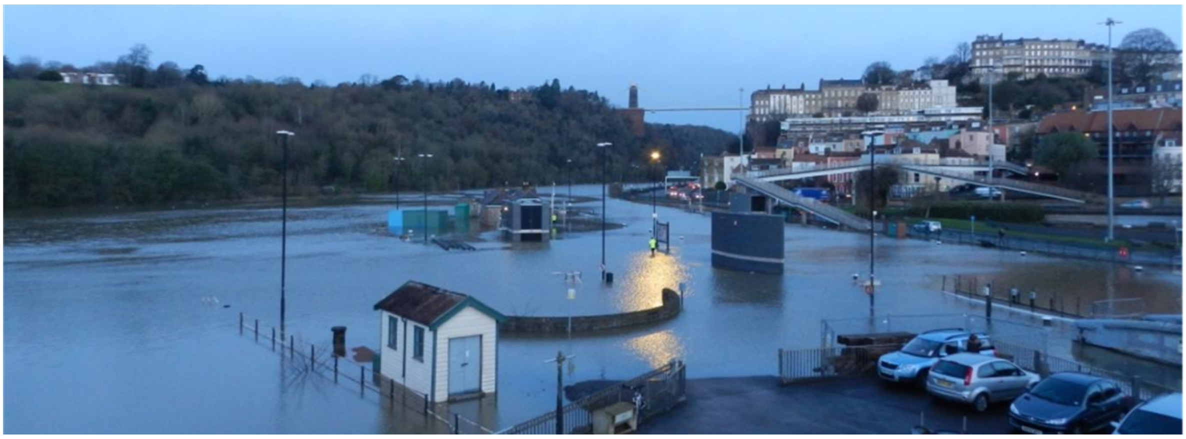
Level 2
Strategic Flood Risk Assessment



2023

Contents

List of Figures

List of Tables

Purpose of the document

The Bristol City Council (BCC) Level 2 Strategic Flood Risk Assessment (SFRA) provides detailed information about areas at greater risk of flooding in Bristol and sets out requirements for developments here that need to apply the Exception Test. This includes parts of Avonmouth, Bristol City Centre, areas along the river Avon and areas at higher risk of surface water flooding. Where land allocated for development or subsequent planning proposals cannot occur outside of these areas the Level 2 SFRA provides further, additional supporting information for application of the Exception Test. This includes provision of more detailed flood modelling and mapping to illustrate the nature of the flood risks as well as associated planning recommendations to ensure this risk can be appropriately managed. The site-specific flood risks should be analysed in the accompanying flood depth, hazard, velocity, rate of rise, and duration maps with the related text and area specific development requirements outlined in this document. This is to ensure development is safe against the predicted risk of flooding over its intended lifetime through necessary flood mitigations highlighted in this report to manage the current and future risk. This Level 2 SFRA report has been prepared in accordance with the National Planning Practice Guidance (NPPG) and the Environment Agency's How to prepare a SFRA for Local Planning Authorities (LPA). The BCC Level 2 SFRA analyses and expands upon the flooding mechanisms associated with those flood extents and sources of flooding deemed more significant according to the BCC Level 1 SFRA. The flood risks have been assessed based on their current and projected future risk inclusive of the predicted effects of climate change. The Level 2 SFRA aids application of the Sequential Test approach in steering development towards site specific areas at lowest risk or severity of flooding and to regions of least vulnerability. A primary aim of the Level 2 SFRA is to enable application of the Exception Test where applicable to ensure that development in areas of flood risk is safe for its lifetime. If it is not possible to demonstrate that development would be safe over its intended lifetime such development would not be supported or granted planning permission.

1.0 Background and strategic planning

1.1 Introduction

The BCC Level 2 SFRA builds on the citywide Level 1 SFRA by focusing in on specific areas identified as at higher risk of flooding and assessing the risk posed to these areas in greater detail than the Level 1. The Level 2 SFRA has been completed in line with the guidance for LPA's. It aims to identify variations in the likelihood and severity of flooding within areas at high risk of surface water flooding and within Flood Zones 2 and 3 (fluvial and tidal flooding) inclusive of climate change. It also sets out how the Sequential and Exception Tests should be applied to inform future development plans and planning applications. As with the BCC Level 1 SFRA this Level 2 SFRA has been prepared by the BCC Lead Local Flood Authority (LLFA), comprising internal BCC teams such as Flood Risk and Data Management, Strategic City Planning (SCP) and the Emergency Preparedness and Resilience Team (EPRT) and in coordination with key stakeholders within the BCC LPA boundary. The primary stakeholders are the other Risk Management Authorities (RMAs) operating in the area, namely the Environment Agency (EA), Wessex Water (WW) and the Lower Severn Internal Drainage Board (LSIDB). For further detail of the RMAs roles and responsibilities please see the BCC Level 1 SFRA report.

1.2 Context

Certain areas of Bristol have been identified as at greater risk of flooding, therefore this Level 2 SFRA is required to locate and aid appropriate development design where there are wider sustainability benefits for developments being located within these areas. Where sites at lower risk of flooding are unavailable, development proposed in higher risk areas will need to demonstrate how flood risk will be effectively managed over the planned lifetime of the development. This will have to be combined with wider sustainability benefits to the surrounding community and ensure that flood risk is not increased elsewhere while also making an overall reduction to the risk of flooding where possible. The lifetime for residential development is generally termed as 100 years other than in rare exceptions. For other types of development this is estimated based on the experience of the LPA. For example, commercial developments are typically deemed to have a 75-year intended lifetime.

The principal functions of the Level 2 SFRA are to:

- Provide the technical evidence base to support the Bristol Local Plan and its policies.
- Provide detailed flood mapping, illustrating the nature of potential flooding in areas of high risk.
- Identify the communities, features, structures, and properties affected by flood risk.
- Assess the consequences if flood risk management features and structures fail and describe the flooding mechanisms related to the possibility of this, recognising the residual risk posed.
- Help apply the Sequential and Exception Tests processes.
- Inform site specific Flood Risk Assessments (FRAs), Sustainable Drainage Strategies and Sequential and Exception Tests reports (where required).
- Present measures which may assist in passing the Exception Test in respect of identifying ways to reduce flood risk overall and providing wider sustainability benefits to the community that outweigh flood risk.
- Provide planning recommendations to ensure development is made safe from flooding for its lifetime, designed so it will not increase flood risk elsewhere.

1.3 Modelling used to inform this SFRA

Like all models, the modelling used to inform this SFRA has limitations. The tidal and fluvial flood maps presented are primarily based on the outputs of two separate models. The flood risk in the Avonmouth Severnside area is based on outputs from the 2020 1D-2D tidal inundation model (known as the ASEA model). The defended scenario maps include a representation of the Avonmouth Severnside Enterprise Area Ecology Mitigation and Flood Defence project which is near the end of the construction phase and expected to be fully completed in 2026. Updates to this model have since been made and are ongoing as of October 2023 to represent the as-built flood defences and improve other modelling parameters.

