6.3 Flooding from Rivers and Sea

Fluvial flooding is caused by rivers, watercourses or ditches overflowing. Tidal flooding is caused by elevated sea levels or overtopping by wave action.

Based on the Environment Agency's "Flood Risk from Rivers or the Sea" (refer to Figure 6.2), **the site is at very low risk** - an area assessed as having less than 0.1% annual probability (1 in 1000 annual probability) of river or sea flooding.

The EA data contained in Appendix 3 confirms that the flood defences in the area are **maintained in good condition and are therefore unlikely to fail**.

Using all the available evidence it is therefore considered that the site has a **very low probability of flooding** from fluvial and tidal sources.

There is a residual risk to the area from a potential breach in the River Thames flood defences. The risk associated with a breach is discussed further in Section 7.0.

6.4 Flooding from Sewers

Sewer and highway drainage flooding occurs when the capacity of systems are exceeded, or the function of the system is impeded (e.g. tide locking), which results in surcharging of the system and water being forced to the surface via gullies, manholes, foul water appliances such as toilets or other dedicated overflows.

The available Thames Water record plan (Figure 6.3 below) indicates a large diameter combined public sewer in the vicinity of the site. The consequences of sewer flooding may be high due to the limited inflow capacity of road drains in the event of an extreme storm. This may be worsened by blocked drains or gullies.

Figure I in the Richmond upon Thames SFRA indicates that there hasn't been a single "Localised Flood Incident" in the post code area TW9 4 (contained in Appendix 1).

Using all the available evidence it is therefore considered that t**he site has a low probability of flooding from sewers and the local drainage network**, as long as they continue to be adequately maintained.

6.5 Flooding from Groundwater

Groundwater flooding is caused by the emergence of water originating from sub-surface permeable strata and is often highly localised and complex. After a prolonged period of rainfall, a considerable rise in the water table can result in inundation for extended periods of time.

A large proportion of the London Borough of Richmond upon Thames overlays London Clay and consequently the risk of groundwater flooding will typically be low. Areas adjoining the River Thames corridor however are often characterised by deposits of gravel above the clay layer. These are referred to as 'Thames Gravels' and there is evidence within adjoining Boroughs of groundwater flooding occurring some distance from the river as a result of water finding a pathway through the gravels during high river levels.

Figure D from the Richmond upon Thames SFRA 'Areas Benefiting from Defences and Groundwater Flooding Incidents' confirms that there has not been a single groundwater flooding incident in the proximity of the development. In addition, Figure E of the SFRA 'Susceptibility to Groundwater Flooding' confirms that the development lies outside the areas which have potential for groundwater flooding below ground level.

The groundwater levels were monitored in well installations in November 2015 and were found to exists between 4.10m to 6.35m below ground level. See Appendix 2 for an extract from ESI Factual Report.

Based on this evidence, we believe that **the site is at low risk of flooding from groundwater sources**.

6.6 Flooding from Artificial Sources

Where infrastructure retains, transmits or controls the flow of water; flooding may result if there is a structural, hydraulic, geotechnical or mechanical failure of the infrastructure.

The Thames Water Asset Map (Fig. 6.4) indicates that there is a 180mm dia. water main running adjacent to the site. Although unlikely, a water main can burst at anytime which can result in the flooding of nearby properties. Thames Water are currently replacing the Victorian water mains across London and the local mains appear to be modern HPPE which will lower the probability of water main bursting and therefore reduce the risk of flooding to the building.

The topography shows that the local road network falls to a low point to the Southwest of the site meaning flood water from a burst main would flow to this point. This is backed up by the risk due to surface water flooding maps which indicate that water ponds in this low point - this will be discussed further in the next section. However, the finished floor level of the development has been set approximately 0.5m above the surface level of the adjacent road.

To further reduce the flood risk from water mains, any initial sign of a burst water main should be reported to Thames Water as soon as possible and the local highway drainage system should be adequately maintained.

Figure 6.5 shows the Environment Agency's Flood Map for Reservoirs which indicates that the site is at risk from flooding associated with reservoirs. Reservoirs are maintained to a very high standard and are inspected regularly under the Reservoirs Act 1975. The likelihood of flooding from reservoirs is therefore very low.

Based on this information it is therefore considered that **the site is at very low risk of flooding from artificial sources.**

