

AMBIENTAL

ENVIRONMENTAL ASSESSMENT

Flood Risk Assessment & Surface Water Drainage Statement

Hampton Quay, Littlehampton, West
Sussex, BN17 5RA

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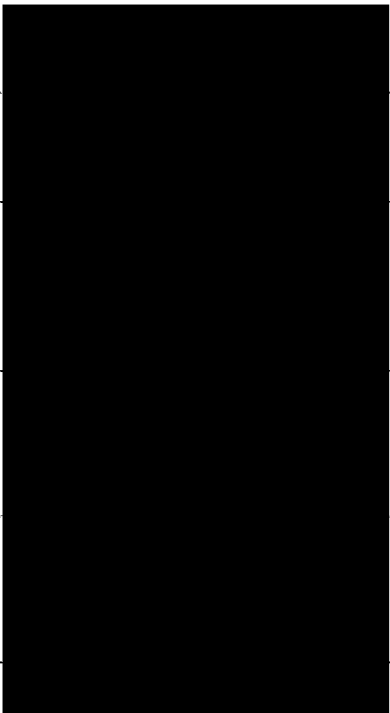
Project: Flood Risk Assessment, & Surface Water Drainage Statement

Prepared for The Littlehampton Yacht Club

Reference: 4732

Site Location: Hampton Quay, Littlehampton, West Sussex, BN17 5RA

Proposed Development: The development is for the redevelopment of a former Camp Site on the edge of the River Arun to provide; circa 115 homes, 300-400sqm of commercial/leisure use, and leisure moorings along the river.

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1. Summary

- 1.1 Ambiental Environmental Assessment has been appointed by The Littlehampton Yacht Club to undertake a National Planning Policy Framework (NPPF) compliant Flood Risk Assessment (FRA) for the proposed development at Hampton Quay, Littlehampton, West Sussex, BN17 5RA.
- 1.2 **This version of the report has been updated to address the points raised by both Arun District Council and the Environment Agency, who were provided with a previous version of the report. A meeting was held with the Environment Agency (14 Jan 2020) to discuss the points they have raised. These points have been considered and incorporated into the design and have been updated in this version of the report. A copy of the stakeholder comments, the comments response, and a copy of the meeting minutes are included as part of this report. The main change to the development proposals between the previously submitted FRA and this updated version are that; residential moorings are not now proposed. The Environment Agency were supportive of the details presented in relation to the finished floor levels of the residential accommodation relative to the design flood level including climate change. The Environment Agency required further clarification on the provision of access for maintenance of the new and proposed sluices / headwalls penetrating the flood defences, and how safe access and egress would be maintained.**
- 1.3 **Following the meeting an updated version of the report was submitted to the Environment Agency who have stated in their letter dated 09 July 2020 have stated that they “have no objection in principle to the proposal”.**
- 1.4 The development is for the redevelopment of a former Camp Site on the edge of the River Arun to provide; circa 115 homes, 300-400sqm of commercial/leisure use, and leisure moorings along the river.
- 1.5 With reference to the Environment Agency (EA) Flood Map for Planning, the proposed development is located within Flood Zone 3, with some areas in Flood Zone 1. The previous site use, Camp Site, would be classified as ‘More Vulnerable’. The proposed development is considered ‘More Vulnerable’ and ‘Water Compatible’ under the National Planning Policy Framework (NPPF). The Flood Zone designation does not take account of the presence of flood defences, or mitigation measures implemented on site.
- 1.6 The proposals include the creation of new waterside amenity uses by providing moorings. The moorings will need to be located in front of the flood defences, in the River Arun. Therefore, these moorings will be designed to move with the tide. In the event of a predicted extreme tidal event, a flood evacuation plan would be put in place, to enable visitors and users of the moorings to be evacuated to temporary refuge areas within the apartment blocks (reception lobbies), or to a central refuge location designated by the Emergency Planning team. The design of the moorings will need to take account of the fast-flowing nature of the River Arun, and suitable methods of securing moored vessels will need to be developed during the detailed design. This may include the requirement for routine inspections of moorings, to minimise the risk of vessels coming away from the moorings and posing a hazard to navigation and potentially flood defence assets.
- 1.7 The apartments blocks are to be located within an area that benefits from the presence of recently upgraded flood defences. As part of the proposals, opportunities to provide space for future upgrades of the flood defences will be included in the river side landscaping plan, and this will be developed during detailed design. All habitable uses, within the apartment blocks, will be located above the predicted with climate change tidal flood level for the 1:200 year tidal event in the year 2115. Therefore upgrade works to the flood defences would only be required if the impacts of climate change on tidal flooding are determined

to be more extreme over the next 100 years, which would require strategic improvements to all of the flood defences of Littlehampton. The development proposals have been discussed with the Environment Agency and maintenance access routes have been incorporated into the development layout, to facilitate the ongoing maintenance of the flood defences.

- 1.8 The Environment Agency have indicated that the flood defences on site are private. Therefore, opportunities to integrate the flood defences into the development plans have been implemented, to create better quality amenity spaces along the River Arun to improve access and improve the quality of the landscape.
- 1.9 Due to the presence of flood defences along the River Arun, there is a residual risk of tidal flooding from a flood defence breach. However, as the proposed habitable uses at the site are located above the predicted 1:200 year 2115 flood level, residents and users of the site would be protected from the consequences of a breach in the flood defences.
- 1.10 A Main River and an Ordinary Watercourse cross the site and discharge via a 600mm diameter outfall through the flood defences. It is understood that this structure is operated by the Environment Agency. The inlet culverts of these two watercourses are larger than the outlet structure. So, under the present arrangement, the total inflow could exceed the outflow, and therefore fluvial flooding could occur. At ground floor level, it is proposed to provide open play areas, car parking and other 'less vulnerable uses' which are compatible with the fluvial flood risk. It is proposed to create a new additional headwall, increasing the discharge capacity from the site, serving the Ordinary Watercourse to the north of the site and integrating this into the proposed landscaping strategy. This would result in a loss of existing open channel. To offset this loss, a high level swale is to be constructed along the development edge facing the River Arun. This channel will intercept and convey surface water flows from the buildings and other high level adjacent areas, with the surface water outfalls set at a level to discharge over the top of the flood defence level.
- 1.11 From discussions with West Sussex County Council 6 March 2020, to discuss the County wide strategy for "over the wall surface water disposal", it was identified that the provision of surface water overflows over the top of flood defences could provide meaningful benefits to the public sewer infrastructure, and have wider sustainability benefits. It is understood that West Sussex County Council is looking into this further, with a view to providing a guidance document in the near future.
- 1.12 The site is located in an area with the potential for elevated groundwater levels. This risk will need to be considered during construction and operation of the site. The mitigation measures to deal with the tidal flood risk, during the operational phase, will provide suitable controls to the risk of groundwater flooding.
- 1.13 The Environment Agency surface water flood mapping indicates that there is a risk of surface water flooding within the site. This can be managed by providing a suitable surface water drainage scheme, to alleviate the risk of flooding.
- 1.14 Surface water run-off from the roofs and podium deck will be collected by a swale and discharged at a high level into the Tidal River Arun. At lower areas of the site, surface water run-off will be collected and managed by permeable paving, before discharging into the Ordinary Watercourse and Main River within the Site.
- 1.15 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 lifetime of the development.

Development Description	Existing	Proposed
Development Type:	Previous use; campsite	Circa 115 homes, 300-400sqm of commercial/leisure use, leisure moorings along the river
Number of Bedrooms:	None	N/A
EA Vulnerability Classification:	Highly vulnerable	More Vulnerable and Water Compatible
Ground Floor Level:	Elevations vary between approximately 0.60mAOD and 6.47mAOD, with an average elevation of 2.29mAOD.	The ground floor of the apartments is to be set to 5.6mAOD.
Level of Sleeping Accommodation:	None	Habitable uses Finished Floor Levels: 5.6mAOD
Impermeable Surface Area:	Approximately 300m ² , which consists of the access road to the site	Approximately 5,410m ² , which comprises of the residential buildings, road, paths and hard surfaces.
Surface Water Drainage:	Via overland flows to watercourses	Roofs and podium to swale, discharging to the River Arun. Low lying open areas, will discharge into the Ordinary Watercourses.
Site Size:		Approx. 27,755m ²
Risk to Development	Summary	Comment
EA Flood Zone:	Flood Zone 3 (elements in 3a and 3b) and Flood Zone 1	No change.
Flood Source:	Tidal	Flood defences integrated into the development proposals will manage these risks. Raised finished floor levels for habitable uses will set sleeping accommodation above the 1:200 + climate change flood level in accordance with industry practice.
1:200 Year Defended Flood Level	3.40mAOD	
1:200 Year Defended Flood Level & Climate Change	5.00mAOD	
1:1000 Year Flood Level	4.13mAOD	
Recorded Flood Events in Area:	No	
Recorded Flood Events at Site:	No	
SFRA Available:	Yes	Arun District Council Level 1 & 2 SFRA Update, 2016
Management Measures	Summary	Comment
Ground floor level above extreme flood levels:	Extant camping use would be at ground level.	FFLs of habitable uses should be set no lower than 5.6mAOD.
Safe Access/Egress Route:	Yes	Access road onto Bridge Road Roundabout, A259. The development proposal includes a raised podium which will provide access from the residential apartments above the design flood level.
Flood Resilient Design:	Yes	Lower ground floor uses to be designed to be compatible with residual flood risk.
Site Drainage Plan:	Yes – Concept Strategy	Roof and podium surface water drainage to swale. Lower level access ramp to drain via the watercourses within the site boundary.
Flood Warning & Evacuation Plan:	Yes	EA Flood Alert and Warning Service
Offsite Impacts	Summary	Comment
Displacement of floodwater:	No	
Increase in surface run-off generation:	Yes	As the discharge will be to tidal features, there is no requirement to provide onsite attenuation
Impact on hydraulic performance of channels:	Yes	Design of culverted watercourse and improvements to watercourses to be developed with consenting authorities.

Table 1 Summary of flood risks, impacts and proposed flood mitigation measures.

N/A¹ not required for this assessment; N/A² data not available.

2. Policy Compliance

- 2.1 The purpose of this assessment is to demonstrate that the development proposal outlined above can be satisfactorily accommodated, without worsening flood risk for the area and without placing the development itself at risk of flooding, as per national guidance provided within the National Planning Policy Framework (NPPF) 2019, the National Planning Practice Guidance (NPPG), DEFRA's National Standards for Sustainable Drainage and Local guidance.
- 2.2 This Flood Risk Assessment has been developed in accordance with the guidance and legislation set out in the below documents:

National Policy & Guidance

- Water Industry Act (1999)
- EU Water Framework Directive (2000)
- EU Floods Directive (2007)
- The Flood Risk Regulations (2009)
- Flood and Water Management Act (2010)
- Flood Risk and Coastal Change Planning Practice Guidance (PPG, 2014)
- Non-statutory Sustainable Drainage Technical Standards (2015)
- CiRIA SuDS Manual (C753, 2015)
- The Building Regulations, Part H (2015)
- Town and Country Planning, Development Management Procedure, (England) Order (2015)
- British Standards, Drain and sewer systems outside buildings (BS EN 752:2017)
- Draft Sewers for Adoption 8 (SFA8, August 2018)
- National Planning Policy Framework (NPPF, 2019)
- Flood Risk Assessments: Climate Change Allowances, Environment Agency (2019)
- Preparing a Flood Risk Assessment: Standing Advice, Environment Agency and DEFRA (2019)

Local Policy & Guidance

- Arun District Council Flood Risk (planning policy)¹, and associated documents

¹ <https://www.arun.gov.uk/flood-risk-planning-policy/>

3. Development Description and Site Area

Proposed Development Location

- 3.1 The proposed development is located at Hampton Quay, Littlehampton, West Sussex, BN17 5RA (Figure 1 and Figure 2).
- 3.2 It is understood that the development is for the redevelopment of a former campsite on the edge of the River Arun, to provide: circa 115 homes, 300-400sqm of commercial/leisure use and leisure moorings along the river. A copy of the proposal drawings is provided in Appendix 1.



Figure 1 Location Map, identifying the location of the proposed development (Source: OS)



Figure 2 Aerial Map, identifying the location of the proposed development (Source: GlobalMapper)

Topography

- 3.3 Topographic levels vary between approximately 0.60m AOD and 6.47m AOD, with an average of 2.29m AOD. It should be noted that the lowest level is part of the open watercourse that passes through the site. Appendix 1 presents a copy of the Environment Agency LiDAR data for the site.

Geology

- 3.4 The British Geological Survey (BGS) Geology of Britain Viewer indicates that the bedrock underlying the site is Lewes Nodular Chalk Formation, Seaford Chalk Formation, Newhaven Chalk Formation, Culver Chalk Formation and Portsdown Chalk Formation (undifferentiated), comprising Chalk (Source: BGS). This formation is considered to be a Principal aquifer (Source: EA; Magic Map online resource). A Principal aquifer is a highly permeable, supporting water supply and/or river base flow on a strategic scale.
- 3.5 The British Geological Survey (BGS) Geology of Britain Viewer indicates that the superficial deposits underlying the site are Raised Marine Deposits, comprising Clay, Silt, Sand and Gravel. This formation is a Secondary 'A' aquifer (Source: EA; Magic Map online resource). A Secondary 'A' aquifer is permeable, supporting water supplies at a local scale and may contribute to base flow of rivers.
- 3.6 The BGS onshore borehole record database indicates that a number of historic borehole records are available within the site. A summary of the findings recorded for borehole ID 19952423 are provided in Table 2. This indicates that groundwater is approximately 1.2m below ground level, which is similar to the other borehole logs in the area.

Layer	Thickness	Infiltration Potential	Depth to Groundwater
Firm Brown CLAY	0.55 m	Low	
Firm to stiff grey and brown CLAY	0.55 m	Low	
Soft to very soft grey and mottled orange brown slightly sandy CLAY	0.60 m	Low	1.2 m
Very loose brown grey fine to coarse SAND	0.45 m	Medium	
Very loose dark grey fine to coarse SAND with rare pockets of dark brown fibrous peat	1.20 m	Medium	
Very loose locally loose dark grey predominantly fine and medium SAND	2.00 m	High	
End of log			

Table 2: Historic BGS Borehole Record

- 3.7 This aquifer is considered to be a highly vulnerable principal aquifer, meaning that soils have little ability to attenuate pollutants and therefore pollutants can rapidly reach groundwater.
- 3.8 The site is not within an EA groundwater Source Protection Zone.