The flood risk in the city centre and surrounding areas influenced by the tidal river Avon is based on outputs from the 2019 1D-2D Strategic Flood Risk Assessment model. The defended scenario maps include a representation of existing defences only. The undefended maps are used in the Flood Map for Planning to account for the potential for defences to fail. This model was also used as the baseline to develop the Bristol Avon Flood Strategy strategic outline business case and has since also been updated to support the outline business case. Since the 2019 model outputs were produced, guidance on climate change allowances for the new development have also been updated and are not captured in this SFRA flood mapping.

The flood maps provided in this SFRA should therefore be used with caution and early engagement with the Environment Agency and city council should be sought to determine whether more up to date information is available to inform site specific flood risk assessments. For providing the evidence for the Local Plan the modelling presented here can be used as an interim measure (as outlined in this report) until the modelling is updated. It is the intention of the council to update the flood maps and data in this SFRA with the more recent modelling when those outputs are available.

1.4 Planning Policy

The corresponding Planning Policy section in the BCC Level 1 SFRA provides further explanation as to the relevant planning policies linked to the SFRA since the same national and local policies are applicable. In summary, at a national level the Planning Practice Guidance (PPG) section on managing flood risk and coastal change provides the guidance for developing an SFRA.

Section 14 of the National Planning Policy Framework (NPPF) relates to 'Meeting the challenge of climate change, flooding and coastal change'. This states how the development vulnerability classification is crucially involved in the Exception Test process and defines the wider criteria to determine if it has been reached (in order to pass the test) which is elaborated on in Section 1.6 below.

At a local level the relevant policies include BCS16 contained within the Bristol Core Strategy, BCAP5 of the Bristol Central Area Plan (2015), Bristol Site Allocations and Development Management Policies (2014) and BCC Climate Change and Sustainability Practice Note (2020). See also the planning position statement on development in areas of flood risk (2022).

Please note the above policies are subject change and will be superseded when updated in due course but are current at the time of writing.

The draft Local Plan 2023 publication version proposes two policies in relation to flood risk:

- Policy FR1: Flood risk and water management
- Policy FR2: Bristol Avon Flood Strategy

Policy FR1 is based on the core strategy policy BCS16 and applies to all development in the city. Policy FR2 pertains to proposed flood defences as set out in the Bristol Avon Flood Strategy. More detail on this is provided in section 3.2.

1.5 Sequential Test

While the BCC Level 1 SFRA aims to steer development towards Flood Zone 1, away from Flood Zones 2 and 3, where this is not possible the Sequential Test approach points development to respective sections of relatively lower risk within the higher risk zones. If there are no reasonably available sites in Flood Zone 1, then Flood Zone 2 (marking the medium risk extreme flood outline), is the next preference avoiding Flood Zone 3. If this is not feasible then areas of Flood Zone 3a that have lower flood hazards are of the next preference, then the remainder of Flood Zone 3a, then Flood Zone 3b. Following this process is only suitable however if the development is deemed appropriate in accordance with Table 2 Flood risk vulnerability and flood zone 'compatibility'. The extents of these Flood Zones are available by referring to the BCC Level 1 SFRA. The sequential approach must consider all sources of flood risk, meaning that sites must be steered away from areas at risk of surface water flooding or other local sources as identified in the BCC Level 1 SFRA.

The sequential approach can also be applied within a site. It must be demonstrated that within the site, the most vulnerable development is in areas of lowest flood risk, unless there are overriding reasons to prefer a different location. Further information for applying the Sequential Test in Bristol is available in the BCC Flood Risk Sequential Test Practice Note. Certain types of application need not apply the Sequential Test, like change of use applications or if BCC have already sequentially tested the site and it has been allocated for development in the Local Plan. A site-specific FRA will still be required in medium and high-risk areas though and application of the Exception Test, where applicable.

1.6 Exception Test

Where development is necessary and sites at lower risk of flooding are not available, the Exception Test may need to be applied (dependant on the vulnerability of the development) to ensure flood risk is managed appropriately. The Exception Test is required in accordance with Table 2: Flood risk vulnerability and flood zone 'compatibility'. There are two parts to the Exception Test, and both must be passed satisfactorily to fully comply with its requirements; these entail that proposed development must demonstrate that:

- development that has to be in a flood risk area will provide wider sustainability benefits to the community that outweigh flood risk; and

- the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

In order to demonstrate that wider sustainability benefits to the community have been derived, the Exception Test process should involve comparison against the BCC Local Plan policies to assess if it scores positively. In areas designated for redevelopment or regeneration, the wider sustainability benefits should be set out with reference to the regeneration objectives of the relevant local plan or neighbourhood plan policy.

To make sure the development is safe over its intended lifetime, the vulnerability of building occupiers must be considered. Climate change impacts affecting flood risk over the development's duration for commercial purposes (typically at least a 75 year period) and residential purposes (typically a 100 year period) must be assessed. Negative third-party impacts must be avoided and reducing flood risk posed to the surrounding area where possible is expected. To build safely with consideration to potential for flooding, the site design and layout can help manage the flood risk, as can consideration of the potential failure of flood management infrastructure, and the need for Flood Warning and Flood Evacuation Plans (FWEP). Development needs to consider how well the site is defended, the potential flood depths and hazards on site over its intended lifetime and then follow the hierarchy of avoid, control, mitigate, and manage in line with PPG recommendations. The Exception Test needs to be applied to specific site allocations and planning applications behind flood defences and a detailed assessment of the flooding characteristics made. Section 8.0 Exception Test of this report expands on how addressing these factors can be achieved.

1.7 Flood risk and water management policy and guidance

In addition to the guidance and legislation noted in the corresponding BCC SFRA Level 1 section 1.6, the following documentation for Avonmouth and central Bristol Floating Harbour areas (available online) may apply:

- Bristol City Council (2009), *Bristol City Docks Bye-Laws*
- Bristol City Council (2011), *Conservation Area 17, City Docks, Character Appraisal & Management Proposals*
- Bristol City Council website (2021), *Bristol Harbour*
- Bristol Port (2005) *General Byelaws*
- European Commission (2006/7), *EU Bathing Water Directive*

2.0 Functional floodplain

In the BCC Level 1 SFRA analysis the following areas were identified as Flood Zone 3b (FZ3b), marking the functional floodplain in Bristol. Please see the corresponding Functional floodplain with river network map.