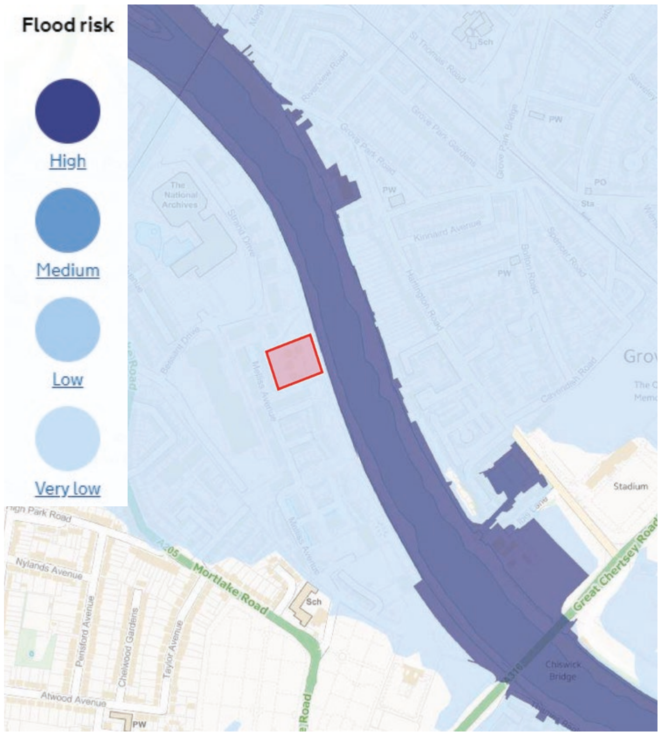


Figure 6.2 Flood Risk from Rivers or the Sea

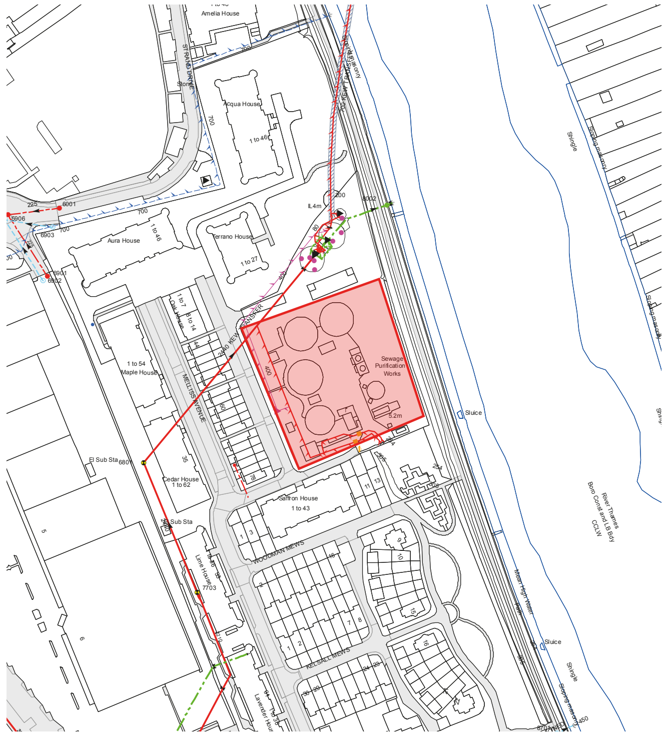


Figure 6.3 Thames Water Asset Record - Sewers

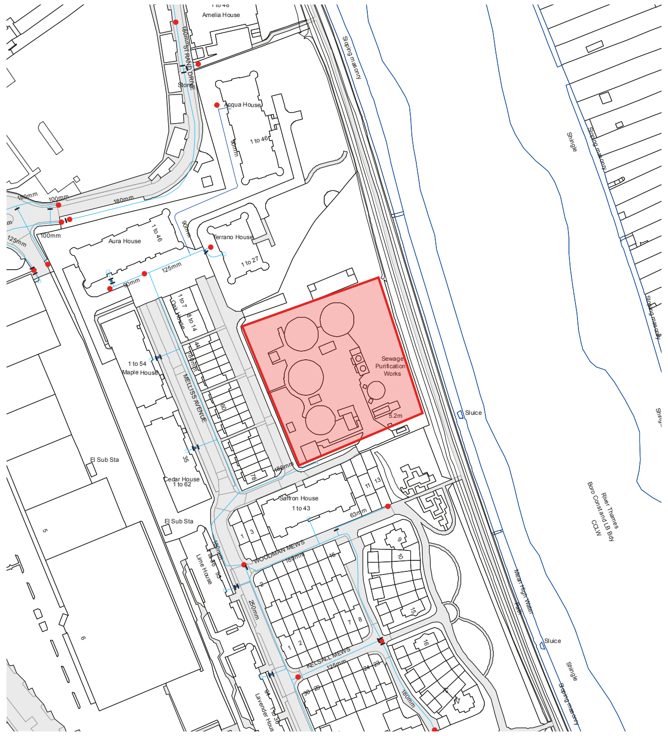


Figure 6.4 Thames Water Asset Record - Water Mains

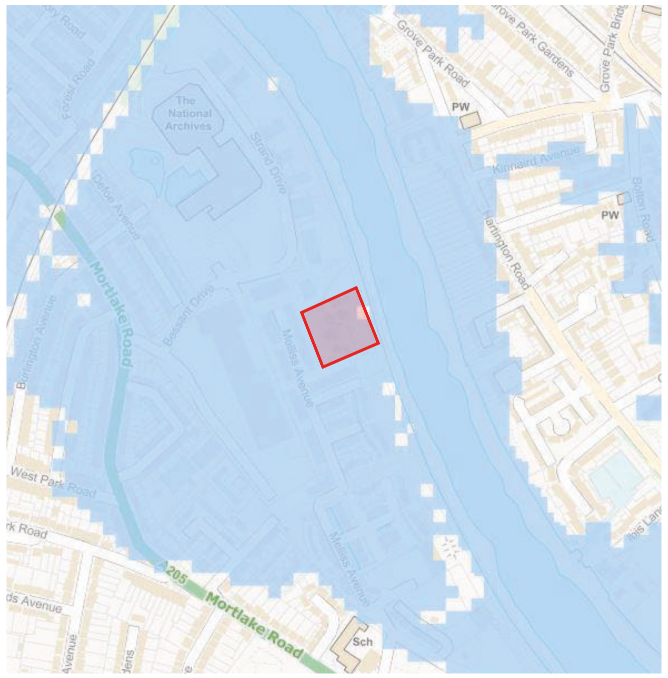


Figure 6.5 Environment Agency Flood Map - Reservoirs

6.7 Flooding from Surface Water

Surface water flooding can occur as a result of either overland flow or ponding. Overland flow occurs following heavy or prolonged rainfall, snow melt, or where intense rainfall is unable to soak into the ground or enter drainage systems due to blockages or capacity issues. Unless it is channelled elsewhere, the run-off travels overland, following the gradient of the land. Ponding occurs as the overland flow reaches low lying areas in the local topography. These flood events tend to have a short duration and depend on factors such as geology, topography, rainfall, saturation, extent of urbanisation and vegetation.

As the surrounding area is highly developed it almost entirely comprises of impermeable hardstanding area which, during high intensity storms, will generate large surface water runoff flows. However, Figure G of the Richmond upon Thames SFRA "Updated Flood Map for Surface Water, - 1% chance of flooding in any one year' " confirms that the proposed development lies outside of the predicted surface water flooding.

The Environment Agency's Risk of Flooding from Surface Water map indicates that the site is at very low risk of surface water flooding but the surrounding Melliss Avenue has a low to medium risk.