Development Proposals

3.9 The development proposals are provided in Appendix 1 and indicate the following key features as relevant to this Flood Risk Assessment:

- **Moorings:** these are to be located within the River Arun and outside of the area benefitting from flood defences. This application does not include residential moorings.
- **New residential apartment blocks:** these are located landward of the flood defences and are connected at a high level, by the provision of a landscaped podium deck (green roof). Car parking will be provided at the lower ground floor level. Vehicular access is provided by modification to the existing vehicular access from the A259 roundabout, which is located in Flood Zone 1.
- **Drainage Swale:** this will collect the surface run-off from the apartment roofs and discharge directly to the tidal River Arun at a high level, above the flood defence level.
- **A Main River** enters the site under the southern arm of the A259 (between the roundabout and the bridge), through a 1200mm diameter culvert. This flows through the southern portion of the site in an open channel, before being discharged via a 600mm diameter culvert. As agreed with the Environment Agency, where the access road is proposed to cross this channel, it will be provided in a free spanning structure.
- **An Ordinary Watercourse** enters the northern part of the site through a 2000mm arch bridge from under the A259, with a smaller culvert (1000mm diameter) adjacent to it. This flows through an open watercourse and drains into the Main River, and then discharges via the same 600mm diameter culvert as the Main River. As part of the proposals, this channel will be re-routed, to follow a more direct line to a new outfall, which will be constructed through the flood defences, subject to a Flood Risk Activity Permit from the Environment Agency. To compensate for the loss of open watercourse, the proposed swale will provide a similar environment to the existing ditch. The provision of an additional outfall will increase the discharge capacity from the Ordinary Watercourse and the Main River, as these currently share an outfall.

Vulnerability Classification

3.10 The EA Flood Map for Planning (Figure 4, a larger copy is provided in Appendix 1) demonstrates that the proposed development lies within Flood Zone 3a, with a high probability of greater than 1 in 100 (1%) of river flooding or a high probability of greater than 1 in 200 (0.5%) of tidal flooding in any year. As some of the redline boundary extends into the River Arun in front of the defences, it is assumed that these areas are within the Functional Floodplain and would therefore be classified as Flood Zone 3b. Access to the site (from the roundabout) is located in Flood Zone 1 via the A259. The mapping produced by the Environment Agency does not indicate that the area benefits from flood defences. However, the Littlehampton flood defences have been recently upgraded and it is understood that the site now benefits from adequate flood defences. This is discussed in more detail later in the report.

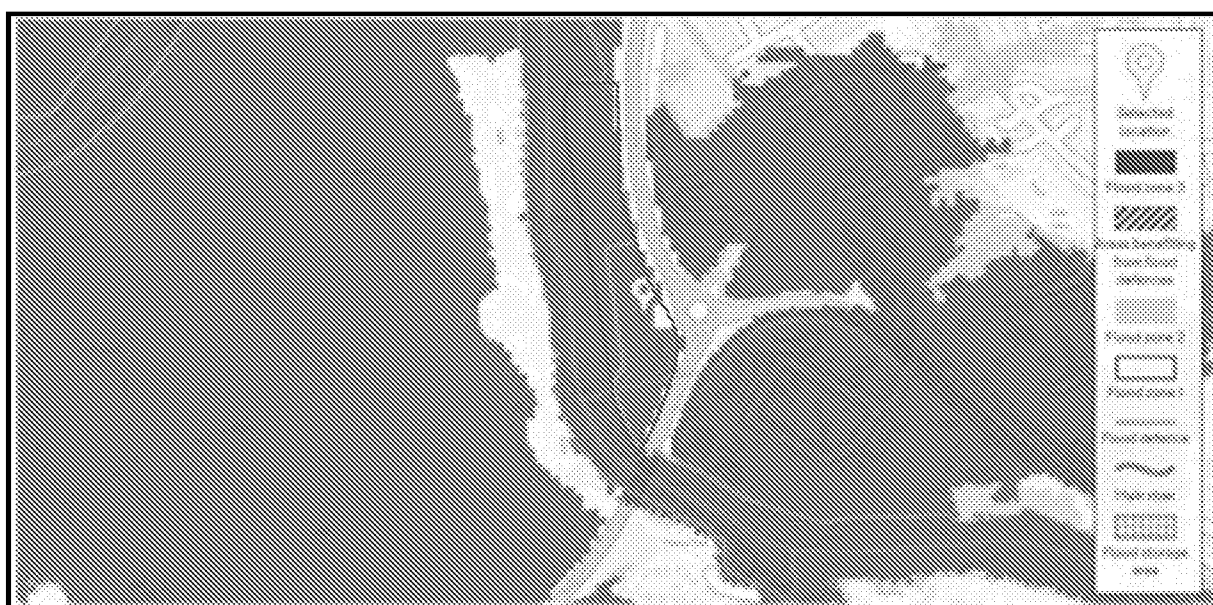


Figure 3: EA Flood Map for Planning, indicating redline application boundary (Source: EA)

- 3.11 The extant usage on site is that of a campsite, which would be classified as 'More Vulnerable'.
- 3.12 The development proposals cover a range of uses, which are located in different flood zone designation areas, as indicated in Figure 3. The residential apartments are to be located behind the recently upgraded flood defences. The moorings are to be located on the active 'River Arun'.
- 3.13 The proposals indicate that there are several development types being proposed as part of the Hampton Quay development. These have been listed in Table 3, each with a description of the development's main use, the flood zone classification and the category of vulnerability that it falls into.

Proposed Uses	Flood Zone	Vulnerability	Appropriate Use?
Residential apartments	3a, defended	More Vulnerable	Yes (Exception Test)
Retail Unit	3a, defended	Less Vulnerable	Yes
Car Park	3a, defended	Water Compatible	Yes
Moorings (not residential)	3b	Water Compatible	Yes

Table 3: Vulnerability Classifications

4. Sequential Test/Exception Test

- 4.1 Under the NPPF, all new planning applications should undergo a *Sequential Test*. This test should 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.
- 4.2 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 <i>Functional Floodplain</i>	Exception Test Required	✓	✗	✗	✗

*Table 3 The Sequential Test: Flood Risk Vulnerability and Flood Zone 'Compatibility' Table as specified by NPPF.
Please note: ✓ means development is appropriate; ✗ means the development should not be permitted.*

- 4.3 As discussed in Section 3, the development proposals for Hampton Quay have different vulnerability classifications.
- 4.4 Using the principles of the Sequential Test outlined above, overall, the proposed development is 'More Vulnerable', 'Less Vulnerable' and 'Water Compatible'. The site is located within Flood Zone 3a (as defined by the EA), with access to the site located in Flood Zone 1. Therefore, under the NPPF, the developments which are classed as 'More Vulnerable' require the application of the Exception Test, whilst the developments that fall under the 'Less Vulnerable' and 'Water Compatible' classification do not.
- 4.5 The current Arun District Council Sequential Test is from 2009 and was written under the Planning Policy Statement 25 guidance, which has since been replaced by the NPPF. The Sequential Test indicates that many of the strategic development sites being considered within the study area include elements of Flood Zone 3a. In terms of flood risk, the 'West Bank' strategic allocation area has similar constraints to the Hampton Quay site. As the 'West Bank' is an allocated site, this demonstrates that development within Flood Zone 3 can be considered sequentially acceptable within Arun District Council. It should be noted that other allocated developments do not have access and egress routes linked directly to Flood Zone 1.
- 4.6 For clarity, although the redline boundary includes areas of Flood Zone 3b, these are required to provide the proposed moorings. By definition, moorings need to be located in an area of active water, meaning that they need to be in Flood Zone 3b. However, the moorings are considered to be a 'Water Compatible' use, as they will provide 'water-based' recreation.

- 4.7 By adopting the Sequential approach, the 'More Vulnerable' uses (residential apartments) are proposed to be located above the predicted tidal flood level for the site and in an area that ordinarily benefits from flood defences (discussed in Section 5). Under the NPPF, proposals for this type of usage require the application of the Exception Test, the flood risk element of which is addressed by this Flood Risk Assessment. The wider sustainability benefits are covered by other documents supporting the Planning Application.
- 4.8 The moorings are considered to be 'Water Compatible' and, therefore, do not require the application of the Sequential or Exception Test.

5. Site Flood Hazards

Sources of Flooding

- 5.1 The proposed development is located within Flood Zone 3 (high risk of flooding) and is considered to be 'More Vulnerable' or 'Water Compatible', according to NPPF guidelines. Access to the site is in Flood Zone 1. Table 4 summarises the potential sources of flooding to the site:

Source	Description
Tidal/Fluvial	High (Flood Zone 3) with site access in Flood Zone 1 (River Arun)
Surface	Relatively low risk
Groundwater	High risk
Sewer	Low risk

Table 4 Summary of flood sources.

Mechanisms and History of Flooding

- 5.2 The EA Flood Map for Planning (Figure 3) demonstrates the site to be located within Flood Zone 3 (high risk of flooding), with access located in Flood Zone 1 (low risk of flooding). It is important to note that the EA Flood Map for Planning shows only the potential floodplain; the mitigating effects of any flood defences currently in place are not considered.

Tidal Flooding

- 5.3 The River Arun, an EA main river, is located directly next to the development site and the proposed moorings (water-based recreation) extend into the River Arun.
- 5.4 The EA Flood Map for Planning (Figure 3) indicates that the proposed site is located within Flood Zone 3, with a high risk of flooding from tidal sources. The access is located in Flood Zone 1 and is, therefore, considered to be at low risk of flooding. The dominant source of flood risk is tidal, due to the proximity to the coast and the tidal range within the River Arun, which continues to Pulborough.
- 5.5 The current Environment Agency Flood Zone maps indicate that the site is located in Flood Zone 3 (with the access in Flood Zone 1) but does not indicate that the site benefits from the recently completed flood defence improvements in the area. Therefore, it does not appear that the EA Flood Map for Planning has been updated to include the protection against tidal flooding provided by the improved EA flood defences along the River Arun. It would be advisable for this information to be updated, as it should indicate the wider benefit that the flood defences have for the Littlehampton area. However, for the purposes of this assessment, a review of the flood defence crest heights and the predicted tidal flood levels (with and without climate change) has been conducted, to establish the standard of protection provided by the flood defences.
- 5.6 The EA Product 4 data provided to Ambiental uses model information from the Lower Tidal River Arun Strategy (LTRAS) Modelling, which was completed by Atkins in 2010. It is understood that improvements were made to the flood defences along the River Arun from 2013 to 2015 and are now complete. As such, the model pre-dates the construction of the flood defences. This may explain the difference between the

mapped areas benefitting from flood defences and the model outputs, as the model does not take account of the protection provided by the flood defences.

- 5.7 Using topographic data provided by the client (Appendix 1), the height of the vertical sheet steel-piled flood defence wall is at least 4.81mAOD. Topographic levels on site vary between approximately 0.60mAOD and 6.47mAOD, with an average elevation of 2.29mAOD. It should be noted that the lowest elevation is part of the watercourses that pass through the site.
- 5.8 According to the Environment Agency modelled flood levels, the present day defended 1:200 year (0.5%) tidal flood level is 3.40mAOD. Current climate change allowances (December 2020) for tidal flooding indicate that 1.60m (Higher Central Allowance) of sea level rise should be applied to present day flood levels, which would result in a **1:200 year flood level of 5.00m AOD by the year 2115**.
- 5.9 The Environment Agency modelled present day defended 1:1000 year (0.1%) tidal flood level is 4.13m AOD. After applying the 1.60m climate change allowance, the flood level would increase to 5.73m AOD by the year 2115.
- 5.10 According to the Environment Agency modelled flood levels, the present day undefended 1:200 year (0.5%) tidal flood level is 3.53mAOD. Applying the current climate change allowances for tidal flooding (1.60m of sea level rise) should be applied to present day flood levels, which would result in a 1:200 year flood level of 5.13m AOD by the year 2115.
- 5.11 The Environment Agency modelled present day undefended 1:1000 year (0.1%) tidal flood level is 3.66m AOD. After applying the 1.60m climate change allowance, the flood level would increase to 5.26m AOD by the year 2115.
- 5.12 A summary of the flood levels is provided in Table 4.
- 5.13 This analysis of flood risk indicates that the recently constructed flood defences are insufficient in protecting the site from the Higher Central climate change prediction of tidal flood levels, 1.6m increase. Even though the flood defences have recently been upgraded, the current climate change predictions (which have increased since the construction of the flood defences) indicate that they could be overtopped. Therefore, the defences in proximity to the site have a declining standard of protection. This may be true also for the wider Littlehampton area. Suitable mitigation for this overtopping risk is discussed in Section 8. It should be noted that the climate change levels provided by the Environment Agency, as part of their modelled data, are lower than those indicated by adding the current allowance. From the information provided, it is not clear which climate change allowance was included in the Environment Agency data. Therefore, Ambiental have adopted a precautionary approach by adding the current published allowance to the predicted present day tidal still water level.

Scenario	1:200 Present	1:200 2115*	1:1000 Present	1:1000 2115*
Defended	3.40mAOD	5.0mAOD	4.13mAOD	5.73mAOD
Undefended	3.53mAOD	5.13mAOD	3.66mAOD	5.26mAOD
Current Flood Defence Level	4.81mAOD			

Table 5: Summary of Environment Agency Flood Levels, Present Day and 2115

- 5.14 The Environment Agency have indicated that the flood defences on site are private. Therefore, over the lifetime of the development, an adaptive approach² will be incorporated into the detailed design of the flood defence walls. Furthermore, the current Environment Agency shoreline management plan for Littlehampton is 'Hold the Line'. This means that flood defences will be maintained in this area for the next 100 years, to provide the same 'standard of protection' as currently provided in the area. The 'Hold the Line' policy is contingent on future funding becoming available. **As will be demonstrated through this Flood Risk Assessment, the proposals are, therefore, not reliant on public flood defence upgrades to be made safe, based on the current tidal flood level predictions for 2115 for the 1:200 year event.**
- 5.15 The proposals have been designed to be above the 1:200 year 2115 tidal level, including 600mm of freeboard (see Section 8 for more details). Based on current predictions, no further improvements, beyond those outlined for the development proposals to the flood defences, are necessary. However, should future predictions of climate change result in higher predicted tidal flood levels, the incorporation of flood defences that can be adapted in the future, will enable the ongoing protection of the site. It must be emphasised that based on the current guidance the proposed flood defences are set to an appropriate level, and the finished floor levels of sleeping accommodation will be above this level.
- 5.16 As part of the mitigation measures for the site, discussions with the Environment Agency have identified an appropriate approach to facilitating access and maintenance to the flood defences within the development proposals. This feature is discussed further in the mitigation section of this report.