- Longmoor Brook and Colliter's Brook at Ashton Vale (map tile 15)
- Boiling Wells Stream at Mina Road Park (map tile 13)
- Boiling Wells Stream and Watercress Stream at Boiling Wells (map tile 10)
- Brislington Brook at Nightingale Valley (map tile 17)
- River Avon at Eastwood Farm Open Space (map tile 17)
- River Trym at Sea Mills (map tile 8)
- River Frome at Napier Road, Glenfrome Road and Eastville Park (map tile 10)
- Hallen rhine network at Hallen Marsh 1 (map tile 4)
- Hallen rhine network at Hallen Marsh 2 (map tile 4)
- Newland rhine drainage network at Lawrence Weston 1 (map tile 4)
- Newland rhine drainage network at Lawrence Weston 2 (map tile 4)

The purpose of the maps is to identify areas where new development is not permitted. Essential infrastructure and Water compatible development may be suitable in FZ3b. Detailed flood mapping is available only for certain areas of FZ3b that adjoin the river Avon and were modelled within the model extent for the central area and surrounds. Further modelling of the other areas identified as FZ3b could be undertaken on a site-specific basis if deemed necessary and would need to be reviewed by the EA. This FZ3b mapping is in line with guidance applicable prior to the August 2022 update to the PPG and will be updated in due course to reflect more recent changes. The current BCC FZ3b mapping is representative of a 1:20 defended fluvial event with Mean High Water Spring Tide (MHWST). In subsequent SFRA updates, once new flood modelling is conducted, this will be with a 1:30 defended fluvial event and MHWST.

3.0 Summary of areas at higher risk of flooding

3.1 Avonmouth

A 2020 Flood Modeller/TUFLOW 1D/2D tidal inundation model (ASEA model) represents the ongoing Avonmouth Severnside Enterprise Area (ASEA) Ecology

Mitigation and Flood Defence Project, referred to herein as the ASEA scheme. Further details of the flood defences being undertaken through the ASEA scheme can be found in the associated planning applications. BCC LPA reference: 18/02847/FB, for the original application and 20/06082/X for the section 73 amendments in the port and subsequent applications. In Bristol this aims to reduce the risk of flooding around the Avonmouth area and to encourage sustainable growth and economic development, as well as protecting existing communities and infrastructure. The ASEA model is deemed fit for purpose for use as part of this SFRA in the interim period, until further updates to the Avonmouth modelling (ongoing during 2023) are completed and will be reflected upon once available. In the ASEA model update the latest LiDAR will be used to represent the land topography and the final design of the scheme will be represented. In the existing ASEA model, used in this interim period, land raising to 9mAOD is included in the digital terrain model (DTM) aspect of this model. It includes the defences which are currently (at the time of writing) in the process of being constructed, a recent LiDAR survey, culvert outlets and has been informed by the EA Coastal Flood Boundary datasets and utilising the M48 Bridge and Avonmouth tidal gauge records. Joint tidal/fluvial modelling assesses tide-locking of tidal outfalls. As confirmed in the Level 1 SFRA, we consider it appropriate for modelled defended scenarios to represent the new and improved ASEA scheme defences given their reasonable certainty of delivery (at the time of writing the defences are under construction). Therefore, the resulting present day defended flood risk posed to the area is negligible. The scheme aims to provide better protection to Avonmouth village and the Enterprise Area until the year 2098. This accounts for the ASEA scheme estimated build-out time of 2038, plus 60 years design life on top of this. Beyond this time scale, key areas at potential future risk include Avonmouth Village, the Port Authority (through overtopping of the docks), Hallen Marsh, St Andrews Road, (the A403) and the area south of Chittening between the flood defences and railway line. Similar areas would be at risk in the unlikely event of a breach of the defences.

The ASEA model represents flow paths across the Avonmouth area from approximately the Avonmouth bridge/M5 flyover in the south to the limit of the council boundary in the north.

As part of the ASEA scheme a purely fluvial flood model (albeit with a tidal downstream boundary to represent tide locking) was also developed, representing the inland rhine network and the capacity of tidal outfalls serving this system.

The main flood risk in this area is from sea level rise when high spring tides combine with a storm surge or from wave action in the Severn Estuary. Areas to the south, alongside the river Avon, were identified as more exposed to higher wave action through wave analysis that has been undertaken.

3.1.1 Climate change

Sea Level Rise

The ASEA flood modelling for Avonmouth was run in part with the climate change allowances in Table 1, for the present day 1:200 tidal event and 2080 epoch. The present day 1:1000 tidal flood events and those scenarios corresponding to the 2098 and 2120 epochs however are in accordance with UKCP18 and Flood risk assessments: climate change allowances December 2019 guidance for the Upper End scenario (see Table 2). This is because they were made available at different stages relating to the ASEA scheme.

Table 1 Sea Level Rise in mm applied to specified Avonmouth scenarios

Epoch	2008 - 2025	2026 - 2055	2056 - 2085	2086 - 2115
South west	3.5	8.0	11.5	14.5

Table 2 Upper end Sea Level Rise in mm applied to specified Avonmouth scenarios

Epoch	Allowance	2000 - 2035	2036 - 2065	2066 - 2095	2096 - 2125
South west	Higher central	5.8	8.8	11.7	13.1
South west	Upper end	7	11.4	16	18.4

For the ASEA model, updated sea level rise calculations to reflect the changes in Flood risk assessments: climate change allowances and the Coastal Flood Boundary (2018) have been run for the present day 1:1000 tidal flood events and those scenarios corresponding to the 2098 and 2120 epochs.

Wave action affecting Avonmouth has also been uplifted to account for climate change in line with the below projections in Table 3. This factored in water level, wave height, peak wave period, toe level, foreshore slope, local wave amplification and projected wave period to typical wave periods in the Bristol Channel.

Table 3 Future offshore extreme wave height allowances applied

Scenario	1990 to 2055	2055 to 2115
Extreme wave height allowance	+5%	+10%

If the flood modelling available does not match the design life of a development, then site specific modelling can be conducted or interpolation between the dataset epochs available. New flood modelling for the Avonmouth area is at the time of writing currently underway and will represent a more up to date model with updated climate change allowances which will be reflected in subsequent mapping accompanying this report.

Fluvial Flows
In the Avonmouth fluvial model +40% was added to fluvial flows up to 2098. Beyond this timeframe a purely tidal inundation model is used for the Avonmouth area since this becomes the dominant source of flooding.

3.1.2 Residual risk

Existing flood defences
The ASEA works entail raising the height of the flood defences between Aust and Avonmouth comprising a range of solutions to manage tidal flood risk including:

- Raising the height of existing flood banks and earth embankments
- Building new, higher concrete flood walls
- Building new, higher flood defences from steel sheet pile
- Incorporating flood gates at Lamplighter's Marsh
- Avonmouth Dock flood gates

The height increase required varies depending on the standard of the existing flood defences and the topography. Some do not need raising at all, (see Figure 1) whereas in other areas new defences up to 2.5m in height are proposed. The design crest levels vary along the reach to achieve the 1:200 level of protection from 10.0 to 11.73mAOD according to localised flooding and dock operational requirements. A consistent level of protection is achieved by tying into high ground, earth bund with concrete kerb, raising headwalls of outfalls and structures in conjunction with the other defences mentioned with rip-rap rock armour protection to avoid scour and erosion. The flood defence design drawings were part of the planning application. The lowest spots along the shoreline are presently (at the time of writing) being addressed initially, such as Area 1 in SGC; Aust to Severn Beach north of Port land and in Area 2; Avonmouth with most of that work due for completion in late 2023. It is then on to the next lowest in stages to finally reach a consistent level over the entire coastline defences by 2026/2027 (ASEA scheme timeline).