The Environment Agency provide further maps which break down this flooding into probabilities ranging from "High" to "Very Low" risk of occurring where "High" is a greater than 1 in 30 (3.3%) chance of occurring, "Medium" is a between 1 in 30 (3.3%) and 1 in 100 (1%) chance of occurring, "Low" is a between 1 in 100 (1%) and 1 in 1000 (0.1%) chance of occurring and "Very Low" is a less than 1 in 1000 (0.1%) chance of occurring.

- The "High" probability maps shown in Figs. 6.6 and 6.7 indicate there is no surface water flooding on the site and the surrounding roads.
- The "Medium" probability maps in Figs. 6.8 and 6.9 show the site is still clear of flooding. A small patch of slow moving water is noted south west of the site on Melliss Avenue (300-900mm deep and less than 0.25m/s).
- The "Low" probability maps in Figs. 6.10 and 6.11 show a localised flooding on the site. However, this is shallow and slow moving (less than 300mm deep and less than 0.25m/s) and coincides with a low point on the site which will be removed and drained by a new drainage in the proposed scheme. The flooding now extends further but still is localised around the south west corner of the site and generally remains less than 900mm deep. The flooding is generally slow moving less than 0.25m/s.

The proposed Finished Floor Level will be set at 4.6m AOD which is approximately 0.5m above the surface level of Melliss Avenue.

Based on the above, the development is considered **to be at very low risk of flooding from surface water**. Roads in the surrounding area are at low to medium risk but do not impact the site. Safe egress from the site is discussed in the next section.

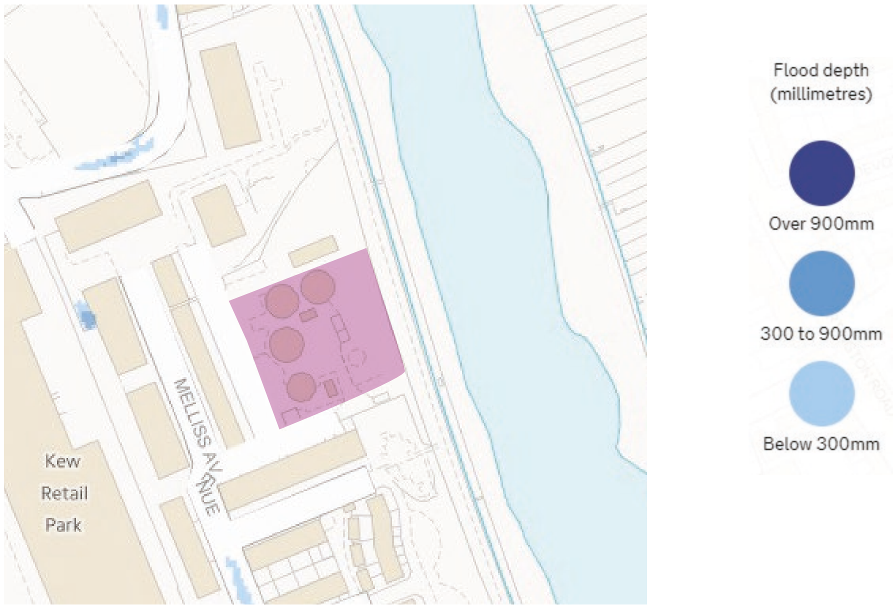


Figure 6.6 Environment Agency's Flooding from Surface Water Map (High Probability - Depth)

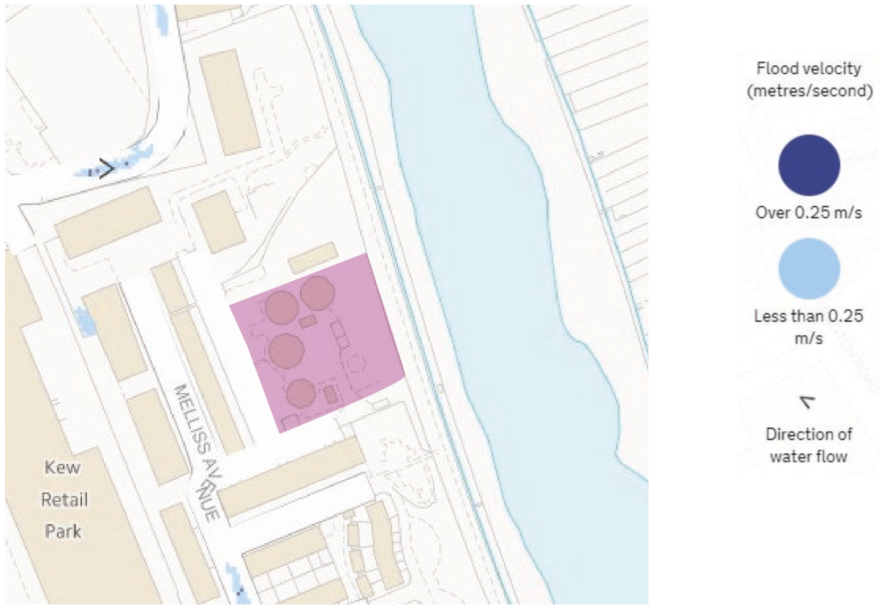


Figure 6.7 Environment Agency's Flooding from Surface Water Map (High Probability - Velocity)