Fluvial Flooding

- 5.17 The product 4 data provided by the Environment Agency (Appendix 2) includes Fluvial and Tidal levels. In all instances, the Tidal Levels are greater than the Fluvial Levels. Taking the Fluvial Defended levels (which are most representative of the situation at the site), the site is not at risk of fluvial flooding. Furthermore, as the site benefits from flood defences, the requirement for floodplain compensation is not considered necessary. A summary of the fluvial flood levels are presented in Table 6, which indicate that all of the fluvial flood levels (defended and undefended) are lower than the current flood defence level.

Scenario	1:20 Present	1:100	1:100+20%	1:1000
Defended	-	-	2.87mAOD	-
Undefended	2.59mAOD	2.59mAOD	3.43mAOD	2.59mAOD
Current Flood Defence Level	4.81mAOD			

Table 6: Summary of Environment Agency Fluvial Flood Levels

- 5.18 The climate change level presented is related to the old 20% allowance, and the current flow allowance is 105%. The findings of the Environment Agency flood model outputs are ambiguous with all scenarios (except the with climate change) recording the same flood level. This is likely to indicate that the tidal boundary condition is the dominant factor in the area, with fluvial model tidal boundaries often being set

² An adaptive approach to flood risk enables future upgrades to flood defence infrastructure to be implemented through minimal changes to the development proposals. For instance, flood defence walls can be designed to enable increases in the defence height, by providing sufficient foundation details and methods of construction that enable future retrofit with minimal disruption.

to one event. The present-day events presented all indicate the same level, which is assumed to be the same as the tidal boundary adopted in the model, supporting the assumption that a single tidal boundary value has been used for all present-day events. This is supported by the value for the with 20% being 0.84m higher than all of the other presented results, indicating that climate change may have been applied to the tidal boundary for that specific event.

- 5.19 Based on the above interpretation of the data provided by the Environment Agency, and on the basis that the fluvial flood levels are lower than the predicted tidal levels, it is considered that mitigation measures for the tidal flood risk are more than adequate for the fluvial flood risk.
- 5.20 A watercourse runs through the centre of the site from two branches, as shown in Figure 4. By comparing the inlet structures for the Main River (1,200 mm diameter) and the Ordinary Watercourse (2,000 mm arch) with the outlet structure (600mm diameter), it is determined that the existing outlet structure is smaller than the inlets. As such, there is the potential for more water to enter the site than leave. This likely to be the case during high tide events, which could surcharge the outfall and potentially result in flooding of the lower land areas. Therefore the development proposals have included water compatible uses on the ground floor, namely the play area and car park.



Figure 4: Location of Watercourses within the site.

- 5.21 The nearby Environment Agency gauge data information on the River Arun (see Figure 5), the general tidal trend is that the outfall (at zero mAOD) could be surcharged for up to 6.5 hours per day, based on the current record, taken in March during a period of extreme weather which resulted in flooding in some parts of Littlehampton. When considering the predicted impacts of sea level rise, resulting in the still water level rising by 1.6m by 2115, the existing 600mm diameter outfall could be permanently submerged. Overtime,

this would limit the ability of the Ordinary Watercourse and Main River to drain, resulting in a slow accumulation in water throughout the upstream drainage network. It is therefore considered that, during the lifetime of the development, a retrofit of the existing outfall would be required, and this will be facilitated by the provision of the access and maintenance routes within the development. The upgrading of the outfalls would need to be designed in a co-ordinated way so that discharges into the tidal environment could be maintained.

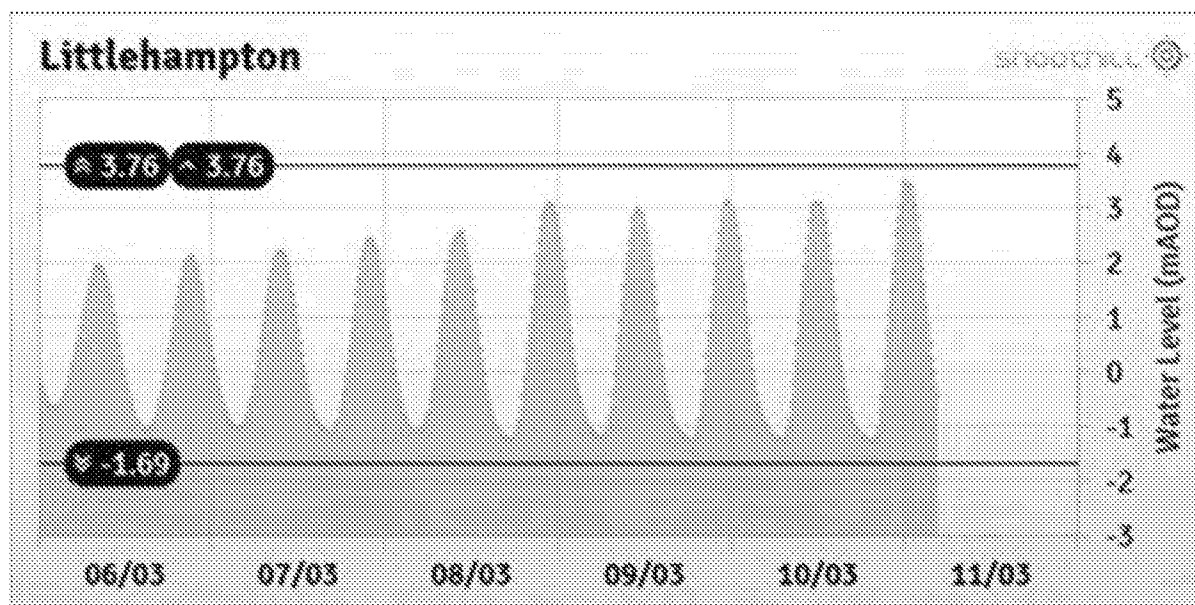


Figure 5: River Arun level gauge for early March 2020. (Source: EA)

- 5.22 An overflow from the Main River to the play area will be incorporated into the landscaping. By doing this, if flows in the Main River exceed the outfall capacity, flood waters will be directed into the play area. The play area itself will be designed using finishes and equipment that are resistant to flooding and can be easily cleaned should a flood occur. This is similar to the open space play area adjacent to the Thames Barrier in London.
- 5.23 If water levels in the watercourse were to continue to rise, these flows would be directed towards the under-croft parking areas. The parking areas will be surfaced with permeable paving and all electronics (lighting) will be installed at a high level, to minimise the potential impacts of this scenario.
- 5.24 Following consultation with the Environment Agency, a new outfall through the headwall will be considered (subject to submission of a Flood Risk Activity Permit, post Planning Approval). This outfall would enable the diversion of the Ordinary Watercourse to the west, following the general flow route of the area. This would result in the abandonment of approximately 145m of existing open channel, a schematic is presented as Figure 6.

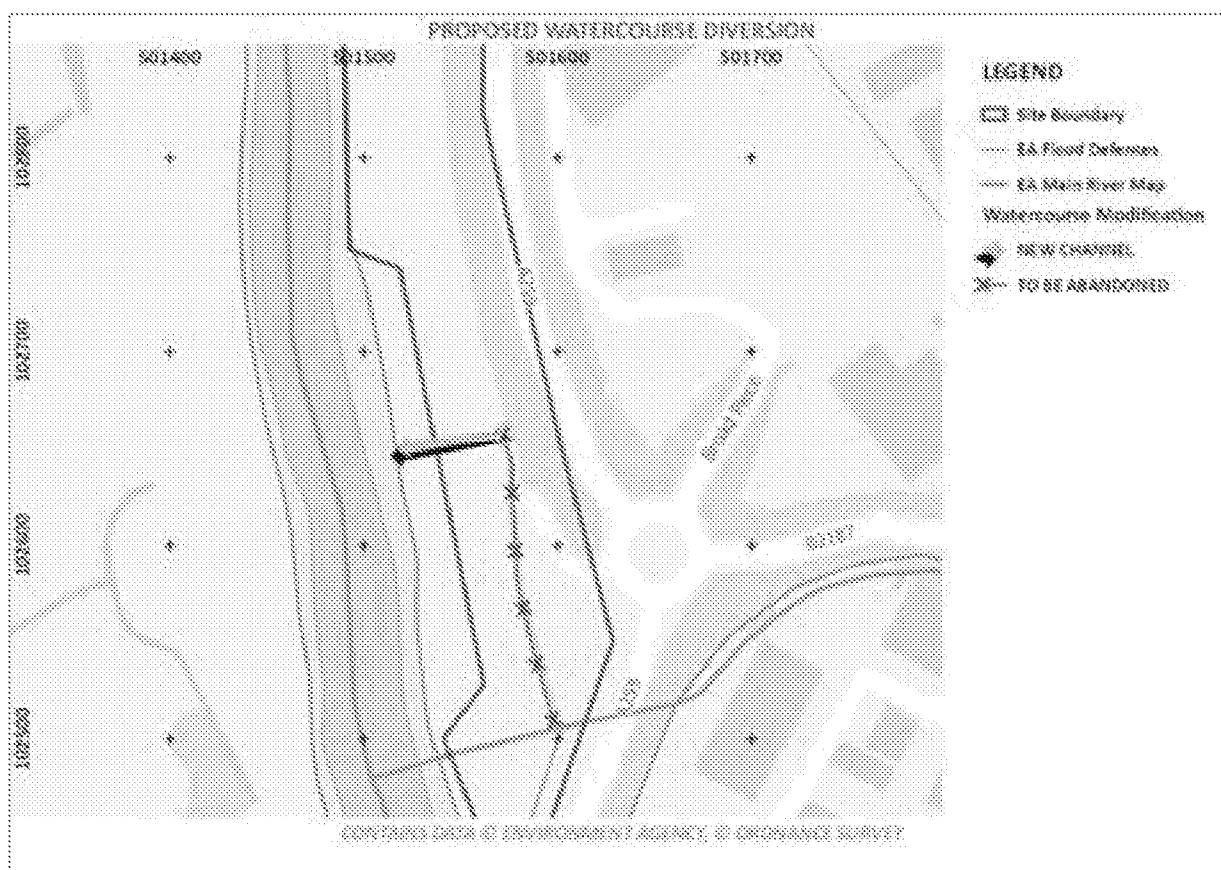


Figure 6: Proposed Watercourse Diversion

- 5.25 The diverted channel would be approximately 45m in length, from the existing inlet culvert under the A259 to the centre of the current flood defence bund. Assuming a gradient of 1 in 1,000, this would necessitate a fall of 45mm. The lowest incoming pipe in this area is the 1m diameter pipe, which has an invert level of 0.08m AOD, this would result in the invert level of the new outfall being similar to the existing Environment Agency maintained provision.
- 5.26 From analysis of Environment Agency LiDAR data, the catchment delineation of the upstream flow pathways is inconclusive. This is due to the urbanisation that has occurred in the upper reaches, which has modified the flow routes through the provision of below ground drainage infrastructure. From review of the Environment Agency Risk of Surface Water Flooding Map (which give an indication of likely overland flow routes), it can be seen that the railway line acts as a barrier to flow, which would limit the flow within the watercourses to the capacity of culverts under the railway line. Furthermore, the A259 is 6m higher than the surrounding land; therefore, the road would act as a significant barrier to overland flows that exceed the capacity of the culverted sections of the watercourse, leading to ponding on the upstream face of the A259.
- 5.27 The maximum permissible flow into the site will be limited by the capacity of the upstream structures discharging into the site. Therefore, provided the combined capacity of the outlets into the site is maintained through the site, the proposals should not increase flood risk at the site or too others. As it is proposed to provide a new outfall for the Ordinary Watercourse, increasing the potential discharge capacity, the risk of flooding upstream can be considered to be reduced.
- 5.28 The Ordinary Watercourse has two outfalls discharging into it:

- 2.0m arch (1.6m² cross-sectional area).
- 1.0m diameter culvert (0.8m² cross-sectional area).

- 5.29 The size of the new outfall into the River Arun will need to be agreed with the Environment Agency during the detailed design stage, it is likely that an array of large diameter pipes would be installed. It is recommended that one of the pipes is installed at a lower level to minimise the risk of sedimentation occurring in all the pipes. Each pipe should be equipped with its own flap valve. Safe access and maintenance considerations will need to be included into the design.
- 5.30 The development proposals will require building over a portion of the existing Main River. During consultation, the Environment Agency have stated that they would require a free spanning structure that is set back from the banks by at least 600mm. This approach will be adopted throughout the scheme.
- 5.31 The Main River currently has the Ordinary Watercourse discharging into it. Post development, the Ordinary Watercourse will discharge directly to the River Arun via a newly constructed headwall through the flood defence, reducing the amount of flow that will discharge through the existing provision.
- 5.32 Overall, the risk of tidal flooding to the proposed site, when accounting for the presence of the flood defences, is low, and the risk of fluvial flooding is medium. All habitable uses at the site will be located above the predicted tidal flood level (which is higher than the fluvial level), and water compatible uses are provided within the areas at risk of flooding i.e. areas lower than the tidal flood defences.
- 5.33 As the proposals will result in construction works within bye-law distance of Main Rivers and Ordinary Watercourses, as well as flood defences, it is likely that permits and licences to undertake the works will need to be secured from the Environment Agency, West Sussex County Council and Arun District Council.

Surface Water (Pluvial)

- 5.34 The Environment Agency Flood Risk from Surface Water map (Figure 7) shows the proposed development to be within an area of 'Low' to 'Medium' risk of flooding from surface water. Areas identified to be at 'Low' risk have a 0.1% to 1.0% annual risk of flooding from this source. Areas identified to be at 'Medium' risk have a 1.0% to 3.3% annual risk of flooding from this source. 'High' risk areas have a greater than 3.3% annual risk of flooding from this source.
- 5.35 The EA Surface Water Flood Depth Map for the High-Risk Scenario (Figure 8) indicates that the proposed development is not affected in this event. Larger sized plans of the risk of surface water flooding are provided in Appendix 1.
- 5.36 The EA Surface Water Flood Depth Map for the Medium Risk Scenario (Figure 9) indicates that the proposed development may experience flood levels of 300mm to 900mm in this event. The areas affected by surface water flooding are located close to the watercourse. A Medium Risk Scenario has a 1% to 3.3% annual risk of occurring.
- 5.37 The EA Surface Water Flood Depth Map for the Low Risk Scenario (Figure 10) indicates that the proposed development may experience flood levels of greater than 900mm in this event. The areas located close to the ordinary watercourse are affected by depths of over 900mm of surface water flooding. A Low Risk Scenario has a 0.1% to 1% annual risk of occurring.
- 5.38 Overall, the risk of flooding from surface water can be considered **relatively low**, with much of the risk attributable to the surface water that lands on the site i.e. its own catchment, which will be managed through the provision of an onsite surface water management system.