Land at Hallen Marsh is being delivered to provide wetland habitat compensation. This area comprises a network of permanent ponds and areas of shallow water and wet grassland.

Land is designated for those features listed above and set aside solely for this flood management function and is indicated in Figure 1 below.

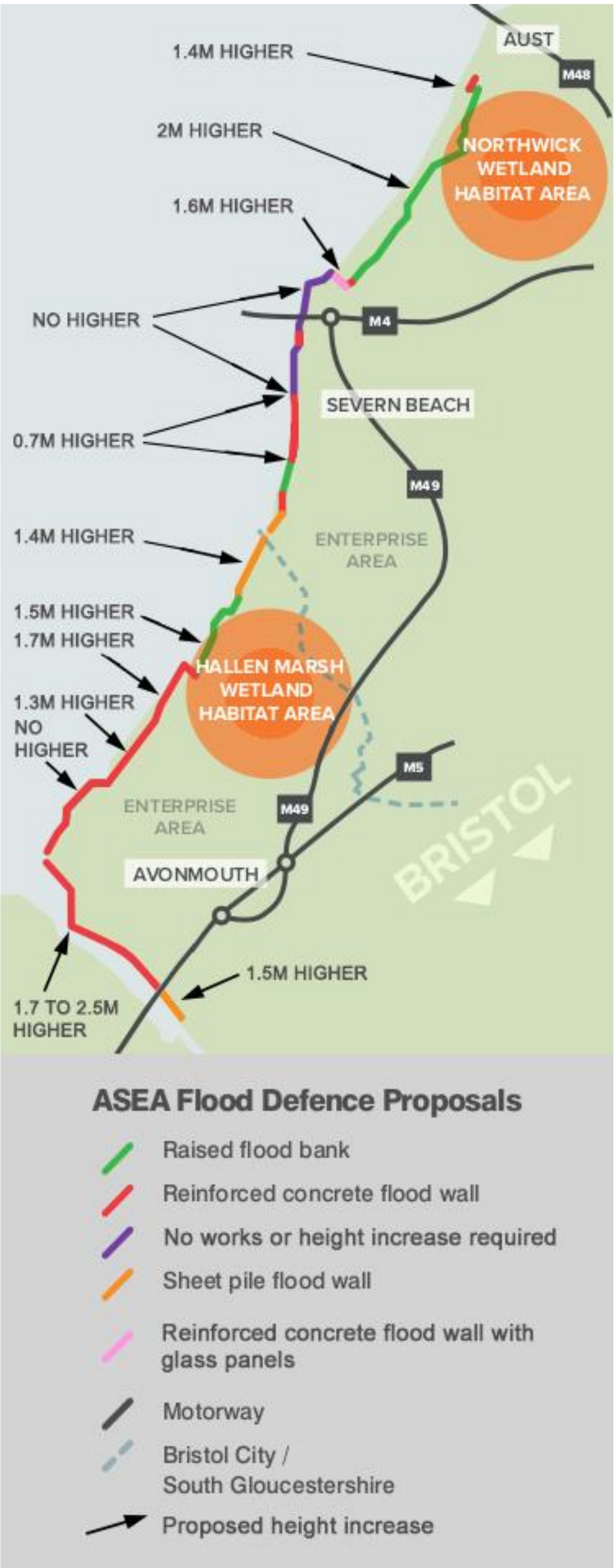


Figure 1 ASEA Scheme Flood Defence Proposals (see: Map and Timeline – Avonmouth and Severnside Enterprise Area (asea-flood-ecology.co.uk)

The ASEA scheme is designed to protect against climate change and rising sea levels over at least a 60-year period into the future. Spanning over what was the typical design lifetime for commercial development according to the PPG at the time the project commenced. Designed to make it suitable for warehousing, distribution, industrial and environmental technologies purposes and employment land allocated in the Core Strategy.

The Severn Estuary Shoreline Management Plan 2 (SMP2) (Severn Estuary Coastal Group, 2017) sets out policies for shoreline management in the River Severn Estuary for the next 100 years. Policy choices relevant to the ASEA scheme are 'Hold The Line' (0 to 100 years). The draft Severn Estuary Flood Risk Management Strategy states: 'continued maintenance by the EA, landowners or other authorities is required to ensure defences will be effective into the future'. A freeboard allowance has been applied on top of the initially estimated defence crest levels. The freeboard allowance accounts for the residual uncertainty in Extreme Water Levels and where wave overtopping is a viable flooding mechanism and other variables. The wave overtopping residual uncertainty allowance is discounted beyond the bend of the river Avon around Shirehampton, where wave action ceases; however, a level of residual uncertainty is included for other variables. The residual uncertainty estimates include aspects such as settlement allowances for embankments and planning uncertainties if for instance climate guidance were to change. The proposed defences will provide benefit to the Avonmouth community and the ASEA.

Existing flood defence failure

The predominant residual risk posed to the Avonmouth and Severnside flood cell is from either breach or overtopping of the ASEA scheme defences. In line with the scheme proposed in planning application, reference 20/06082/X, controlled overtopping during a design event (1:200) in the Port estate has been accounted for up to the year 2098. Therefore, the predominant residual risk from overtopping would be sourced from an event of greater magnitude than the design standard (e.g., 1:1000 in 2098), as well as potential for breaching of the defences. Breaching of the defences has been assessed by the ASEA scheme and this SFRA as shown in the Flood Defence Failure Breach Scenario mapping. The breach scenario model methodology being followed in the 2023 model update will involve a simultaneous breach of various points along the coast, rather than individual breaches. Opposed to use of this one, more simplified catastrophic event developers can opt to request the ASEA model and run an isolated breach for a single, relevant location if preferred. There are three breach mechanisms possible:

1. Failure or breach of the defences before a flood event – this could occur if a catastrophic failure of the defences occurred in advance of a flood event, leaving a breach or gap in them through which flood water would flow.
2. Failure to close flood gates leading to inundation through the gates.
3. Self-breaching of the defences – if overtopping or overflowing of the defences or debris strike was significant enough to reach a scour velocity then the

defences could be breached when such flow velocities were reached. The ASEA model includes calculations and allowances to facilitate a self-breach if the thresholds are reached. Based on existing climate change predictions, such self-breaching of the defences during a 1:200 event is unlikely before 2080 but would be likely along some reaches in 2120 given this is beyond the design year of the defences. The likely performance of the defences in relation to overtopping and breaching will be reviewed throughout the century. Site-specific FRAs should continue referring to the specific Breach scenario mapping however to inform development.

