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FLOOD RISK ASSESSMENT IN SUPPORT OF A PLANNING APPLICATION,
ST PAUL'S SCHOOL, LONSDALE ROAD, LONDON SW13 9JT

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Terms of Reference

Michael Barclay Partnership has been instructed by St Paul's School to prepare a Flood Risk Assessment in support of an application currently with London Borough of Richmond upon Thames. The application is for an extension of time to implement development, submitted by Nathaniel Lichfield & Partners on behalf of St Paul's School.

Preamble

This report has been prepared by Michael Barclay Partnership LLP on the instructions of, and for the sole use and benefit of, the Client.

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Issue Record

Date	Version	Issued By
19.12.16	v1 Draft for comment	NP
20.12.16	v2 Final	NP

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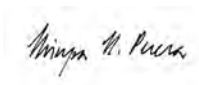

For Michael Barclay Partnership LLP Date: 20.12.2016

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Project:	**Phase 1 Flood Risk Assessment (FRA)**
Prepared for:	Michael Barclay Partnership LLP
Reference:	2931
Date:	December 2016
Version:	Final v2.0

Document Issue Record

Project: Phase 1 Flood Risk Assessment

Prepared for: Michael Barclay Partnership LLP

Reference: 2931

Site Location: St Paul's School, Lonsdale Road, London, SW13 9JT

Proposed Development: Redevelopment of the existing educational facilities and construction of ancillary residential accommodation at the site.

Consultant		Date	Signature
Author	Nick Drewett	06/12/2016	
Document Check	Thea Powell	14/12/2016	
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Contents

1. Summary

1.1 Ambiental Technical Solutions Limited has been appointed by Michael Barclay Partnership LLP, to undertake a National Planning Policy Framework (NPPF) compliant Flood Risk Assessment (FRA) for the ongoing redevelopment of St Paul's School, Lonsdale Road, Barnes, London, SW13 9JT.

1.2 It is understood that the proposed redevelopment includes the demolition of most of the existing buildings on site, and the refurbishment of the existing sports hall, the construction of a maximum of 13,159m^2 built footprint of education facilities which will include classrooms, a dining hall, kitchen, library, chapel and ancillary residential accommodation. It is further understood that the proposed development includes the reconfiguration of car parking facilities, and the construction of 1,084m^2 built footprint of buildings (3/4 storeys including lower ground floor and attics) to provide 33 residential units.

1.3 With reference to the NPPF and the Environment Agency (EA) standing advice on development and flood risk, as well as the low detail, national-scale flood mapping created on behalf of the EA, the proposed site is located within Flood Zones 1, 2 and primarily 3, and therefore in line with a conservative approach, the site will be considered as within Flood Zone 3 (High Risk; >0.5% chance of annual tidal flooding) and is considered to be a 'More Vulnerable' development.

1.4 The site currently benefits from the presence of defences (including the Thames Barrier) which act to protect to the 1:1000 year standard. Analysis of the EA defence data has shown the site will remain protected to the 1:1000 year level of protection until at least 2100.

1.5 Analysis of the EA data provided for this assessment has demonstrated that the site is unaffected by the modelled 2014 breach event, but would be partially affected by the 2065 and 2100 breach flood events.

1.6 Residential accommodation is proposed at the site, Block A is proposed to construct a perimeter wall and step up step down entrance to mitigate breach. Block B will place residential units at the upper ground floor level and above, which is above the breach 2100 modelled flood level and Block C is located outside of the breach.

1.7 The EA have provided upstream inundation modelling which shows that if the site did not benefit from the presence of defences it would be partially affected for the 2014, 2065 and 2100 epochs, however the site benefits from the presence of defences to the 1 in 1000-year standard of protection and the scenario whereby the linear defences were removed is **very unlikely**.

1.8 As such, and given that:

a) the proposed development is located in an **existing developed area**, and includes the **replacement** of several school **buildings**, and the construction of residential blocks on the perimeter of an existing residential street;

b) the site has been shown to be **defended to the 1:1000 year standard**, and will remain so until at least 2100;

c) the site is **primarily unaffected by the modelled breach extents** for all **three epochs**, but **appropriate mitigation measures** have been recommended to **protect** more vulnerable uses, such as the lower ground flood of Block A, that are **within the breach extents**;

d) betterment can be provided by the formalisation of a **flood warning and evacuation plan**, which it is understood has already been agreed with the Council,

following the guidelines contained within the NPPF, the proposed development is considered **to be suitable** assuming appropriate mitigation (including adequate warning procedures) can be maintained for the temporary lifetime of the development.

Development Description	Existing	Proposed
Development Type:	School complex	Demolition of most buildings on site. Redevelopment to include refurbishment of the existing sports hall, the construction of new education facilities and ancillary residential accommodation blocks
(Number of Bedrooms):	N/A[2]	N/A[2]
EA Vulnerability Classification:	More Vulnerable	No Change
Ground Level:	Approximately between 3.53mAOD and 6.93mAOD across whole site	FFLs will vary across site
Level of Sleeping Accommodation:	N/A[2]	Lower Ground Floor of Block A: 3.22mAOD Upper Ground Floor of Block B: 5.735mAOD Upper Ground Floor of Block C: 6.66mAOD The likely relocation of existing boarding accommodation to the site adjacent to the Thames Water building: 5.86mAOD
Impermeable Surface Area:	42,874m^2	43,636m^2
Surface Water Drainage:	N/A[1]	Attenuate to London Plan
Site Size:	N/A[2]	No change
Risk to Development	**Summary**	**Comment**
EA Flood Zone:	Flood Zone 3	
Flood Source:	Tidal	River Thames
Present day extreme water level	5.04mAOD; 5.03mAOD	Node Point 2.18 and 2.19 respectively, from Thames Estuary 2100 study completed by HR Wallingford in 2008.
2065 to 2100 Design water level	5.50mAOD; 5.49mAOD	
From 2100 Design water level	5.94mAOD; 5.93mAOD	
Recorded Flood Events in Area:	Yes	January 1928
Recorded Flood Events at Site:	No	Site outside January 1928 flood extent.
SFRA Available:	Yes	London Borough of Richmond Strategic Flood Risk Assessment Update (2016) and Surface Water Management Plan (June 2011)
Management Measures	**Summary**	**Comment**
Ground floor level above extreme flood levels:	N/A[1]	Site benefits from Thames Barrier and therefore defended to the 1:1000 year event
Safe Access/Egress Route:	Yes	Safe access away from the source of flooding
Flood Resilient Design:	Yes	Section 8 of this FRA
Site Drainage Plan:	N/A[1]	It is recommended that the developer attenuate runoff and net volume in accordance with the London Plan drainage policy
Flood Warning & Evacuation Plan:	Yes	Client has stipulated that the school has a formal evacuation plan in place (last reviewed 1st November 2016)
Offsite Impacts	**Summary**	**Comment**
Displacement of floodwater:	N/A[1]	Site lies in area of tidal flood risk
Increase in surface run-off generation:	Yes	Attenuate to London Plan
Impact on hydraulic performance of channels:	None	Does not affect channel

Table 1: Summary of flood risks, impacts and proposed flood mitigation measures.
N/A[1] not required for this assessment; *N/A[2]* data not available.

2. Development Description and Site Area

Proposed Development and Location

2.1 The proposed development site is located at St Paul's School, Lonsdale Road, Barnes, London, SW13 9JT (*Figure 1*).

2.2 The existing site consists of several school buildings, educational facilities and associated sports fields/ facilities.

2.3 The client has provided a previous flood risk assessment for the proposed redevelopment of St Paul's School, which was undertaken by Crane Environmental in 2008. The previous FRA contains plans for the proposed redevelopment.

2.4 It is understood that the proposed redevelopment includes the demolition of most of the existing buildings on site, and the refurbishment of the existing sports hall, the construction of a maximum of 13,159m^2 footprint of education facilities which will include classrooms, a dining hall, kitchen, library, chapel and ancillary boarding accommodation. It is further understood that the proposed development includes the reconfiguration of car parking facilities, and the construction of 1,084m^2 footprint of buildings (3/4 storeys including lower ground floors and attics) to provide 33 residential units.

2.5 It is understood from plans provided in a previous FRA for the site, that the existing boarding accommodation is likely to be relocated to the site adjacent to the Thames Water building. It is further understood from this that the new boarding building would have its ground floor level set at 5.86mAOD. The client has stipulated that the relocation of the boarding accommodation and the proposed redevelopment of the building parcels has been consented to previously.

2.6 The proposed residential accommodation blocks will be located west of Lillian Road and Glentham Road, in place of the existing car parking facilities. Three ancillary residential accommodation blocks are proposed as part of the development, located west of Lillian Road and Glentham Road.

2.7 Block A will include residential and sleeping accommodation at the lower and upper ground floors, with the lower ground floor being set at 3.22mAOD, and the upper ground floor being set at 6.220mAOD.

2.8 Block B will incorporate car parking, storage and laundry into its lower ground floor (at 2.90mAOD to 3.75mAOD), and sleeping accommodation at the upper ground floor (at a level of at least 5.735mAOD).

2.9 Block C will include residential uses (but not sleeping accommodation) at the lower ground floor at 4.05mAOD, and sleeping accommodation at the upper ground floor (6.660mAOD).

2.10 The nearest watercourse to the site is the River Thames, which abuts the curved northern boundary of the site. The River Thames is classified as an EA main river.

2.11 Topographic levels across the site vary approximately between 3.53mAOD and 6.93mAOD (*Source: 2m LiDAR*). The topographic levels at the centre of the site, where the new school buildings are to be located, are approximately between 4.88mAOD and 6.93mAOD.

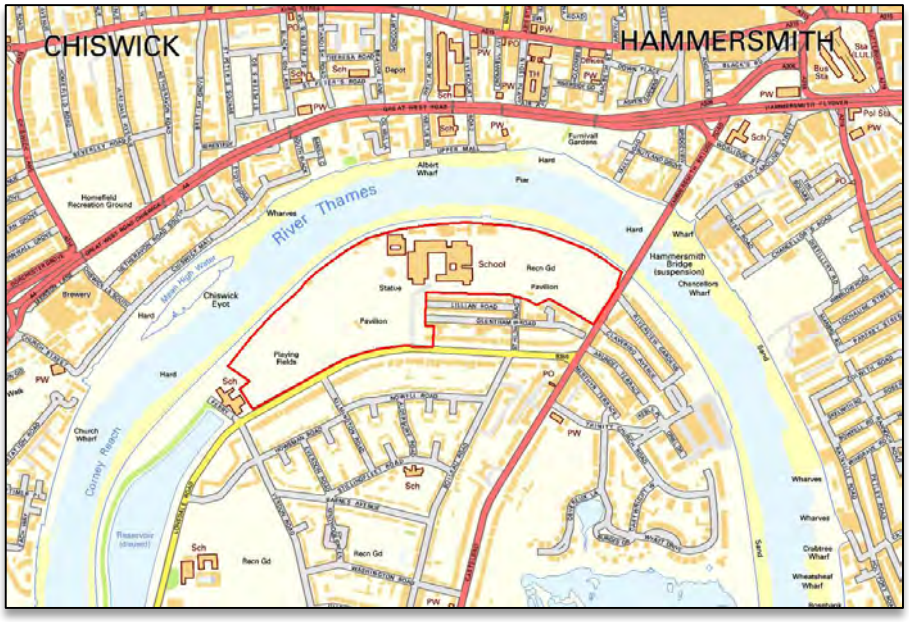

Figure 1: Site Location Map-Site outlined in red (Source: OS)

Vulnerability Classification

2.13 According to the NPPF and the Environment Agency (EA) standing advice on development and flood risk, as well as the low detail, national-scale flood mapping created on behalf of the EA the proposed development and existing site is located in Flood Zones 1, 2 and primarily 3, although adopting a conservative approach, the site should be considered as within Flood Zone 3 (High risk; with a greater than >0.5% chance of annual tidal flooding) as this covers most of the site. The EA Flood Map for Planning is provided in *Figure 2*.

2.14 Under the NPPF the site is currently classified as a "More Vulnerable" development. Post development there will be no change in vulnerability classification and will remain being classified as "More Vulnerable", under the NPPF.

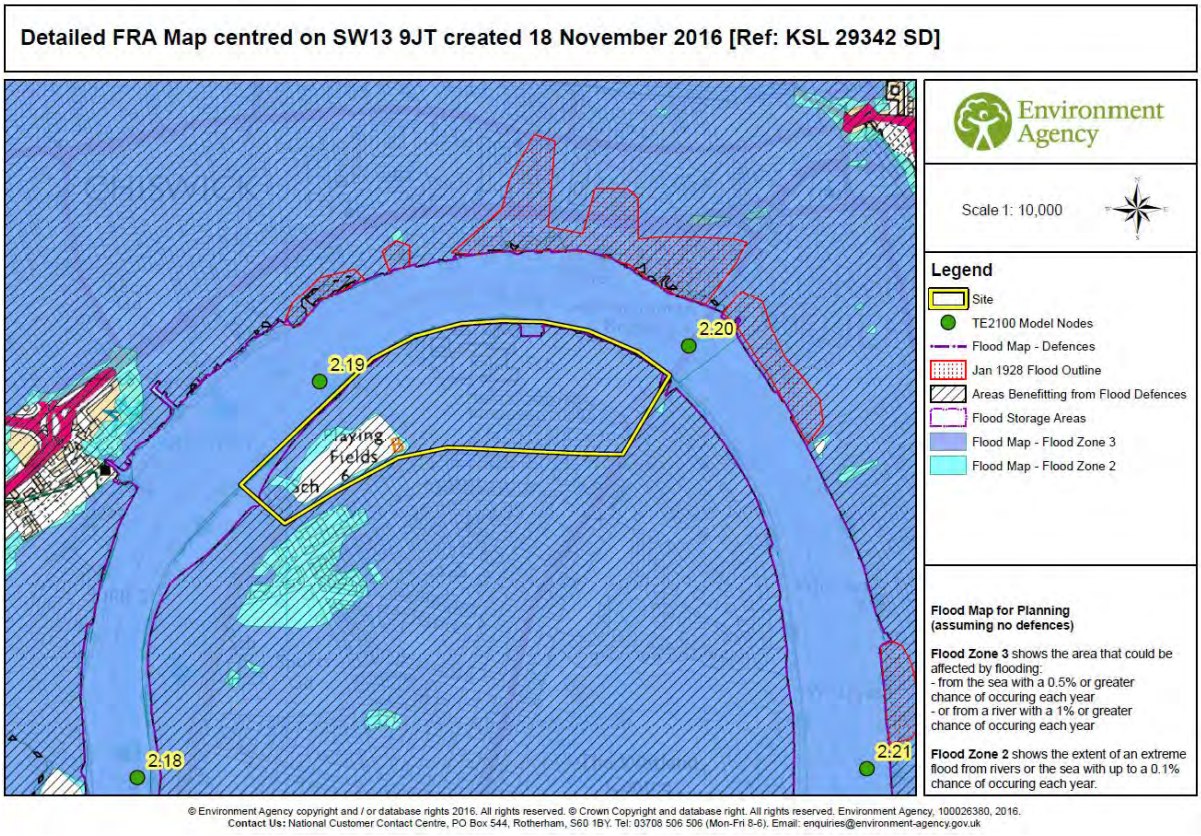

Figure 2: EA Flood Zone Map (Source: EA Online)

Geology

2.15 According to the British Geological Survey (BGS) the bedrock of the site is of the London Clay Formation, comprising of clay and silt. The superficial geology has been identified as Alluvium formed of clay, silt, peat and sand.

3. Sequential Test/Exception Test

3.1 Under the NPPF, all new planning applications must undergo a *Sequential Test*. This test must be implemented by local planning authorities with a view to locating particularly vulnerable new developments (e.g. residential, hospitals, mobile homes etc.) outside of the floodplain. The test refers to the EA Flood Zones described in Table 2. For reference, the NPPF *Sequential Test: Flood Risk Vulnerability and Flood Zone 'Compatibility' Table* is reproduced below.

Flood Risk Vulnerability Classification		Essential Infrastructure	Water Compatible	Highly Vulnerable	More Vulnerable	Less Vulnerable
Flood Zone	Zone 1	✓	✓	✓	✓	✓
	Zone 2	✓	✓	Exception Test Required	✓	✓
	Zone 3a	Exception Test Required	✓	×	Exception Test Required	✓
	Zone 3b *Functional Floodplain*	Exception Test Required	✓	×	×	×

Table 2: The Sequential Test: Flood Risk Vulnerability and Flood Zone 'Compatibility' Table as specified by NPPF. Shaded cells denote the proposed re-development. Please note: ✓ means development is appropriate; × means the development should not be permitted.

3.2 Using the principles of the Sequential Test outlined above, the proposed development is "More Vulnerable". The site is located within Flood Zone 3 (as defined by the EA) and as such, under the NPPF, this development requires the implementation of the Exception Test.

For the Exception Test to be passed, the proposed development must meet the following criteria:

- it must be demonstrated that the development provides wider sustainability benefits to the community that outweigh the flood risk, as informed by a Strategic Flood Risk Assessment;
- a Flood Risk Assessment demonstrates that the development will be safe, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

(*Source: the NPPF)*

3.3 As such, and in order to address these requirements, the planning application is required to be accompanied by a FRA which shows that the development can be achieved in a sustainable manner, with an overall reduction to flood risk to the site and surrounding area.

4. Site Flood Hazards

Sources of Flooding

4.1 As outlined in Figure 2, the proposed development is located within Flood Zone 3 (High Risk of flooding), and is considered to be "More Vulnerable" under the NPPF. Communication with the Environment Agency (EA) has identified the following potential sources of flooding to the site:

Source	Description
Tidal	River Thames
Surface	On site
Groundwater	On site
Sewer	Local sewer network

Table 3: Summary of flood sources.

Mechanisms and History of Flooding

4.2 According to the low detail, national-scale flood mapping created on behalf of the EA the proposed development is located within Flood Zone 3 of the tidal flood plains of the River Thames.

Figure 2 outlines only the potential floodplain; and the mitigating effects of flood defences currently in place are not considered. The site benefits from flood defences (including the Thames Barrier) which act to protect to the 1:1000 year standard.

Tidal

4.3 The EA Flood Map for Planning (*Figure 2*) confirms that the site lies within Flood Zone 3 (High Risk), with a greater than 0.5% annual chance of tidal flooding from the River Thames.

4.4 The nearest watercourse to the site is the River Thames, which abuts the curved northern boundary of the site. The River Thames is classified as an EA main river.

4.5 The EA data has shown the site is currently protected by defences to the 1:1000 year standard and would remain so, up to at least the year 2100.

4.6 The EA has provided extreme modelled flood levels from the Thames Estuary 2100 study (*Table 4*). Modelled flood levels upstream of the Thames Barrier are the highest levels permitted by the Thames Barrier.

4.7 The EA provided modelled flood data for several in-channel nodes along the River Thames as it passes the site (*Figure 2*).

4.8 The EA has identified node 2.19 to be closest, and therefore most representative of flood risk to the site. However, best practice for flood risk requires the assessment to analyse the closest **upstream** node to the site. As such, extreme modelled flood levels from both Node 2.18 and Node 2.19 have been used for this assessment.

Node 2.18	Present Day (2008) (Extreme)		2065 – 2100	From 2100
Water Design Level (mAOD)	5.04mAOD		5.50mAOD	5.94mAOD
Defence Level (mAOD)	Left Defence	Right Defence	6.25mAOD	6.70mAOD
	5.54mAOD	5.94mAOD		
Node 2.19	**Present Day (2008) (Extreme)**		**2065 – 2100**	**From 2100**
Water Design Level (mAOD)	5.03mAOD		5.49mAOD	5.93mAOD
Defence Level (mAOD)	Left Defence	Right Defence	5.95mAOD	6.40mAOD
	5.54mAOD	5.94mAOD		

Table 4: Modelled extreme water level data from Nodes 2.18 and 2.19 (Source: EA)

4.9 Detailed modelling available at Node 2.18 has revealed an extreme water level for the present day (as of 2008) of 5.04mAOD, a 2065 to 2100 design water level of 5.50mAOD and a 2100 design water level of 5.94mAOD, as demonstrated in Table 4.

4.10 Detailed modelling available at Node 2.19 has revealed an extreme water level for the present day (as of 2008) of 5.03mAOD, a 2065 to 2100 design water level of 5.49mAOD and a 2100 design water level of 5.93mAOD, as demonstrated in Table 4.

4.11 As such, Node 2.18 provides marginally greater flood levels (0.01m greater for each epoch) and will be used for the remainder of this assessment.

4.12 Site levels vary between approximately 3.53mAOD to 6.93mAOD (*Source: 2m LiDAR*).

4.13 Based on levels at Node 2.18, comparison between the modelled flood levels and site topographic levels indicates a **potential maximum flood depth of 1.51m** for the **present day** a **potential maximum flood depth** of **1.97m** for the **2065-2100** epoch, and a **potential maximum flood depth** of **2.41m**.

4.14 The EA however has provided defence levels of 5.54mAOD and 5.94mAOD (left and right defences, respectively) for the present day, 5.95mAOD for 2065 to 2100 and 6.40mAOD from 2100 at Node 2.19.