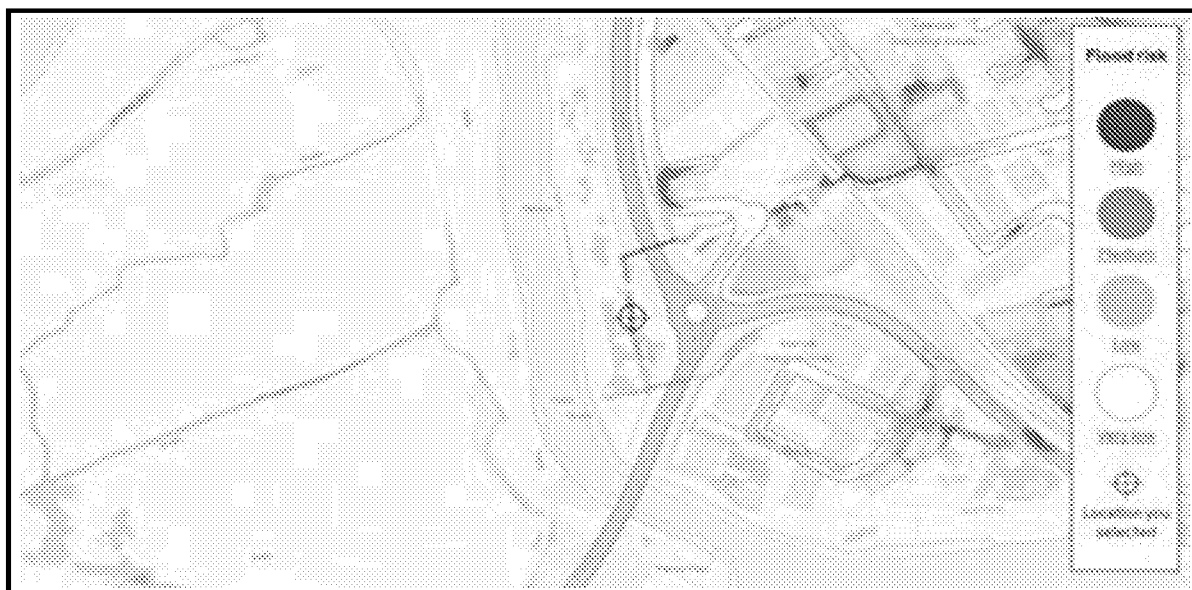


Figure 7 EA Surface Water Flood Risk Map. (Source: EA)



Figure 8 Surface Water Depths for a High Risk Scenario. (Source: EA)

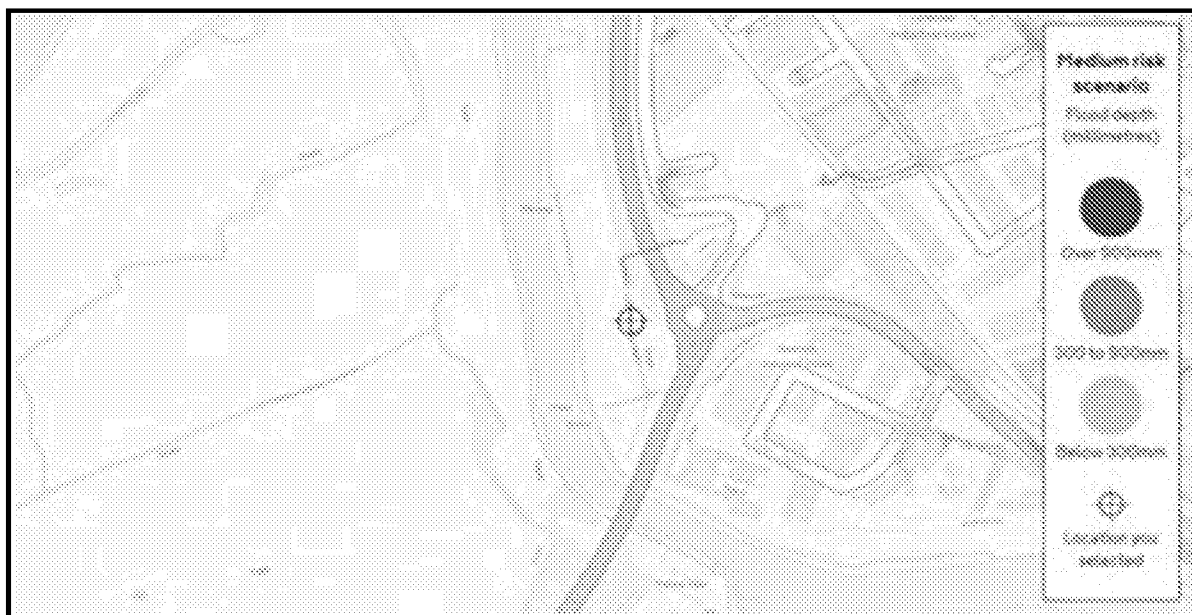


Figure 9 Surface Water Depths for a Medium Risk Scenario. (Source: EA)

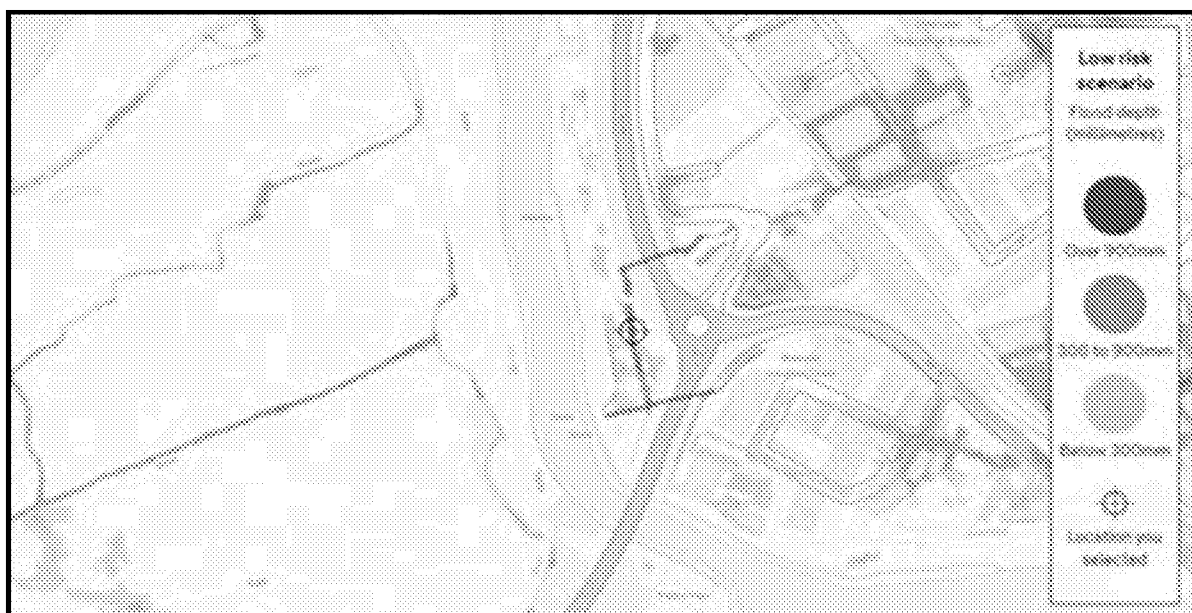


Figure 10 Surface Water Depths for a Low Risk Scenario. (Source: EA)

Groundwater

- 5.39 The Arun District Council SFRA (2016) indicates that the proposed development site is located within a 1km grid square of which more than 75% is considered susceptible to groundwater flooding (Figure 11).
- 5.40 Based on the historic boreholes at the site, groundwater is likely to be approximately 1.2m below existing ground levels.
- 5.41 Overall, the risk of flooding from groundwater sources to the proposed development can be considered **moderate**. Mitigation measures for this risk are discussed in Section 8, however as the proposed uses at ground level are considered to be water compatible, the risk to uses and residents of the site is considered low.



Figure 11 Groundwater Susceptibility (Source: Aruni District SFRA)

Sewer

5.42 The Arun District Council SFRA (2016) maps (Figure 12) historic incidents of sewer flooding within the District and indicates that there have been several flooding incidents caused by sewers in the past, but none of the recorded events are near the site.

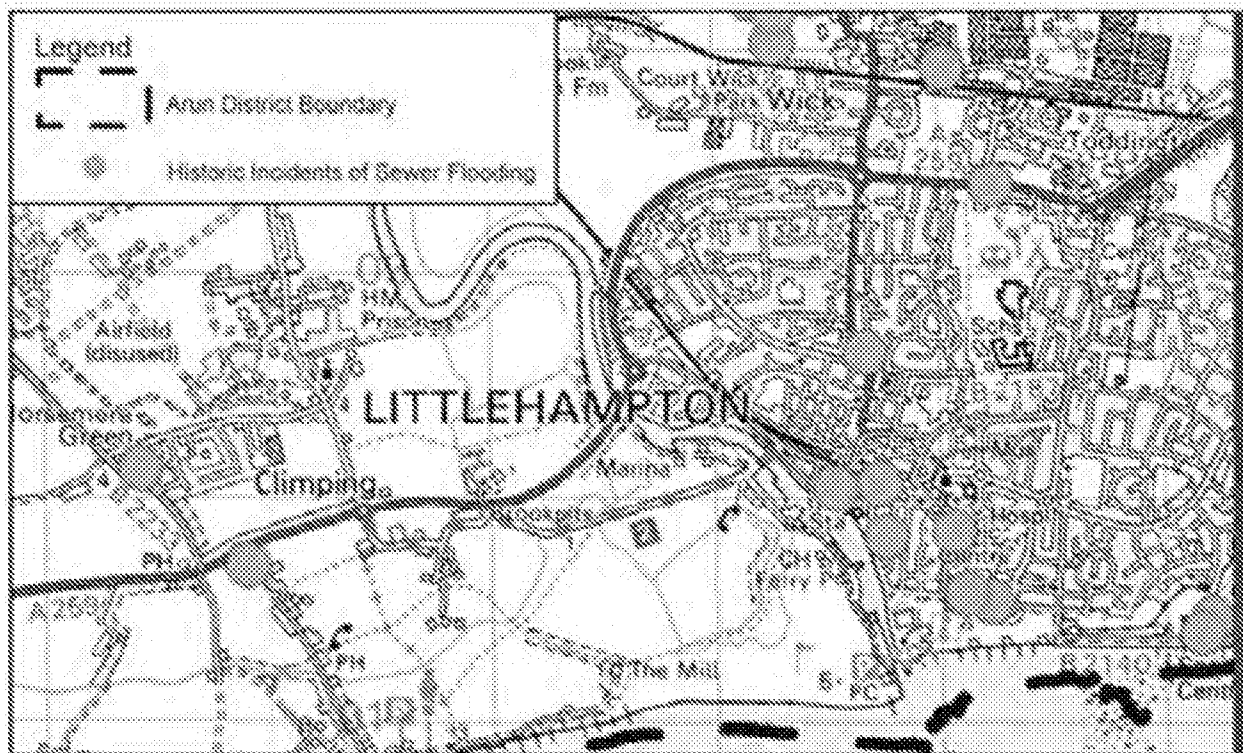


Figure 12 Sewer. (Source: SFRA, based on DG5 Register)

Records of Historical Flooding

- 5.43 The Arun District Council SFRA (2016) maps (Figure 13) historical flooding information for the District and indicates that there have been numerous flooding events in the wider area around the site, from a variety of sources of flooding. The closest flooding incident is located approximately 240m south-east of the site and was a fluvial event.
- 5.44 The Arun District Council SFRA (2016) maps historic incidents of sewer flooding within the District and indicates that there have been several flooding incidents caused by sewers in the past; however, none are indicated to have flooded the site.

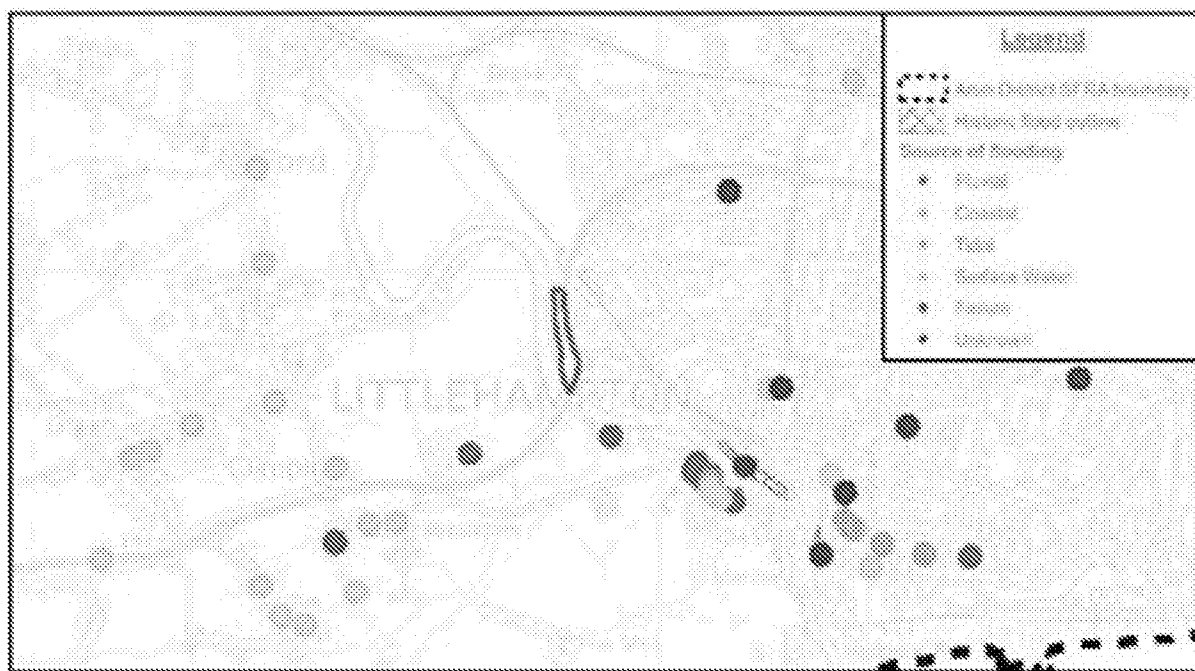


Figure 13 Historic Flooding. (Source: EA)

- 5.45 The Environment Agency historic flood mapping records indicate that the site is not within an area that has a recorded flood history. A copy of the mapping is provided in Appendix 1.