By 2120 the flood defences become overwhelmed due to sea level rise and tidal flood risk, as is seen in the future flood mapping for this timeframe. With its associated consequences and repercussions in the Avonmouth area, the flood risk posed from 2098 onwards is at a very significant level from the extreme 1:1000 flood event or if the flood defences were to fail. As is seen in the associated flood depth, velocity, and hazard mapping for these future time periods. The defences offer protection against the 1:200 tidal flood in 2098 but cannot withstand flooding of this magnitude by 2120.

To manage fluvial flooding many outfall structures discharge flows from local drainage ditches and the Avonmouth rhine network to the Severn Estuary. Although they serve a flood risk management function, they also represent another source of vulnerability since fluvial and pluvial flood flows can accumulate at these points due to tide-locking. The risk is more so from tidal flows propagating up through the drainage rhine network through surcharging if in the event of an outfall failure since capacity checks through the ASEA scheme concluded they would not need upgrading in the immediate future. The drain down time is still however important (especially during higher tide periods), in determining whether the system becomes backed up, subsequently leading to an increased risk of flooding.

The post ASEA scheme design simulations include a breach and overtopping flood defence failure scenario up to 2120 for the 1:200 design event. In the present day there is no notable flooding experienced with inclusion of the defences. Minor flooding is observed around the railway line and Avonmouth Docks in the 2076 scenario according to the planning application: 18/02847/FB FRA. Please note subsequent refinements to the defences and flood modelling are involved in an ongoing process with further updates expected in 2023 to reflect the completed defences in line with more recent guidance. By 2098 wave overtopping of defences (incorporated in the defended scenario) causes wider scale flooding around Avonmouth Docks and extends further inland from this point. There is also more extensive flooding around the railway and Chittening while the ASEA area is largely unaffected. The Avonmouth Dock gates at an existing level of 8.75mAOD at their lowest are set to rise to 10.25mAOD and the water level behind at 7.3mAOD compared to the level of adjacent defences at 11.68mAOD. This marks the de-facto breach in defences at this point, because of wave overtopping of the docks and simulating them failed (as open has been modelled). In the existing ASEA model the proposed defences represented the lock gates as a fixed weir with a crest level of 9.2mAOD, representing a lower point and level of SoP at this position. A discontinuity of defences by the railway line adjacent to Seabank Power Station results in a gap in defences, however this is managed through an overlap on either side of the railway line to limit the amount of flood water ingress. The A403 is a potential emergency access and egress route during a tidal flood event, and it remains outside the predicted flood extents up to 2076. By 2098 flood waters partially affect sections of the A403 road from the railway and dock gates. The flow paths described above cause the worst amount of flooding around where Chittening Road joins Severn Road at St Andrews Road adjacent to St Andrews railway station. Beyond 2098 the flood defences are shown unable to cope with the threat of sea level rise and a significant flood event, as displayed in the 2120 1:200 tidal flood maps.

The ASEA works result in no significant change to existing surface water drainage arrangements, as the scheme will not change the impermeable footprint. Defence works will also have no impact on groundwater flooding, as the foundations will not be deep enough to intersect groundwater flow paths.

The risk of defences deteriorating is nullified by passing most maintenance operations to the EA, paid for by BCC and SGC. The exception to this being the new dock gates which will be operated and maintained by the Bristol Port Company. The gates will probably need refurbishing in approximately 30 years' time. This aspect is therefore not considered a substantial risk unless funding for much needed repairs was unavailable, but the risk associated with this is deemed as low. Details of the funding streams utilised is described at: 'Who is paying for it?'

Flood mechanisms

Until recently, wave overtopping due to mixed Standard of Protection (SoP), sea level rise and a reliance on de facto defences has presented a future flood risk to Avonmouth. The ASEA scheme brings a consistent SoP for the Avonmouth and Severnside flood cell, being 1:200 in the present day. Most of the Enterprise Area and Avonmouth village are offered some protection against a 1:200 tidal flood event until at least the year 2098 (the design year for the ASEA scheme in Bristol) or there is limited flood risk by this point that is of a manageable level. The 2098 epoch is used for areas south of the first Severn crossing at Severn Beach for the ASEA scheme. North of the bridge an epoch of 2076 has been used, which is explained in the scheme FRA. The scheme facilitated a slightly different approach to the wave-overtopping rates for defences around the BPC estate but proposed entrance lock gates to ensure they act as flood gates (as confirmed in planning application reference 20/06082/X). The new flood gates will be higher than the existing gates but will have a lower crest level than the above-ground defences (see also the related planning application, reference: 21/05689/X). Therefore, whilst the SoP to the Port estate in the present day is 1:200, this SoP reduces through the century meaning that by 2098 flooding would be expected in the Port estate. The ASEA scheme ensures, however, that despite the flooding in the Port estate, the rest of the Enterprise Area and Avonmouth village is predominantly flood-free during a 1:200 event in 2098.

With the ASEA scheme in place and operating effectively, the flood mechanism in this flood cell would be overtopping of defences during events of a greater magnitude than the defence design standard, as well as overtopping of the lock (flood) gates. Both inundation routes lead to filling of the docks themselves, which could overtop the quay walls. The breach of defences, reflecting the residual risk, remains however and it is very important this is accounted for in site-specific FRAs. Significant flooding is shown in Avonmouth in the 2120 future case 1:200 tidal flood scenario.

3.2 Bristol City Centre

The area at greatest risk of flooding from the tidal river Avon is the north bank of the New Cut, including St Phillips Marsh, Redcliffe, Spike Island, and areas around the Floating Harbour. The Flood Investigation: March 2020 Tidal Flooding Report details more about actual recent flooding experienced in these areas. Flooding around the south bank relates mostly to fluvial tributaries feeding into the river Avon, in combination with tidal influences. Approximately 1,200 properties are at risk of tidal or fluvial flooding from the river Avon in the present day across the city and 200 properties are at risk in neighbouring upstream and downstream communities. The number of properties across the city at risk increases to approximately 4,500 by 2125 due to climate change. To increase the storage capacity of the Floating Harbour, the water level may be lowered prior to a forecast flood event. The Floating Harbour can be lowered by up to 0.5m; however, this can result in significant damage and disruption to vessels moored within the harbour. It has been demonstrated through the development of the Bristol Avon Flood Strategy that pre-lowering of the Floating Harbour has a limited impact on water levels during a severe tidal or fluvial flood event, however for events with smaller return periods it can provide a useful buffer.

Flood mechanisms

The city centre is at risk from both tidal surges and high river flows. Overtopping or outflanking of existing defences and natural banks occurs due to high tides or high fluvial flows which lead to direct flooding of surrounding low-lying areas. Large areas of the city centre are not currently defended to the standard required for new development.

The harbour's capacity is limited, and the tidal flood gates are increasingly vulnerable to operational failure, overtopping and outflanking by flood water. During a tidal or fluvial flood event, even with the harbour fully operational, modelling shows that the overtopping from the river Avon could lead to the harbour filling up and then also overtopping and flooding surrounding areas.