4.15 At Node 2.18, the EA has provided defences levels of 5.54mAOD and 5.94mAOD (left and right defences, respectively) for the present day, 6.25mAOD for 2065 to 2100 and 6.70mAOD from 2100.

4.16 Therefore, when compared with the modelled flood levels, **it would appear that the site will be defended against tidal flooding to the 1:1000 year standard of protection until at least the year 2100.**

4.17 It is important to note that tidal flooding is generally caused by low pressure weather systems creating storm-surges (or storm tides), chiefly via high speed winds. These winds (and to a certain extent, the low pressure) create a 'bulge' of water which, if it coincides with high tide, can generate very high, stormy, water levels. However, because this mechanism is well understood, it is very likely that an early warning will be issued before such an event strikes. As such, it is very unlikely that the site would be subject to tidal flooding without several hours of early warning.

4.18 Given the site has been shown to benefit from flood defences which provide a 1:1000 year standard of protection and will remain as such up to at least 2100, the risk of flooding from tidal sources is deemed to be **relatively low.**

Surface Water (Pluvial)

4.19 The EA online Risk from Surface Water Flooding Map has identified the site to be located in an area that is primarily of "Very Low" and "Low" risk of surface water flooding (*Figure 3*). Low lying areas in the north and south of the western playing fields are at a "Medium" and "High" risk of surface water flooding.

4.20 The EA Online Surface Water Flood Depth Map for a High risk scenario demonstrates that the majority of the development site would be affected for the low risk event, with a small, low lying area in the south of the western playing fields experiencing flood depths of less than 300mm.

4.21 The EA Online Surface Water Flood Depth Map for a Medium risk scenario (*Figure 4*) demonstrates that the majority of the site, including the built up area in the centre of the site, would be unaffected for the Medium risk scenario. Small, low lying areas in the north and south of the western playing field would be affected by flood depths of less than 300mm for the medium risk scenario.

4.22 The EA Online Surface Water Flood Depth Map for a Low risk scenario (*Figure 5*) demonstrates that the majority of the site would be unaffected for this scenario. Low lying areas in the north of the western playing field could experience flood depths of between 300mm and 900mm, while a small area in the built up area of the site could experience depths of less than 300mm. A small area in the north of the eastern playing field could also experience similar depths of less than 300mm.

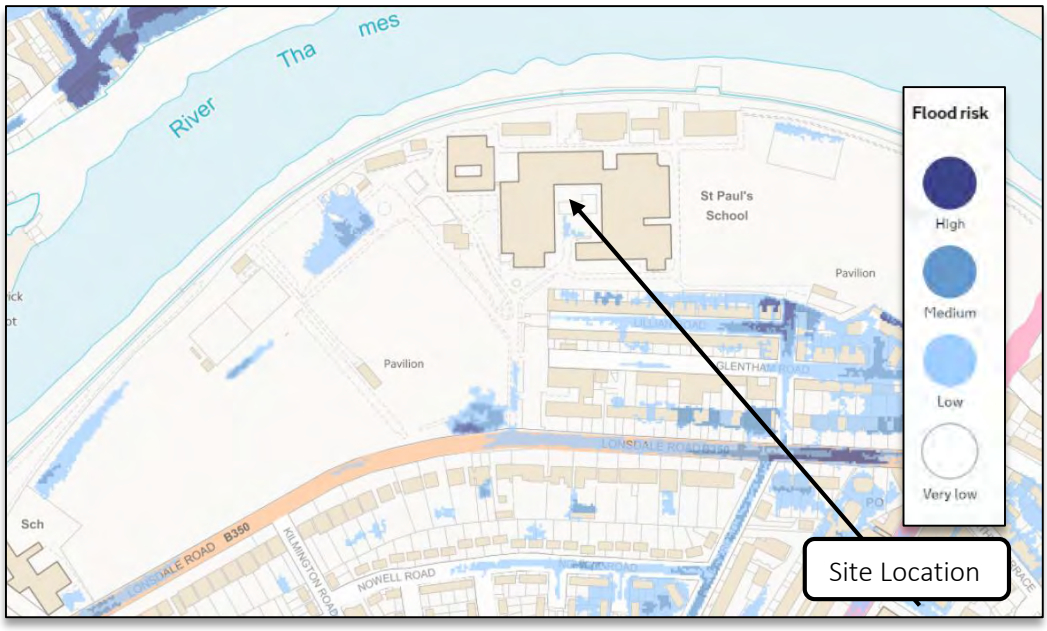

Figure 3: EA Online Surface Water Flood Risk Map (Source: EA Online)

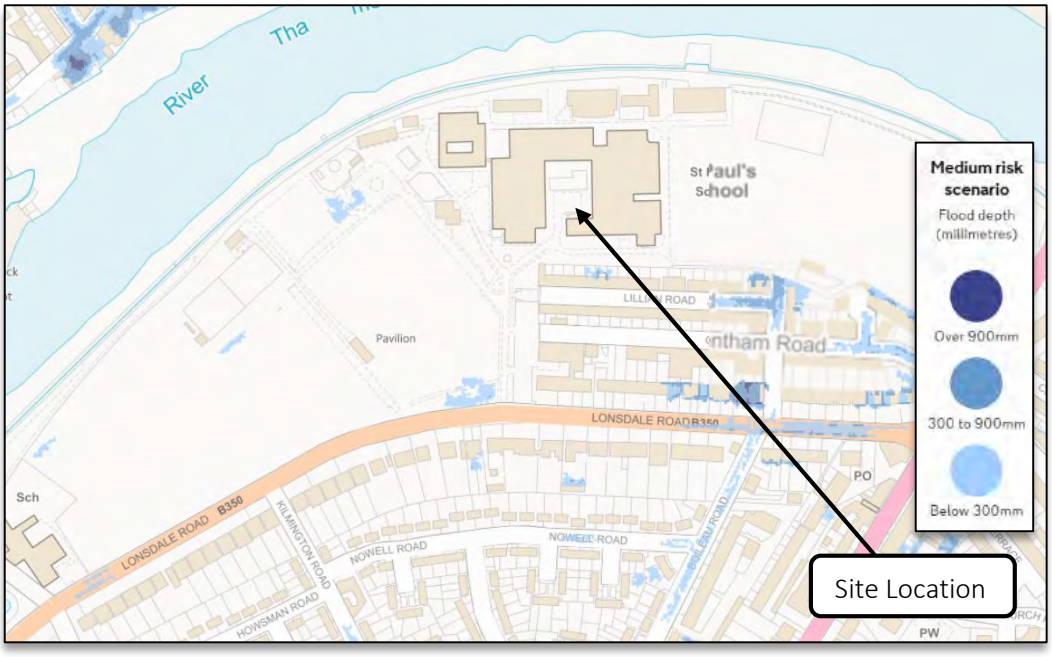

Figure 4: EA Online Surface Water Flood Depth Map; Medium risk scenario (Source: EA Online)

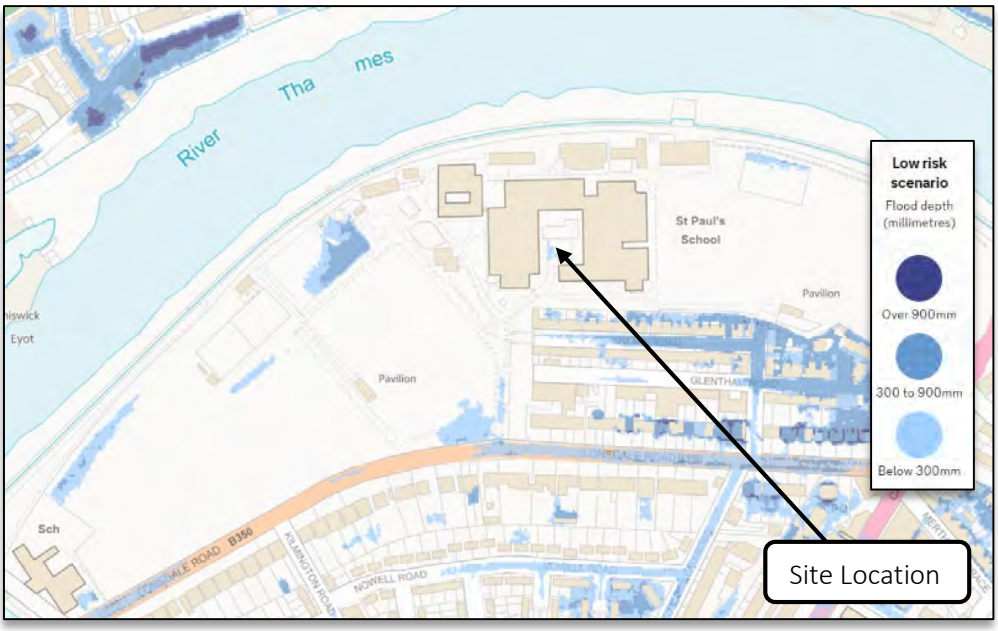

Figure 5: EA Online Surface Water Flood Depth Map; Low risk scenario (Source: EA Online)

4.23 The London Borough of Richmond Surface Water Management Plan 'Surface Water Flooding Incidents and Surface Water Depth (m) 1 in 100 Chance of Rainfall Event Occurring in Any Given Year' Map (*Figure 6*) has identified the site to be located in an area where there have been no recorded surface water flooding incidents. Furthermore, the map shows that across the site, flood depths would mostly be <0.1m, although higher flood depths are concentrated towards the bank of the Thames, and small low lying areas in the north of the playing fields could experience depths between 0.25m and 0.5m.

4.24 As such, the risk of flooding from this source to the proposed buildings can be considered **relatively low**, although the risk of flooding from this source to the less vulnerable playing fields on site could be considered **moderate**.

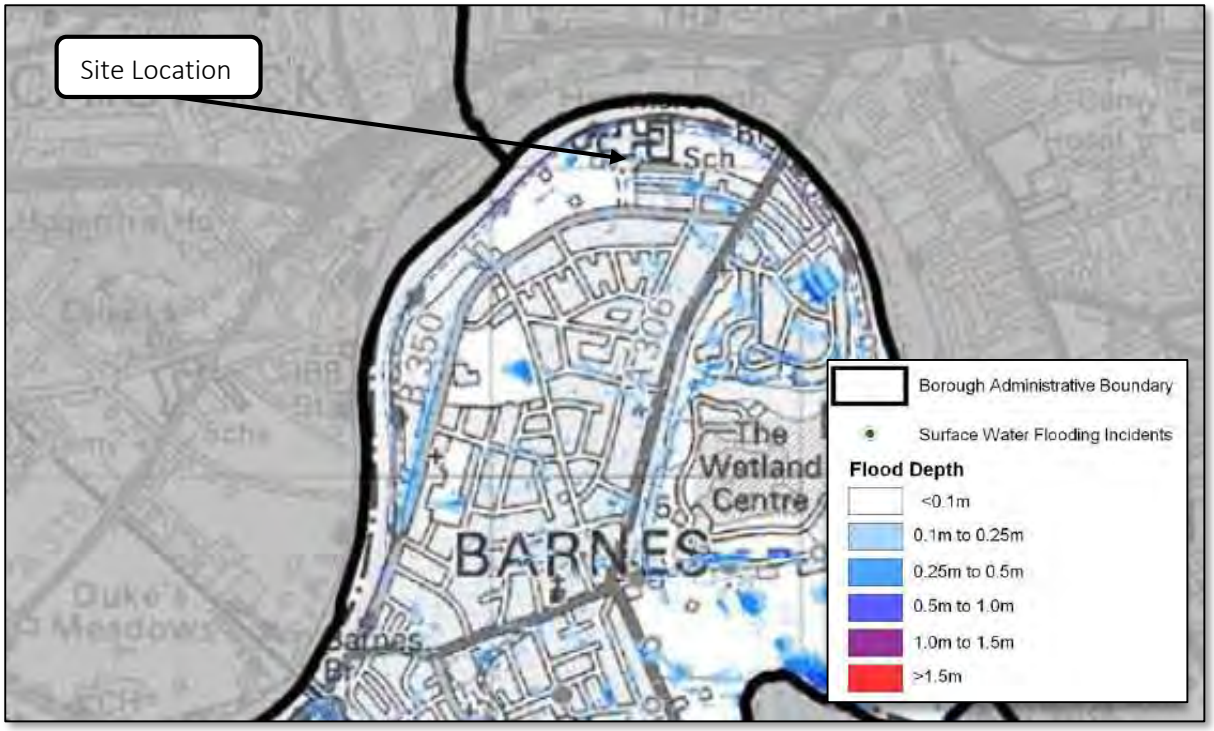

Figure 6: Richmond SWMP Surface Water Map (Source: Richmond SWMP)

Groundwater

4.25 The EA has not identified the site to be located in a Groundwater Source Protection Zone, however the site is underlain by a Minor Aquifer of High vulnerability.

4.26 The Richmond upon Thames Surface Water Management Plan (2011) states that superficial deposits (primarily River Terrace Deposits) in the borough are water bearing and have an increased potential for elevated groundwater. Whilst no groundwater level data are available for the superficial deposits, where groundwater tables exist they are expected to be close to or at ground level, and may fluctuate with river stage.

4.27 Figure 3.5.1 of the Richmond BC SWMP (2011) demonstrates that the northern boundary of the site is underlain by permeable superficial deposits that have increased potential for elevated groundwater (IPEG). An extract of this is provided in *Figure 7.*

4.28 Figure E of the Richmond SFRA (2016) demonstrates that there is 'potential for groundwater flooding of property situated below ground level' and 'potential for groundwater flooding to occur at surface' across the School grounds.

4.29 Susceptibility to groundwater flooding in the Richmond BC area may change as a result of climate change, or changes to flood management. One of the climate change predictions includes an increase of high rainfall events. This could lead to further groundwater flooding in the Richmond BC area due to increased perched groundwater levels and associated spring flows.

4.30 No Groundwater flood incidents have been recorded on site or in the area surrounding the site by the EA or Richmond SWMP/ SFRA, as such the risk of flooding from this source is considered to be **moderate.**

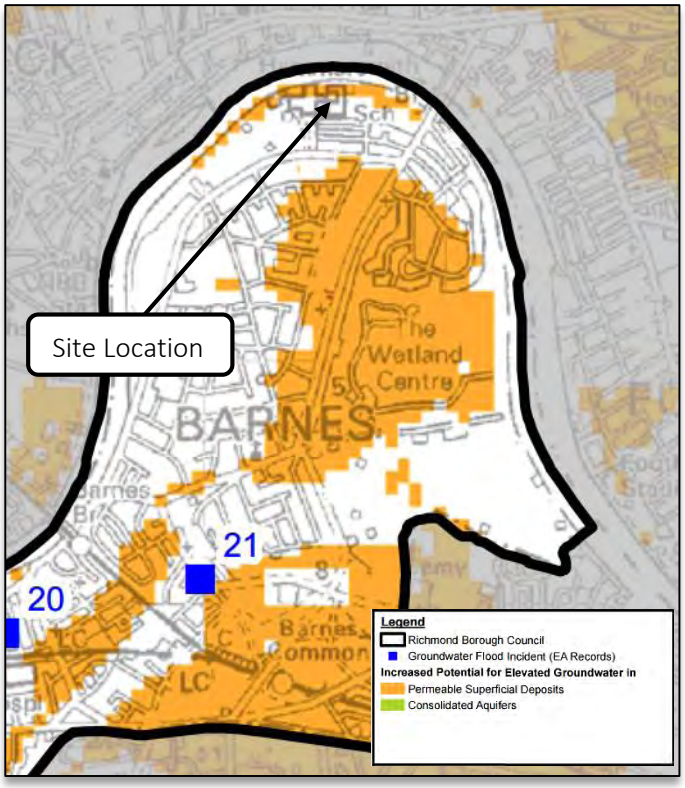

Figure 7: Richmond SWMP Increased Potential for Elevated Groundwater Map (Source: Richmond SWMP)

Sewer

4.31 The EA has provided no records to show that the site has flooded previously from this source.

4.32 The Richmond SWMP (2011) has identified the SW13 9 postcode area to have between 21-50 sewer flood records. No further information has been provided at this stage in regards to the severity, cause or exact location of these flood events.

4.33 The Richmond SFRA (2016) used DG5 data provided by Thames Water to identify postcode areas which are more susceptible to sewer flooding. It was identified that TW3 and SW15 were deemed most susceptible across the Borough.

4.34 Figure I of the SFRA further documents that the SW13 9 postcode area has experienced 21-25 incidents of sewer flooding based on DG5 data. This reiterates the figures provided in the SWMP, although limits the previous numbers to a maximum of 25, rather than 50.

4.35 The development is for the construction of new buildings, and in order to mitigate against sewer flooding it is recommended to install a non-return valve on all new sewer connections on site.

4.36 As such, the risk to the site from this flood source can be considered **relatively low to moderate.**

Surface Water Drainage Strategy

4.37 The existing site contains a number of school buildings and associated playing fields. It is understood that the proposed redevelopment includes the demolition of most of the existing buildings on site, and the refurbishment of the existing sports hall, the construction of a maximum of 13,159m^2 footprint of education facilities which will include classrooms, a dining hall, kitchen, library, chapel and ancillary boarding accommodation. It is further understood that the proposed development includes the reconfiguration of car parking facilities, and the construction of 1,084m^2 footprint of buildings (3/4 storeys including basement and attics) to provide 33 residential units.

4.38 A previous Flood Risk Assessment for the proposed redevelopment of St Paul's School, provided by the Client, and undertaken by Crane Environmental in 2008, stipulates that as existing, 42,874m^2 (41% of planning application boundary area) of the site is impermeable, while post development, this will increase slightly to 43,636m^2 (42% of planning application boundary area).

4.39 It is understood that soakaways are currently utilised across the site to attenuate runoff. It is recommended that further surface water investigations are conducted and that SuDS are implemented across the site to provide a betterment to existing runoff conditions.

4.40 It is understood that a Surface Water Drainage Strategy has been previously agreed with the council.

4.41 The London Plan states that Sustainable Urban Drainage Strategies (SuDS) should be utilised unless there are practical reasons for not doing so.

Records of Historical Flooding

4.42 The EA and Richmond SFRA (2008) have not provided any records of historic flood events from rivers or the sea affecting the site. However, this does not mean that flooding has not occurred in the past, as EA records are not comprehensive.

5. Probability of Flooding

5.1 According to the low detail, national-scale flood mapping created on behalf of the EA the site lies within Flood Zone 3 (High Risk), with a greater than 0.5% annual chance of tidal flooding from the River Thames.

5.2 Tidal flooding is generally caused by low pressure weather systems creating storm-surges (or storm tides), chiefly via high speed winds. These winds (and to a certain extent, the low pressure) create a 'bulge' of water which, if it coincides with high tide, can generate very high, stormy, water levels. However, because this mechanism is well understood, it is very likely that an early warning will be issued before such an event strikes. As such, it is very unlikely that the site would be subject to tidal flooding without several hours of early warning.

5.3 This information is supported by the EA Flood Map for Planning (Figure 2) which has been produced in part using JFLOW/HYDRO-F – a relatively coarse, national scale flood modelling strategy and in part using detailed flood models. These maps indicate the potential spatial extent of a tidal flood event which has a magnitude that is, on average, likely to occur once in every two hundred years (i.e. the 1:200 year tidal floodplain). It is important to note that only the *potential* floodplain is shown; ***the mitigating effects of any flood defences currently in place are not considered***. For reference, the definition of the NPPF flood risk zones is included in Table 5.

Zone	Description
1	Low Probability. This zone comprises land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (<0.1%).
2	Medium Probability. This zone comprises land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% – 0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% – 0.1%) in any year.
3a	High Probability. This zone comprises land assessed as having a 1 in 100 or greater annual probability of river flooding (>1%) or a 1 in 200 or greater annual probability of flooding from the sea (>0.5%) in any year.
3b	The Functional Floodplain. This zone comprises land where water has to flow or be stored in times of flood. SFRA's should identify this Flood Zone (land which would flood with an annual probability of 1 in 20 (5%) or greater in any year or is designed to flood in an extreme (0.1%) flood, or at another probability to be agreed between the LPA and the EA, including water conveyance routes).

Table 5: Definition of the NPPF Flood Zones. Shaded cells denote the proposed development. (Source: EA)

Climate Change on Site

5.4 Climate change is likely to increase the flow in rivers, and raise sea levels and storm intensity.

5.5 The EA have recently updated the peak river flow allowances to use for different types of development. Communication with the EA, Flood and Coastal Risk Management Officer has

confirmed that the changes are only focused to river flow and rainfall allowances. Tidal allowances are detailed in Table 3 of the new changes (https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances). As a result of this dialogue it has been confirmed that the EA detailed data sets provided are relevant for the purposes of this assessment given that the dominant source of flooding is tidal.

5.6 The EA have also stated that the climate change will increase the peak rainfall intensity allowance in small and urban catchments.

Applies across all of England	Total potential change anticipated for 2010 to 2039	Total potential change anticipated for 2040 to 2059	Total potential change anticipated for 2060 to 2115
Upper end	10%	20%	40%
Central	5%	10%	20%

5.7 The EA however has provided defence levels of 5.54mAOD and 5.94mAOD (left and right defences, respectively) for the present day, 5.95mAOD for 2065 to 2100 and 6.40mAOD from 2100 at Node 2.19.