6. Drainage Strategy

- 6.1 A key component of the Flood Risk provisions of the NPPF are the requirements that proposals do not increase the risk of flooding to others. Where development proposals increase the amount of hardstanding (roofs, roads, car parks, service yards, etc.), the amount of rainfall that is converted to surface water flow is greater than that which would have been generated as a result of the rain falling on an area of open land. The cumulative impact of creating more hard standing areas within a catchment can, therefore, result in more surface water within the drainage system, which can contribute to local flooding.
- 6.2 A central component of sustainable surface water management is to demonstrate how the increases in impermeable surfaces and the associated increases in surface water run-off will be mitigated. Fundamentally, it needs to demonstrate that:
- The total rate of surface water discharged from the site will not be greater post development than it was predevelopment; and,
 - The water quality discharged from the site will not be polluted, by particles and other material mobilised from the ground surfaces as a result of rainfall events.
- 6.3 The above objectives are achieved through the provision of surface water storage (attenuation) and the provision of Sustainable Drainage Systems (SuDS). Surface water run-off generated by development sites, where impermeable surface areas are increased have the potential to exacerbate flood risk to others, by increasing the peak rate of surface water discharged from the Site.
- 6.4 SuDS components should be designed to accommodate and dispose of runoff from storms, without causing flooding to properties, up to and including the 1:100 year, including an allowance for the current predicted impacts of climate change, which increase peak rainfall intensities by 40%.

Scale of Change

- 6.5 There is limited hard standing currently on the site, and for the purposes of this assessment, it is considered that the site is greenfield.
- 6.6 The total proposed impervious area is as follows, as taken from measurements of the drawings:
- Roof Area 3,244.6m² (The Saltings 845.2m², North Court 736.5m², South Court 725.8m², and Bridge Reach 937.1m²).
 - Local Area of Play 554.9m².
 - Car Parking 4,847m²; some of this area is below the above buildings.
- 6.7 The development proposals will, therefore, result in an increase in impermeable area.

Infiltration Potential

- 6.8 The BGS historic boreholes indicate that clay and sand could be expected below the site, with poor rates of infiltration anticipated for the clay and moderate for the sand. However, the boreholes indicate that groundwater could be expected at up to 1.2 m Below Ground Level, and therefore infiltration methods of drainage are not considered appropriate for this site, as the base of an infiltration device is likely to be too close to the existing ground water level to provide sufficient clean material to ameliorate the water quality.

Surface Water Disposal Point

6.9 Under the requirements of the non-statutory technical standards for sustainable drainage systems (SuDS), where practicable, peak surface water discharge rates should be limited to as close to the pre-development (greenfield) surface water run-off rate as possible.

6.10 The non-statutory drainage technical standards state:

“S1, Where the drainage system discharges to a surface water body that can accommodate uncontrolled surface water discharges without any impact on flood risk from that surface water body (e.g. the sea or a large estuary) the peak flow control standards (S2 and S3 below) and volume control technical standards (S4 and S6 below) need not apply.”

6.11 As the surface water from the site will discharge to the tidal River Arun, consequently there is no requirement to limit the surface water discharge rate, or provide surface water attenuation to a restricted rate, provided a gravity connection from the development to the River Arun can be provided. Should the outfall be subject to tide locking, then attenuation should be provided, to store surface water for the duration of the tidal cycle above the outfall.

6.12 An independent workshop meeting with West Sussex County Council was held on the 6 March 2020, which discussed the over-arching principles of discharging to tidal watercourses over the top of the flood defences. It understood that West Sussex County Council are in the process of developing a guidance document to support this approach, and, as such, this should be further explored during detailed design.

6.13 Any surface water features that occur below the tidal flood level may need to consider the requirements for attenuation, to offset the potential for tide locking.

Sustainable Drainage (SuDS) Assessment

6.14 The suitability of SuDS components has been assessed (Table 7) to determine which methods are appropriate to be used within the proposed development.

SuDS Component	Description	Constraints and Opportunities	Suitability
Infiltrating SuDS	Infiltration can contribute to reducing runoff rates and volumes while supporting baseflow and groundwater recharge processes. The suitability and infiltration rate depend on the permeability of the surrounding soils.	Dependent on infiltration parameters, and a 5 m clear zone from buildings and roads. High groundwater (1.2m BGL) precludes the use of infiltrating SuDS.	X
Permeable Pavement	Pervious surfaces can be used in combination with aggregate sub-base and/or geocellular/modular storage to attenuate and/or infiltrate runoff from surrounding surfaces and roofs. Liners can be used where ground conditions are not suitable for infiltration.	Permeable paving should be provided within suitable hardstanding areas. A clear zone for the provision of utility services should be allowed for outside of the permeable paving. Furthermore, infiltrating paving should be located at least 1.5 m away from proposed and existing buildings and foundations.	✓
Green Roofs	Green Roofs provide areas of visual benefit, ecological value, enhanced building performance and the reduction of surface water runoff. They are generally more costly to install and maintain than conventional roofs, but can provide many long-term benefits and reduce the on-site storage volumes.	The volume of surface water attenuation achieved by green roofs is limited and is therefore not included in these calculations. Any suitable low pitch roof structures, such as bin stores or bike stores, should be equipped with green roofs.	-

SuDS Component	Description	Constraints and Opportunities	Suitability
Rainwater Harvesting	Rainwater Harvesting is the collection of rainwater runoff for use. It can be collected from roofs or other impermeable areas, stored, treated (where required) and then used as a supply of water for domestic, commercial and industrial properties.	As the volume within a Rainwater Harvesting system does not contribute to the overall attenuation, these systems have not been considered further here. However, opportunities during detailed design should be considered; this could be through the provision of water butts and rain planters.	-
Swales	Swales are designed to convey, treat and attenuate surface water runoff and provide aesthetic and biodiversity benefits. They can replace conventional pipework as a means of conveying runoff; however, space constraints of some sites can make it difficult incorporating them into the design.	A strategic swale is to be located between the building line and the River Arun. This will collect the surface water from the adjacent buildings and disperse into the River Arun. The high groundwater level and the development density would limit the efficiency of open surface water attenuation features.	✓
Rills and Channels	Rills and Channels keep runoff on the surface and convey runoff along the surface to downstream SuDS components. They can be incorporated into the design, to provide a visually appealing method of conveyance. They also provide effectiveness in pre-treatment removal of silts.		-
Bioretention Systems	Bioretention systems can reduce runoff rates and volumes and treat pollution using engineer soils and vegetation. They are particularly effective in delivering interception, but can also be an attractive landscape feature, whilst providing habitat and biodiversity.		-
Retention Ponds and Wetlands	Ponds and Wetlands are features with a permanent pool of water that provide both attenuation and treatment of surface water runoff. They enhance treatment processes and have great amenity and biodiversity benefits. Often a flow control system at the outfall controls the rates of discharge for a range of water levels during storm events.		X
Detention Basins	Detention Basins are landscaped depressions that are usually dry, except during and immediately following storm events, and can be used as a recreational or other amenity facility. They are generally appropriate to manage high volumes of surface water from larger sites, such as neighbourhoods.		X
Geocellular Systems	Attenuation storage tanks are used to create a below-ground void space for the temporary storage of surface water before infiltration, controlled release or use. The inherent flexibility in size and shape means they can be tailored to suit the specific characteristics and requirements of any site.	If necessary, these could be provided to complement the other SuDS solutions.	-
Proprietary Treatment Systems	Proprietary treatment systems are manufactured products that remove specific pollutants from surface water runoff. They are especially useful where site constraints preclude the use of other methods and can be useful in reducing the maintenance requirements of downstream SuDS.	If necessary, these could be provided to complement the other SuDS solutions.	-

SuDS Component	Description	Constraints and Opportunities	Suitability
Filter Drains and Filter Strips	Filter drains are shallow trenches filled with stone, gravel that create temporary subsurface storage for the attenuation, conveyance and filtration of surface water runoff. Filter strips are uniformly graded and gently sloping strips of grass or dense vegetation, designed to treat runoff from adjacent impermeable areas by promoting sedimentation, filtration and infiltration	These may be used to provide interception drainage for overland flows from offsite.	-

Table 7: SuDS Selection Matrix (x = not suitable, - = limited potential, ✓ = suitable)

Water Quality

6.15 In order to protect the downstream receiving water body, a key element of SuDS is that they have the potential to improve the quality of surface water discharged from a site. In order to assess this, the "Pollution hazard indices for different land use classifications", provided in the CIRIA SuDS Manual (C753) as table 26.2, has been reviewed. The indices use four different methods of assessing pollution potential, based on the hazard level, total suspended solids (TSS), metals and hydrocarbons.

6.16 The Pollution Hazard Indices are summarised in Table 8 (reference: Table 26.3.CIRIA SuDS Manual 2015)

Land Use	Pollution Hazard Level	Total suspended Solids (TSS)	Metals	Hydrocarbons
Residential Roofs	Very Low	0.20	0.20	0.05
Individual property driveways	Low	0.50	0.40	0.40
Commercial Yard and delivery areas	Medium	0.70	0.60	0.70
Sites with heavy pollution (haulage yards, trunk roads etc.)	High	0.80	0.80	0.90
Standard to be achieved		0.70	0.60	0.70

Table 8 Summary of Pollution hazard Indices for different Land Use.

6.17 From review of the available SuDS which could be implemented (See SuDS Selection Matrix Table 6),

Provided SuDS	Treatment Stage	Total suspended Solids (TSS)	Metals	Hydrocarbons
Swale (For Roof area)	Primary	0.50	0.60	0.60
Permeable Pavement (For Hardstanding)	Primary	0.70	0.60	0.70
Total Provision		0.70	0.60	0.70
Adequate Provision		Yes	Yes	Yes

6.18 Table 9 assesses the potential water quality index score against the most appropriate approach, given the constraints at the site.

Provided SuDS	Treatment Stage	Total suspended Solids (TSS)	Metals	Hydrocarbons
Swale (For Roof area)	Primary	0.50	0.60	0.60
Permeable Pavement (For Hardstanding)	Primary	0.70	0.60	0.70
Total Provision		0.70	0.60	0.70

Provided SuDS	Treatment Stage	Total suspended Solids (TSS)	Metals	Hydrocarbons
Adequate Provision		Yes	Yes	Yes

Table 9 Cumulative Score for Proposed SuDS Management Train

- 6.19 Runoff from roof areas is considered to generally be uncontaminated. However, to prevent any potential sediment from impacting the SuDS system, Sediment Traps should be provided on the downpipes' outlet to the storage structure, to prevent sedimentation, with rodding access provided either side for cleaning and maintenance. Ideally, all downpipes should be equipped with water butts or rain planters (that can act as sediment and silt traps), or high level architectural overflows.

Long Term Storage

- 6.20 Long-term storage is usually required to address the additional runoff caused by the development, compared to the volume that would be contributed from the site in its Greenfield state. The specialised literature CIRIA 753 'The SUDS Manual' provides two approaches for the rates of discharge, in relation to runoff mitigation. However, as the proposed strategy is to discharge all surface water generated at the site to the sea, there is no specific requirement for flow restriction at the site.

Proposed Approach

Building Roofs & Podium

- 6.21 The proposals include the provision of a swale, which will be constructed in the podium deck and link the apartment blocks. The proposals include the provision of a new elevated footpath and open space area along the river frontage. As this area is to be constructed over of the car parking in some locations, it will effectively form a green roof.
- 6.22 The invert level of the bio swale will vary, but the base will generally be above the present day 1:200 year tidal flood level (3.40m AOD). Furthermore, the landscaped areas between the tidal River Arun and the Swale will vary around the 5.00m AOD level, which is equivalent to the 1:200 year (2115) tidal level. Therefore, an outfall from the swale should be engineered to be at 5.0m AOD. This outfall should be equipped with a non-return valve, to minimise the risk of saline intrusion during a higher order tidal event.
- 6.23 As the podium and bio-swale will be raised above the 1:200 year flood level (used to determine the extents of Flood Zone 3), it is considered that the bio-swale will be outside of the Flood Zone 3 area.
- 6.24 The following is recommended: conveyance from the roof area to the bio-swale should make use of rills / channels within the landscaping strategy; each rainwater downpipe should be directed towards the swale; the routing of the channel will need to be informed by the overall landscaping strategy; the width of the channel will need to manage the 1:100 year +40% rainfall event. Once details of the rainwater downpipes are developed during detailed design, they should be used to inform the overall drainage strategy for the site.
- 6.25 If the proposed building is separated from the podium deck / river frontage (see draft cross-section as Figure 15), options to provide high level structural downpipes (Figure 14) could be considered. These would need to be designed to bridge the gap between the building and the bio-swale, to minimise the amount of surface water being directed to the permeably paved car parking area below, such as the scheme implemented in Figure 15.

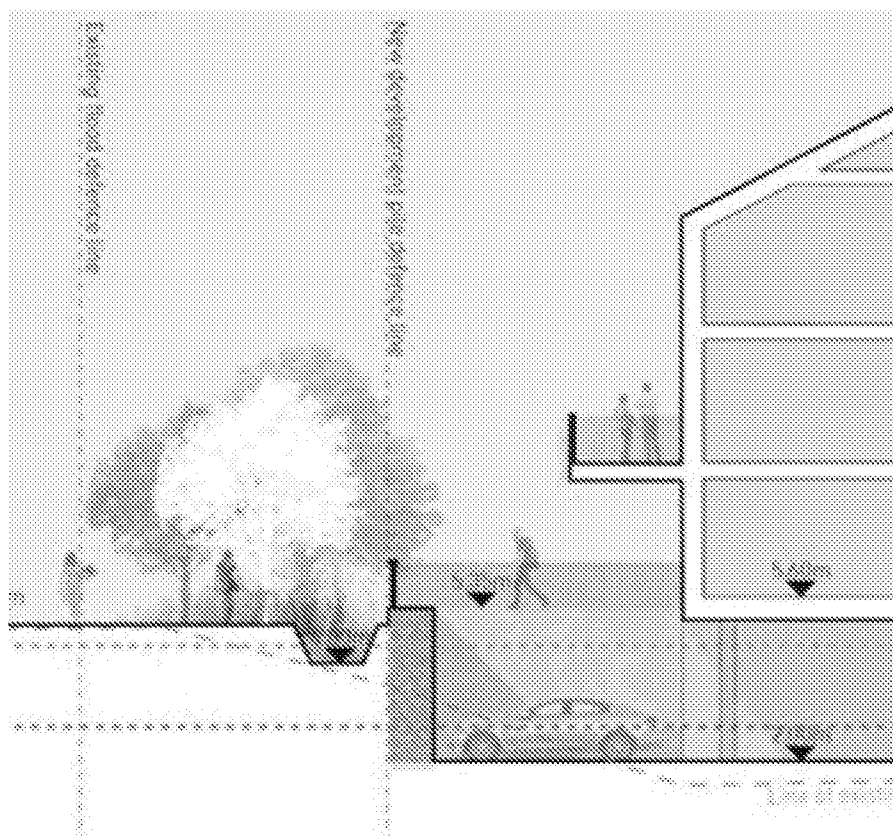


Figure 14: Draft Cross-Section, Indicating Building Separation from Bio-Swale.