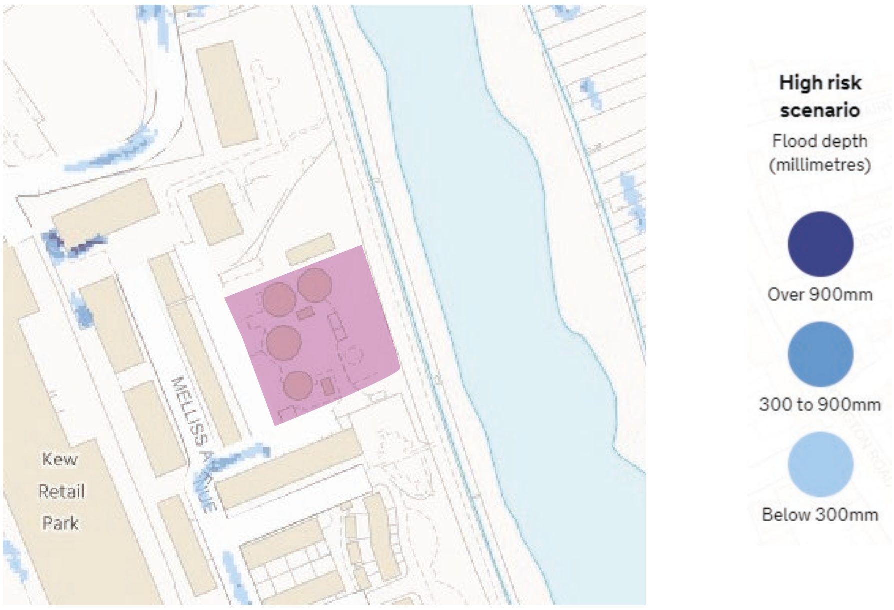


Figure 6.8 Environment Agency's Flooding from Surface Water Map (Medium Probability - Depth)

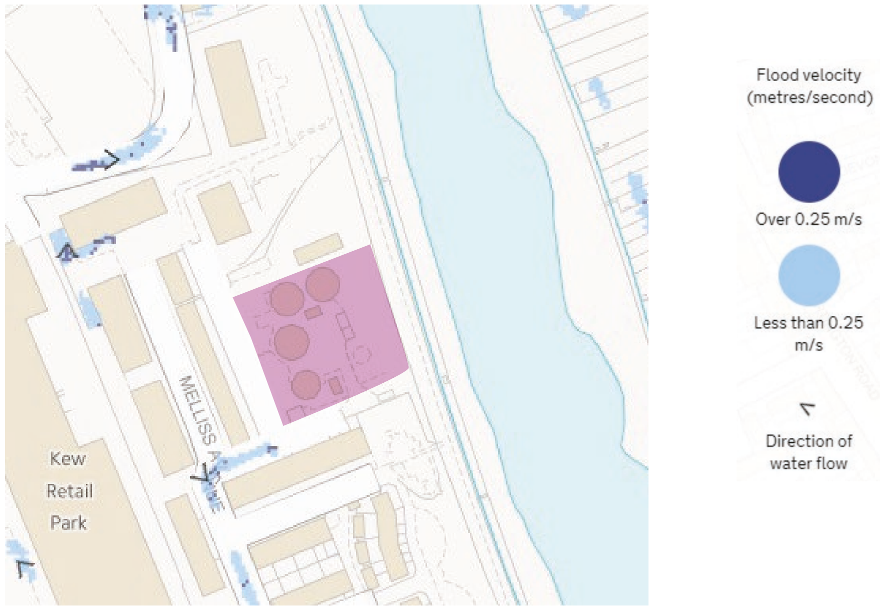


Figure 6.9 Environment Agency's Flooding from Surface Water Map (Medium Probability - Velocity)

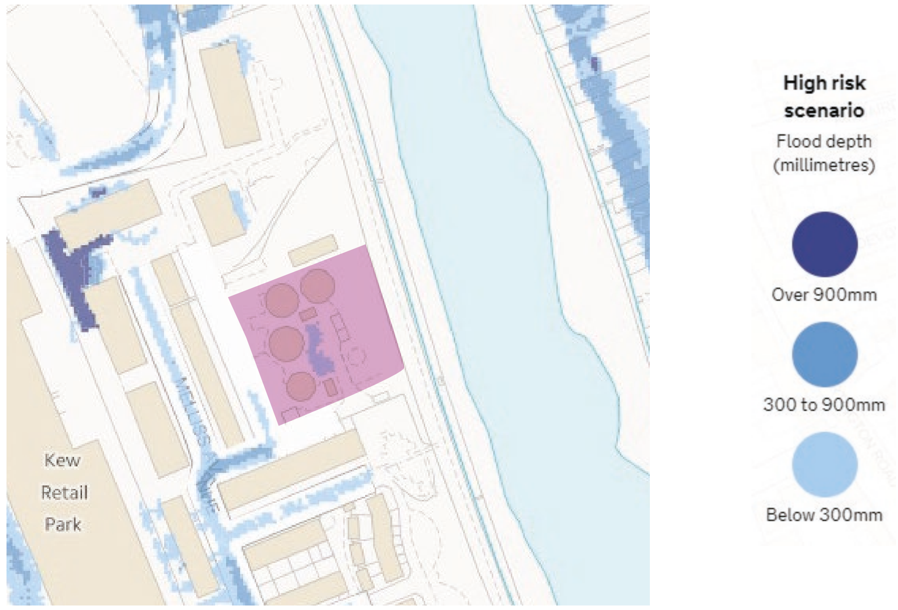


Figure 6.10 Environment Agency's Flooding from Surface Water Map (Low Probability - Depth)

Figure 6.11 Environment Agency's Flooding from Surface Water Map (Low Probability - Velocity)

6.7.1 Safe Access

As the site does not flood due to surface water, occupiers could safely remain in the buildings during any flood events in the surrounding area without endangering themselves.

In the event that occupiers do wish to leave the site during flood events, the EA and Defra published FD2321/TR2 "Flood Risks to People" in March 2006. Guidance Note 2, Figure 2.1 provides details on combinations of flood depth and velocities that cause danger to people. This table shows that people can become endangered in shallow but fast moving water through to still but deep water (refer to Fig. 6.12).

The area of Melliss Avenue in front of the development is clear of flood water so occupiers could exit the building on this elevation and walk eastward toward the elevated path along the River Thames in safety. Alternatively, the residents could reach the river path via the the entrance at the back.

From the Environment Agency Surface Water Flooding Maps discussed above, the maximum depth is less than 900mm and the maximum velocity is less than 0.25m/s on the surrounding streets. Fig. 6.12 shows that this represents a danger for elderly and children. However, Figure 6.13 demonstrates that the dry ground can be reached by escaping to the north without walking through the surface water flood.