5.8 At Node 2.18, the EA has provided defences levels of 5.54mAOD and 5.94mAOD (left and right defences, respectively) for the present day, 6.25mAOD for 2065 to 2100 and 6.70mAOD from 2100.

5.9 Therefore, when compared with the modelled flood levels, **it would appear that the site will be defended against tidal flooding to the 1:1000 year standard of protection until at least the year 2100.**

6. Residual Risks

6.1 Residual risks are those remaining after applying the sequential approach to the location of development and taking mitigating actions. Examples of residual flood risk include:

- the failure of flood management infrastructure such as a breach of a raised flood defence, blockage of a surface water conveyance system, overtopping of an upstream storage area, or failure of a pumped drainage system;
- failure of a reservoir, or;
- a severe flood event that exceeds a flood management design standard, such as a flood that overtops a raised flood defence, or an intense rainfall event which the drainage system cannot cope with.

6.2 The site benefits from flood defences which provide a protection level of up to 1:1000 years. As such there is a residual risk to the site of breach failure of the defences, from upstream inundation and overtopping of defences.

6.3 The controlling residual flood risk mechanism on site is tidal. Tidal flooding is generally caused by low pressure weather systems creating storm-surges (or storm tides), chiefly via high speed winds. These winds (and to a certain extent, the low pressure) create a 'bulge' of water which, if it coincides with high tide, can generate very high, stormy, water levels. However, because this mechanism is well understood, it is very likely that an early warning will be issued before a tidal flood event occurs. As such, it is very unlikely that the site would be subject to tidal flooding without several hours of early warning.

6.4 Given the nature of the tidal cycle flood waters on site will likely recede as in-channel water levels fall.

Reservoir Failure

6.5 The EA Risk from Reservoir Map has identified the site to be partially located in an area of reservoir flooding (*Figure 8*). The reservoir could potentially affect the site in the unlikely event of flooding from this source. According to the EA, there has been no loss of life in the UK from reservoir flooding since 1925. All large reservoirs must be inspected and supervised by reservoir panel engineers as detailed by the enforcement authority for the Reservoirs Act 1975 in England. The EA are responsible to ensure that reservoirs are inspected regularly and essential safety work is carried out. As such the risk of flooding from this source is **relatively low**.

6.6 In the unlikely event that a reservoir dam fails, a large volume of water would escape at once and flooding could happen with little or no warning. The EA Risk from Reservoir map has identified the site to be located in an area of reservoir flooding.

6.7 The EA have identified the site to be affected by less than 0.3m and between 0.3m and 2m of flood depth for reservoir flooding. The flooding is shown in a worst case scenario, and therefore it is unlikely the maximum flood depth would occur at the site.

6.8 As reservoir flooding is unlikely and the modelled flood depths are based on the worst case scenario, flooding from this source is deemed to be **relatively low** risk.

Figure 8: Maximum extent of flooding from reservoir failure (Source EA Online)

Defence Breach

6.9 The EA have provided Thames tidal breach data for the proposed development from the Thames Tidal Breach Modelling Study completed by CH2M HILL in March 2015. The extent of the breach model is provided in *Figure 9*.

6.10 The modelled levels shown assume that the Thames defences have been breached at locations, Barn03 and Barn04.

6.11 It can be identified from *Figure 9* that the site would be partially affected by a breach event in the 2065 and 2100 epochs. In addition, Figure C1 of the Richmond SFRA (2016) rates the extent of flood water for the 2100 tidal breach and the hazard ratings associated. This mapping has been reproduced in *Appendix B*. In line with these classifications, the site would be at a Low, Moderate, and Significant Hazard Rating.

6.12 The EA have provided 25 node points across the site and surrounding area (*Figure 10, Table 6*). Nodes 10, 11, 12 and 13 are most representative of the flood mechanism at the location of the **existing buildings and proposed redevelopment**. The EA breach model at both Barn03 and Barn04 provided a value of **Nil Return for all three epochs at all nodes**.

6.13 The proposed development incorporates the likely relocation of the existing ancillary boarding accommodation on site to the site adjacent to the Thames Water building, with ground floor levels of the proposed building to be set at 5.86mAOD. The Thames Water site is located outside of the EA modelled breach extent for all three epochs, and therefore the proposed ancillary boarding accommodation would be unaffected by any breach event.

6.14 It is understood that staff residential blocks will be constructed as part of the redevelopment, south of the existing main school buildings. These proposed residential buildings will be located in the south corner of the site, at the west end of both Lillian Road and Glentham Road.

Site Level Breach Analysis

6.15 Out of the EA 2D nodes provided, Nodes 8, 9 and 25 would be most representative of the breach flood mechanism at the location of the **proposed residential blocks**. The EA Breach model at both Barn03 and Barn04 breach locations provided a value of Nil Return for all three epochs at Nodes 8 and 25.

6.16 At Node 9 of the EA data, values of Nil Return were recorded for all epochs based on the Barn04 breach location. Values of Nil Return were recorded for the 2014 and 2065 epochs based on the Barn03 breach for node 9, however a **flood level of 5.03mAOD was recorded for the 2100 epoch at Node 9.**

6.17 Figure C1 of the Richmond SFRA (2016) identifies the location of the proposed residential blocks to have a Low to Moderate Breach Hazard Rating *(Appendix B)*.

6.18 Based on the EA modelled breach map, other affected areas include the southwest corner of the development site, and an area to the west of the proposed residential buildings, along the south boundary (*Figure 9*).

6.19 Node 2 would be considered most representative of the affected area in the **southwest corner** of the development site. The EA model returned values of Nil Return across all three epochs at **Node 2** for the Barn04 model, while for the Barn03 model, there is a value of Nil Return for the 2014 epoch, and flood levels of 5.61mAOD and 5.75mAOD for the 2065 and 2100 epochs respectively.

6.20 Figure C1 of the Richmond SFRA (2016) identifies the location of the affected area in the southwest corner of the site to have a Significant Breach Hazard Rating *(Appendix B)*.

6.21 Nodes 7 and 8 would be considered most representative of the breach flood levels at the **affected area along the south border in the west playing fields**. Node 8 provides values of Nil Return across all three epochs for both the Barn03 and Barn04 breach event. At Node 7, the EA breach model at Barn04 provided values of Nil Return across all three return periods, and the breach model at Barn03 provided a value of Nil Return for the 2014 epoch. The Barn03 model provided **flood levels of 4.94mAOD and 5.05mAOD** for the **2065 and 2100** epochs respectively.

6.22 Figure C1 of the Richmond SFRA (2016) identifies the location of the affected area along the south border of the western playing fields to have a Moderate to Significant Breach Hazard Rating *(Appendix B)*.

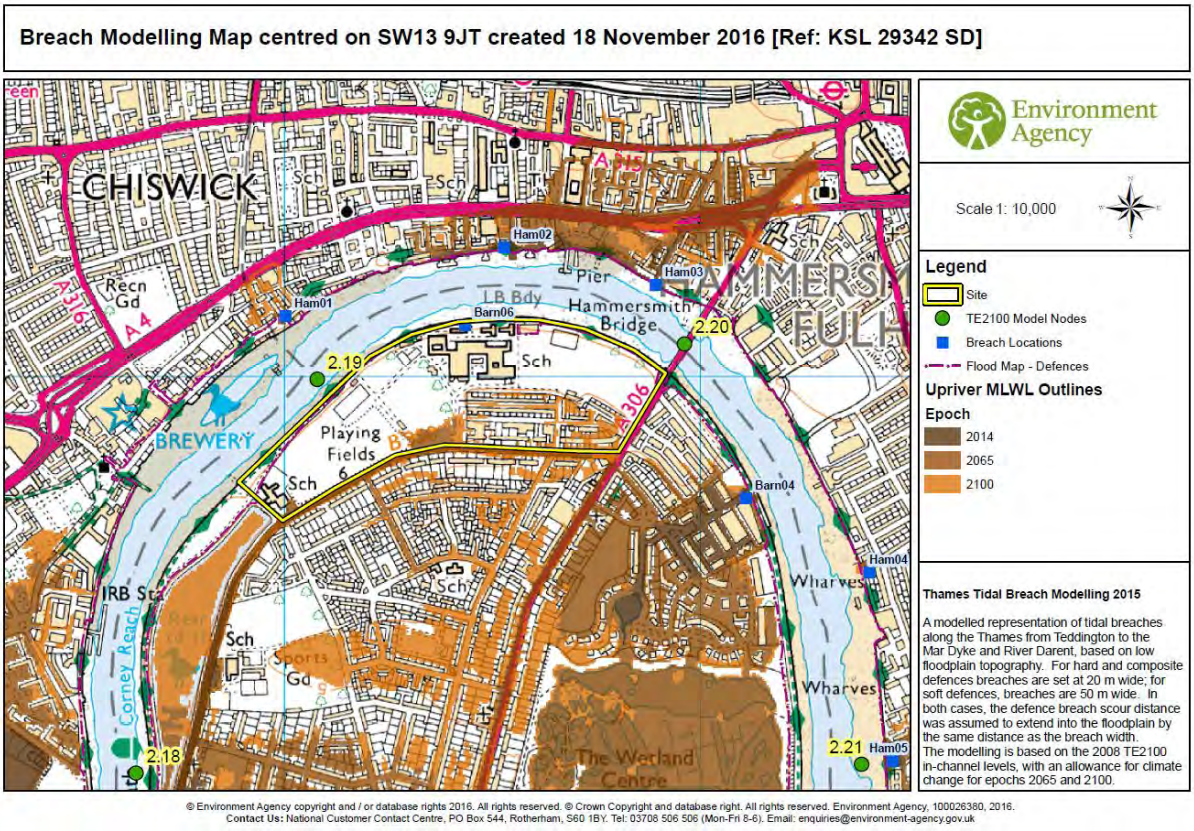

Figure 9: EA modelled breach extent map (Source: EA)

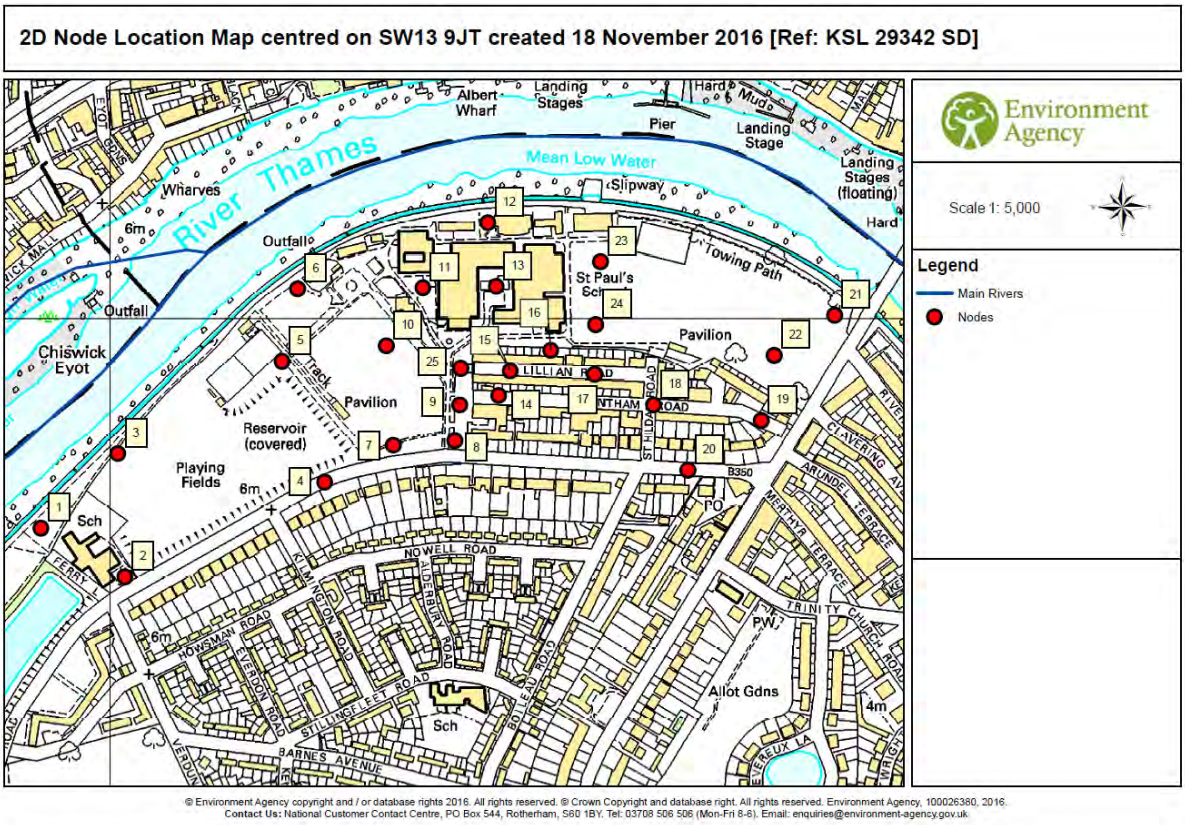

Figure 10: Node Location Map

			Barn03			Barn04		
	National Grid Reference		Modelled levels in mAODN			Modelled levels in mAODN		
Node	Easting	Northing	2014	2065	2100	2014	2065	2100
1	521916	177745	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
2	522018	177686	Nil return	5.61	5.75	Nil return	Nil return	Nil return
3	522009	177835	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
4	522260	177801	Nil return	5.50	5.60	Nil return	Nil return	Nil return
5	522209	177947	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
6	522227	178034	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
7	522343	177845	Nil return	4.94	5.05	Nil return	Nil return	Nil return
8	522418	177851	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
9	522423	177894	Nil return	Nil return	5.03	Nil return	Nil return	Nil return
10	522335	177966	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
11	522379	178036	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
12	522458	178115	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
13	522468	178037	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
14	522471	177905	Nil return	Nil return	4.61	Nil return	Nil return	Nil return
15	522485	177936	Nil return	Nil return	3.99	Nil return	Nil return	4.11
16	522534	177960	Nil return	Nil return	3.99	Nil return	Nil return	4.11
17	522587	177931	Nil return	Nil return	3.99	Nil return	Nil return	4.11
18	522658	177894	Nil return	Nil return	3.99	Nil return	Nil return	4.11
19	522789	177875	Nil return	Nil return	3.99	Nil return	Nil return	4.11
20	522700	177815	Nil return	4.41	4.60	Nil return	Nil return	4.65
21	522877	178003	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
22	522804	177954	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
23	522594	178067	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
24	522588	177991	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
25	522425	177938	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return

Table 6: Thames Tidal Breach Modelled Flood Levels (Source: EA)

Detailed Level Breach Analysis

6.23 Figure 11 below summarises the potential flood depths for the EA modelled breach extents across the site, based on topographic levels at various affected areas.

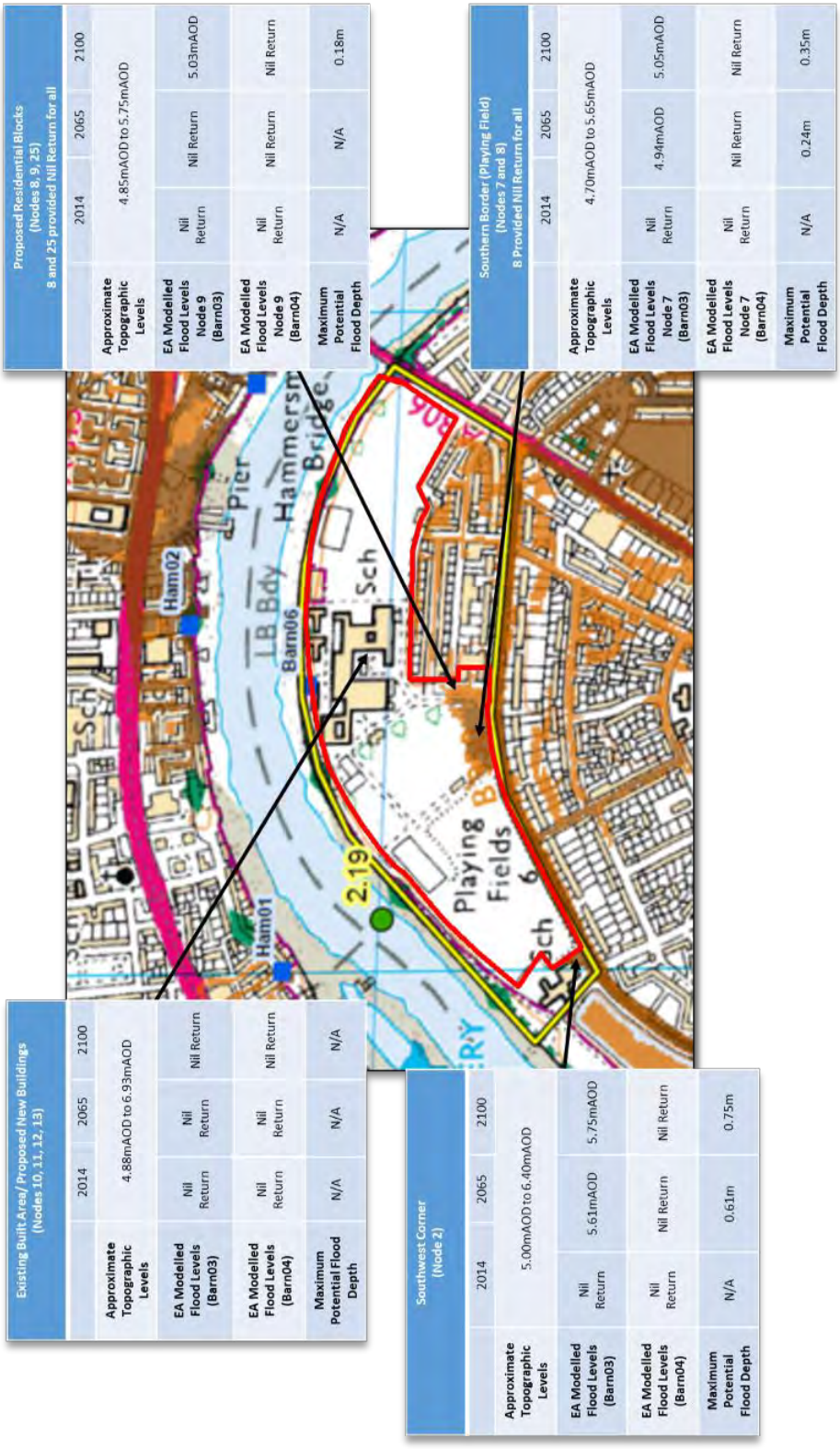

Figure 11: Development specific breach analysis

6.24 It can be identified from Figure 11 that the location of the existing school buildings in the centre of the development site would remain unaffected by breach events in all three epochs.

6.25 It can be identified from Figure 11 that the **location of the proposed residential blocks** at the west end of Lillian Road and Glentham Road could experience a **potential maximum flood depth** of **0.18m** for a **breach event** at **Barn03** in the **2100** epoch, based on topographic levels. Although, it is important to note that plans provided to Ambiental demonstrate that the internal upper ground floor levels of Block A are to be set at 6.22mAOD, of Block B are to be set at 5.735mAOD, and for Block C to be set at 6.66mAOD. Therefore, it could be argued that the upper ground floors of the proposed accommodation blocks are set a minimum of 0.705m (705mm) above the modelled breach level (*Table 7*).

	Block A	Block B	Block C
Upper Ground Floor Level (mAOD)	6.22mAOD	5.735mAOD	6.66mAOD
EA Modelled Breach Flood Level (mAOD)	5.03mAOD	5.03mAOD	5.03mAOD
Elevation of Upper Ground Floor Above Flood Level (m)	1.19m	0.705m	1.63m

Table 7: Comparison between upper ground floor of proposed residential blocks and modelled breach flood levels

6.26 It can be identified from Figure 11 that the **affected area along the southern border of the development, in the west playing fields,** could experience a **potential maximum flood depth** of **0.24m** for a **breach** event at **Barn03** in **2065** epoch, and a **potential maximum flood depth** of **0.35m** for a **breach** event at **Barn03** in the **2100** epoch.

6.27 It can be identified from Figure 11 that a small area in the s**outhwest corner of the development site** could experience a **potential maximum flood depth** of **0.61m** for a **breach** event at **Barn03** in **2065** epoch, and a **potential maximum flood depth** of **0.75m** for a **breach** event at **Barn03** in the **2100** epoch.

6.28 Therefore, it could be argued that much of the site would be unaffected by a defence breach, and the majority of the areas that would be affected are less vulnerable, floodable assets such as playing fields. However, it is important to note that the location of the proposed residential blocks (more vulnerable) could experience a potential maximum flood depth of 0.18m for the 2100 epoch, based on a breach at Barn03 and minimum topographic levels in that area of the development site.

Residential Accommodation Block Breach Analysis

6.29 The lower ground floor of Block A is set at 3.22mAOD. The lower ground floor of Block B is set at 2.90mAOD and the lower ground floor of Block C is set at 4.05mAOD.

6.30 As such, comparisons between the EA modelled Breach level (5.03mAOD) at the site of the proposed residential blocks and the internal floor levels of the lower ground floor for each block indicates a potential **maximum flood depth of 1.81m** at the lower ground floor of **Block A.**, **2.13m** at the lower ground floor of **Block B**. **Block C** is **located outside** of the **modelled breach extent** and the lower ground floor would therefore be unaffected.