Figure 15: Structural Downpipe, image obtained from susdrain.org

- 6.26 The podium will be constructed above the 1:1,000 year and 1:200 year (2115) tidal flood levels. Therefore, a gravity connection from the landscaped podium area to the River Arun, above the tidal level, is expected. This area will drain the roofs of the proposed buildings and the soft landscaping of the podium deck. The

provision of a swale is, therefore, considered sufficient to manage the low pollution potential of these areas.

6.27 The sizing of the proposed-bio-swale has been tested using MicroDrainage (Appendix 3). The results are based on the following:

- The distribution of the roof areas into the bio-swale;
- A working head of 450mm is provided, with a 150mm freeboard;
- A minimum width of 4,300mm.

As such, the results demonstrate that the Bio-Swale will manage the run-off from the roof for the 1:100year +40% climate change rainfall scenario, without flooding. The outfall has been modelled as an array of 3 No. 150mm diameter pipes, with a peak outflow of 66.8 l/s. As this will discharge into the River Arun, it is likely that a flow distributor will be required, to disperse the discharge especially during low tide, this could be achieved by creating a stepped cascade that would dissipate the energy of the discharged water.

Lower Ground Floor

6.28 Drainage of the under-croft parking areas would normally be directed to the foul network. However, comments received from Arun District Council indicate that they would not support such an approach for this scheme.

6.29 Open areas at ground level should be directed to the 'Ordinary Watercourse' and 'Main River' that passes through the site. Where these are to be formed of hard landscaping these areas should be surfaced with permeable pavement, oil interceptors or filter strips, which will provide sufficient water quality improvement, to enable discharge to open watercourses. Should the tidal outfall be submerged, the resultant rainfall depth would be distributed across the car-parking area.

6.30 MicroDrainage calculations are presented in Appendix 3, which demonstrate that, with a 0 l/s outfall (assuming tide locking), constructing the lower ground floor car park area from permeable paving would be able to attenuate the 1:100 year +40% climate change storm event. It should be noted that the car park area has been modelled without the buildings above, and, therefore, represents a very conservative case; for example, as the car park is below significant building footprint the total drained catchment area would be smaller (due to the rain shadow) than that initially modelled, indicating that this approach would provide additional flood resilience.

6.31 Therefore, all lower ground floor areas should be constructed using permeable paving, with an attenuating subbase depth of 400mm, this should be underlain by impermeable membranes to minimise the risk of groundwater intrusion. It should be emphasised that, as the River Arun tidal flood defence will provide a level of protection greater than the 1:1,000 year, the lower ground floor level can be considered to be outside of Flood Zone 2 and 3. Therefore, it should be considered suitable for the provision of SuDS, through the use of self-attenuating permeable paving.

6.32 The Environment Agency's flood map for surface water indicates that, for the extreme 1:1,000 year rainfall event, localised and shallow depths of surface water flooding are indicated, with much of the onsite flooding attributable to the site catchment. Therefore, the provision of permeable paving at the ground floor level will improve the volume of surface water attenuation provided for pluvial flood events on site. The surface water flood map indicates that greater surface water flood risk exists upstream of the site,

especially east of the railway line. As the site forms the downstream boundary of the surface water drainage network, it is unlikely that the proposals will result in an increase in flood risk to others.

Drainage Exceedance

- 6.33 In the event of extreme rainfall events, flooding may occur within the site, and the surface water runoff flows would be dictated by the local topography on site. Design of external ground levels needs to be undertaken at detailed design stage, to finalise overland conveyance routes. Design of the ground levels and road alignment will need to consider the risk of preferential flow routes, with particular attention to where vehicle cross-overs over the footway are proposed. This is because they can act as spillways to highway flows, especially where the surrounding land is lower than the carriageway level. As most of the proposed surfaces at ground level will be permeable, either soft landscaping or permeable paving, this should provide a reasonable level of resilience to more extreme rainfall events. Furthermore, all vulnerable uses will be located at the podium level and above. Therefore, it is considered that this will provide a high degree of resilience to extreme rainfall events.

Foul Water Drainage Strategy

- 6.34 Foul drainage for the site is likely to require pumping to the Southern Water foul drainage network. This could either be collected to a central pumping facility or each apartment block could be provided with a separate private facility.
- 6.35 Given the potential for elevated groundwater levels, the detailed design of the building structures is likely to require consideration for buoyancy issues of any wet-wells / foul pumping infrastructure. The systems would also need to be designed to withstand the potential for rare flooding from the Main River and Ordinary Watercourse crossing the site. The foul drainage system is, therefore, likely to be sealed from both groundwater intrusion and surface water flows. The details and positioning of this system will need to be developed in combination with Southern Water and the Structural Engineering elements of the scheme.

7. Probability of Flooding

Flood Zones

- 7.1 According to the EA Flood Map for Planning, the site is located within Flood Zone 3 (high risk of flooding), with the access located in Flood Zone 1.
- 7.2 The EA Flood Map for Planning has been produced in part using a relatively coarse, national scale flood modelling strategy, and in part by detailed modelling. It is important to note that only the potential floodplain is modelled; **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 below.

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 9 Definition of the NPPF Flood Zones. (Source: EA)

Climate Change on Site

- 7.3 The proposed development site is located within an area at risk of both tidal and fluvial flooding.
- 7.4 The EA has also stated that sea levels will rise with climate change. The EA climate change allowances for sea level rise are shown in Table 10 below. These allowances indicate that the proposed development will be at more risk of sea level rise, and thus tidal flooding, in the future, unless adequately mitigated.

South East	Sea Level Rise from 1990 to 2025	Sea Level Rise from 2026 to 2055	Sea Level Rise from 2056 to 2085	Sea Level Rise from 2086 to 2115	Cumulative Sea Level Rise from 1990 to 2115
Higher Central	5.7 (200)	8.7 (261)	11.6 (348)	13.1 (393)	1.2
Upper End	6.9 (242)	11.3 (339)	15.8 (474)	18.2 (546)	1.6

Table 10: Sea level allowance for each epoch in mm per year with cumulative sea level rise for each epoch in brackets (1990 baseline)

- 7.5 With regards to rainfall, the published EA climate change allowances (Table 11) show that a 20% increase in peak rainfall should be allowed for in the design of drainage strategies, with the systems tested for a 40% increase.

Applies across all of England	Total potential change anticipated for the '2020s' (2015 to 2039)	Total potential change anticipated for the '2050s' (2040 to 2069)	Total potential change anticipated for the '2080s' (2070 to 2115)
Upper End	10%	20%	40%
Central	5%	10%	20%

Table 11: Peak Rainfall Intensity Allowance in Small and Urban Catchments (use 1961 to 1990 baseline) (Source: EA)

8. Residual Risks

Identification of Residual Risks

8.1 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; and
- 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.

Defence Breach

8.2 The EA Flood Map for Planning (Figure 3) indicates that the proposed site is located within Flood Zone 3, with a high risk of flooding from tidal sources. It also indicates that there are flood defences along the River Arun in the vicinity of the proposed site. However, the proposed development site is not designated as being located in an area benefitting from defences. It should be noted that access to the site is in Flood Zone 1.

8.3 The Environment Agency carried out improvements on the tidal flood defences along the East Bank of the River Arun in Littlehampton between 2013 and 2015. The improved flood defences offer a standard of protection against 1 in 300 year flood events.

8.4 Due to the presence of flood defences along the River Arun, there is a residual risk of tidal flooding from defence breach or overtopping of flood defences.

8.5 The EA Product 4 data provided to Ambiental uses model information from the Lower Tidal River Arun Strategy (LTRAS) Modelling, which was completed by Atkins in 2010. It is understood that improvements were made to the flood defences along the River Arun from 2013 to 2015 and are now complete.

8.6 Previously, it has been demonstrated that, with a flood defence level of 4.81mAOD, the site would be protected from tidal flooding for the 1:200 year event (modelled flood level of 3.40mAOD). However, during the 1:200 year (2115) event (predicted flood level of 5.00mAOD), the flood defences could be overtopped by 190mm of tidal flooding.

8.7 Due to site's proximity to the River Arun and the presence of the elevated A259 behind the site, if the flood defences were overtopped, the water is likely to be retained within the development site; although, some floodwater is likely to flow upstream along the Main River and Ordinary Watercourse, but these losses are considered to be minimal. As a worst case, if the duration of inundation was sufficient, the flood level on either side of the breached flood defence would become the same, i.e. in equilibrium. Therefore, taking a worst-case basis for assessment, as a result of the breach, the peak water level on site would be the same as the level in the River Arun.

8.8 As the finished floor level of the habitable rooms will be above the 1:1,000 year (2115) tidal flood level, they would be protected if a breach or an overtopping event occurred. Therefore, no further mitigation measures would be required. It should be noted that the design level adopted for the internal finished floor level for all habitable uses is 5.60m AOD, which is 0.60m above the 1:200 year (2115) tidal flood level for

the site. Safe access from the car parking areas up to the higher level, via stairs, are included in the design. See Figure 16 for indicative access and egress routes.

- 8.9 The green roof forming the podium level over the car park will connect to the main vehicular route before it connects to the A259. This route will provide access at a high level for emergency vehicles, such as ambulances, and will also provide a safe access and egress route from the development to the A259. It should be emphasised that, under normal operating conditions, the site would not be at risk of flooding, and the lower ground floor car park area will have inbuilt resiliency, due to the specification of permeable paving.
- 8.10 However, considering the high standard of protection and good condition of the recently improved flood defences, the likelihood of defence breach is relatively low.

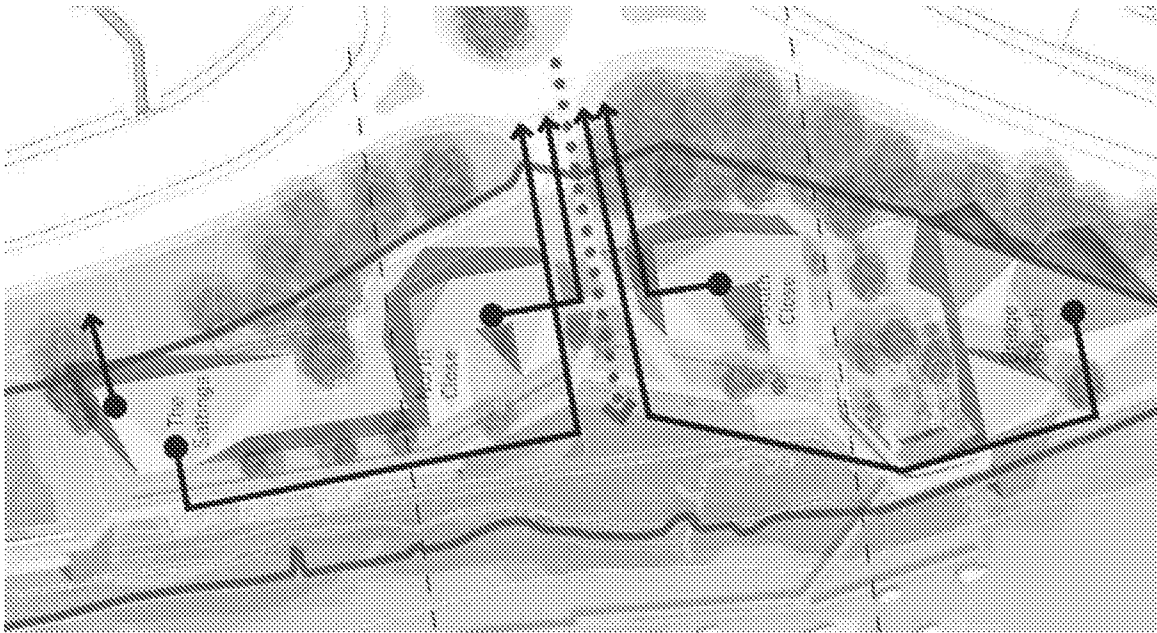


Figure 16: Safe Access and Egress Routes (Black Lines).

Reservoir Failure

- 8.11 The EA Risk from Reservoir Flooding Map demonstrates that the site is outside flood extents in the event of reservoir flooding.

Drainage Exceedance

- 8.12 In the event of drainage failure/exceedance, overland flows would be dictated by site topography. In this instance, they would gravitate towards the open watercourse within the site and potentially accumulate within the car park.

9. Flood Risk Management Measures

Flood Risks

- 9.1 The main flood risk attributable to the site is the tidal River Arun. The recently completed flood defences by the Environment Agency have a top of wall level of 4.81m AOD. The present day predicted flood level for the site is 4.13m AOD for the 1:1,000 year event, which means that the flood defences are 680mm above the predicted flood level. Consequently, for the present-day scenario, the site would, under normal operating conditions, not be at risk of flooding.
- 9.2 When accounting for the predicted impacts of climate change, the Environment Agency flood levels are predicted to rise by 1.21m. As such, the predicted flood level for the 1:200 year (2115) tidal event would be 4.61m AOD. Therefore, the freeboard on the flood defences would be 200mm. As part of the pre-application discussions with the Environment Agency, they have advised that a freeboard of 300mm above the tidal flood levels should be allowed for. It is usual to design to the 1:200 year plus climate change level for tidal events within England. Thus, the design flood level for this would be 4.91m AOD.
- 9.3 A proposed cross-section through the scheme is provided as Figure 17, and included in Appendix 1. It indicates that the Finished Floor Levels of the Residential Units will be set to 5.60m AOD. This would provide a freeboard above the predicted 1:200 year (2115) tidal flood level of 600mm. This would appropriately manage the risk of flooding for the habitable uses within the buildings onsite. The access to the moorings will be set to the flood defence level, to facilitate safe access and egress should evacuation of this area be required.