In addition to these escape routes, the SFRA states that flood warnings are provided within the Borough, relating to fluvial and tidal flooding. The Environment Agency strives to provide as much forewarning as possible of a pending flood event. This provides the Borough, emergency services, residents & businesses with an opportunity to prepare to minimise property damage and risk to life. The flood warning method will also inform the staff/care , present 24 hours a day 7 days a week, so that appropriate action can be instigated.

It is recommend that the building management register with the Environment Agency flood warning alerts of potential flood events and therefore choose their escape route prior to the event. This is discussed in more detail in Section 7.0.

Velocity (m/s)	Depth (m)									
	0.25	**0.50**	**0.75**	**1.00**	**1.25**	**1.50**	**1.75**	**2.00**	**2.25**	**2.50**
0.00	0.13	0.25	0.38	0.50	0.63	0.75	0.88	1.00	1.13	1.25
0.50	0.25	0.50	0.75	1.00	1.25	1.50	1.75	2.00	2.25	2.50
1.00	0.38	0.75	1.13	1.50	1.88	2.25	2.63	3.00	3.38	3.75
1.50	0.50	1.00	1.50	2.00	2.50	3.00	3.50	4.00	4.50	5.00
2.00	0.63	1.25	1.88	2.50	3.13	3.75	4.38	5.00	5.63	6.25
2.50	0.75	1.50	2.25	3.00	3.75	4.50	5.25	6.00	6.75	7.50
3.00	0.88	1.75	2.63	3.50	4.38	5.25	6.13	7.00	7.88	8.75
3.50	1.00	2.00	3.00	4.00	5.00	6.00	7.00	8.00	9.00	10.00
4.00	1.13	2.25	3.38	4.50	5.63	6.75	7.88	9.00	10.13	11.25
4.50	1.25	2.50	3.75	5.00	6.25	7.50	8.75	10.00	11.25	12.50
5.00	1.38	2.75	4.13	5.50	6.88	8.25	9.63	11.00	12.38	13.75

Flood Hazard Rating (HR)	**Colour Code**	**Hazard to People Classification**
< 0.75		Very low hazard - Caution
0.75 to 1.25		Danger for some – includes children, the elderly and the infirm
1.25 to 2.00		Danger for most – includes the general public
> 2.00		Danger for all – includes the emergency services

Figure 6.12 FD2321/TR2 "Flood Risk to People" Extarct

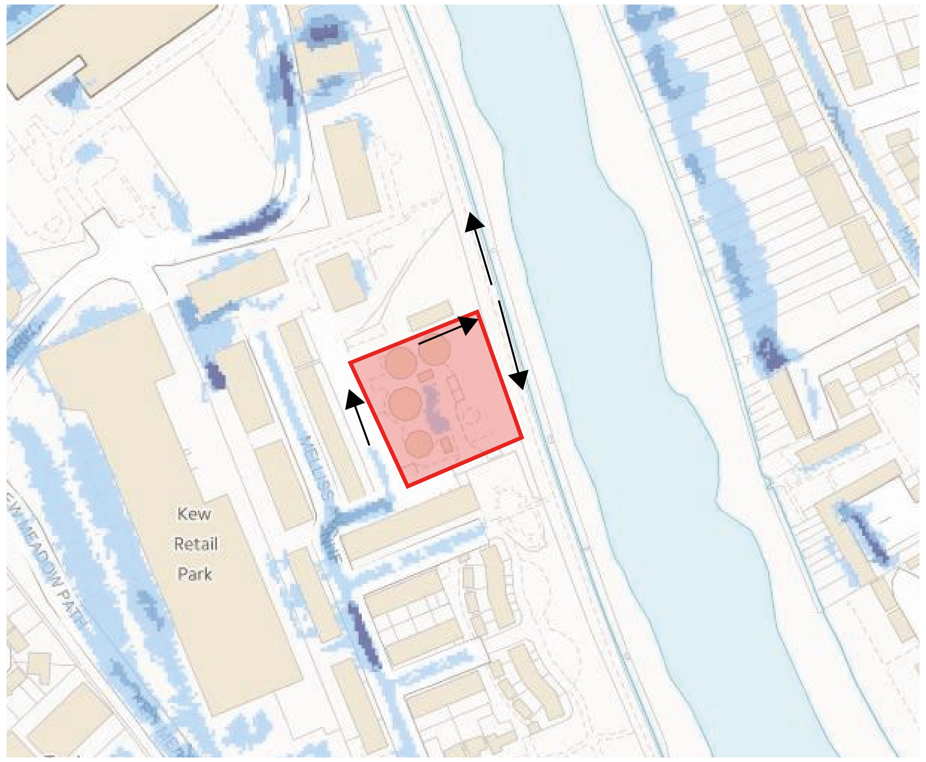


Figure 6.13 Safe access routes

7 EA Breach Modelling

The Environment Agency have provided the modelled flood extents from their 'Thames Tidal Upriver Breach Inundation Modelling Study 2017' completed by Atkins Ltd. in May 2017 (see Appendix 3).

The modelled breach extent in Figure 7.1 indicates that the site is impacted and the resulting flood level is 6.09m AOD.

Comparison of the site topographic survey and the modelled breach flood level mentioned above indicates that the site would be impacted by a breach to a maximum depth in excess of 2m.

The Environment Agency have confirmed that the site is within an area benefiting from flood defences. The flood defences are inspected twice a year to ensure that they remain fit for purpose.

The current condition grade for defences in the area of the breach is **2 (good)**, on a scale of 1 (very good) to 5 (very poor).