6.31 A summary of flood depths at the lower ground floors of the accommodation blocks is provided in *Figure 12.*

Figure 12: Maximum potential breach event flood depths at the lower ground floor of the proposed residential blocks. The breach extent is shown by the orange area. It can be identified that Block C is located outside the modelled breach extent and therefore the lower ground floor would be unaffected.

6.32 As such, it can be argued that the risk of flooding from breach to the majority of the site is **relatively low**, although mitigation measures are recommended (*Section 8 of this report*) to protect more vulnerable areas at risk of inundation following a breach, such as the lower ground floors of the proposed residential Block A.

Overtopping

6.33 No overtopping data has been provided by the EA with regards to this site.

6.34 As such, given that height of the linear defences along the Thames relative to the modelled in-channel flood levels, the risk posed to the development from overtopping is deemed to be **relatively low.**

Upstream Inundation Model

6.35 The EA have provided modelled flood extents and levels at 25 data nodes from their Upstream Inundation Modelling study completed by CH2M Hill in March 2015. The extent of their model is provided in *Figure 13*.

6.36 It can be identified from Figure 13 that the site would be partially affected in the 2014, 2064 and 2100 epochs.

6.37 The extent of the 2014 epoch upstream inundation event would partially affect the west corner of the site, along with a small, low lying area along the north boundary.

6.38 The extent of the 2065 epoch upstream inundation event would affect a much larger portion of the development site, and would affect the location of the existing school buildings, proposed residential blocks and the eastern most playing field on the west side of the development.

6.39 The extent of the 2100 epoch upstream inundation event follows a similar outline as that of the 2065 epoch, however the whole eastern playing fields would be affected, as would the north of the western playing fields.

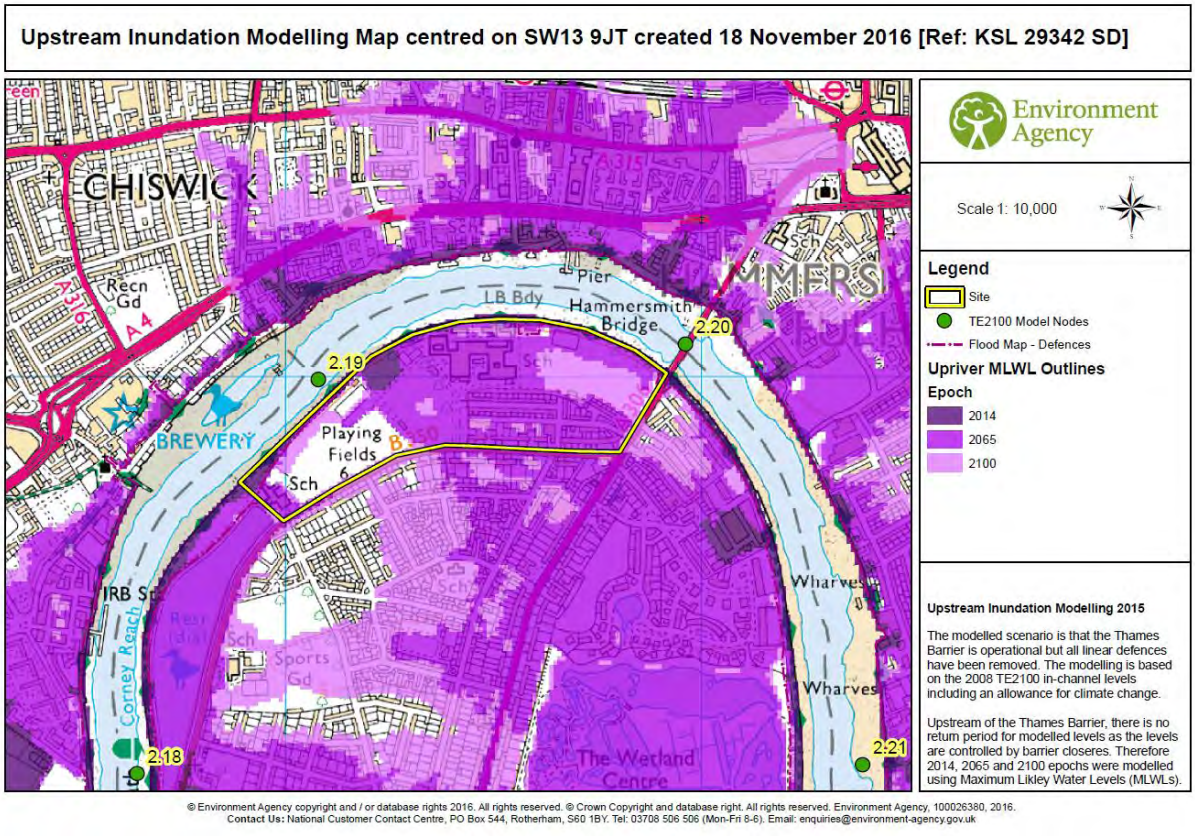

Figure 13: EA Modelled Upstream Inundation Model (Source: EA)

	National Grid Reference		Modelled levels in mAODN		
Point	Easting	Northing	2014	2065	2100
1	521916	177745	5.01	5.63	5.92
2	522018	177686	Nil return	5.26	5.91
3	522009	177835	Nil return	Nil return	5.92
4	522260	177801	Nil return	Nil return	5.65
5	522209	177947	Nil return	5.63	5.91
6	522227	178034	4.99	5.63	5.91
7	522343	177845	Nil return	5.17	5.59
8	522418	177851	Nil return	5.12	5.59
9	522423	177894	Nil return	5.21	5.59
10	522335	177966	Nil return	5.60	5.86
11	522379	178036	Nil return	5.59	5.85
12	522458	178115	Nil return	Nil return	5.88
13	522468	178037	Nil return	5.27	5.60
14	522471	177905	Nil return	4.68	5.59
15	522485	177936	Nil return	4.68	5.59
16	522534	177960	Nil return	4.68	5.59
17	522587	177931	Nil return	4.68	5.59
18	522658	177894	Nil return	4.68	5.59
19	522789	177875	Nil return	4.68	5.59
20	522700	177815	Nil return	4.68	5.59
21	522877	178003	Nil return	5.62	5.91
22	522804	177954	Nil return	Nil return	5.59
23	522594	178067	Nil return	5.36	5.68
24	522588	177991	Nil return	5.31	5.59
25	522425	177938	Nil return	5.35	5.60

Table 8: EA inundation data (Source: EA)

Site Level Upstream Inundation Analysis

6.40 Nodes 10, 11, 12 and 13 would be considered most representative of flood levels at the location of the existing school buildings and the proposed new buildings. In the EA Upstream Inundation Model data provided, all four nodes recorded values of Nil Return for the 2014 epoch. Node 10 provides the greatest flood level for the 2065 epoch, with a level of 5.60mAOD, while Node 12 provides the greatest flood level for the 2100 epoch, with a modelled level of 5.88mAOD.

6.41 Nodes 8, 9 and 25 would be considered most representative of flood levels at the location of the proposed residential blocks towards the west end of Lillian Road and Glentham Road. All three nodes recorded values of Nil Return for the 2014 epoch. Node 25 provides the greatest flood levels for both the 2065 and 2100 epochs, with modelled levels of 5.35mAOD and 5.6mAOD respectively.

6.42 The remainder of the affected area for all three epochs would be considered Water Compatible or floodable assets, as they are used as playing fields.

Detailed Level Upstream Inundation Model Analysis

6.43 Figure 14 below summarises the potential flood depths for the EA modelled upstream inundation extents across the site, based on topographic levels at various affected areas.

6.44 It can be identified from Figure 14 that the **location of the existing school buildings (and proposed new buildings)** could experience a **potential maximum flood depth** of **0.72m** for the **2065** epoch upstream inundation event, and a **potential maximum flood depth** of **1m** for the **2100** epoch upstream inundation event.

6.45 It can be identified from Figure 14 that the **location of the proposed residential blocks** at the west end of Lillian Road and Glentham Road could experience a **potential maximum flood depth** of **0.5m** for the **2065** epoch upstream inundation event, and a **potential maximum flood depth** of **0.75m** for the **2100** epoch upstream inundation event.

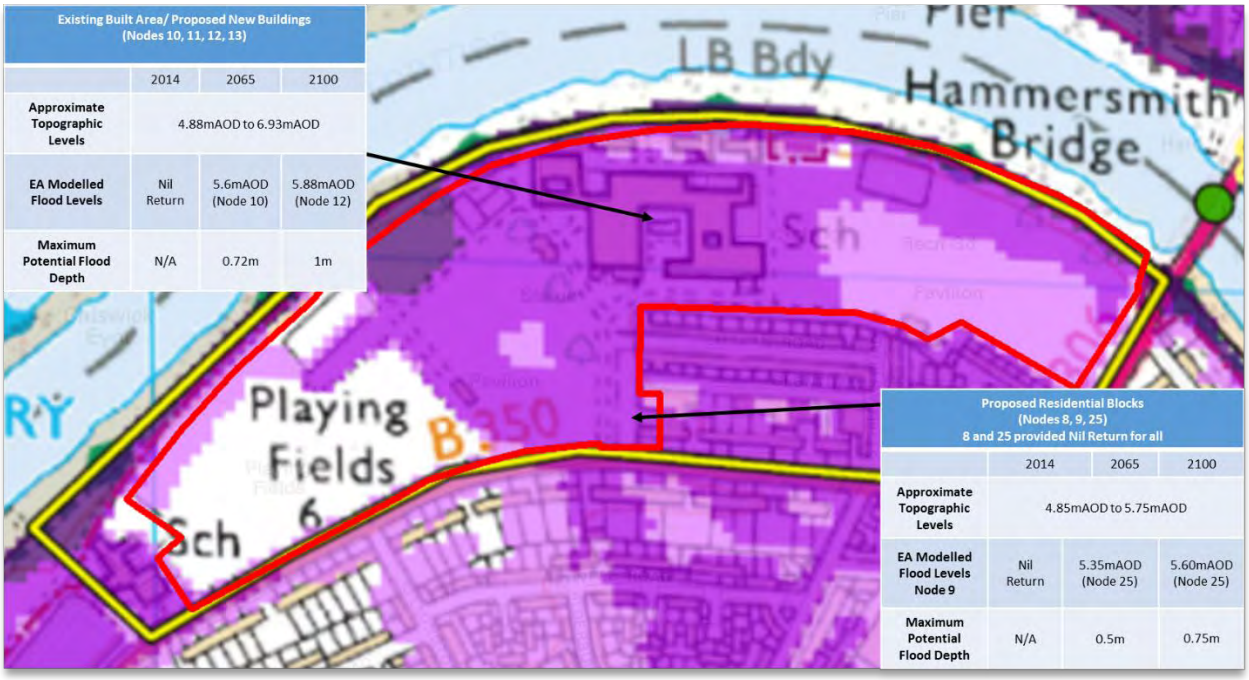

Figure 14: Development specific upstream inundation model analysis

Residential Accommodation Block Level Upstream Inundation Analysis

6.46 The lower ground floor of Block A is set at 3.22mAOD. The lower ground floor of Block B is set at 2.90mAOD and the lower ground floor of Block C is set at 4.05mAOD.

6.47 As such, comparisons between the EA upstream inundation model level for the 2100 epoch at the site of the proposed residential blocks (5.60mAOD) and the internal floor levels of the lower ground floor for each block; indicates a potential **maximum flood depth of 2.38m** at the **lower ground floor** of **Block A**, **2.7m** at the **lower ground floor** of **Block B**, and **1.55m** at the lower ground floor of **Block C.**

6.48 A summary of upstream inundation model flood depths at the lower ground floors of the accommodation blocks is provided in *Figure 15.*

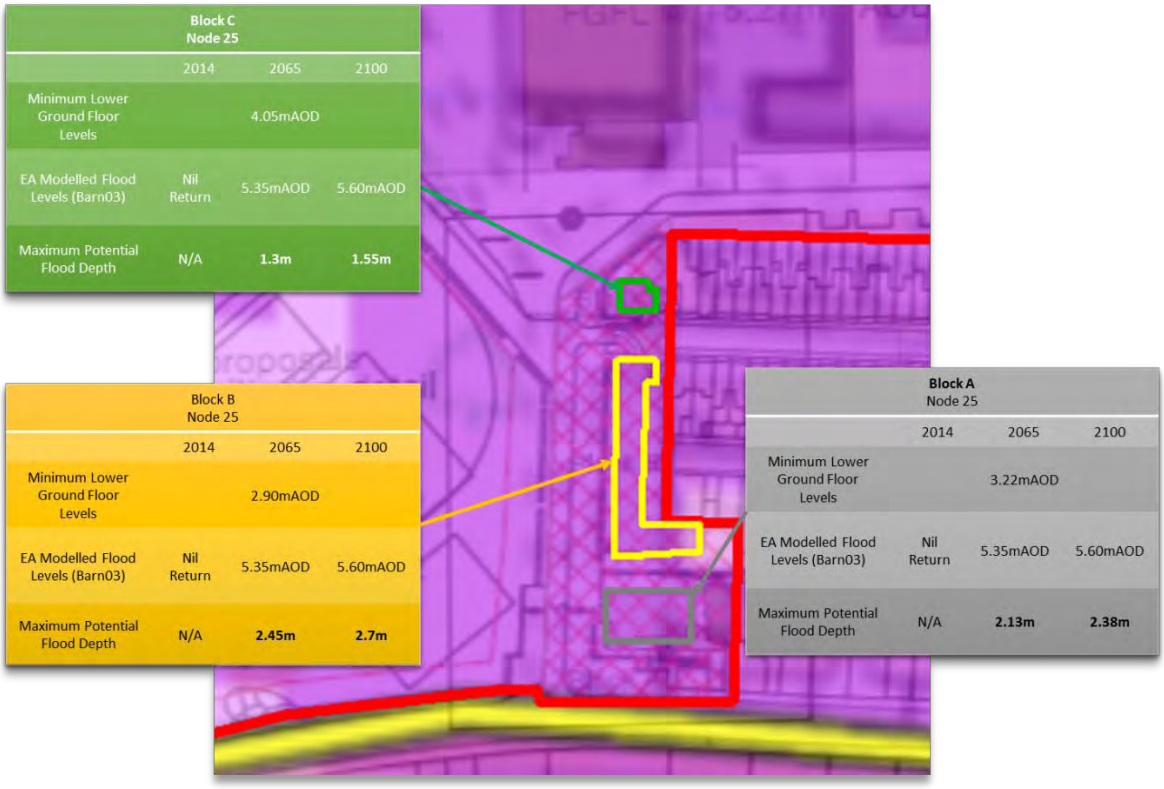

Figure 15: Maximum potential flood depths at the lower ground floor of the proposed residential blocks for the upstream inundation scenarios.

6.49 The upstream inundation model flood extents are based on the Thames Barrier being operational but all linear defences having been removed. This scenario is unlikely and as such **the risk posed to the development from upstream inundation is deemed to be relatively low.**

7. London Borough of Richmond SFRA Development Control Recommendations

7.1 The London Borough of Richmond upon Thames published a new Strategic Flood Risk Assessment (SFRA) in March 2016, which takes into account the new climate change data provided by the Environment Agency, and as such there are several new policies and development control recommendations that the proposed development must accommodate.

7.2 The proposed development site is primarily located within Flood Zone 3, and is defended to the 1:1000 year standard by defences such as the Thames Barrier. As such, there is a residual risk of defence breach/ failure to the site.

7.3 Analysis of the EA data and the Breach map published in the Richmond SFRA (2016) has identified the site to have a "Moderate" and "Significant" breach hazard rating. Specific analysis of the various developments within the design, with focus to the residential blocks demonstrates that the residential blocks according to the SFRA, are located in a Moderate breach hazard rating.

7.4 Therefore, there are requirements that the development must meet due to it being located within this hazard rating location, set out in *7.4.6 Spatial Planning and Development Control Recommendations* of the Richmond SFRA, which is reproduced in *Appendix B* and are summarised below:

- Ground floor levels:
  - ground floor levels should be situated above the Thames 2100 Year 2100 tidal flood level;
- Site Access and Egress:
  - for residential property, dry access is to be provided above the year 2100 tidal flood level. For non-residential property, access must be 'safe';
  - a dedicated 'safe haven' should be provided above the year 2100 tidal flood level to enable rapid escape in the event of a defence breach;
- Basements:
  - new basements must be restricted to Less Vulnerable/ Water Compatible uses only;
  - more vulnerable uses will only be considered if a site-specific FRA can demonstrate the risk to life from breach events can be managed;
  - must have internal access that is above the 2100 tidal flood level, assuming a defence breach,
  - flood resilient designs to be adopted.
- Site runoff:
  - implement SuDS to ensure that runoff from the development is not increased as a minimum. Reduction should be sought to achieve greenfield runoff rates.

- **Buffer Zone**:
  - No development to take place within 16m of the tidal River Thames.
    - Advice must be sought from the Environment Agency

8. Flood Risk Management Measures

8.1 The existing site is located in Flood Zone 3 (High Risk of flooding as defined in the NPPF) according to the EA Flood Map for Planning, but is however defended to the 1:1000 year standard and shall remain so until at least 2100. As such, the site is at risk of flooding from a breach of the Thames defences. In line with the Richmond SFRA (2016), the proposed development will require flood mitigation measures.

8.2 The proposed development is for the redevelopment of St Paul's School, Lonsdale Road, Barnes, London, SW13 9JT. It is understood that the redevelopment will include the demolition of several existing school buildings on site, and the construction of new buildings in their place, along with the construction of residential accommodation blocks. It is further understood that the lower ground floor of accommodation blocks A and C will be used for residential uses (sleeping accommodation in the former), and the lower ground floor of Block B will be used for parking facilities and less vulnerable uses.

8.3 As such the following mitigation measures are recommended for the proposed residential blocks;

- It is recommended that the upper ground floor of the proposed residential accommodation blocks A, B and C be set no lower than 5.63mAOD (600mm above the modelled breach level for the 2100 epoch) as they are to be used for sleeping accommodation;
  - It is understood that the upper ground floor of Block A will be set at 6.220mAOD, Block B will be at 5.735mAOD, and Block C will be 6.660mAOD and as such all **upper ground floors will be at least 600mm above the modelled breach flood level** *(Tables 7 and 9)*;

	Block A	Block B	Block C
Upper Ground Floor Level (mAOD)	6.22mAOD	5.735mAOD	6.66mAOD
EA Modelled Breach Flood Level (mAOD)	5.03mAOD	5.03mAOD	5.03mAOD
Elevation of Upper Ground Floor Above Flood Level (m)	1.19m	0.705m	1.63m

Table 9: Comparison between upper ground floor of proposed residential blocks and modelled breach flood levels

- It is understood that the client has previously submitted plans to include a **perimeter wall** around the proposed **Block A** to act as a mitigation measure to protect the lower ground

floor residential usage, to which the Environment Agency did not object at the time (*see Appendix C)*. It is understood that the client has previously submitted plans to construct the perimeter wall to a height of 5.743mAOD. As such, the crest of the wall shall be set 713mm above the 2100 breach flood level. It is recommended that the wall incorporate a stoop/ step up-step-down threshold to allow access and egress to and from the building. A schematic of how a step-up/step-down system be implemented is provided in *Figure 16*.

- In line with the LB of Richmond SFRA (2016), new basement developments must be restricted to less vulnerable/ water compatible uses unless it can be demonstrated that the risk to life from the breach can be managed (*see Appendix B)*, which the perimeter wall should do;
- The proposed lower ground floor of Block B is to be used for car parking, store and laundry. Despite the block being located in the breach, these uses within the residential block should be acceptable. Client has stipulated that they are accepting of sacrificial use of these areas;
- Block C is for a more vulnerable use outside the modelled breach extent;

- It is recommended that internal stair access to and from lower floors for all of the proposed residential blocks, are to be maintained for the lifetime of the development, to provide access and egress routes in the event of a breach;
  - Internal access must be above the 2100 epoch breach level. Recommended to have access for the proposed accommodation blocks set at 5.63mAOD (600mm above the 2100 breach level at Node 9). Plans provided suggests the upper ground floors will be at a greater elevation than this;
- It is understood that entrance points into the residential units at the lower ground floor are part of the design, as such it is recommended that these thresholds are of flood resilient design;
- It is recommended that a dedicated 'safe haven' be identified within each residential block, above the modelled breach levels, accessed via the internal stairs;

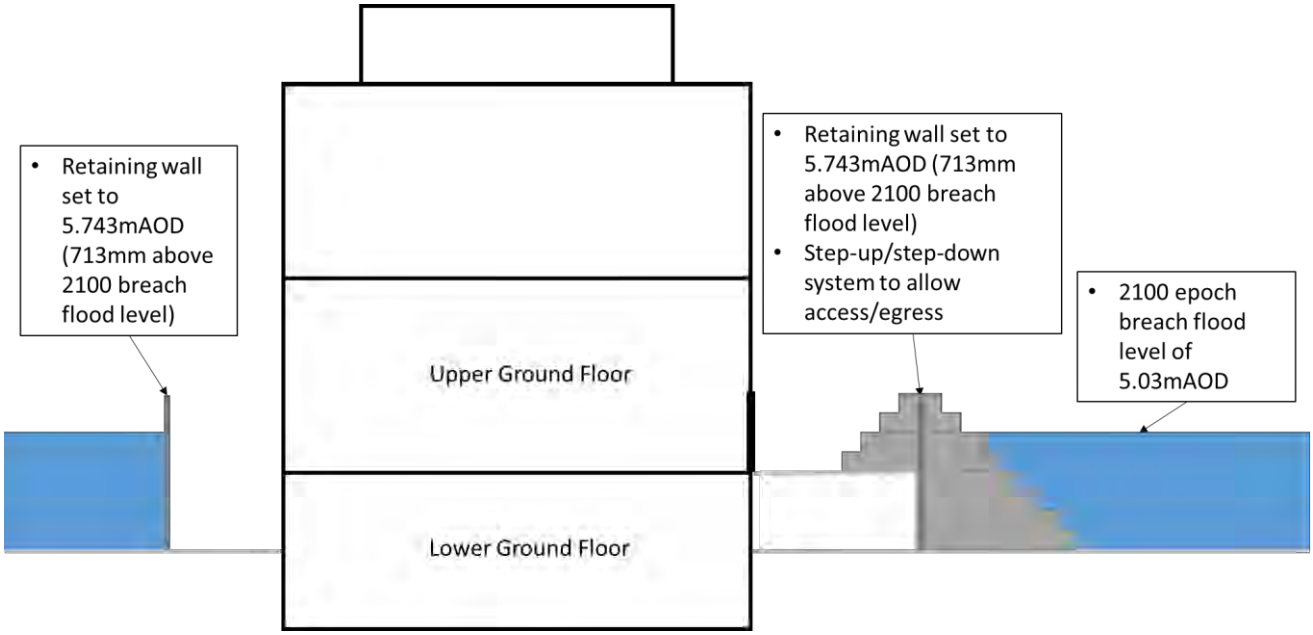

Figure 16: A perimeter wall with a step-up/step-down system would be implemented around accommodation Block A

8.4 The mitigation measures proposed for the residential blocks, to comply with the Richmond SFRA (2016) are summarised in *Table 10* and *Figure 17* below.