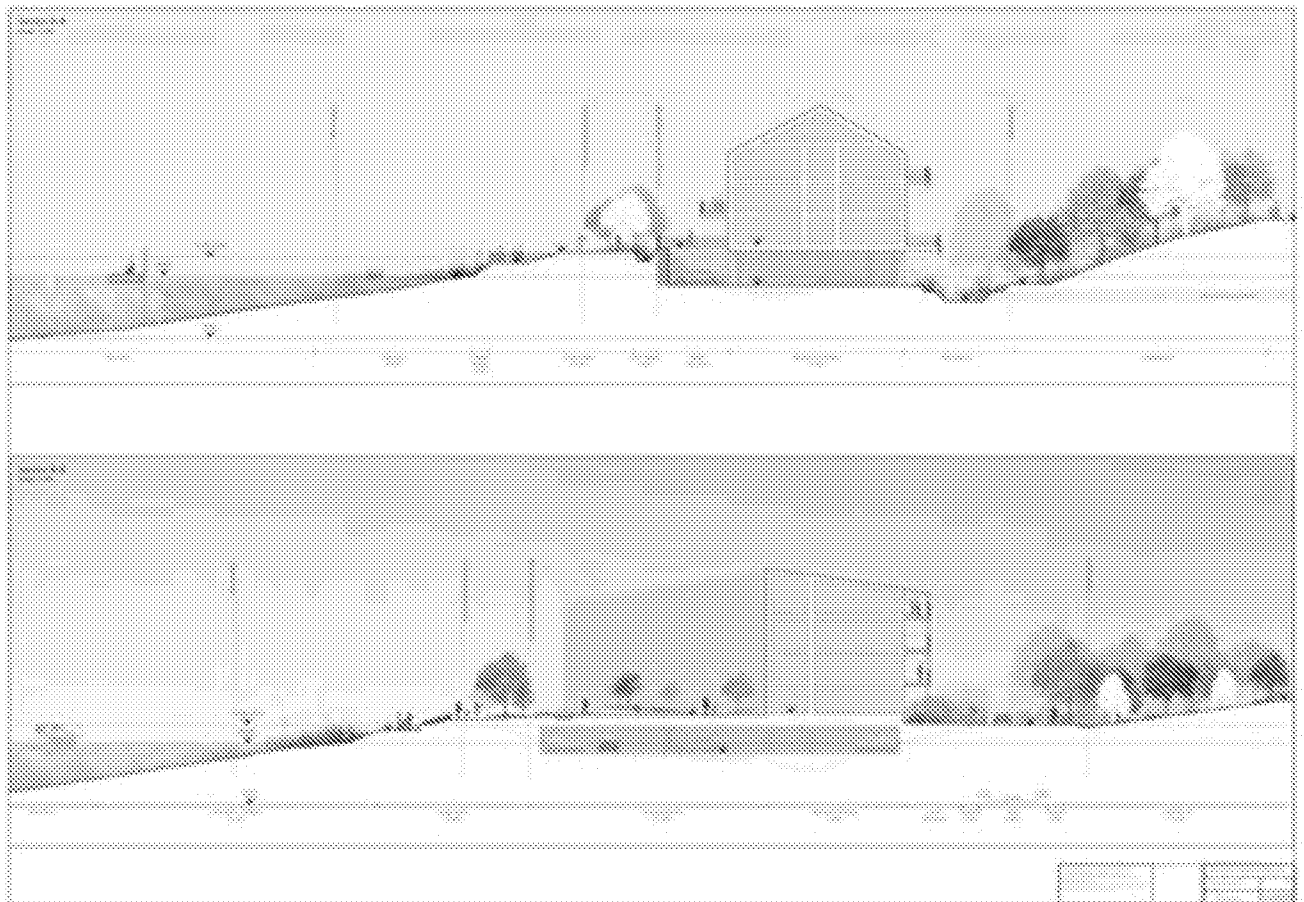


Figure 17: Proposed Development Cross-Section

- 9.4 It is noted that the ground floor parking areas are lower than the design flood levels; however, as the recently constructed tidal flood defences afford sufficient protection for the present day and 2115 1:200 year predicted tidal flood levels, the risk to these areas is considered low. The incorporation of the flood defences within the landscaping strategy and provision of a podium green roof will provide an additional level of flood protection to the car park from tidal sources. Furthermore, internal stairs from the lower car park area up to the residential block / podium level will provide adequate safe access to upper floors, should flooding occur within the car park.
- 9.5 If climate change predictions increase over the lifetime of the development beyond those designed for, an adaptive response could be implemented through further raising of the flood defence walls. These are likely to require strategic input from the Environment Agency or the Competent Authority for tidal and fluvial flooding at the time the design work is required.
- 9.6 The moorings to be constructed in the River Arun will be able to move with the tide, to a certain extent. However, if a significant tidal flood event were predicted, the safest course of action would be to evacuate these facilities to an area benefitting from flood defences or to a local refuge centre.
- 9.7 Downstream of the site is the A259 bridge and the cycle foot bridge linking Ferry Road to Wharf Road. Littlehampton marina is located between these two bridges. Upstream of the site, the Railway crossing (Ford to Littlehampton line) is the first bridge. However, just downstream of this bridge is a mooring facility, associated with the Ship and Anchor Pub. Due to this, there is already a risk that a vessel could become detached from its moorings; therefore, it is considered that the risk of blockage of these structures is not materially altered by the proposals. Furthermore, it should be noted that the only time that a vessel has broken its moorings in the last 15 years (maybe more) was the 'Cornish Maid', which was the subject of vandalism. As part of the operation of the mooring routine inspections will be undertaken to verify that any moored vessels are secured appropriately.
- 9.8 An initial Flood Emergency Plan has been provided below.

Flood Warning Service

- 9.9 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.
- 9.10 The proposed development site is located within an EA Flood Warning Service Area. As such, it is recommended that all residents and site operators sign up to this service.



Figure 19 Flood Warning Area (Source: EA)

Flood Evacuation Plan

- 9.11 The access and egress route across the podium will be designed to accommodate emergency vehicles, to support emergency responses, even if the flood defences fail.
- 9.12 Upon receipt of a Flood Warning, site users are advised to evacuate the site to a designated place of safe refuge within Flood Zone 1. It should be noted that the residential apartments are located above the 1:1,000 year (2115) tidal flood level and therefore should be safe.
- 9.13 If flood waters along the proposed evacuation route have exceeded 25cm, site users are advised, if possible, to seek refuge at the upper floors on site.
- 9.14 However, it is important to note that the site is at risk of flooding from tidal defence breach/failure. In the event of a defence breach, a sudden onset of water could reach the site without warning and thus limit the potential for evacuation, if such an event was to occur the safest course of action is to stay put within the upper floors of the building.
- 9.15 The A259 behind the development is located above the 1:1,000 year (2115) level and, therefore, would facilitate safe access and egress. The landscaped podium deck between the residential blocks has been designed to be above the 1:1,000 year (2115) level. The proposed vehicular access will make use of the existing roundabout spur from the A259, which also has levels above the 1:1,000 year (2115) level. Therefore, where the podium ties into the access ramp would provide a dry escape route from the development, should emergency evacuation be required.
- 9.16 Should evacuation of the moorings be required, this could be facilitated by use of lobby areas or communal podium levels of the apartment blocks, to provide a temporary refuge. It is envisaged that separate flood evacuation plans for the residential apartments will be required, as the actions required for these uses are different.

10. Off Site Impacts

Flood Water Displacement

- 10.1 As the site is located in an area that benefits from flood defences, under normal circumstances, the site would not flood; therefore, any proposed development would not displace flood waters, due to the presence of the flood defences.

Generation of Runoff

- 10.2 The proposed development will discharge surface water from the roofs and podium deck via a swale into the River Arun, in accordance with the non-statutory SuDS guidance. It is proposed that run-off from hardstanding areas below the swale level will be managed by permeable paving and released at a restricted rate into the watercourse. It is considered that these outfalls are connected to tidal watercourses and, therefore, specific volumetric attenuation is not required.

11. Conclusion

- 11.1 Ambiental Environmental Assessment has been appointed by The Littlehampton Yacht Club to undertake a National Planning Policy Framework (NPPF) compliant Flood Risk Assessment (FRA) for the proposed development at Hampton Quay, Littlehampton, West Sussex, BN17 5RA.
- 11.2 **This version of the report has been updated to address the points raised by both Arun District Council and the Environment Agency, who were provided with a previous version of the report. A meeting was held with the Environment Agency (14 Jan 2020) to discuss the points they have raised. These points have been considered and incorporated into the design and have been updated in this version of the report. A copy of the stakeholder comments, the comments response, and a copy of the meeting minutes are included as part of this report. The main change to the development proposals between the previously submitted FRA and this updated version are that; residential moorings are not now proposed. The Environment Agency were supportive of the details presented in relation to the finished floor levels of the residential accommodation relative to the design flood level including climate change. The Environment Agency required further clarification on the provision of access for maintenance of the new and proposed sluices / headwalls penetrating the flood defences, and how safe access and egress would be maintained.**
- 11.3 **Following the meeting an updated version of the report was submitted to the Environment Agency who have stated in their letter dated 09 July 2020 have stated that they “have no objection in principle to the proposal”.**
- 11.4 The development is for the redevelopment of a former Camp Site on the edge of the River Arun to provide; circa 115 homes, 300-400sqm of commercial/leisure use, and leisure moorings along the river.
- 11.5 With reference to the Environment Agency (EA) Flood Map for Planning, the proposed development is located within Flood Zone 3, with some areas in Flood Zone 1. The previous site use, Camp Site, would be classified as ‘More Vulnerable’. The proposed development is considered ‘More Vulnerable’ and ‘Water Compatible’ under the National Planning Policy Framework (NPPF). The Flood Zone designation does not take account of the presence of flood defences, or mitigation measures implemented on site.
- 11.6 The proposals include the creation of new waterside amenity uses by providing moorings. The moorings will need to be located in front of the flood defences, in the River Arun. Therefore, these moorings will be designed to move with the tide. In the event of a predicted extreme tidal event, a flood evacuation plan would be put in place, to enable visitors and users of the moorings to be evacuated to temporary refuge areas within the apartment blocks (reception lobbies), or to a central refuge location designated by the Emergency Planning team. The design of the moorings will need to take account of the fast-flowing nature of the River Arun, and suitable methods of securing moored vessels will need to be developed during the detailed design. This may include the requirement for routine inspections of moorings, to minimise the risk of vessels coming away from the moorings and posing a hazard to navigation and potentially flood defence assets.
- 11.7 The apartments blocks are to be located within an area that benefits from the presence of recently upgraded flood defences. As part of the proposals, opportunities to provide space for future upgrades of the flood defences will be included in the river side landscaping plan, and this will be developed during detailed design. All habitable uses, within the apartment blocks, will be located above the predicted with climate change tidal flood level for the 1:200 year tidal event in the year 2115. Therefore upgrade works to the flood defences would only be required if the impacts of climate change on tidal flooding are determined to be more extreme over the next 100 years, which would require strategic improvements to all of the flood

defences of Littlehampton. The development proposals have been discussed with the Environment Agency and maintenance access routes have been incorporated into the development layout, to facilitate the ongoing maintenance of the flood defences.

- 11.8 The Environment Agency have indicated that the flood defences on site are private. Therefore, opportunities to integrate the flood defences into the development plans have been implemented, to create better quality amenity spaces along the River Arun to improve access and improve the quality of the landscape.
- 11.9 Due to the presence of flood defences along the River Arun, there is a residual risk of tidal flooding from a flood defence breach. However, as the proposed habitable uses at the site are located above the predicted 1:200 year 2115 flood level, residents and users of the site would be protected from the consequences of a breach in the flood defences.
- 11.10 A Main River and an Ordinary Watercourse cross the site and discharge via a 600mm diameter outfall through the flood defences. It is understood that this structure is operated by the Environment Agency. The inlet culverts of these two watercourses are larger than the outlet structure. So, under the present arrangement, the total inflow could exceed the outflow, and therefore fluvial flooding could occur. At ground floor level, it is proposed to provide open play areas, car parking and other 'less vulnerable uses' which are compatible with the fluvial flood risk. It is proposed to create a new additional headwall, increasing the discharge capacity from the site, serving the Ordinary Watercourse to the north of the site and integrating this into the proposed landscaping strategy. This would result in a loss of existing open channel. To offset this loss, a high level swale is to be constructed along the development edge facing the River Arun. This channel will intercept and convey surface water flows from the buildings and other high level adjacent areas, with the surface water outfalls set at a level to discharge over the top of the flood defence level.
- 11.11 From discussions with West Sussex County Council 6 March 2020, to discuss the County wide strategy for "over the wall surface water disposal", it was identified that the provision of surface water overflows over the top of flood defences could provide meaningful benefits to the public sewer infrastructure, and have wider sustainability benefits. It is understood that West Sussex County Council is looking into this further, with a view to providing a guidance document in the near future.
- 11.12 The site is located in an area with the potential for elevated groundwater levels. This risk will need to be considered during construction and operation of the site. The mitigation measures to deal with the tidal flood risk, during the operational phase, will provide suitable controls to the risk of groundwater flooding.
- 11.13 The Environment Agency surface water flood mapping indicates that there is a risk of surface water flooding within the site. This can be managed by providing a suitable surface water drainage scheme, to alleviate the risk of flooding.
- 11.14 Surface water run-off from the roofs and podium deck will be collected by a swale and discharged at a high level into the Tidal River Arun. At lower areas of the site, surface water run-off will be collected and managed by permeable paving, before discharging into the Ordinary Watercourse and Main River within the Site.
- 11.15 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 lifetime of the development.