	National Grid Reference		Modelled levels in mAODN for Max Likely Water Level	
Node	Easting	Northing	2014	2100
1	519838	176851	5.23	6.02
2	519780	176826	5.24	6.03
3	519725	176806	5.24	6.03
4	519717	176852	5.24	6.03
5	519686	176929	5.24	6.03
6	519709	176965	5.24	6.04
7	519788	176989	5.25	6.01
8	519794	176949	5.25	6.06
9	519810	176903	5.25	6.05
10	519760	176880	5.27	6.09
11	519740	176934	5.24	6.05

Table 1 Site-specific flood levels modelled by the Environment Agency

7.1 Mitigation Measures

7.1.1 General

- The building managers will be registered with the EA Flood Warning system and the Flood Warning and Evacuation Plan will be developed in accordance with the LBRuT Development Management Plan Policy DM SD 6 'Flood Risk'. Therefore, in the event of any warning of an imminent breach event the evacuation strategy will be implemented.
- There will be trained staff present on the site 24 hours a day, 7 days a week.

7.1.2 Habitable Floor Levels

It is proposed to provide the habitable floors at first floor level (8.60m AOD) and above which is approximately 2.5m above the TE2100 breach level of 6.09m. Ground floor will be occupied only by 'less vulnerable' uses .

7.1.3 Safe Access and Refuge

The residual risk of a breach in the River Thames flood defences would impact on safe access. As confirmed above, the habitable floors are located 2.5m above the breach level. Therefore, in the event of a breach, any residents on the habitable floors will remain there, safely above the flood level. Any residents in the communal ground floor areas will evacuate to their apartments, or be relocated by trained staff as per agreed strategy, on the habitable floors where they can remain until flood waters subside, or the residents could be relocated as per agreed strategy.

7.1.4 Ground Floor Construction

It is proposed to construct the lower level utilising water resistant techniques in accordance with CIRCa Report 139.

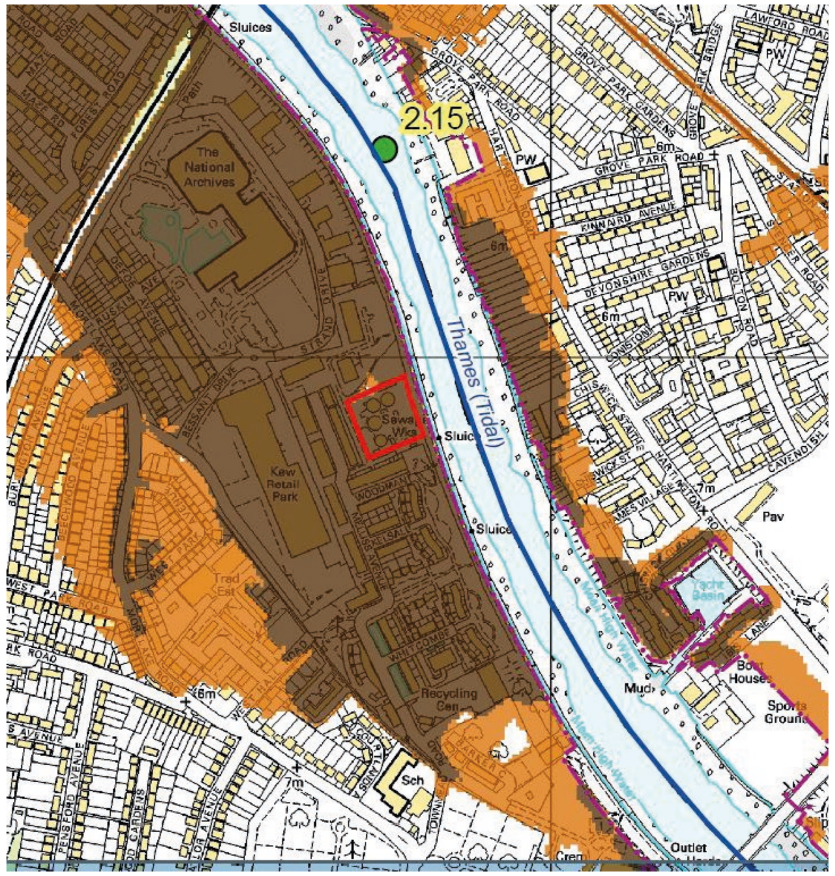


Figure 7.1 Environment Agency Breach Inundation Map

Figure 7.2 Environment Agency 2D Node location map

8 Run-off Assessment

8.1 Existing Site Run-off

The existing site is approximately 6,970m² and is covered approximately 40% with hardstanding, resulting in impermeable area of 2,900m². In accordance with the Modified Rational Method, the peak existing run-off from the site is calculated from the formula:

$Q = 3.61 \times Cv \times A \times i$

where Cv is the volumetric runoff coefficient, A is the catchment area in hectares and i is the peak rainfall intensity in mm/hr.

For the peak 1 in 1 year return period storm event this gives an existing discharge rate from the site of:

$Q_1 = 3.61 \times 0.75 \times 0.290 \times 31.4 =$ **24.7 litres/sec**

and for the peak 1 in 100 year return period storm event this gives an existing discharge rate from the site of:

$Q_{100} = 3.61 \times 0.75 \times 0.290 \times 99.7 =$ **78.3 litres/sec**

8.2 Proposed Site Run-off

The proposed impermeable area is approximately 3,700 m². Again using the Modified Rational Method, the proposed (unattenuated) peak run-off from the site for the 1-in-1-year return period storm would be:

$Q_1 = 3.61 \times 0.75 \times 0.370 \times 31.4 =$ **31.5 litres / sec**

and for the peak 1-in-100-year return period storm event:

$Q_{100} = 3.61 \times 0.75 \times 0.370 \times 99.7 =$ **99.9 litres / sec**

The Environment Agency updated their guidance on climate change allowance in February 2016 to include an upper and lower allowance to be considered depending on the specific site characteristics. Figure 2.2 shows the revised figures based on various building life spans. Therefore, making an allowance for climate change of 40% this would give an unattenuated design discharge of:

$Q_{1\,(+40\%)} =$ **44.1 litres / sec** and $Q_{100\,(+40\%)} =$ **139.9 litres / sec**

In accordance with the Environment Agency's guidelines, the Building Regulations and the Water Authority's advice, the preferred means of surface water drainage for any new development is into a suitable soakaway or infiltration drainage system. Sustainable Urban Drainage Systems (SuDS) can reduce the impact of urbanisation on watercourse flows, ensure the protection and enhancement of water quality and encourage recharging of groundwater in a manner which mimics nature.