	SFRA Development Control	Block A (within breach)	Block B (within breach)	Block C (outside breach)
Proposed Mitigation Measures	Ground Floor Levels	Upper ground floor will be 1.19m above 2100 breach flood level	Upper ground floor will be 0.705m above 2100 breach flood level	Upper ground floor will be 1.63m above 2100 breach flood level
	Site Access/ Egress	Internal stairs to floors above 2100 breach flood level	Internal stairs to floors above 2100 breach flood level	Internal stairs to floors above 2100 breach flood level
	Basements/ Lower Ground Floor	Proposed Use: Residential Risk to life managed/ mitigation: Retaining wall around perimeter set to 5.743mAOD (713mm above 2100 breach flood level) which will include step-up/step-down system to allow access/egress from building	Proposed Use: Car Park, Storage, Laundry Deemed appropriate. Mitigation not needed: Client has stipulated that they are accepting of sacrificial use of these areas.	Proposed Use: Residential Deemed appropriate. Mitigation not needed: Outside modelled breach extent
Comply with Policy?		**Yes**	**Yes**	**Yes**

Table 10: Summary of proposed mitigation measures to comply with development control recommendations in the Richmond SFRA (2016). Ground Floor Levels based on plans in previous FRA provided by client.

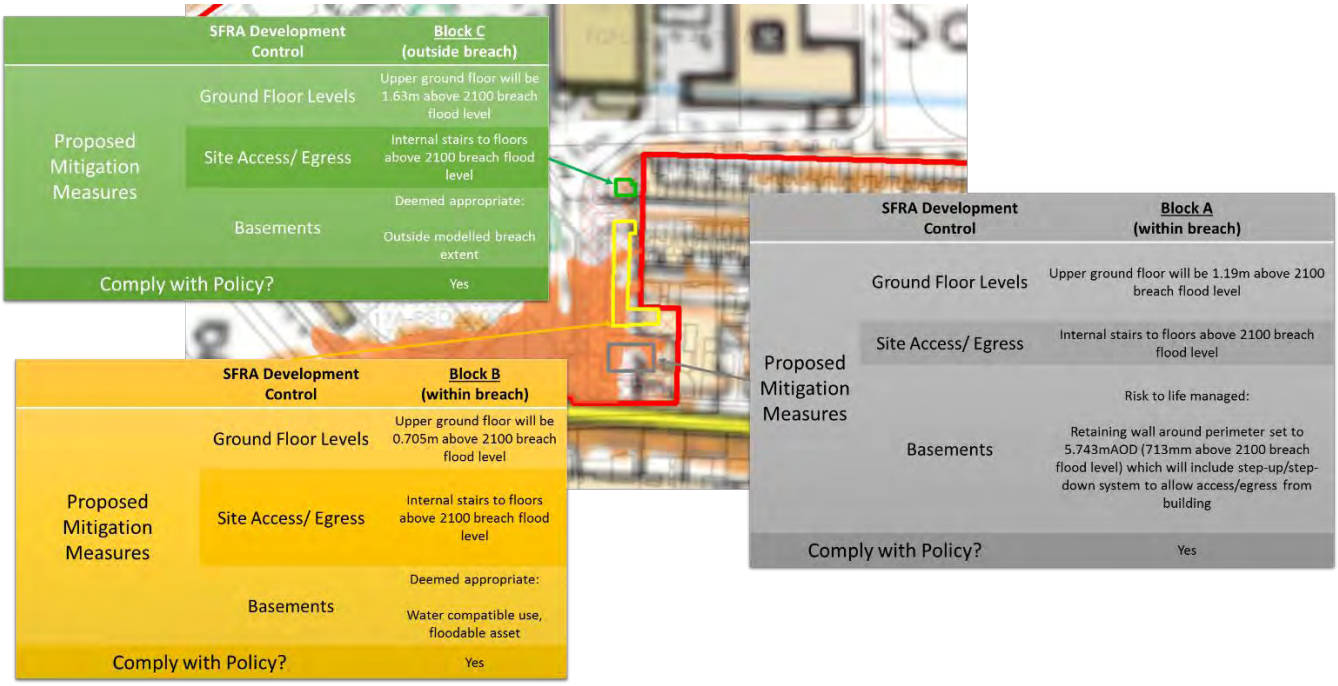

Figure 17: Summary of proposed mitigation measures to comply with development control recommendations in the Richmond SFRA (2016). Ground Floor Levels based on plans in previous FRA provided by client. Orange outline represents EA Modelled Breach Extent provided to Ambiental.

8.5 The following mitigation measures are recommended across the whole development site:

- Bringing down electrical services from ceilings, where possible;
- Solid, impermeable (concrete) walls and floors at basement level, where possible;
- Installation of a pumped device to the basement level in case of any intrusion (where appropriate);
- Raised wiring and power outlets on lower ground and ground level;
- Ensure any basement level windows, and doors are of a flood proof design to ensure flood water cannot enter the properties;
- All plumbing insulation to be of closed-cell design;
- Non-return valves on any new sewer connections to prevent back-flow;
- Sign up to the EA Flood Warning Service.

8.6 It is understood that the client has previously agreed a Surface Water Drainage Strategy with the Council.

8.7 The client is aware that should the proposed development encroach within 16m of the River Thames, they must apply for an environmental activity permit and liaise with the Environment Agency. To find out more, please us the below link:

https://www.gov.uk/guidance/flood-risk-activities-environmental-permits

Access / Egress

8.8 The River Thames abuts the curved north boundary of the development site. The River Thames has been identified as a main river by the EA.

8.9 The EA data has shown the site is currently protected by defences to the 1:1000 year standard and would remain so up to at least 2100.

8.10 The EA data provided for this assessment has demonstrated that the majority of the School grounds are not located within an area at risk of flooding following a breach of the Thames defences. However, the locations of the proposed residential blocks B and C are deemed to be within the area of risk following a breach. As such, and considering the proposed development incorporates the construction of lower ground floors below the EA modelled 2100 breach flood level, a route of safe and dry escape must be identified.

8.11 A previous FRA supplied to Ambiental by the client included plans for the proposed residential Blocks A, B and C. These plans indicate that internal stairs will be maintained between the lower ground floors (below flood level) to the upper ground floors of their respective buildings. The plans provided to Ambiental demonstrate that the internal Finished Floor Levels of the upper ground floors of all three proposed blocks (A, B and C) are at least 600mm above the modelled 2100 breach flood level (*Paragraph 8.3)*. As such, there would be safe and dry access/ egress to and from the lower floors of the proposed development following a breach event.

8.12 It has been stipulated by the client that St Paul's School currently has a formal flood evacuation plan in place, that was last reviewed by the council on the 1st November 2016.

8.13 As such, it is advised that the school continue to use this existing evacuation plan.

8.14 If flooding has already occurred prior to evacuation, it is advised to remain in the property and await instruction from the emergency services or until it is deemed safe to evacuate. Residents should move via internal stairwells to the upper floors of the property so as to be located within an area of safe refuge. No evacuation should be sought if flood depths exceed 25cm, evacuation should only be sought with the assistance of the emergency services in these circumstances.

8.15 As the site is located within a flood warning service area (*Figure* 18) it is recommended the site owner and occupants sign up to the EA flood warning service if they have not done so already in order to provide betterment to the site. It is recommended that all new site owners and occupants are made aware are of the potential flood risk to the site and that they sign up to the EA flood warning service.

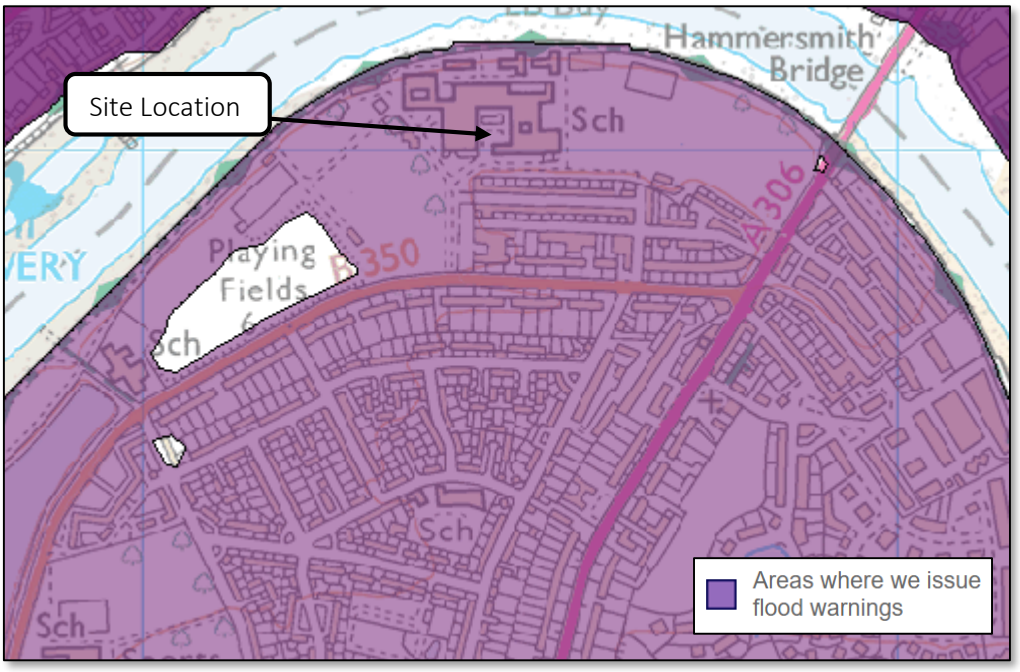

Figure 18: EA Flood Warning Area (Source: EA Online)

8.16 The EA operates a 24-hour telephone service on 0345 988 1188 that provides frequently updated flood warnings and associated floodplain information. Further information can be found on www.environment-agency.gov.uk/floodline. Floodline Warnings Direct is a free service operated by the EA that provides flood warnings direct to occupants by telephone, mobile phone, fax or pager.

9. Off Site Impacts

Impact to Flood Risk Elsewhere

9.1 The site is located in Flood Zone 3, (tidal flood risk) and under the NPPF:

> *"unless the development is located in an area which is subject to tidal flooding and which serves no conveyance function, land raising must be accompanied by compensatory provision of flood storage either on- or off-site"*

as such there is no requirement for compensatory flood storage.

Generation of Runoff

9.2 The existing site contains a number of school buildings and associated playing fields. It is understood that the proposed redevelopment includes the demolition of most of the existing buildings on site, and the refurbishment of the existing sports hall, the construction of a maximum of 13,159m^2 footprint of education facilities which will include classrooms, a dining hall, kitchen, library, chapel and ancillary boarding accommodation. It is further understood that the proposed development includes the reconfiguration of car parking facilities, and the construction of 1,084m^2 footprint of buildings (3/4 storeys including basement and attics) to provide 33 residential units.

9.3 A previous Flood Risk Assessment for the proposed redevelopment of St Paul's School, provided by the Client, and undertaken by Crane Environmental in 2008, stipulates that as existing, 42,874m^2 (41% of planning application boundary area) of the site is impermeable, while post development, this will increase slightly to 43,636m^2 (42% of planning application boundary area).

9.4 It is understood that soakaways are currently utilised across the site to attenuate runoff. It is recommended that further soakaways are implemented across the site to provide a betterment to existing runoff conditions.

9.5 Given the size of the proposed development, a detailed Surface Water Drainage Strategy is recommended, in order to adhere to the London Plan and provide a betterment to the existing runoff conditions.

9.6 The London Plan states that Sustainable Urban Drainage Strategies (SuDS) should be utilised unless there are practical reasons for not doing so.

10. Conclusion

10.1 Ambiental Technical Solutions Limited has been appointed by Michael Barclay Partnership LLP, to undertake a National Planning Policy Framework (NPPF) compliant Flood Risk Assessment (FRA) for the ongoing redevelopment of St Paul's School, Lonsdale Road, Barnes, London, SW13 9JT.

10.2 It is understood that the proposed redevelopment includes the demolition of most of the existing buildings on site, and the refurbishment of the existing sports hall, the construction of a maximum of 13,159m^2 built footprint of education facilities which will include classrooms, a dining hall, kitchen, library, chapel and ancillary residential accommodation. It is further understood that the proposed development includes the reconfiguration of car parking facilities, and the construction of 1,084m^2 built footprint of buildings (3/4 storeys including lower ground floor and attics) to provide 33 residential units.

10.3 With reference to the NPPF and the Environment Agency (EA) standing advice on development and flood risk, as well as the low detail, national-scale flood mapping created on behalf of the EA, the proposed site is located within Flood Zones 1, 2 and primarily 3, and therefore in line with a conservative approach, the site will be considered as within Flood Zone 3 (High Risk; >0.5% chance of annual tidal flooding) and is considered to be a 'More Vulnerable' development.

10.4 The site currently benefits from the presence of defences (including the Thames Barrier) which act to protect to the 1:1000 year standard. Analysis of the EA defence data has shown the site will remain protected to the 1:1000 year level of protection until at least 2100.

10.5 Analysis of the EA data provided for this assessment has demonstrated that the site is unaffected by the modelled 2014 breach event, but would be partially affected by the 2065 and 2100 breach flood events. Residential accommodation is proposed at the site, Block A is proposed to construct a perimeter wall and step up step down entrance to mitigate breach. Block B will place residential units at the upper ground floor level and above, which is above the breach 2100 modelled flood level and Block C is located outside of the breach.

10.6 The EA have provided upstream inundation modelling which shows that if the site did not benefit from the presence of defences it would be partially affected for the 2014, 2065 and 2100 epochs, however the site benefits from the presence of defences to the 1 in 1000-year standard of protection and the scenario whereby the linear defences were removed is **very unlikely**.

10.7 As such, and given that:

a) the proposed development is located in an **existing developed area**, and includes the **replacement** of several school **buildings**, and the construction of residential blocks on the perimeter of an existing residential street;

b) the site has been shown to be **defended to the 1:1000 year standard**, and will remain so until at least 2100;

c) the site is **primarily unaffected by the modelled breach extents** for all **three epochs**, but **appropriate mitigation measures** have been recommended to **protect** more vulnerable uses, such as the lower ground flood of Block A, that are **within the breach extents**;

d) betterment can be provided by the formalisation of a **flood warning and evacuation plan**, which it is understood has already been agreed with the Council,

following the guidelines contained within the NPPF, the proposed development is considered **to be suitable** assuming appropriate mitigation (including adequate warning procedures) can be maintained for the temporary lifetime of the development.

Environment Agency

Product 4 (Detailed Flood Risk) for: St Paul's School, Lonsdale Road, London, SW13 9JT
Requested by: Thea Powell, Ambiental
Reference: KSL 29342 SD
Date: 18 November 2016

Contents

The information provided is based on the best data available as of the date of this letter.

You may feel it is appropriate to contact our office at regular intervals, to check whether any amendments/ improvements to the data for this location have been made. Should you re-contact us after a period of time, please quote the above reference in order to help us deal with your query.

This information is provided subject to the enclosed notice which you should read.

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Email: kslenquiries@environment-agency.gov.uk
Website: https://www.gov.uk/government/organisations/environment-agency

Flood Map for Planning (Rivers and Sea)

The Flood Map:

Our Flood Map shows the natural floodplain for areas at risk from river and tidal flooding. The floodplain is specifically mapped ignoring the presence and effect of defences. Although flood defences reduce the risk of flooding they cannot completely remove that risk as they may be over topped or breached during a flood event.

The Flood Map indicates areas with a 1% (0.5% in tidal areas), Annual Exceedance Probability (AEP) - the probability of a flood of a particular magnitude, or greater, occurring in any given year, and a 0.1% AEP of flooding from rivers and/or the sea in any given year. In addition, the map also shows the location of some flood defences and the areas that benefit from them.

The Flood Map is intended to act as a guide to indicate the potential risk of flooding. When producing it we use the best data available to us at the time and also take into account historic flooding and local knowledge. The Flood Map is updated on a quarterly basis to account for any amendments required. These amendments are then displayed on the internet at

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

At this Site:

The Flood Map shows that this site lies within the outline of Flood Zone 3. This zone comprises land assessed as having a 0.5% (1 in 200) or greater annual probability of tidal flooding.

Enclosed is an extract of our Flood Map which shows this information for your area.

Method of production

The Flood Map at this location has been derived using detailed modelling of the Thames Tidal Defences Study completed in 2006 by Halcrow Ltd.

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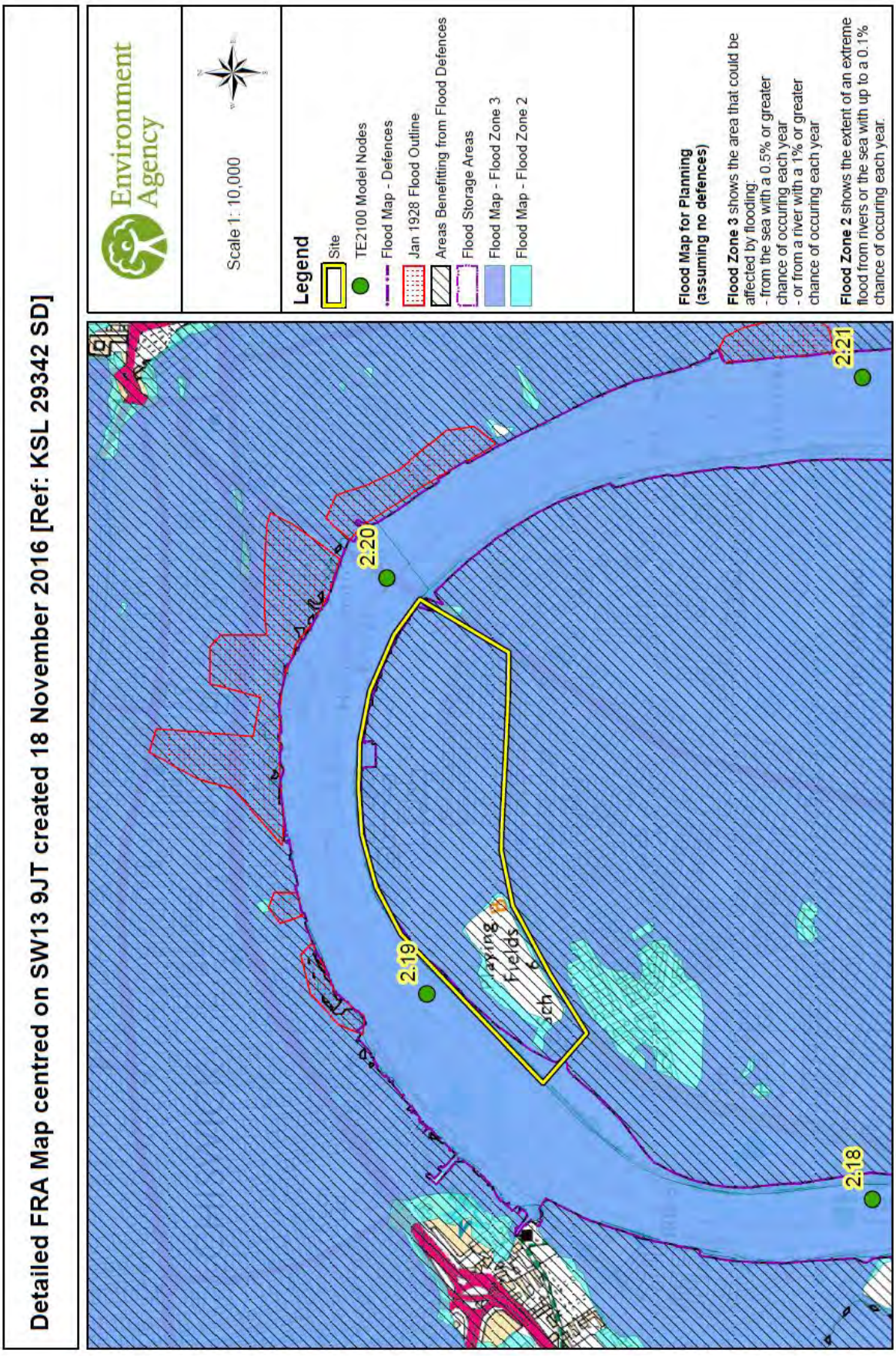

Thames Estuary 2100 (TE2100)

You have requested in-channel flood levels for the tidal river Thames. These have been taken from the Thames Estuary 2100 study completed by HR Wallingford in 2008. The modelled node closest to your site is 2.19; the locations of nearby nodes are also shown on the enclosed map.