Furthermore, the harbour is also vulnerable to direct inflows from the river Frome. Although flows from the river Frome can be diverted away from the harbour via the Northern Storm Water Interceptor tunnel, its capacity is limited and when this is exceeded, flow from the Frome discharges directly into the Floating Harbour. This could lead to the harbour filling up and flooding low-lying surrounding areas.

3.2.1 Climate change

Sea Level Rise

The fluvial and tidal flood modelling for the central area was undertaken for the SFRA Level 1 in accordance with UKCP09 recommendations as agreed with the EA at the time, as the latest UKCP18 were unavailable through national policy when the flood models were completed. The December 2015 climate change allowances contained in the Flood risk assessments: climate change allowances (reflected in Table 1) were applied at the time of those model runs. At that time, it was agreed with the EA that as an interim measure, developers either run the model with latest UKCP18 uplifts or include an allowance of at least 300mm on top of the climate change level plus a 300mm freeboard (to account for the differences in sea level rise estimates between UKCP09 and UKCP18). The methodology in: Accounting for residual uncertainty: updating the freeboard guide could instead be applied as an alternative to the 300mm freeboard allowance. The 1:200 tidal dominant flood events have been run in combination with a 1: 2 fluvial flow over three climate epochs of 2020, 2080 and 2120.

Table 4 Sea Level Rise in mm applied to the Bristol city centre area

Epoch	2008 - 2025	2026 - 2055	2056 - 2085	2086 - 2115
South West	3.5	8.0	11.5	14.5

However as noted in section 1.3, please contact the Environment Agency or Bristol City Council to determine whether more up to date or appropriate information is now available.

Fluvial Flows

For both the flood defence failure and defended central area runs the 1:100 fluvial event Higher Central and Upper End climate change allowance categories were applied (corresponding to a scaling factor of 35% and 70% respectively) and combined with a 1:1 tidal flow for the 2020, 2080 and 2120 epochs. These allowances corresponded to the requirements for FRA: climate change allowances for the Severn River Basin District at the time the flood modelling was conducted. The guidance has since been updated for the Avon Bristol and North Somerset Streams management catchment climate change allowances. The Higher Central and Upper End climate uplifts of 35% and 70% applied in this SFRA are near equivalent to the current 2050's upper end (38% uplift), 2080's higher central (39% uplift) and 2080's upper end (71% uplift). The current FRA: climate change allowances advise to use the following climate uplifts based on the type of development:

In flood zones 2 or 3a for:

- essential infrastructure – use the higher central allowance
- highly vulnerable – use central allowance (development should not be permitted in flood zone 3a)
- more vulnerable – use the central allowance
- less vulnerable – use the central allowance
- water compatible – use the central allowance

In flood zone 3b for:

- essential infrastructure – use the higher central allowance
- highly vulnerable – development should not be permitted
- more vulnerable – development should not be permitted
- less vulnerable – development should not be permitted
- water compatible – use the central allowance

Using the Higher Central runs shown in this SFRA (35% uplift) to represent the current 2080's central allowance (26%) is therefore a conservative approach and is recommended.

The central area modelling has undergone many iterations in recent years and will continue to do so meaning in due course there will be more up to date modelling available for the city centre. In the interim period, contact the LPA, LLFA and EA to discuss which modelling should be used.

3.2.2 Residual risk

Existing flood defences

Reference should be made to the BCC Level 1 SFRA Section 3.1 for detail of the main flood defences in Bristol central area and surrounds.

Existing flood defence failure

Section 3.1 of the BCC Level 1 SFRA explains the existing flood defence failure scenario simulated for the central area and along the river Avon. This is displayed in the Flood Defence Failure maps. This entails Junction Lock flood gates and Netham Lock gates open, whilst the Northern Storm Water Interceptor sluice gates are closed. Sections of the raised flood defence walls at Totterdown are also removed. The failure mechanisms involve outflanking, overtopping at low points or the breach of existing defences.

Vulnerabilities lie at Junction Lock and Netham Lock, where quayside levels adjacent to the stop gates are lower than the crest level of the gates resulting in outflanking for high tidal river levels. The hydraulic power units at Junction Lock are also only resilient up to flood levels of 9.6mAOD. Mechanical failure of Junction Lock, Netham Lock and the Underfall Sluices are potential flood mechanisms from the harbour. Bathurst Basin Dam set at approximately 8.3mAOD represents another low spot and inflow into the

Floating Harbour. Other known low points include Cumberland Road, Commercial Road, Clarence Road and Cattle Market Road (seen in the [Flood Investigation: March 2020 Tidal Flooding Report]). Further risk along the river Avon New Cut appears in the poor form and condition of many riparian retaining walls. Failures through deterioration over time have already occurred at Cumberland Road (1981), Clarence Road (2014), Gaol Ferry Bridge (2020) and the Chocolate Path (2020) causing collapse due to ground failure. The residual risk of flood defence failure should be considered in any site-specific Flood Risk Assessment.

3.2.3 Proposed flood defences: Bristol Avon Flood Strategy

The Bristol Avon Flood Strategy is a two phased approach of managing flood risk from the Bristol River Avon led by Bristol City Council in partnership with the Environment Agency. The first phase (planned for 2026 – 2030's) involves replacement of the harbour flood gates, the creation of new defences along the river corridor, and raising existing defences where required. The second phase (anticipated to be required by around 2065) will extend and raise those features and create new defences as required to respond to climate change. At the time of writing, the ambition of the council is to start phase one construction by around 2026, with phase two indicatively proposed for 2065.

The work would be delivered through a variety of measures seeking to provide wider benefits such as sustainable transport, place making, biodiversity and amenity improvements. In some instances, it may be appropriate to incorporate defences into new development, tying into the wider strategy. Refer to our planning position statement on development in areas of flood risk for further information. The extent of the proposals is illustrated in Figure 2 below.