In addition to this, the National Planning Policy Framework requires that surface water arising from a developed site should, as far as is practicable, be managed in a sustainable manner to mimic surface water flows arising from the site prior to the proposed development, whilst reducing flood risk to the site itself and elsewhere, taking climate change into account.

Range	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%

Figure 8.1 Peak rainfall intensity climate change allowance

Therefore, as an absolute minimum, the proposed site discharge under the 1-in-100-year storm plus climate change should be no greater than the existing 1-in-100-year storm discharge (i.e. mitigate the impact of climate change and any increase in the area of hardstanding). In this case, this would mean that, rather than discharging 139.9 litres / sec, the maximum permissible discharge from the site would be **78.3 litres / sec**.

Further to the above, the London Plan's Policy 5.13 states that "Development proposals should aim to achieve greenfield run-off rates . The Environment Agency (EA) also suggests that Developers should aim to achieve greenfield run off from their site. In accordance with the method outlined in the Institute of Hydrology Report 124, the Greenfield runoff for the site is calculated from the formula:

$Q_{BAR} = 0.00108 \times AREA^{0.89} \times SAAR^{1.17} \times SOIL^{2.17}$

where AREA is the site area in km² (pro rata of 50 ha if the site is less than 50 ha), SAAR is the Standard Average Annual Rainfall in mm and SOIL is the Soil Index both read from The Wallingford Procedure maps. This gives a greenfield runoff for the site of:

$Q_{BAR} = 0.00108 \times 0.50^{0.89} \times 600^{1.17} \times 0.30^{2.17} =$ **76.1 litres / sec (for 50 ha)**

Scaling this for the actual site area gives:

$Q_{BAR} = (76.1 \times 0.699) \div 50 =$ **1.06 litres / sec**

Using the Hydrological Growth Curve for south east England, the growth factor from Q_{BAR} to Q_{100} is 3.146 which gives a value for $Q_{100} =$ **3.35 litres / sec.** However, Clause 17 of the DEFRA / EA publication 'Rainfall runoff management for developments' states that "A practicable minimum limit on the discharge rate from a flow attenuation device is often a compromise between attenuating to a satisfactorily low flow rate while keeping the risk of blockage to an acceptable level. This limit is set at 5 litres per second, using an appropriate vortex or other flow control device. Where sedimentation could be an issue, the minimum size of orifice for controlling flow from an attenuation device should normally be 150 mm laid at a gradient not flatter than 1 in 150, which meets the requirements of Sewers for Adoption 7th Edition".

As the project is a new build, it is proposed to limit the surface water discharge rate from site to 5 litres/sec.

Potential approaches that can be taken to achieve the above reduction are discussed in the next section.

8.3 Disposal Methods

SuDS Management Train

A useful concept used in the development of sustainable drainage systems is the SuDS management train (sometimes referred to as the treatment train) and this approach is cited in London Plan. Just as in a natural catchment, drainage techniques can be used in series to change flow and quality characteristics of the runoff in stages. There are a variety of measures that can be implemented to achieve these goals:

Site Management / Prevention

Site management procedures are used to limit or prevent runoff and pollution and include:

- Minimising the hardened areas within the site
- Frequent maintenance of impermeable surfaces
- Minimising the use of de-icing products

Source Control

Source control techniques will be used where possible as they control runoff at source in smaller catchments. They can also provide effective pollution control and treatment, thereby improving the quality of the effluent discharged to the receiving waters.

Site Control

Where source control techniques do not provide adequate protection to the receiving watercourses in terms of flood protection and pollution control, site control may be required.

Regional Control

Where large areas of public space are available regional control can be incorporated to provide additional "communal" storage and treatment to runoff from a number of sites. However, in this case, all storage and treatment will be implemented on-site.

Drainage Hierarchy

Based on the above, the following drainage hierarchy will therefore need to be considered when preparing the surface water disposal strategy:

1. Store water for later use
2. Use infiltration techniques such as porous surfaces in non-clay area
3. Attenuate rainwater in ponds or open water features for gradual release to a watercourse
4. Attenuate rainwater by storing in tanks or sealed water features for gradual release to a watercourse
5. Discharge rainwater direct to a watercourse
6. Discharge rainwater to a surface water drain
7. Discharge rainwater to a combined sewer

It is believed that this is the most feasible disposal option is to connect to the existing storm water sewer under Melliss Avenue which ultimately discharges to the River Thames. The table below presents the approximate tank volume required under the 1-in-100-year (plus 40% climate change) storm event:

Discharge condition	Discharge rate	Storage volume required
Greenfield (Environment Agency's preferred rate)	5.00 litres/sec	230 m³

The attenuation tank will be located high enough to allow a new sewer connection to be made to the public sewer by gravity.

Ground investigations confirmed that the site is overlaid by gravelly clay followed by a made ground comprising of clayey gravelly sand and sandy gravelly clay which would offer little porosity. There is a layer of Kempton Park Gravel beneath the clay strata, however high groundwater table would not allow soakaways to function. In addition, there may be a risk associated with contamination as the result of the former use of the site and therefore, soakaways have been discounted taking into account the ground conditions. Refer to Appendix 2 for the site investigation extract.

It is proposed that the run-off from the paths and the children's play area at the back of the development will discharge onto the surrounding soft landscaping. Refer to Appendix 2 for the site investigation extract.

Refer to the AKT II SuDS Statement report dated August 2018 for a schematic SuDS layout and the pre-planning response and correspondence with Thames Water.