Details about the TE2100 plan

The TE2100 plan is now live and within it are a set of levels on which the flood risk management strategy is based. The plan is the overarching flood management strategy for the Thames Estuary and therefore any development planning should be based on the same underlying data.

Details about the TE2100 in-channel levels

The TE2100 in-channel levels take into account operation of the Thames Barrier when considering future levels. The Thames Barrier requires regular maintenance and with additional closures the opportunity for maintenance will be reduced. When this happens, river levels – for which the Barrier would normally shut for the 2008 epoch – will have to be allowed through to ensure that the barrier is not shut too often. For this reason, levels upriver of the barrier will increase and the tidal walls will need to be heightened to match.

Why is there no return period for levels upriver of the barrier?

The levels upriver of the barrier are the highest levels permitted by the operation of the Thames Barrier. If levels and flows are forecast to be any higher, the Thames Barrier would shut, ensuring that the tide is blocked and the river maintained to a low level. For this reason the probability of any given water level upriver of the Barrier is controlled and therefore any associated return period becomes irrelevant. The Thames Barrier and associated defence system has a 1 in 1000 year standard which means it ensures that flood risk is managed up to an event that has a 0.1% annual probability. The probability of water levels upriver is ultimately controlled by the staff at the Thames Barrier.

For further information about the Thames Barrier please visit our website at:

https://www.gov.uk/the-thames-barrier

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TE2100 2008 levels:

Levels downriver of the Thames Barrier are 0.1% AEP (1 in 1000) and levels upriver are the highest levels permitted by the Thames Barrier, described as the Maximum Likely Water Levels (MLWLs). The defence levels (left defence, right defence) are the minimum levels to which the defences should be built.

Location	Node	Easting	Northing	Extreme water level (m)	Left defence (m)	Right defence (m)	Allow for future defence raising to a level of...	
							Left Bank (m)	Right Bank (m)
Brentford	2.18	521644	177047	5.04	5.54	5.94	6.40	6.40
	2.18a	521776	177707	5.04	5.54	5.94	6.40	6.40
Barnes	2.19	522080	177994	5.03	5.54	5.94	6.40	6.40
	2.20	522963	178079	5.01	5.54	5.94	6.40	6.40
	2.21	523388	177068	4.96	5.54	5.94	6.40	6.40

TE2100 climate change levels:

The water levels in west London are lower than the current day extreme levels because they do not take into account extreme fluvial events; they are tidal only levels.

				2065 to 2100		2100	
Location	Node	Easting	Northing	Design water level	Defence level (both banks)	Design water level	Defence level (both banks)
Brentford	2.18	521644	177047	5.50	6.25	5.94	6.70
	2.18a	521776	177707	5.50	5.95	5.94	6.40
Barnes	2.19	522080	177994	5.49	5.95	5.93	6.40
	2.20	522963	178079	5.48	5.95	5.92	6.40
	2.21	523388	177068	5.45	5.95	5.89	6.40

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Thames Tidal Breach Modelling

The table below displays site-specific modelled flood levels at your site. These have been taken from the Thames Tidal Breach Modelling Study 2015 completed by CH2M HILL in March 2015. The exact location of the given site-specific levels and the extent of the breach are shown on the enclosed map.

This modelling simulates tidal breaches along the Thames from Teddington to the Mar Dyke and River Darent. A series of 113 tidal models were developed for the Environment Agency at pre-determined breach locations. These were chosen using a risk-based approach by examining critical locations based on low floodplain topography. For hard and composite defences breaches are set at 20 m wide; for soft defences, breaches are 50 m wide. In both cases, the defence breach scour distance was assumed to extend into the floodplain by the same distance as the breach width.

Based on the 2008 TE2100 in-channel levels, the 0.5% (1 in 200 year) and 0.1% (1 in 1000 year) annual probability of exceedance tidal events were modelled for all breach locations downriver of the Thames Barrier. These were modelled for the 2014 year epoch, as well as a 2065 and 2100 epoch which include allowances for climate change.

For breaches upriver of the Thames Barrier, there is no return period for modelled levels as the levels are controlled by barrier closures. The levels used are referred to as Maximum Likely Water Levels (MLWLs). Therefore 2014, 2065 and 2100 epochs were modelled on that basis.

The modelled levels shown assume that the Thames defences have been breached at locations Barn01, Barn02, Barn03 and Barn04. The most critical breaches are Barn03 (NGR TQ2169976989) and Barn04 (NGR TQ2311077710).

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Environment Agency

			Barn03			Barn04		
	National Grid Reference		Modelled levels in mAODN			Modelled levels in mAODN		
Node	Easting	Northing	2014	2065	2100	2014	2065	2100
1	521916	177745	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
2	522018	177686	Nil return	5.61	5.75	Nil return	Nil return	Nil return
3	522009	177835	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
4	522260	177801	Nil return	5.50	5.60	Nil return	Nil return	Nil return
5	522209	177947	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
6	522227	178034	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
7	522343	177845	Nil return	4.94	5.05	Nil return	Nil return	Nil return
8	522418	177851	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
9	522423	177894	Nil return	Nil return	5.03	Nil return	Nil return	Nil return
10	522335	177966	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
11	522379	178036	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
12	522458	178115	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
13	522468	178037	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
14	522471	177905	Nil return	Nil return	4.61	Nil return	Nil return	Nil return
15	522485	177936	Nil return	Nil return	3.99	Nil return	Nil return	4.11
16	522534	177960	Nil return	Nil return	3.99	Nil return	Nil return	4.11
17	522587	177931	Nil return	Nil return	3.99	Nil return	Nil return	4.11
18	522658	177894	Nil return	Nil return	3.99	Nil return	Nil return	4.11
19	522789	177875	Nil return	Nil return	3.99	Nil return	Nil return	4.11
20	522700	177815	Nil return	4.41	4.60	Nil return	Nil return	4.65
21	522877	178003	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
22	522804	177954	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
23	522594	178067	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
24	522588	177991	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return
25	522425	177938	Nil return	Nil return	Nil return	Nil return	Nil return	Nil return

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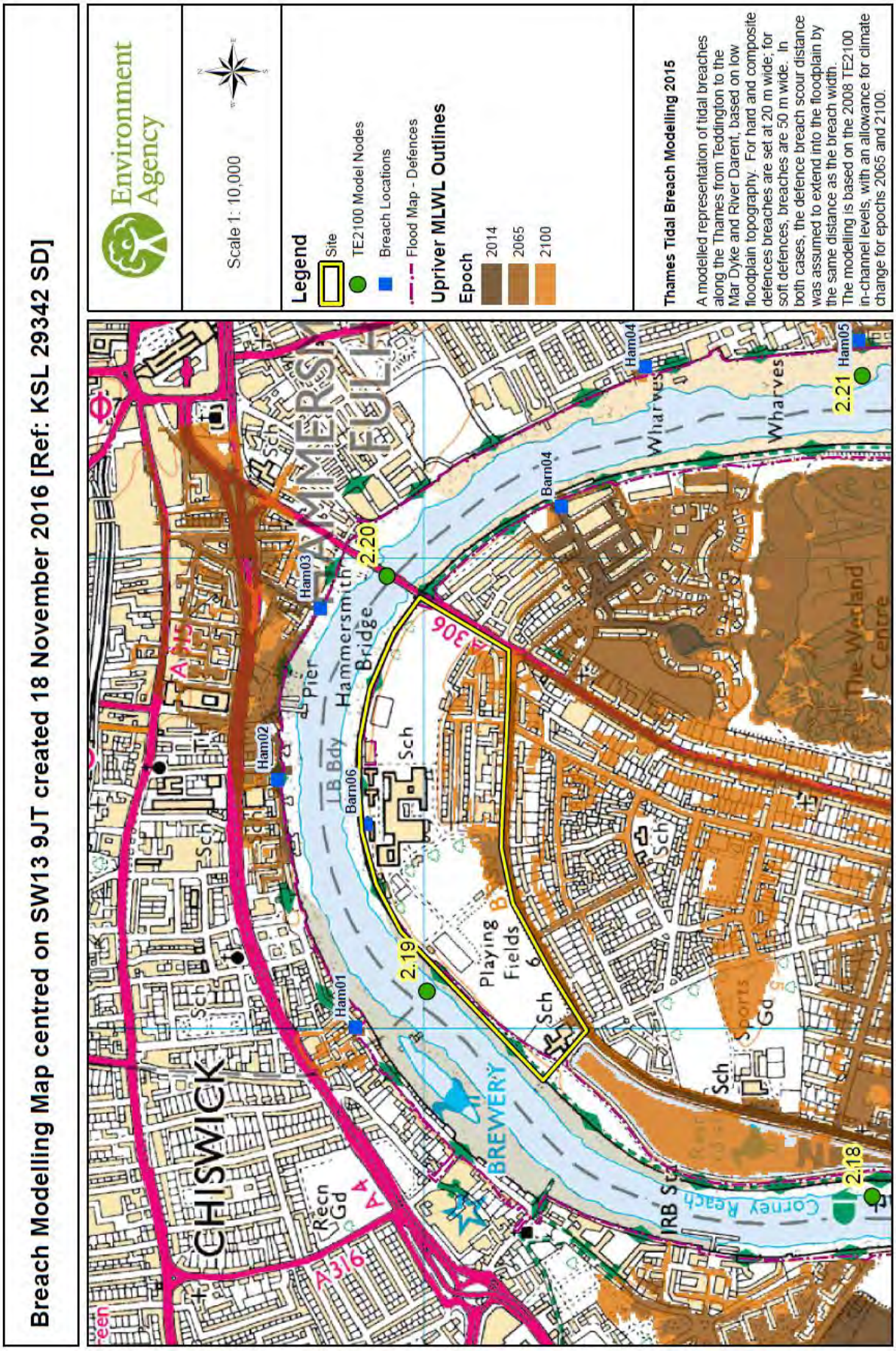

Thames Tidal Upstream Inundation Modelling

The enclosed map shows results for the Thames Tidal Upstream Inundation Modelling Study 2015 completed by CH2M HILL in March 2015.

Upriver of the Thames Barrier, there is no return period for modelled levels as the levels are controlled by barrier closures. Therefore 2014, 2065 and 2100 epochs were modelled on that basis.

Using the domains updated as part of the Thames Tidal Breach Modelling Study 2015 completed by CH2M HILL in March 2015, the project generated outputs for water depths, velocity, levels and hazard. However the scenario modelled is that the Thames Barrier is operational but all linear defences have been removed. It uses the TE2100 in-channel levels calculated in 2008 and only provides data for embayments upriver of the Thames Barrier.

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	National Grid Reference		Modelled levels in mAODN		
Point	Easting	Northing	2014	2065	2100
1	521916	177745	5.01	5.63	5.92
2	522018	177686	Nil return	5.26	5.91
3	522009	177835	Nil return	Nil return	5.92
4	522260	177801	Nil return	Nil return	5.65
5	522209	177947	Nil return	5.63	5.91
6	522227	178034	4.99	5.63	5.91
7	522343	177845	Nil return	5.17	5.59
8	522418	177851	Nil return	5.12	5.59
9	522423	177894	Nil return	5.21	5.59
10	522335	177966	Nil return	5.60	5.86
11	522379	178036	Nil return	5.59	5.85
12	522458	178115	Nil return	Nil return	5.88
13	522468	178037	Nil return	5.27	5.60
14	522471	177905	Nil return	4.68	5.59
15	522485	177936	Nil return	4.68	5.59
16	522534	177960	Nil return	4.68	5.59
17	522587	177931	Nil return	4.68	5.59
18	522658	177894	Nil return	4.68	5.59
19	522789	177875	Nil return	4.68	5.59
20	522700	177815	Nil return	4.68	5.59
21	522877	178003	Nil return	5.62	5.91
22	522804	177954	Nil return	Nil return	5.59
23	522594	178067	Nil return	5.36	5.68
24	522588	177991	Nil return	5.31	5.59
25	522425	177938	Nil return	5.35	5.60

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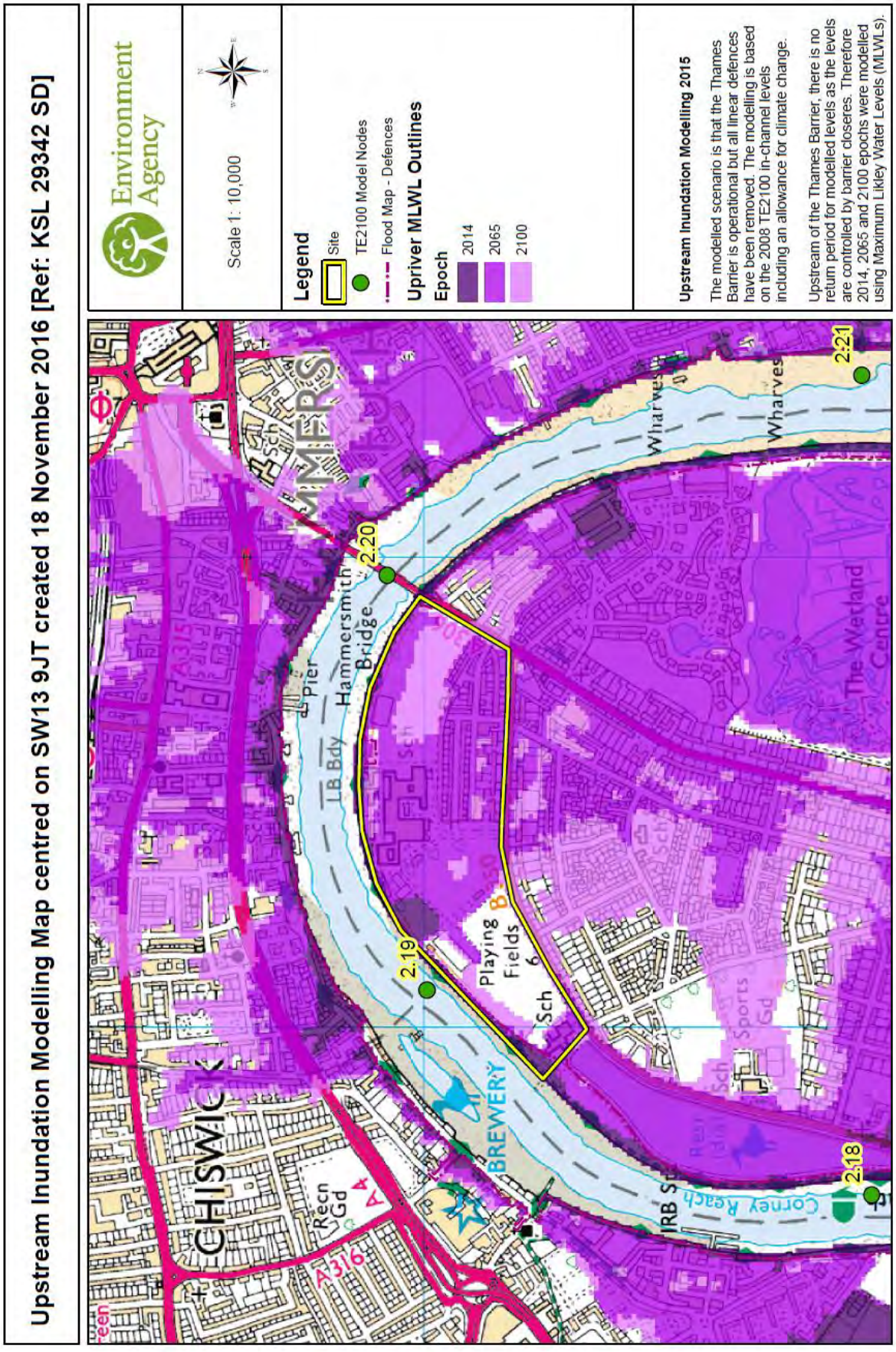

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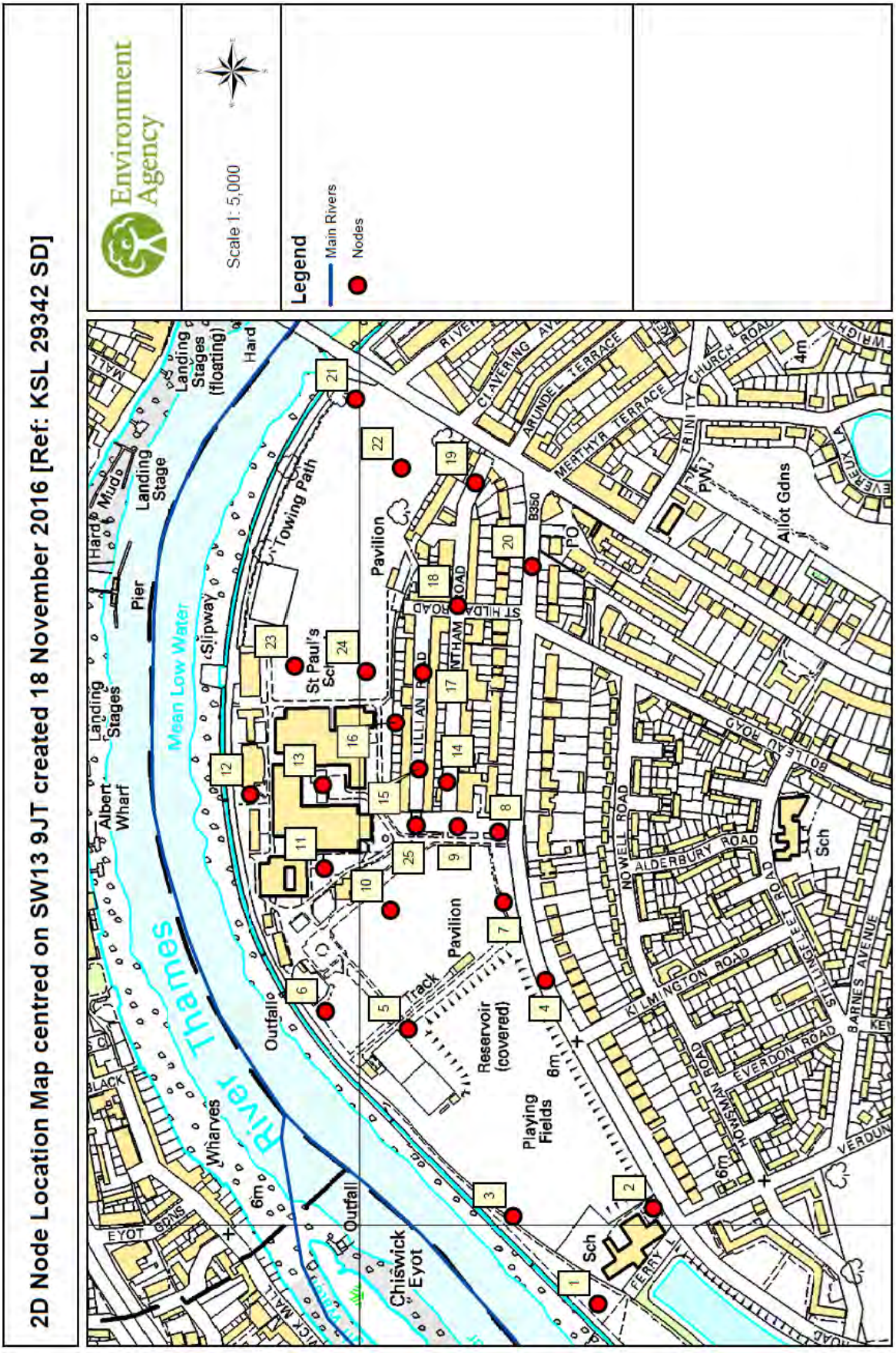

Defence Details

The design standard of protection of the flood defences in this area of the Thames is 0.1% AEP; they are designed to defend London up to a 1 in 1000 year **tidal** flood event. The defences are all raised, man-made and privately owned. It is the riparian owners' responsibility to ensure that they are maintained to a crest level of 5.94m AODN (the Statutory Flood Defence Level in this reach of the Thames). We inspect them twice a year to ensure that they remain fit for purpose. The current condition grade for defences in the area is 2 (good), on a scale of 1 (very good) to 5 (very poor). For more information on your rights and responsibilities as a riparian owner, please see our document 'Living on the edge' found on our website at:

https://www.gov.uk/government/publications/riverside-ownership-rights-and-responsibilities

There are no planned improvements in this area. Please see the 'Thames Estuary 2100' document on our website for the short, medium and long term Flood Risk Management strategy for London:

https://www.gov.uk/government/publications/flooding-thames-estuary-2100-te2100-plan

Areas Benefiting from Flood Defences

This site is within an area benefiting from flood defences, as shown on the enclosed extract of our Flood Map. Areas benefiting from flood defences are defined as those areas which benefit from formal flood defences specifically in the event of flooding from rivers with a 1% (1 in 100) chance in any given year, or flooding from the sea with a 0.5% (1 in 200) chance in any given year.