Appendix I - Site Plans



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CLIENT
HQ Ltd

PROJECT
Hampton Quay

SHEET
Site Location Plan

Rev A / 26.03.2019 / Site Location Plan			
Date 26.03.2019	Project number 030	Sheet size A3	Scale 1 : 2500
Drawn by EK	DRAWING NUMBER 030-S2-E000		REV
Checked by RB			A

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The Saltings
40 Car parking spaces
45 Cycle spaces
9sqm waste store

Moorings
4 Car parking spaces
25 Cycle spaces

North Court
50 Car parking spaces
50 Cycle spaces
11sqm waste store

South Court
55 Car parking spaces
40 Cycle spaces
14sqm waste store

Restaurant
16 Car parking spaces
10 cycle spaces

Bridge Reach
37 Car parking spaces
35 Cycle spaces
11sqm waste store

Total
202 Car parking spaces
205 Cycle spaces
55sqm waste store

- KEY**
- Site Boundary
 - Highways Boundary
 - Constraints lines
 - Access for maintenance
 - Waste store
 - Cycle location
 - Stair and lift core
 - Proposed trees
 - Existing trees



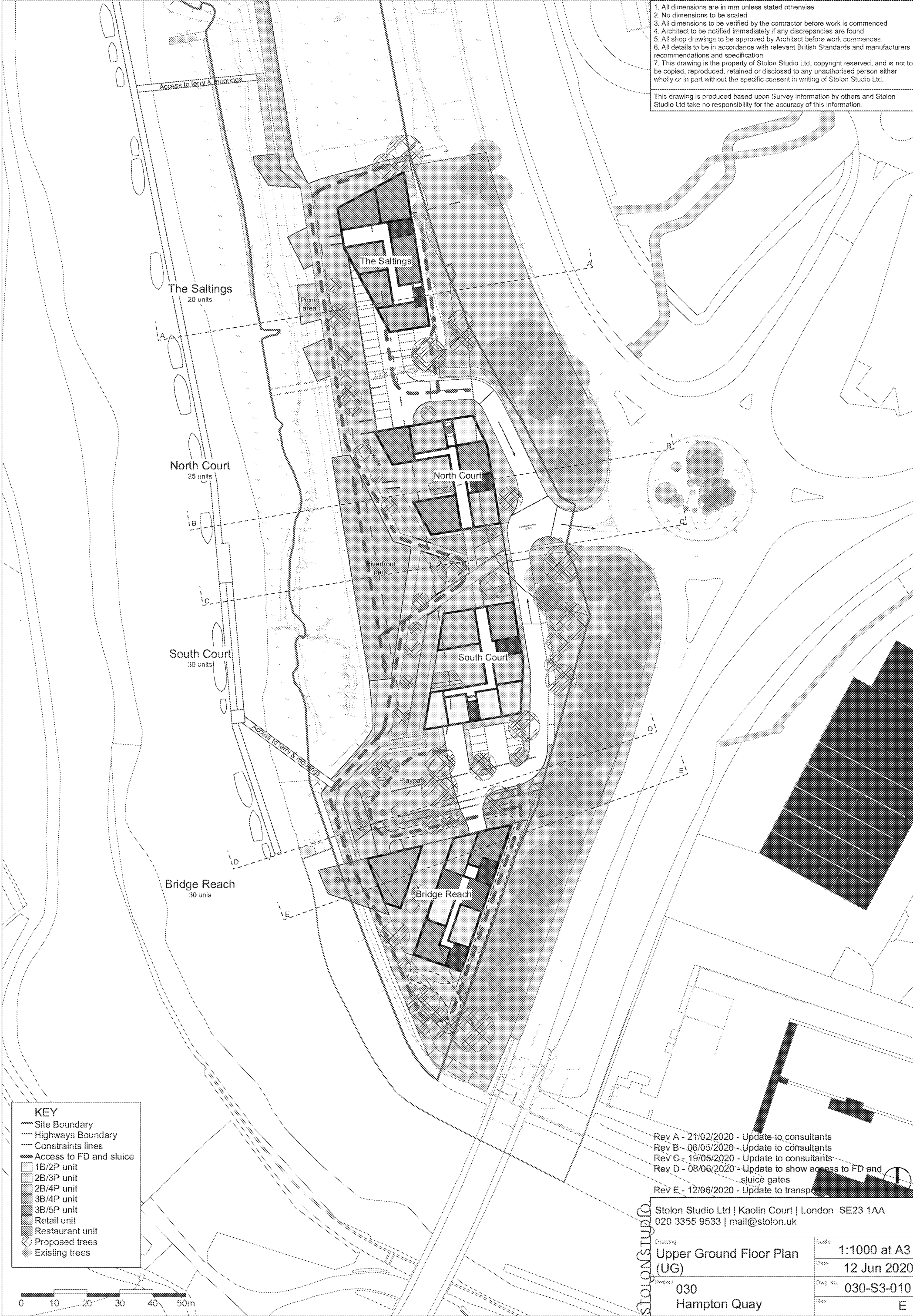
Rev A - 21/02/2020 - Update to consultants
Rev B - 06/05/2020 - Update to consultants
Rev C - 12/06/2020 - Update to transport

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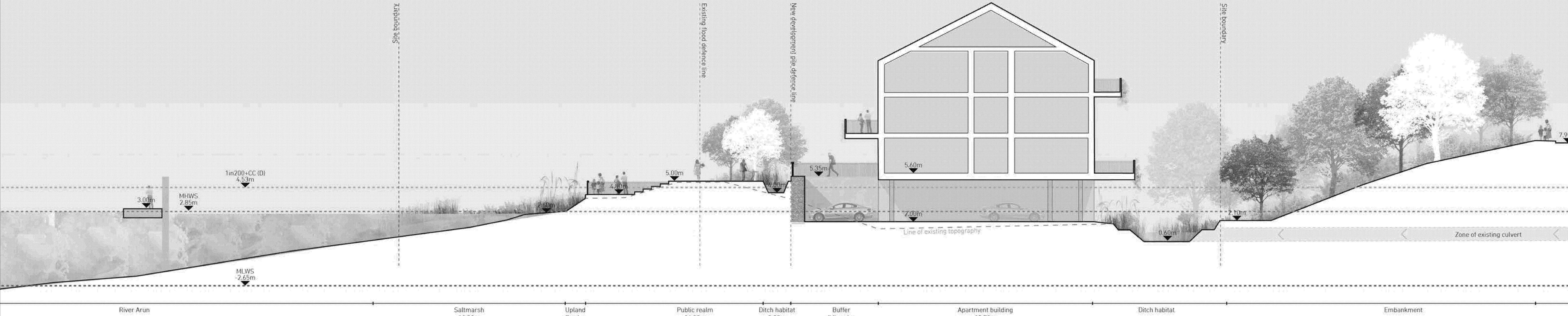
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Project	Date
030 Hampton Quay	12 June 2020
	Dwg No.
	030-S3-000
	Rev
	C

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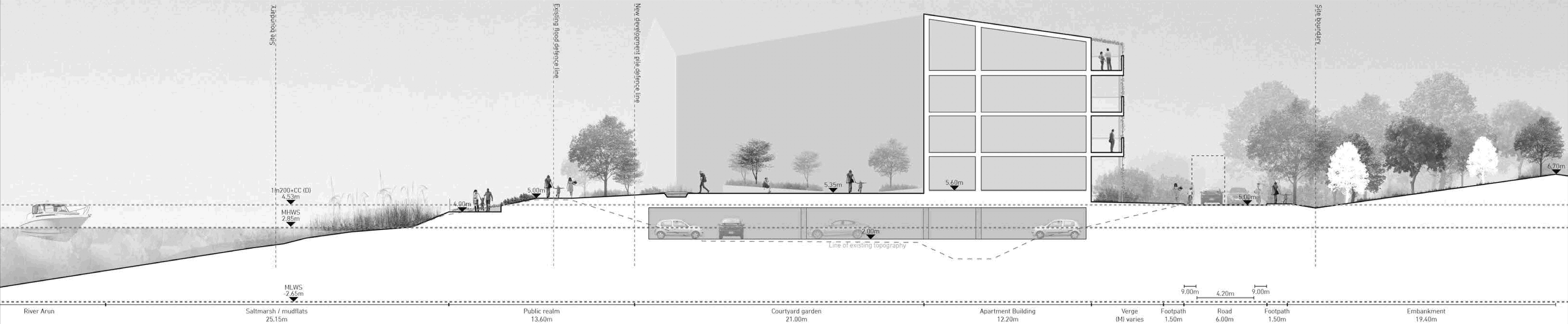
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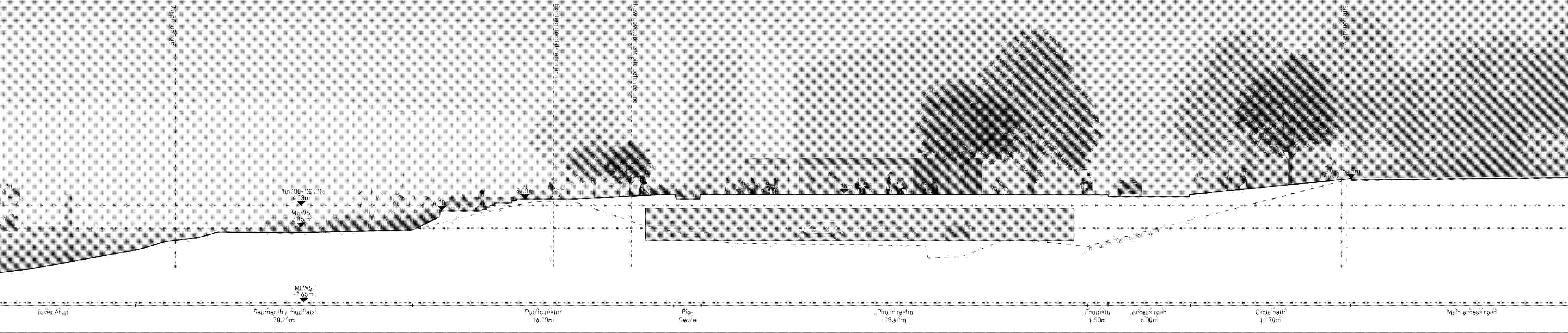
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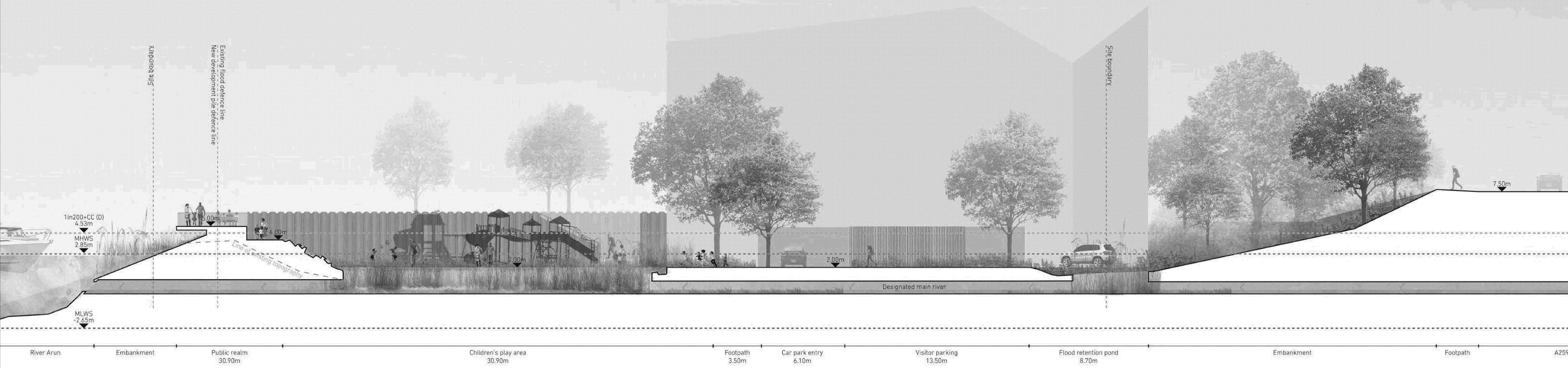
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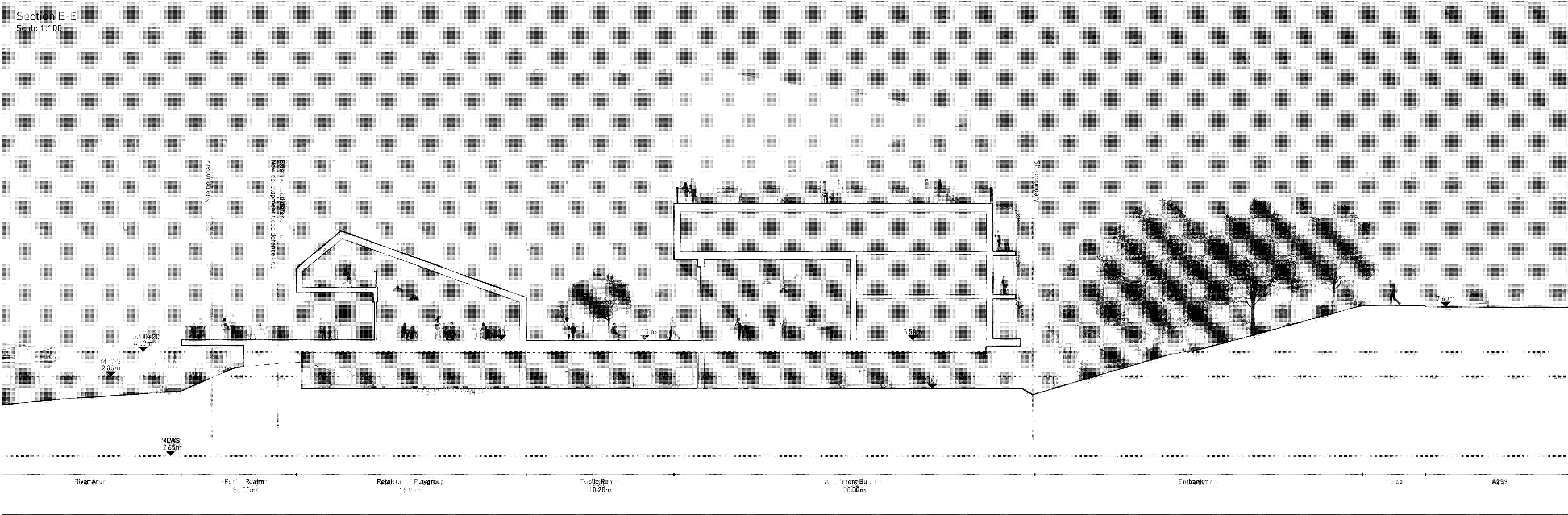
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Scale 1:100



Section D-D
Scale 1:100



Section E-E
Scale 1:100



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Rev. A: 19/05/2020 - Update to consultants
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Cross Sections E
19/05/2020
Hampton Quay
030-52-202

- Flood defence key**
- Existing line of steel sheet piling flood defences
 - Existing line of embankment flood defences
 - Proposed secondary line of defences
 - Proposed line of concrete capping beam to existing steel sheet piling

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FD A-A

FD B-B

FD C-C

FD D-D

FD E-E

FD F-F

Stone edging on concrete haunching

New gravel path with reinforcement for wheelchair access on min. 150mm Hardcore and Terram

Clay lining to bio-swale

Existing ground line

Centre-line of existing flood defence embankment

4.45m wide

Nominal water level

Bio-swale

Proposed secondary line of defence

Residential building

1000x1000mm Concrete capping beam

Steel sheet piling A239-700 or Larssen 603 subject to structural engineer calculations

Face of sheet steel piling exposed to internal side of car park

400-500mm Reinforced concrete slab on well compacted hardcore

Well-compacted hardcore

Rev A - 19/05/2020 - Update to consultants

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Drawing
**Flood Defence Detail
FD A-A**

Scale
1:100

Project
**030
Hampton Quay**

Date
19/05/2020

Draw No
030-S3 -SK018