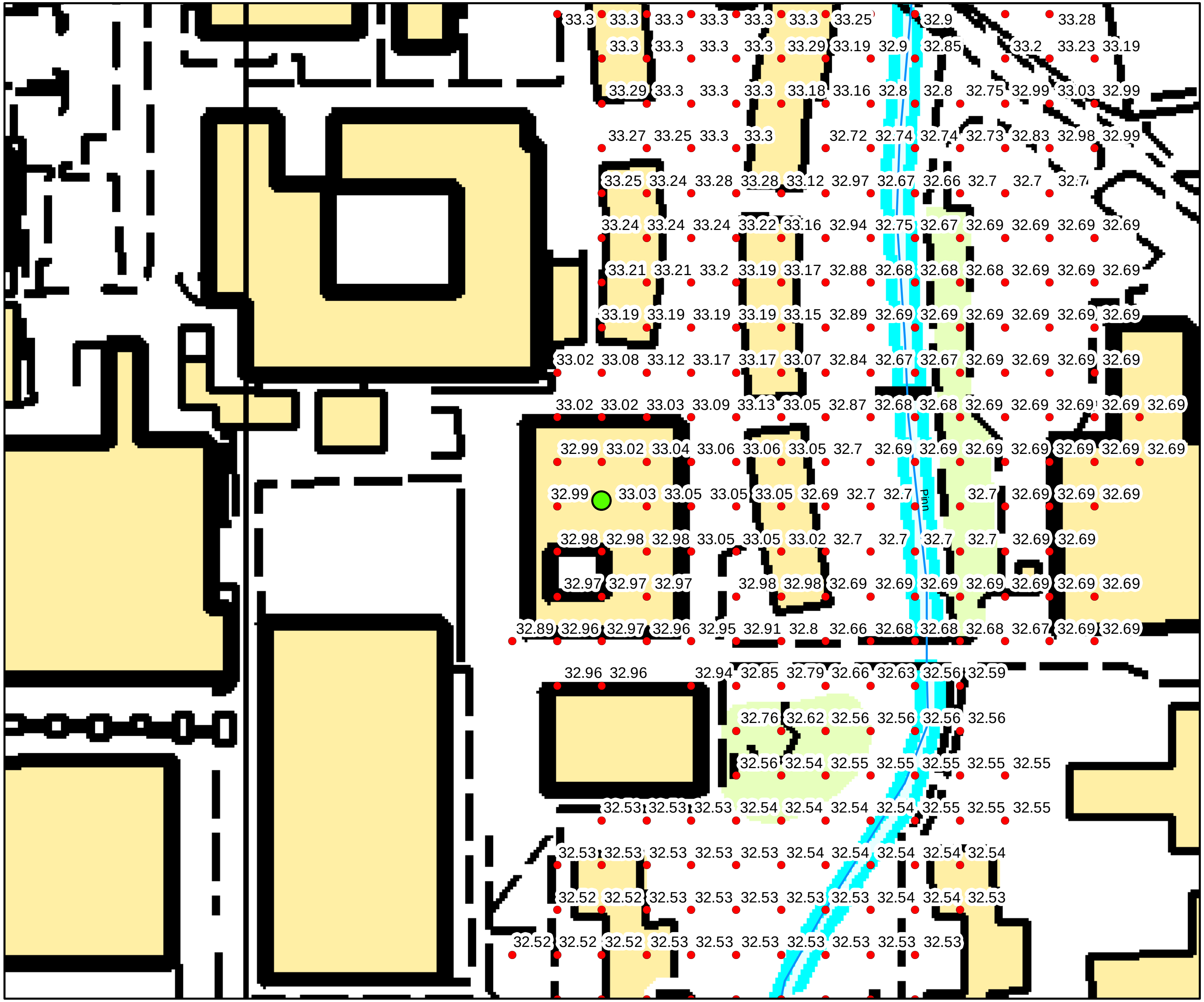
1 in 250 year (0.4%) Defended

The data in this map has been extracted from the River Pinn Mapping Study (JBA, 2015).
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 within the 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 Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR



Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

0 15 30 60
Metres

Legend

Main Rivers

2D Node Results: Heights

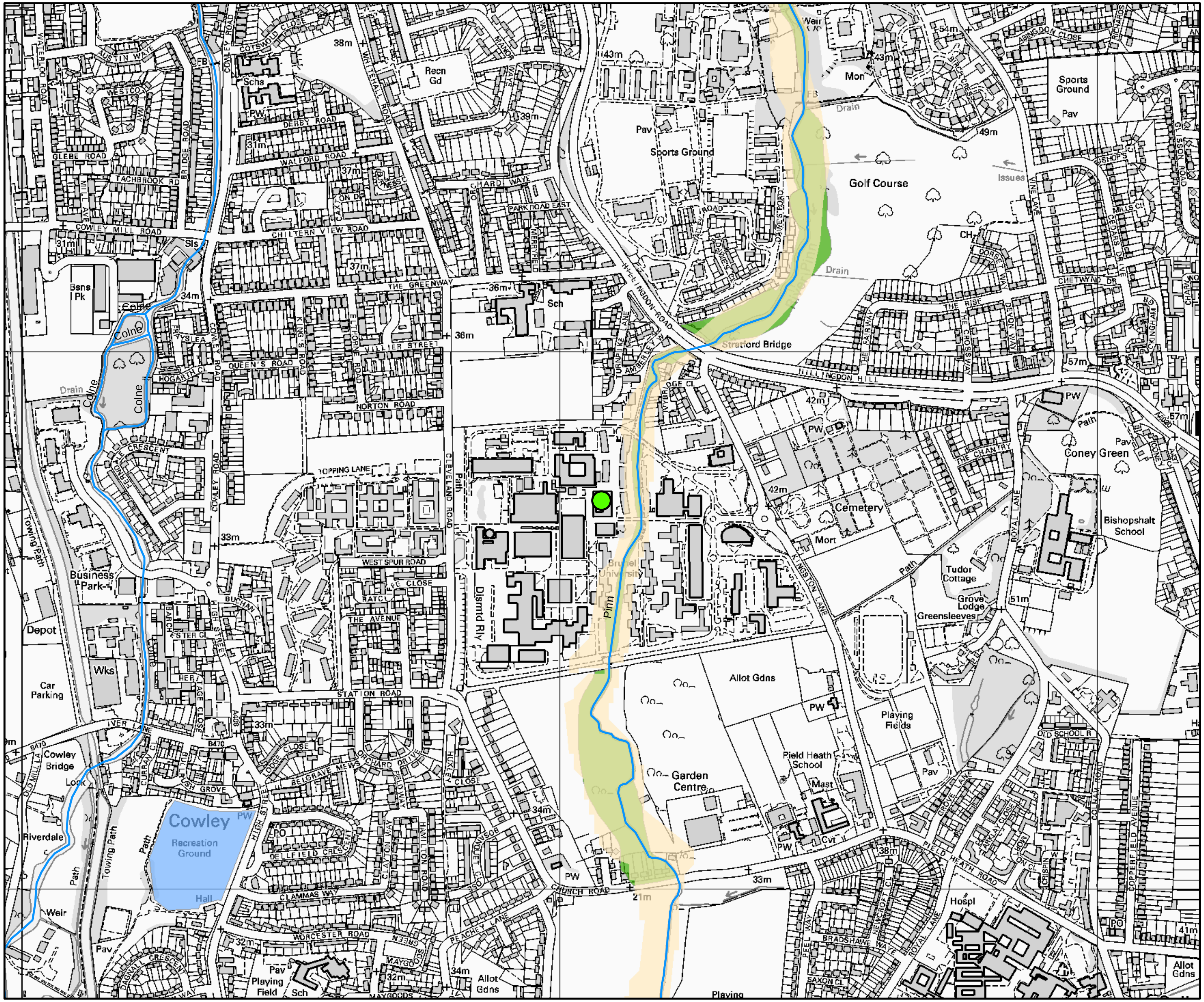
1 in 1000 year (0.1%) Defended

The data in this map has been extracted from the River Pinn Mapping Study (JBA, 2015).
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 within the 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

Historic Flood Map centred on Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR



Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

0 125 250 500
Metres

Legend

Main Rivers

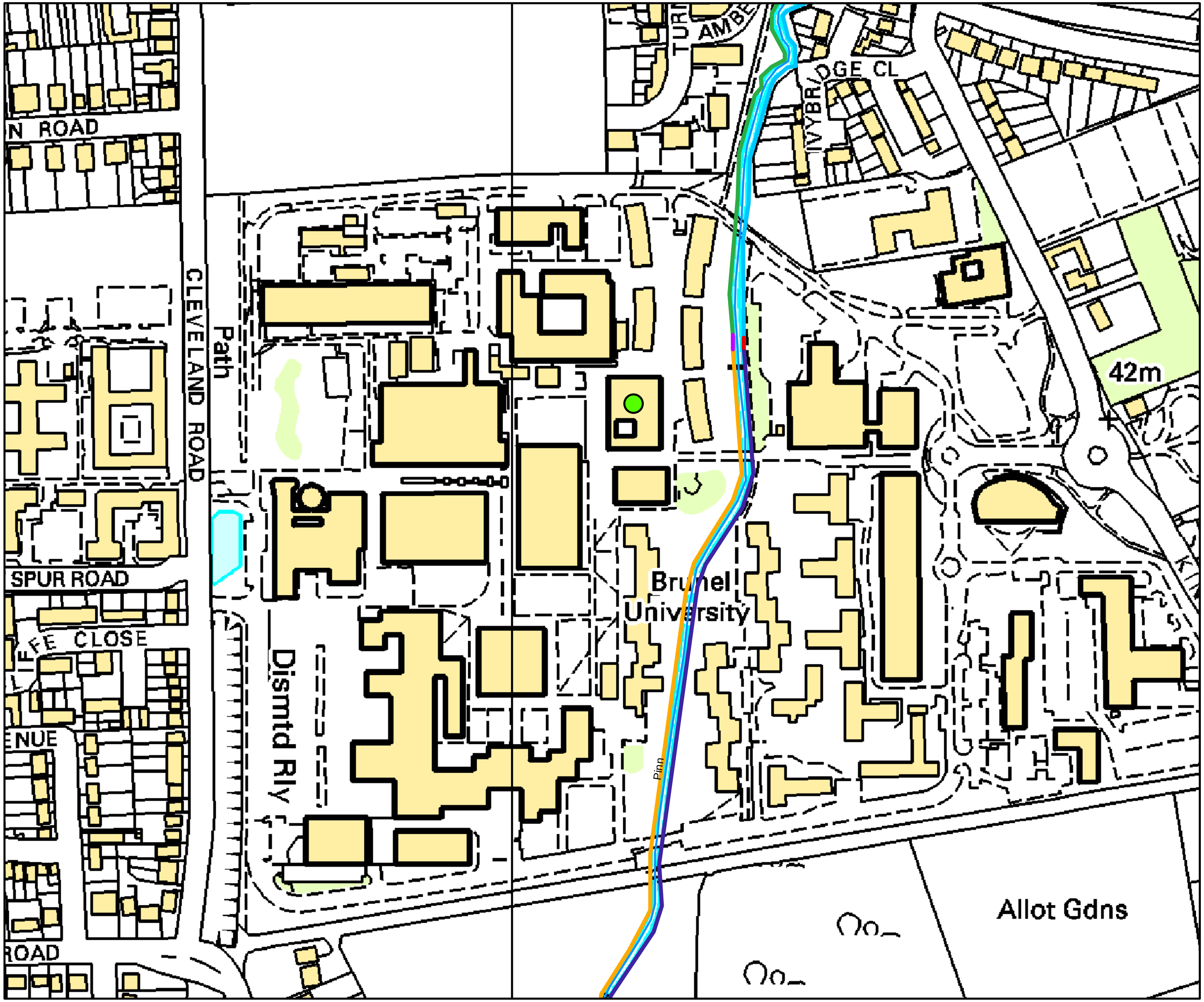
Flood Event Outlines

- 1988
- 1987
- 1977

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.

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

Structures and Defences centred on Learning and Training Centre, University of Brunel, UB8 3PH - 06/03/2018 - HNL77356NR



Environment Agency

Environment Agency
Alchemy,
Bessemer Road,
Welwyn Garden City,
Hertfordshire,
AL7 1HE

0 50 100 200
Metres

Legend

Main Rivers

NAFRA_DEFENCE

ASSET_ID

- 9094
- 153555
- 153556
- 153558
- 154969
- 155138

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

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

Environment Agency ref: HNL77356NR

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)	Downstream Crest Level	Upstream Crest Level	Condition of Defences (1=Good, 5 = Poor)
9094	high_ground	fluvial	Natural Vegetated Bank	Natural Bank	5	32.70	33.30	3
153558	high_ground	fluvial	Natural vegetated Channel	Natural Bank	2	30.50	32.70	3
155138	high_ground	fluvial	Natural vegetated channel	Natural Channel	2	30.40	33.10	3
154969	high_ground	fluvial	Precast concrete channel lining forming flume for possible gauging / telemetry station	Bank protection.	20	32.60	32.60	3
153556	high_ground	fluvial	Natural Vegetated Bank	Bank protection.	2	33.10	33.30	3
153555	high_ground	fluvial	Concrete blockwork channel sides forming flume for possible gauging/telemetry station	Bank protection.	100	33.10	32.60	3

Appendix C – Site 1 and 2 private drainage network

Appendix D – Site 1 and 2 catchment areas