If the defences were not there, these areas would be flooded. An area of land may benefit from the presence of a flood defence even if the defence has overtopped, if the presence of the defence means that the flood water does not extend as far as it would if the defence were not there.

Orchard House, Endeavour Park, London Road, Addington, West Malling, Kent, ME19 5SH.
Customer services line: 01732 223 202
Email: kslenquiries@environment-agency.gov.uk
Website: https://www.gov.uk/government/organisations/environment-agency

Recorded Flood Events Data

We hold records of historic flood events from rivers and the sea. Information on the floods that may have affected the area local to your site is provided below and in the enclosed map (if relevant).

Flood Event Data

We do not hold records of historic flood events from rivers and/or the sea affecting the area local to this site. However, please be aware that this does not necessarily mean that flooding has not occurred here in the past, as our records are not comprehensive.

Due to the fact that our records are not comprehensive, we would advise that you make further enquiries locally with specific reference to flooding at this location. You should consider contacting the relevant Local Planning Authority and/or water/sewerage undertaker for the area.

We map flooding to land, not individual properties. Our historic flood event record outlines are an indication of the geographical extent of an observed flood event. Our historic flood event outlines do not give any indication of flood levels for individual properties. They also do not imply that any property within the outline has flooded internally.

Please be aware that flooding can come from different sources. Examples of these are:

- from rivers or the sea;
- surface water (i.e. rainwater flowing over or accumulating on the ground before it is able to enter rivers or the drainage system);
- overflowing or backing up of sewer or drainage systems which have been overwhelmed,
- groundwater rising up from underground aquifers

Currently the Environment Agency can only supply flood risk data relating to the chance of flooding from rivers or the sea. However you should be aware that in recent years, there has been an increase in flood damage caused by surface water flooding and drainage systems that have been overwhelmed.

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Additional Information

Use of Environment Agency Information for Flood Risk/Flood Consequence Assessments

Important

If you have requested this information to help inform a development proposal, then we recommend that you undertake a formal pre-application enquiry using the form available from our website:-

https://www.gov.uk/government/publications/pre-planning-application-enquiry-form-preliminary-opinion

Depending on the enquiry, we may also provide advice on other issues related to our responsibilities including flooding, waste, land contamination, water quality, biodiversity, navigation, pollution, water resources, foul drainage or Environmental Impact Assessment.

In **England**, you should refer to the Environment Agency's Flood Risk Standing Advice, the technical guidance to the National Planning Policy Framework and the existing PPS25 Practice Guide for information about what flood risk assessment is needed for new development in the different Flood Zones. These documents can be accessed via:

https://www.gov.uk/flood-risk-standing-advice-frsa-for-local-planning-authorities

https://www.gov.uk/government/publications/national-planning-policy-framework-technical-guidance

https://www.gov.uk/government/publications/development-and-flood-risk-practice-guide-planning-policy-statement-25

You should also consult the Strategic Flood Risk Assessment produced by your local planning authority.

You should note that:

1. Information supplied by the Environment Agency may be used to assist in producing a Flood Risk/Consequence Assessment (FRA/FCA) where one is required, but does not constitute such an assessment on its own.
2. This information covers flood risk from main rivers and the sea, and you will need to consider other potential sources of flooding, such as groundwater or overland runoff. The information produced by the local planning authority referred to above may assist here.
3. Where a planning application requires a FRA/FCA and this is not submitted or deficient, the Environment Agency may well raise an objection.
4. For more significant proposals in higher flood risk areas, we would be pleased to discuss details with you ahead of making any planning application, and you should also discuss the matter with your local planning authority.

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Environment Agency

Surface Water

We have provided two national Surface Water maps, under our Strategic Overview for flooding, to your Lead Local Flood Authority – London Borough of Richmond upon Thames – who are responsible for local flood risk (i.e. surface runoff, ground water and ordinary watercourse), which alongside their existing local information will help them in determining what best represents surface water flood risk in your area.

The London Borough of Richmond upon Thames have reviewed these and determined what it believes best represents surface water flood risk. You should therefore contact this authority so they can provide you with the most up to date information about surface water flood risk in your area.

You may also wish to consider contacting the appropriate relevant Local Planning Authority and/or water/sewerage undertaker for the area. They may be able to provide some knowledge on the risk of flooding from other sources. We are working with these organisations to improve knowledge and understanding of surface water flooding.

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Website: https://www.gov.uk/government/organisations/environment-agency

Environment Agency

Open Government Licence

Please refer to the Open Government Licence which explains the permitted use of this information.

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Appendix B – Richmond SFRA (2016) Information

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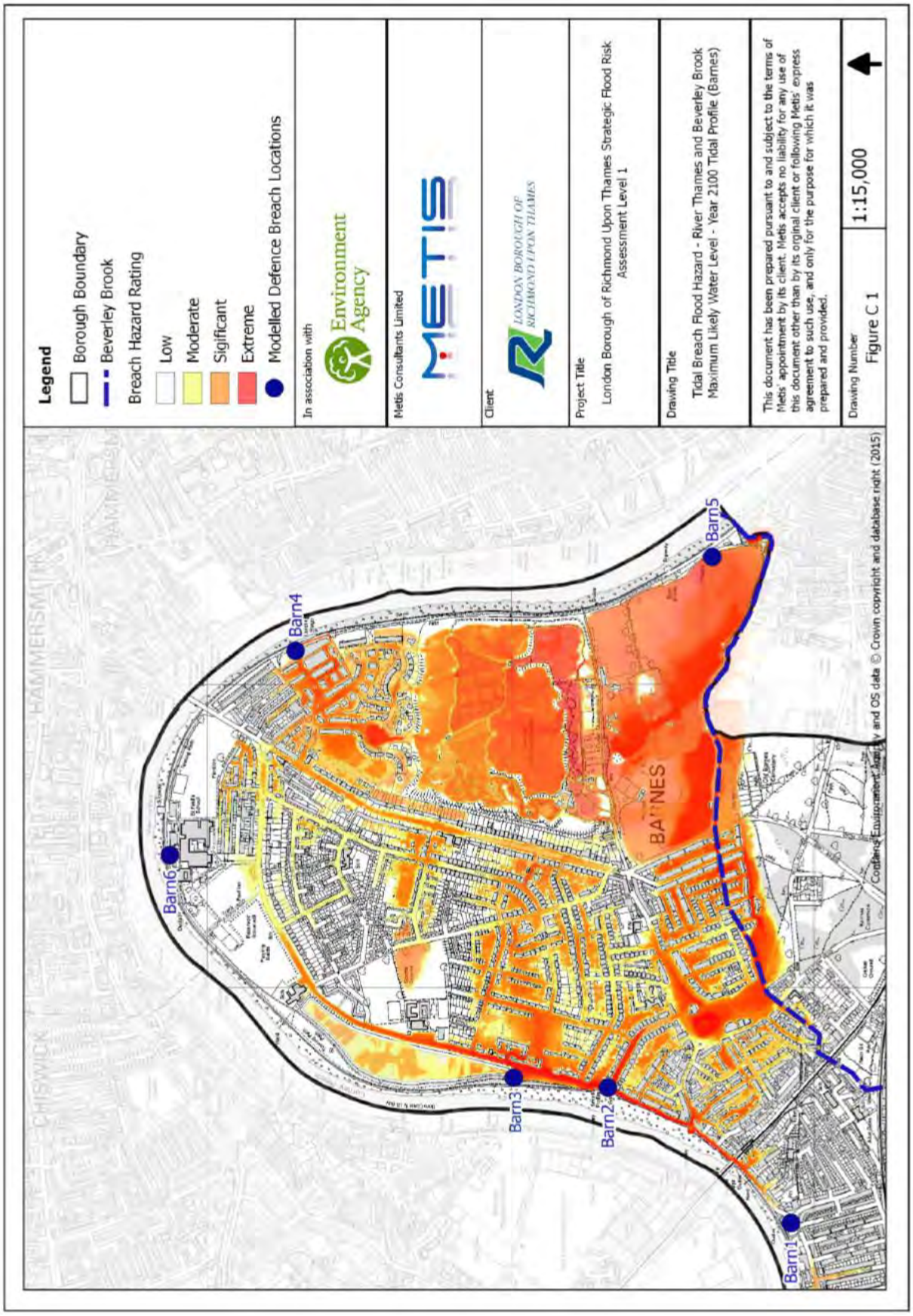

Policy Response	NPPF Flood Zone							
	Zone 3b Functional Floodplain (Tidal & Fluvial)		Zone 3a High Probability *(where combined fluvial / tidal hazard exists, the more conservative recommendations of the two sources should be applied)*					
			TIDAL BREACH FLOOD HAZARD - Defended Only *(Refer Figures C-1 to C-3)*			FLUVIAL FLOOD HAZARD *(Refer Figures C-4 to C-10)*		
	Developed	Undeveloped	Defence Breach 'Extreme & Significant Hazard'	Defence Breach 'Moderate Hazard'	Defence Breach 'Low Hazard' or 'No Hazard'	Undefended 'Extreme & Significant Hazard'	Undefended 'Moderate Hazard'	Defended + Undefended with 'Low Hazard' or 'No Hazard'
SPATIAL PLANNING RECOMMENDATIONS								
Important Considerations	Within Zone 3b Functional Floodplain, 'developed land' relates solely to existing buildings that are impermeable to flood water. The undeveloped land surrounding these buildings are important flow paths and/or flood storage areas. Property within Zone 3b Functional Floodplain will be subject to frequent flooding with a probability of more than 5% in any year. There are clear sustainability implications to be considered in this regard, and it is highly questionable whether insurance against flooding related damages will be available in the longer term.	The undeveloped Functional Floodplain should be protected by not permitted any form of development unless it is for water-compatible development or essential utility infrastructure. Future development within Zone 3b Functional Floodplain can only be considered following application of the Sequential Test and the Exception Test	Future development within Zone 3a High Probability can only be considered following application of the Sequential Test			Future development within Zone 3a High Probability can only be considered following application of the Sequential Test		
Land Use (refer NPPG Table 2)	Redevelopment should only be supported if there is a net flood risk reduction. Change of use or conversion to a use with a higher vulnerability should not be permitted.	Water Compatible Development and Essential Infrastructure	Land use should be restricted to Water Compatible or Less Vulnerable development. More or Highly Vulnerable development may only be considered if Exception Test can be passed			Land use should be restricted to Water Compatible or Less Vulnerable development. More or Highly Vulnerable development may only be considered if Exception Test can be passed		
DEVELOPMENT CONTROL RECOMMENDATIONS								
Detailed Flood Risk Assessment (FRA)	Required	Required	Required			Required		
Ground Floor Level	Ground floor levels should be situated above the 1% chance in any one year plus climate change fluvial flood level plus an appropriate freeboard allowance defined in accordance Section 7.6.2. Ground floor levels should be situated above the Thames 2100 Year 2100 tidal flood level.	N/A	Ground floor levels should be situated above the Thames 2100 Year 2100 tidal flood level.		Flood resiliant design techniques should be adopted to mitigate the potential damage to property in case of flooding. Further guidance is provided in the NPPG	Ground floor levels should be situated above the 1% chance in any one year plus climate change fluvial flood level plus an appropriate freeboard allowance defined in accordance Section 7.6.2.		
Site Access & Egress **(Refer SFRA Appendix E)**	For residential property, dry access is to be provided above the 1% chance in any one year fluvial flood level (including climate change) or year 2100 (from the TE2100 study) tidal flood level (whichever is greater). For non-residential property, access must be 'safe' in accordance with Defra "Flood Risk to People" (FD2320 & FD2321)	N/A	For residential property, dry access is to be provided above the year 2100 (from the TE2100 study) tidal flood level. For non-residential property, access must be 'safe' in accordance with Defra "Flood Risk to People" (FD2320 & FD2321). A dedicated 'safe haven' should be provided above the year 2100 (from the TE2100 study) flood level enable rapid escape should a failure of the defences occur. This may be provided in the form of a sheltered communal space within the building, accessed via internal stairs. It will be necessary to ensure that the safe haven is sufficient in size to safely accomodate all residents / site users.		It is essential to ensure that the nominated evacuation route does not divert evacuees onto a 'dry island' upon which essential supplies (i.e. food, shelter and medical treatment) will not be available for the duration of the flood event	For residential property, dry access must be provided above the 1% chance in any one year fluvial (including climate change) flood level. For non-residential property, access must be 'safe' in accordance with Defra "Flood Risk to People" (FD2320 & FD2321). A dedicated 'safe haven' should be provided with appropriate freeboard (Refer Section 7.6.2) above the 1% chance in any year (including climate change) flood level to enable rapid escape should a failure of the defences occur. This may be provided in the form of a sheltered communal space within the building, accessed via internal stairs. It will be necessary to ensure that the safe haven is sufficient in size to safely accomodate all residents / site users.	It is essential to ensure that the nominated evacuation route does not divert evacuees onto a 'dry island' upon which essential supplies (i.e. food, shelter and medical treatment) will not be available for the duration of the flood event
Basements	No basements are permitted within Zone 3b The Functional Floodplain	N/A	New basement development and extensions, conversions or additions to existing basements restricted to Less Vulnerable / Water Compatible uses only. More Vulnerable uses will only be considered if a site-specific Flood Risk Assessment and analysis of hazard/breach data specific to the development site can demonstrate that the risk to life as a result of a breach or overtopping of the defences can be managed. Highly vulnerable uses will not be permitted. Must have internal access that is above the year 2100 (from the TE2100 study) tidal flood level assuming a breach of the River Thames defences. Flood resilient design techniques must be adopted, as stated in the NPPG.		After passing the Exception Test - New basements and extensions, conversions or additions to existing basements may be permitted for residential use where they are not self-contained or used as bedrooms. Must have internal access that above the year 2100 (from the TE2100 study) tidal flood level assuming a breach of the River Thames defences. Flood resiliant design techniques must be adopted, as stated in the NPPG.	New basement development and extensions, conversions or additions to existing basements restricted to Less Vulnerable / Water Compatible uses only. More Vulnerable uses will only be considered if a site-specific Flood Risk Assessment and analysis of hazard/breach data specific to the development site can demonstrate that the risk to life as a result of a breach or overtopping of the defences can be managed. Highly vulnerable uses will not be permitted. Must have internal access with an appropriate allowance for freeboard (refer Section 7.6.2) above the 1% chance in any one year (including climate change) fluvial flood level. Flood resilient design techniques must be adopted, as stated in the NPPG.	After passing the Exception Test - New basements and extensions, conversions or additions to existing basements may be permitted for residential use where they are not self-contained or used as bedrooms. Must have internal access with an appropriate allowance for freeboad (refer Section 7.6.2) above the 1% chance any one year (including climate change) fluvial flood level. Flood resiliant design techniques must be adopted, as stated in the NPPG.

Site Runoff	Implement SuDS to ensure that runoff from the site (post redevelopment), as a minimum, is not increased. A reduction in site runoff should be sought, aiming to achieve greenfield run-off rates, or reduce run-off rates by at least 50% over current levels. Any SuDS design must take due account of groundwater and geological conditions. Infiltration techniques (including, for example, soakaways) are unlikely to be effective within areas overlying London Clay.
Buffer Zone	A minimum buffer zone must be provided to 'top of bank' within sites immediately adjoining the River Thames. A minimum of 16m for the Tidal River Thames and 8m for the Fluvial River Thames. Advice must be sought from the Environment Agency at an early stage.
Other	Ensure that the proposed development does not result in an increase in the risk of flooding (from all sources) within adjoining properties. This may be achieved by ensuring (for example) that the existing building footprint is not increased, that overland flow routes are not truncated by buildings and/or infrastructure, or hydraulically linked compensatory flood storage is provided within the site (or upstream)

7.6.3 Basements

329. Basements represent a particularly high risk to life within flood affected areas of the Borough, and it is essential that careful consideration is given to their design and use. Basements may be subject to very rapid inundation as floodwater from all sources moves across the floodplain, and it is essential that the minimum design requirements set out in Section 7.4.6 (Page 47) are rigorously adhered to.

330. A summary of the main basement development requirements is provided below:

Flood Zone 3b (Functional Floodplain)	No basement permitted
Flood Zone 3a (Tidal / Fluvial)	**Area of Extreme, Significant and Moderate Breach Hazard**[38] **New Basements:** - Restricted to Less Vulnerable / Water Compatible use only. - More vulnerable uses will *only* be considered if a site-specific Flood Risk Assessment demonstrates that the risk to life can be managed. - Highly vulnerable uses will not be permitted. **Existing Basements:** - No basement extensions, conversions or additions for Highly Vulnerable uses. - More vulnerable uses will *only* be considered if a site-specific Flood Risk Assessment demonstrates that the risk to life can be managed. **Area of Low or No Breach Hazard** **New Basements:** - After passing the Exception Test, basements are permitted for residential use where they are not self-contained or used for bedrooms. **Existing Basements:** - Basement extensions, conversions or additions maybe permitted for existing developments where they are not self-contained or used for bedrooms. *(Refer Section 7.4.6 (Basements) for criteria)*
Flood Zone 2	**New Basements:** - After passing the Exception Test, basements are permitted for residential use where they are not self-contained or used for bedrooms. **Existing Basements:** - Basement extensions, conversions or additions maybe permitted for existing developments where they are not self-

[38] Refer to maps in Appendix C to determine tidal breach hazard rating

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Appendix C – Site Plans/ Supporting Information

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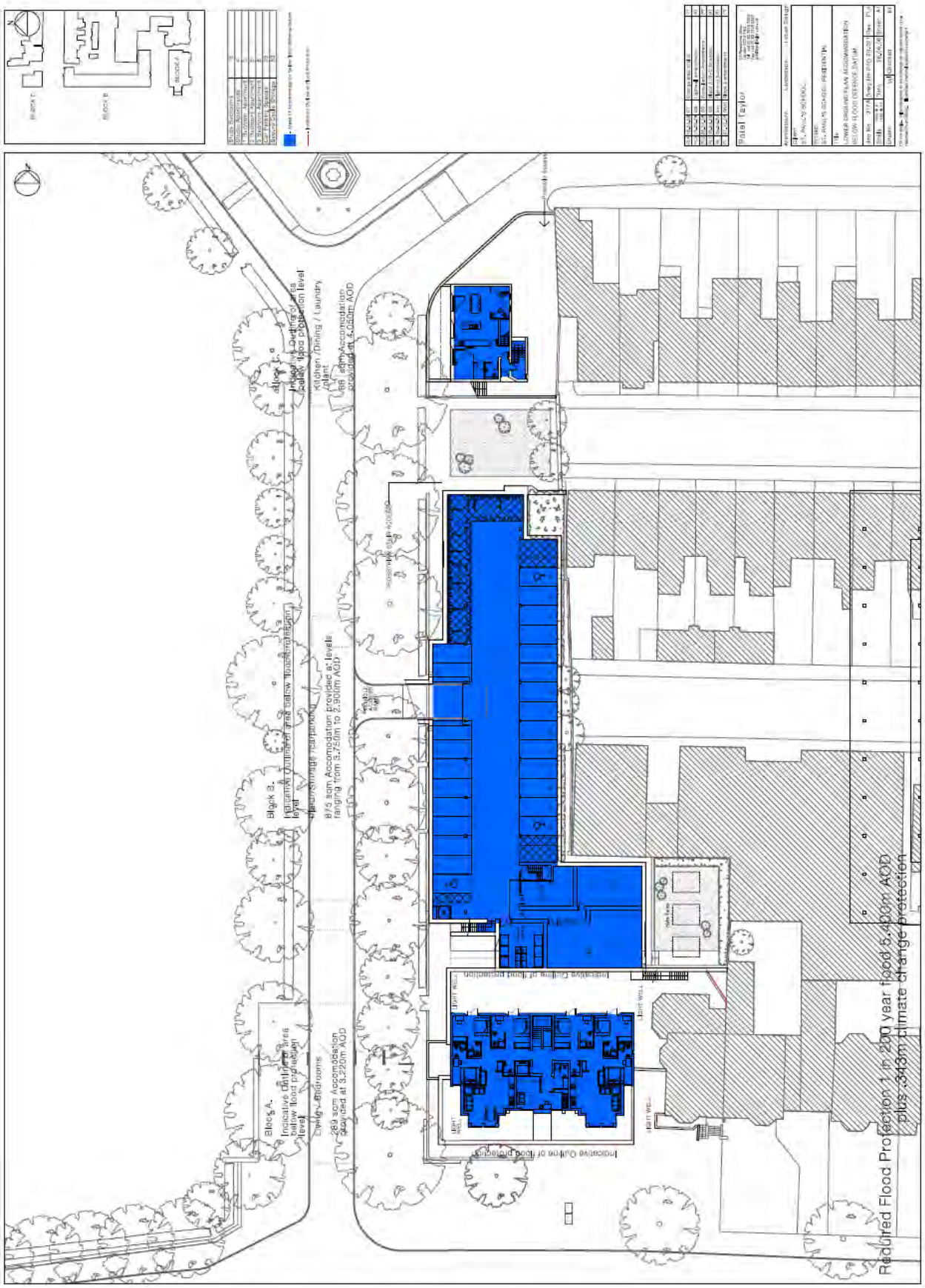