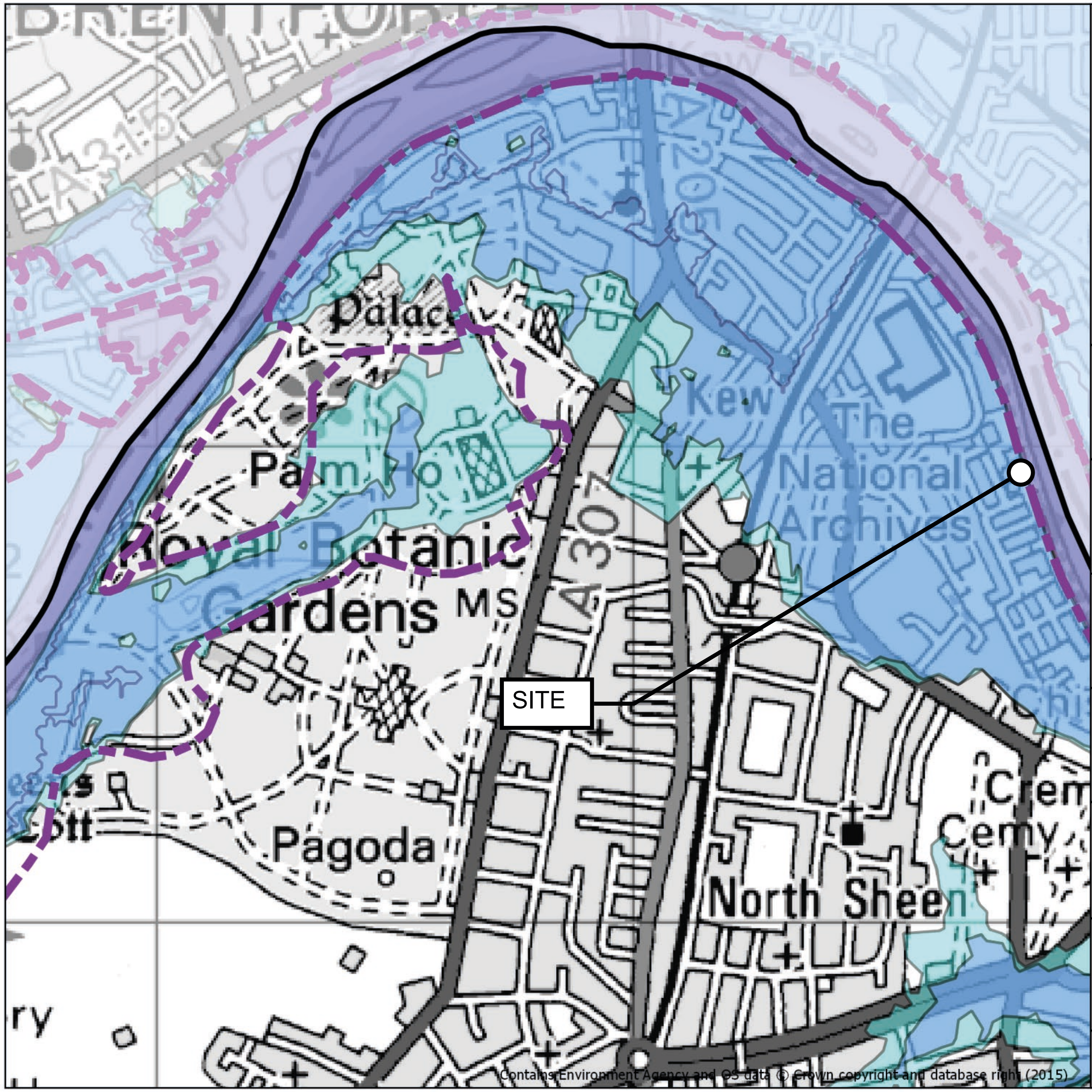
9 Conclusions

- In accordance with the National Planning Policy Framework, we would categorise the site as lying within Flood Zone 3a - an area assessed as having a high probability of flooding without the local flood defences. The flood defences protect the area against a river flood with a 1 in 100 annual probability or 1 in 200 annual probability of sea flooding.
- In accordance with the NPPF, the proposed “less vulnerable” uses located at ground floor level are acceptable within Flood Zone 3a.
- In accordance with the NPPF, the proposed “more vulnerable” residential uses located at first floor and above require the Exception Test to be applied in Flood Zone 3a.
- It is believed that the proposed location of the “more vulnerable” uses on upper floors, the presence and condition of flood defences, the available warning systems and the safe evacuation route satisfy the requirements of the Exception Test.
- The site has been assessed as being at **low risk of flooding from rivers or tidal sources**.
- The site is located within a Flood Warning / Flood Alert area which the building managers and all occupiers will sign up to.
- The site has been assessed as being at **low risk from surcharging sewers.**
- The site has been assessed as being at **low risk from groundwater sources**.
- The site has been assessed as being at **very low risk from artificial sources**.
- The site has been assessed as being at v**ery low risk from surface water flooding** with the surrounding roads being at low to medium risk.
- There is a dry escape route to the east of the site along the river embankment.
- Thorough evacuation procedures will be in place with trained staff available 24/7 on site.
- The proposed redevelopment has an acceptable level of flood risk within the terms and requirements of the National Planning Policy Framework.
- A number of SuDS devices are potentially suitable for use within the development.
- The Environment Agency have been consulted on the proposals and confirmed that they are satisfied with the proposed development in terms of flood risk. Their review letter is contained in Appendix 5.

The conclusions stated above are based on information received from other consultees. The flood risk classification of this site has been based on the above observations, and the recommendations stated

Appendix 1

London Borough of Richmond upon Thames SFRA Maps



Legend

- Borough Boundary
- Localised Drainage Issues
- Flood Defences
- Flood Zone 3b
- Flood Zone 3a
- Flood Zone 2

in association with

Environment Agency

Metis Consultants Limited

METIS

Client

LONDON BOROUGH OF RICHMOND UPON THAMES

Project Title

London Borough of Richmond Upon Thames Strategic Flood Risk Assessment Level 1

Drawing Title

Risk of fluvial and tidal flooding within character area R3 - Kew and North Sheen

Drawing Number	Scale
FIGURE 3	1:12,000