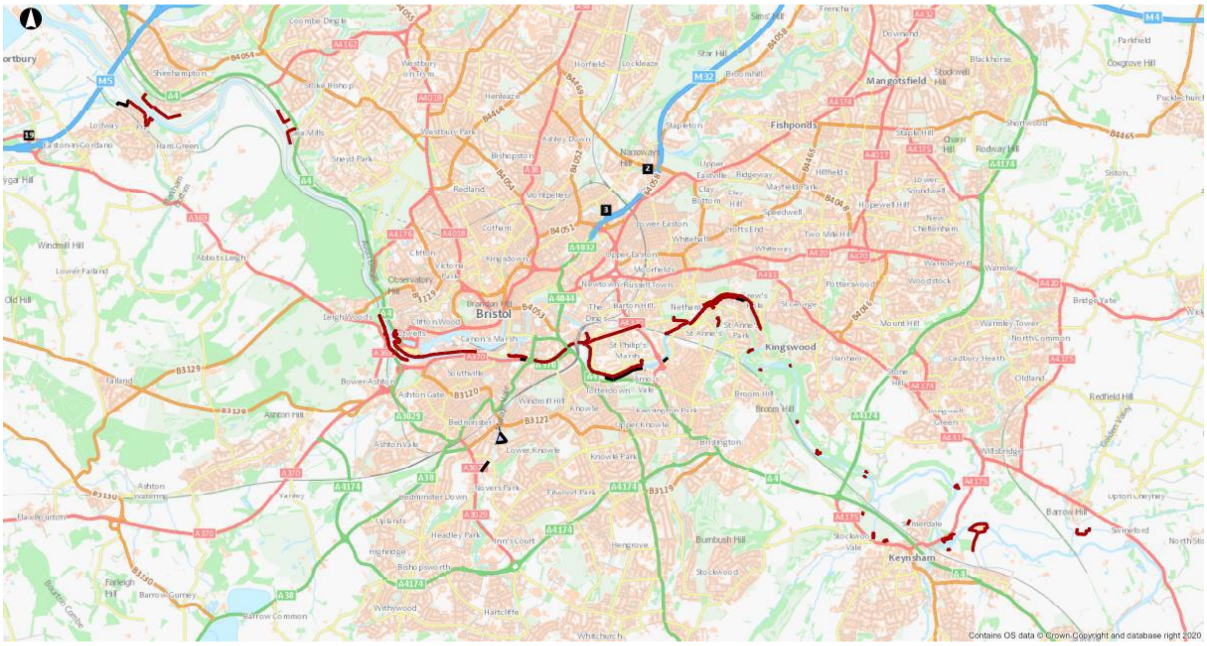


Figure 2 Bristol Avon Flood Strategy defence locations

The plans are currently being developed with the Outline Business Case due to be published in 2024. Until then, for further details of the proposed defences along the above stretches of watercourse, please refer to the [Bristol Avon Flood Strategy Strategic Outline Case](). Where development lies near to or within the footprint of the strategy, speak to us to consider ways in which development could be integrated with our plans to manage the risk.

The 'Land safeguarded from development that is required for current and future flood management' map shows the likely alignment of the proposed defences, though is subject to change as the proposals develop. This is found within the accompanying BCC Level 2 SFRA flood maps.

See section 9.5 of this report for details of how new development proposals may integrate with and benefit from the proposed defences.

3.3 Areas of Growth and Regeneration

Various areas within central Bristol were identified in the 2019 Local Plan review as areas of new growth and regeneration. These included Western Harbour, Frome Gateway, Bristol Temple Quarter, and St Phillips Marsh. Each of these areas are at risk of flooding to varying degrees and a summary of each follows.

Western Harbour

The extents of Western Harbour are shown in Figure 3.

Figure 3 Western Harbour boundary

Flood risk in this area is dominated by tidal flood risk but the degree of risk varies significantly with the varied topography of the area. In the current climate, areas adjacent to the Cumberland Basin, Underfall Yard and Spike Island north of Cumberland Road are at risk. These areas benefit from the operation of existing harbour flood gates. New development proposals should consider the risk of flooding associated with these defences failing by utilising the flood defence failure scenario maps.

By 2120 the flood depths in this area can be expected to reach around 2m even with existing defences remaining operational. New development in this area will benefit significantly by the delivery of the Bristol Avon Flood Strategy. See section 3.2.3 for details.

South of the river Avon, some areas of existing green space are at risk of tidal flooding. Existing development bounded by Clift House Road and the river are on higher ground at very low risk of flooding now and in the future.

Development of sites within Western Harbour that are at risk of flooding should be supported by a flood risk sequential test undertaken within the policy area.

Frome Gateway

The extents of Frome Gateway are shown in Figure 4.

Figure 4. Frome gateway boundary

Flood risk in the Frome Gateway area is complex, being influenced by both fluvial flood risk from the river Frome and the river Avon. Pockets of land at risk of fluvial flooding in the present day can be found on both sides of the river. The area benefits from the river Frome being diverted away from this area through the Northern Storm Water Interceptor tunnel, the entrance to which is found upstream at Eastville. New development proposals should consider the risk of flooding associated with this infrastructure failing by utilising the flood defence failure scenario maps.

The risk of tidal flooding in the current climate is very low throughout the area.

By 2120, much of the area is expected to be at significant risk of both tidal and fluvial flooding even with existing flood risk management infrastructure remaining operational, with depths of up to around 2m. New development in this area will partially benefit from the delivery of the Bristol Avon Flood Strategy but the fluvial flood risk from the river Frome will remain.

Development of sites within Frome Gateway that are at risk of flooding should be supported by a flood risk sequential test undertaken within the policy area.

Bristol Temple Quarter

The extents of Bristol Temple Quarter are shown in Figure 5.

Figure 5. Bristol Temple Quarter boundary

Flood risk in Bristol Temple Quarter varies due to the varied topography of the area. The Temple Island site for example is at very low risk of flooding both now and in the future, while north of the river Avon some sites adjacent to the river are at risk of tidal flooding in the present day, but most of the area is at low risk of flooding from tidal and fluvial flooding in the current climate (assuming existing defences remain in place and operational).

The area benefits from various flood defences including the harbour flood gates at both ends of the harbour and from the Northern Storm Water Interceptor tunnel. New development proposals should consider the risk of flooding associated with this infrastructure failing by utilising the flood defence failure scenario maps. New development in this area will benefit from the delivery of the Bristol Avon Flood Strategy. See section 3.2.3 for details.

Bristol Temple Quarter is particularly vulnerable to increased risk of flooding due to climate change. Except for the Temple Island and Mead St sites, by 2120 most of the area is at significant risk of both tidal and fluvial flooding. Tidal flood risk is more dominant.

Development of sites within Bristol Temple Quarter that are at risk of flooding should be supported by a flood risk Sequential Test undertaken within the policy area.

St Phillips Marsh

The extents of St Phillips Marsh are shown in Figure 6.

Figure 6. St Phillips Marsh boundary

Much of St Phillip's Marsh is at risk of flooding today and the risk will increase significantly with climate change. Some localised defences exist but the area does not benefit from strategic flood risk management infrastructure. By 2120 flood depths can be expected to exceed 2m across large parts of the area. Ensuring new development in this area is safe in the absence of strategic flood risk management infrastructure is extremely challenging.

New development in this area will benefit significantly by the delivery of the Bristol Avon Flood Strategy. See section 3.2.3 for details. It is vitally important that any new development proposals in this area engage with the city council and the Environment Agency at the outset of any proposal to discuss how the development can facilitate the delivery of and integrate with our aspirations to deliver enhanced multi-functional flood risk infrastructure in the area.

3.4 Other areas with existing flood defences

Other flood defences alongside the river Avon along its course through the Bristol area includes the following.

Sea Mills

Some low-lying properties adjacent to the river Avon and its confluence with the river Trym have installed property level flood resistant and resilience measures.