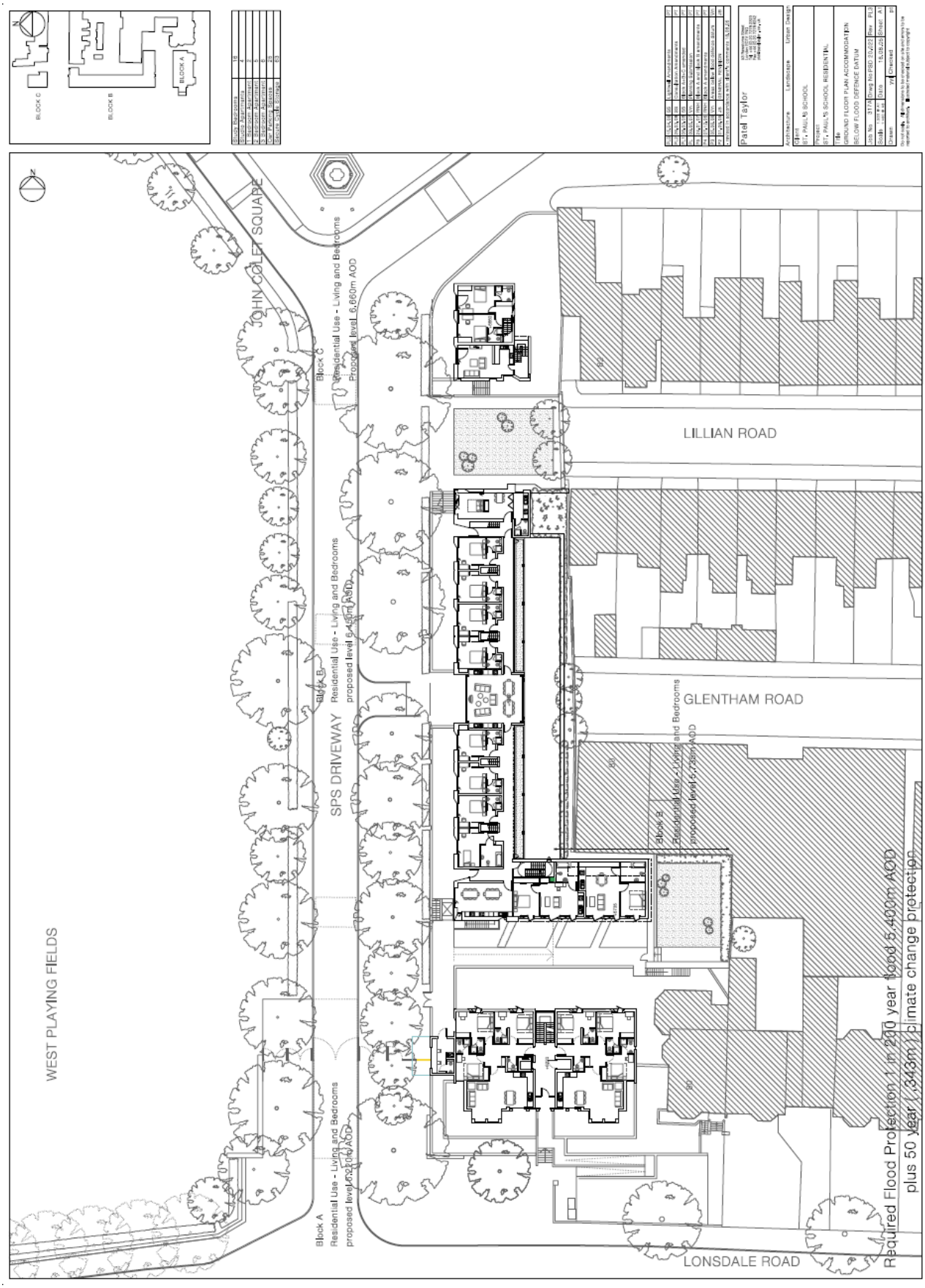

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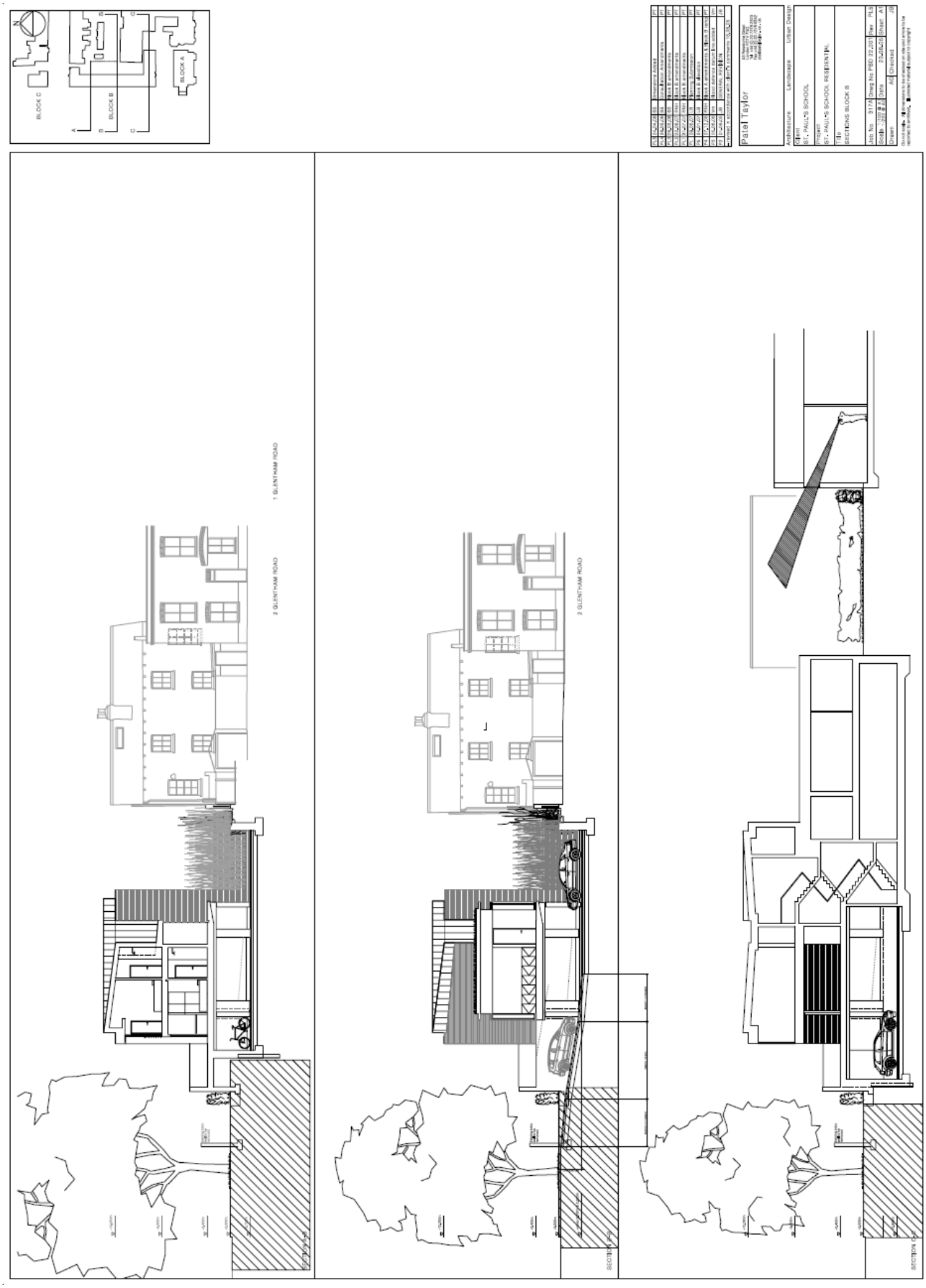

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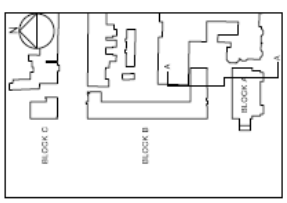

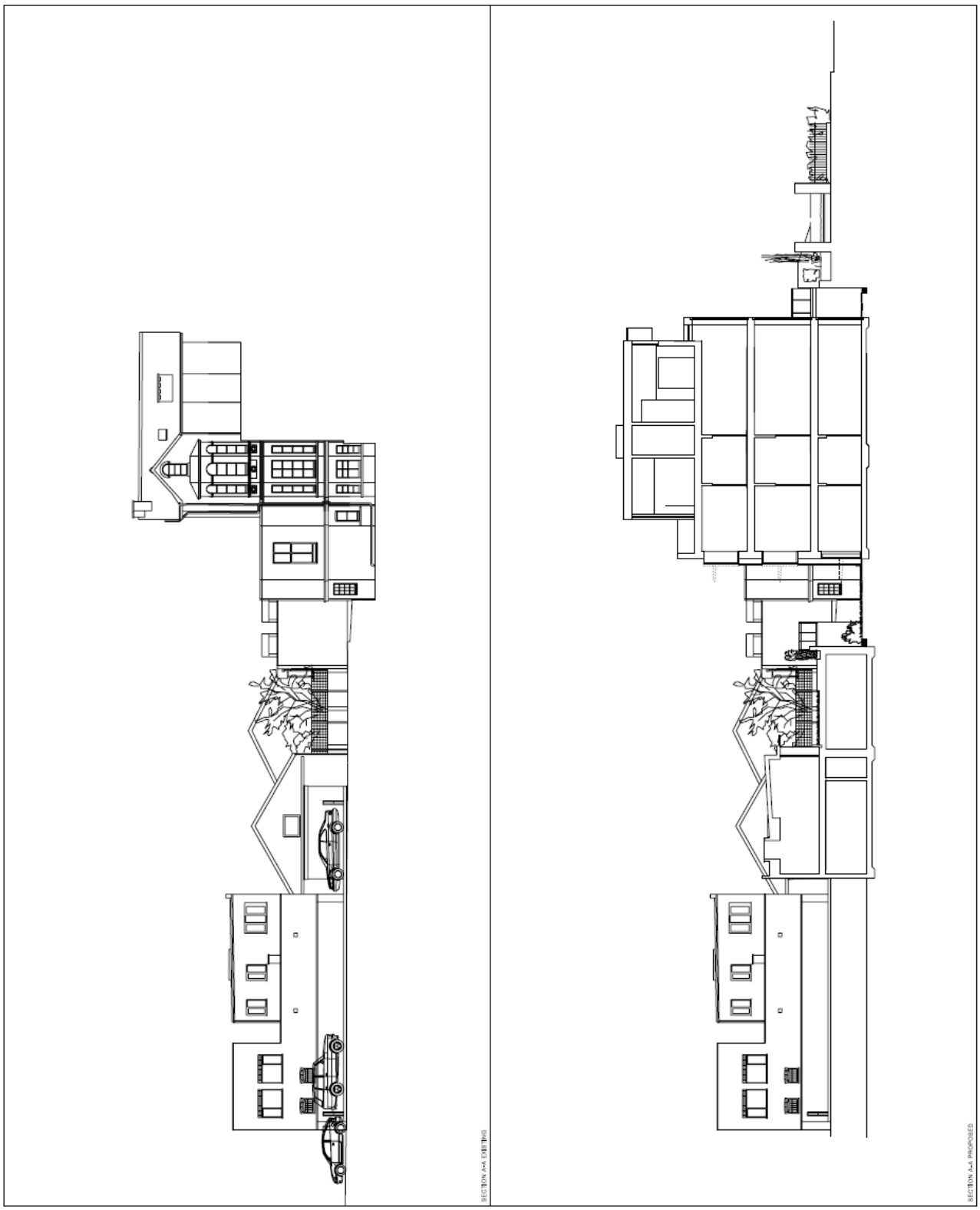

MBP Michael Barclay Partnership
consulting engineers

Environment Agency

Our ref: SL/2007/101260/01-L01
Your ref: 07/1760/OUT

Date: 27th July 2007

Victoria Crosby
London Borough of Richmond upon Thames
44, Civic Centre
York Street
Twickenham
Middlesex
TW1 3BZ

Dear Ms Crosby,

Proposal: **REFURBISHMENT, REPLACEMENT AND DEVELOPMENT OF BUILDINGS AND ASSOCIATED CIRCULATION, PARKING AND LANDSCAPING FOR EDUCATIONAL AND ANCILLARY RESIDENTIAL USE (INCLUDES NEW BUILDING OF 32 NEW RESIDENTIAL UNITS FOR STAFF AND UNDERGROUND PARKING ON CAR PARK TO EAST OF SITE ENTRANCE; REFURBISHMENT OF SPORTS HALL; NEW CLASSROOMS, DINING HALL, KITCHEN, ASSEMBLY HALL, LIBRARY, CHAPEL, MUSIC SCHOOL, BOATHOUSE, STAFF ACCOMMODATION, SPORTS PAVILION AND BOARDING ACCOMMODATION, SPORTS PAVILION AND BOARDING ACCOMMODATION FOLLOWING DEMOLITION OF SOME EXISTING SCHOOL BUILDINGS; RECONFIGURATION OF VEHICULAR CIRCULATION AND CAR PARKING, PLAYING FIELDS, SPORT FACILITIES, LANDSCAPING, CYCLE PARKING, CANOPIES, PERGOLA AND COVERED PLAY AREA).**

Location: **ST PAUL'S SCHOOL, LONSDALE ROAD, BARNES, LONDON SW13 9JT**

Thank you for referring the above application, which was received on June 24th 2007.

The key issues for the Environment Agency at this site are:

- Flood Risk
- Ecological Impact and Mitigation/Compensation Measures
- Management of Contaminated Land & Prevention of Pollution to Groundwater

Please also refer to the following link to our web page on sustainable development and specifically to 'A Guide for Developers' which provides practical advice on making developments better for people and the environment.

http://www.environment-agency.gov.uk/regions/thames/323150/1092076/?version=1&lang=_e

We have the following comments on the planning application:

The Environment Agency has **no objections** to the proposed development, as submitted, subject to the inclusion of the following planning conditions on any planning permission granted:

Flood Risk

We note and commend the proposals for Sustainable Drainage Systems (SUDS) such as Green Roofs, Rainwater Harvesting and Wetland Gardens however due to the application being 'outline', we request the following condition in order to be able to assess the full details of such systems before construction:

Condition: No development approved by this permission shall be commenced until a scheme for the provision and implementation of surface water run-off limitation by means of a sustainable drainage system shall be submitted to and approved in writing by of the Local Planning Authority. The scheme shall be implemented in accordance with the approved programme and details.

Environment Agency, 9th Floor, Eastbury House, 30-34 Albert Embankment, London, SE1 7TL

Telephone number: 020 7091 4029, Fax number: 020 7091 4090

Team email: planning.se@environment-agency.gov.uk
Website: www.environment-agency.gov.uk/thamesplanning

Reason: To prevent the increased risk of flooding and improve the water quality.

Sustainable Drainage Systems:

Further information on Sustainable Drainage Systems can be found in Appendix F of Planning Policy Statement – 'Development & Flood Risk' (PPS25), in the CIRIA C522 document entitled 'Sustainable Urban Drainage Systems - design manual for England and Wales' and in the CIRIA document entitled 'Interim Code of Practice for Sustainable Drainage Systems'.

This Interim Code of Practice provides advice on design, adoption and maintenance issues and gives a good overview of other technical guidance on SUDS. Please note that whilst the focus within the FRA must be on flood risk management, any SUDS should also seek to maximise opportunities for water quality and amenity benefits.

Information on SUDS is also available in paragraph 4C.8 of the London plan.

If the principles of a SUDS system cannot be incorporated within parts of the site, calculations should be submitted to the EA for further analysis.

Further information relating to SUDS and specifically to the use of soakaways and the protection of Groundwater sources can also be found under the 'Management of Contaminated Land & Prevention of Pollution to Groundwater' section of this response.

Regulatory Informatives related to Flood Risk

Under the terms of the Thames River (Prevention of Floods) Acts 1879 -1962 and the Water Resources Act 1991, our prior written consent is required for any proposed works or structures likely to affect the structural integrity of the flood defences.

Under the terms of the Thames River (Prevention of Floods) Acts 1879-1962, the statutory tidal flood defence level, which is 5.54 metres above ODN at this site, must be maintained at all times, with temporary works if necessary.

Under the terms of the Thames River (Prevention of Floods) Acts 1879 -1962 and the Water Resources Act 1991, our prior written consent is required for any proposed works or structures likely to affect the structural integrity of the flood defences.

Decision Notice Request

We require decision notice details for this application, in order to report on our effectiveness in influencing the planning process.
Please email decision notice details to: planning.se@environment-agency.gov.uk, or post a copy to the address at the end of this letter.

Should you have any queries regarding the above, or require any further information, please do not hesitate to contact me.

Yours sincerely

Mr Jack Hayes
Major Projects Officer

Direct dial 0207 091 4029
Direct fax 0207 091 4090
Direct e-mail Jack.Hayes@environment-agency.gov.uk

Environment Agency, 9th Floor, Eastbury House, 30-34 Albert Embankment, London, SE1 7TL

Telephone number: 020 7091 4029, Fax number: 020 7091 4090

Team email: planning.se@environment-agency.gov.uk
Website: www.environment-agency.gov.uk/thamesplanning

Appendix D – Information Relating To JFLOW

JFLOW and flood outlines (Source: EA)

Flood Zones have been produced using JFLOW, a nationally consistent model. JFLOW has been used to produce the 1% (1 in 100 year) and 0.1% (1 in 1000 year) flood outlines.

The flood outlines have been developed by applying flow and tide models to a 3D ground level map of England and Wales, known as a Digital Terrain Model (DTM). This is created by flying an aircraft over the whole of the country using radar to record and create a contoured model of the land. This DTM is used as the basis of a grid of cells which is used to estimate the extent of flooding in a flood of a given return period or probability.

The size of the flood event (1 in 100 or 1 in 100 year) is determined by the inflows to the JFLOW model, which are calculated using statistical techniques from the Flood Estimation Handbook. The technique used is based upon catchment descriptors and data transfer, the details of these can be found in the Flood Estimation Handbook volume 3. The Flood Estimation Handbook provides a consistent technique for estimating inflows to the national model and its methods are widely accepted.

The methodology is a raster-based approach, driven by an underlying Digital Elevation Model (DEM).

- Each cell has a ground level and water depth
- Water can move to any of surrounding 8 cells where the water level is lower
- Water will pond in low spots until the water level is high enough to spill
- The velocity of movement depends on water surface slope and surface roughness

The above points describe the basic principles of the model. The two underlying principles are:

- Mass conservation within each cell
- Calculation of the fluxes between the cells

Each grid cell is treated as a small storage area. Mass conservation is applied to each grid cell. The flux between cells is calculated using a form of the generalised weir equation.

Efficient coding is achieved by keeping a list of all currently wet cells and a list of newly wet cells. This avoids having to search through each cell in the ground grid.

For whole catchment modelling, the hydrographs used as inflow boundary conditions represent the whole hydrograph at that inflow location and a simple conceptual method has been derived to account for the amount of flow within the channel banks. A simple solution was therefore sought which would approximately account for the proportion of flow contained within the channel without requiring further information about the channel.

The simple conceptual method used involves two assumptions:

1. That bankfull flow (Q_b) is equal to QMED as calculated by the Flood Estimation Handbook (FEH) methods. QMED has a return period of 2 years. This assumption derives from the

concept of dominant discharge in fluvial geomorphology (Wolman and Leopold, 1957; Wolman and Miller, 1960) where the cross-section shape is assumed to be formed by a discharge with a recurrence interval of 1-2years.

2. That the additional channel flow (Q_c) scales with both Q_b and depth above bankfull (d).

The basis of the current model is that each grid cell acts as a small flood cell and the links to each of the surrounding cells are automatically calculated. It is therefore capable of simulating the inundation extent at a level of detail equal to the underlying DEM. It is fundamentally volume conservative and so, in a given time period, will simulate the peak water levels across the floodplain depending on the volume of water that has entered the floodplain. This approach is a half-way house between the common 1D hydrodynamic models and a 2D hydrodynamic model.

Limitations

JFLOW was used to produce flood maps for the whole of England and Wales for all catchments greater than 3 sq-km in a consistent manner. The method is therefore very generalised and therefore cannot take account of information that may be very significant locally. This might include:

1. Effects of bridges and other structures including flood defences are not taken into account.
2. Errors in the DTM, caused by trees and buildings for example.
3. The effect of reservoirs and urban drainage and other man made influences on the flow regime can only be taken into account in a very general sense in JFLOW.
4. The channel is assumed to be able to take the 2 year flow. This may not be true especially in those modified by man.
5. Hydraulic roughness is assumed to be the same everywhere in JFLOW, but of course it is not.

For these and many other reasons, the flood outlines produced by JFLOW can only be taken as a rough guide, showing where more detailed flood risk assessments are essential. Flood risk assessments should also be undertaken near small watercourses whose catchments are too small to have been included in the JFLOW modelling.