Shirehampton

Flood defences comprise a solid stone flood wall (52m length, 0.5m thick) to withstand flood water pressure. This is combined with 130m length of trapezium shaped embankments either side of the flood wall. A stainless steel, manually operated, raised flood gate with rubber tubing lines for a watertight seal is incorporated in amongst this. Currently this tidal defence scheme provides protection to 30 properties up to a 1:200 level. The existing residual risk posed here however entails a flood defence failure mechanism of breach or overtopping of the flood defences. Or if the flood gates were not operational for some reason such as due to mechanical failure or the inability of operator personnel being able to enact their usual role and procedures under some unforeseen circumstances.

Totterdown

Properties in the Paintworks development incorporated raised Finished Floor Levels (FFLs), temporary flood barriers and flood resilient construction materials at ground floor level in their design. This was to help manage the flood risk posed to the site from the adjacent tidal river Avon.

For details of the Totterdown flood defence scheme see section 3.1 of the BCC Level 1 SFRA.

4.0 Surface water and ordinary watercourse flooding

There are numerous areas throughout the city of Bristol deemed at greater risk to flooding from heavy rainfall events and so detailed flood mapping is available throughout the entire BCC region. Each of the Level 2 SFRA surface water flood maps should be reviewed in closer detail for any specific site of interest. Surface water flooding could occur quite rapidly, within less than an hour, especially in lower lying areas such as Avonmouth. Wessex Water as a flood Risk Management Authority is concerned with flooding from its foul water, surface water and combined water networks. Wessex Water's Drainage and Wastewater Management Plans (DWMP) for the Bristol Area show specific issues relating to sewerage catchments, see here for further details https://www.wessexwater.co.uk/environment/drainage-and-wastewater-management-plan. The SFRA quite correctly focuses on tidal, fluvial, surface water and ordinary watercourse flooding to steer development towards site specific areas at lower risk. Where the Exception Test is applied development must give due attention to on site drainage to ensure sewers are watertight and at appropriate levels to reduce sewer flood risk.

4.1 Climate change

Rainfall intensity

To assess the risk posed from pluvial or surface water flooding, the Level 1 SFRA utilised outputs from the Bristol Surface Water Management Plan (SWMP) model. Within the SWMP model, peak rainfall intensity was applied in accordance with the Flood risk assessments: climate change allowances guidance applicable when the model was run in 2018. Upper End uplifts of +40% rainfall was applied to the 2080 and 2115 epochs and included an allowance for tidal (to account for tide locked systems) uplifts corresponding to Table 1 above. The SWMP model also accounts for much of the underground piped sewer network, thus providing an estimation of potential future sewer flooding vulnerabilities also.

4.2 Drainage strategies

The Upper End climate change allowances must be applied in respect of rainfall in the design of sustainable drainage systems for developments proposed within the BCC administrative area. Measures to protect people and property will have to be ensured where on-site flooding occurs. Section 4.3 of the BCC Level 1 SFRA specifies the further drainage system requirements for developments in Bristol.

5.0 Flood risk asset blockages

Blockages of key flood risk assets like trash screens or culverts can cause significant flooding impacts, as has been seen in Bristol at various locations in recent years. Examples include at Whitchurch Lane, Hartcliffe on the Pigeonhouse Stream in 2016 and East Street, Bedminster on the river Avon in 2018. The Bristol Flood Risk Asset Register (FRAR) can help identify if a potential development site lies near to a flood risk management structure or feature and who the responsible body or organisation maintaining it to contact is. Email: WessexEnquiries@environment-agency.gov.uk for detail on EA Main River assets. If a flood model is available from the responsible body or organisation with blockage scenarios having been run for the area in question this can be used. If not however, then site specific blockage scenarios and sensitivity analysis must be undertaken to see how a site would be impacted and how this can be mitigated against. For site specific FRAs some blockage scenarios that have been run can be used to evaluate the residual risk at certain locations, such as within the Castle Park vicinity. The following watercourses: the Cranbrook, Coombe Brook, Conham Vale Stream, Fishponds Brook, river Trym, Horfield Brook and Boiling Wells Stream (ex-COWs modelling) have had several blockage scenarios modelled at key locations. These are available on request from: WessexEnquiries@environment-agency.gov.uk. If a site of interest is near a flood risk asset when consulting the FRAR, or next to any of the aforementioned areas and watercourses, please contact the relevant Risk Management Authority identified in the FRAR. Please contact BCC for Frome culverts in Castle Park blockage scenarios via: flood.data@bristol.gov.uk and the EA for ex-COWs blockage scenarios via: WessexEnquiries@environment-agency.gov.uk.

Manhole covers becoming ‘blown’ are another potential risk during surcharged pipe conditions. This should be also duly considered in a site layout and drainage strategy.

6.0 Detailed flood modelling

The BCC Level 2 SFRA flood maps are sufficiently detailed to provide extra information inferred about the type and nature of flooding anticipated in higher risk localities. With knowledge and understanding of the risk presented allows measures to be devised to help plan for and appropriately manage the typical flooding characteristics expected to be encountered. The following flood modelling resources, as outlined in the sections below, are available to be utilised for this purpose. A description of how they are beneficial and can be applied, to inform site specific FRAs and to build sustainability, by factoring in flood resilience and resistance measures is provided. Further information and flood data to inform FRAs if you’re applying for planning permission is available from the Environment Agency including flood level data via Product 4 requests. Email: WessexEnquiries@environment-agency.gov.uk

6.1 Speed of onset and rate of rise

The time elapsed during certain defined stages of a flood event can be useful in preparatory actions. This can assist in determining different accessible points for access and egress purposes during emergency evacuation plans. It can also assess response times needed. In tidally influenced areas adjacent to the tidal river Avon, the tidal rate of onset is very rapid once it over-tops and flooding occurs very quickly. Pluvial flooding from intense rainfall in rapid response catchments can cause an immediate local impact. This is typical in many of the steep, clay based or heavily urbanised catchments in Bristol with smaller watersheds, such as parts of Totterdown and Brislington. Speed of onset and rate of rise for surface water flooding is not available in the Level 2 SFRA mapping, it is simply inferred that this would occur rapidly. Fast moving water under such circumstances makes for hazardous flood conditions in the short term. The fluvial baseflow response on the larger rivers, such as the river Avon and Frome which spread further inland and are served by wider catchments, are generally slower to respond. Slowly rising flood waters do give more opportunity to react, ahead of the gradual build-up of larger fluvial flows. Fluvial flooding has a high influence in the east of the city. In the central area the river Frome responds relatively quickly to rainfall within the heavily urbanised surrounds. Flood Warning services exist for tidal and fluvial flooding but not for surface water flooding and therefore flooding from this source is more likely to occur without any time to plan a response.

Where there are appropriate defences, an area may not flood under normal circumstances, however if those defences were to fail it would result in rapid onset and fast flowing hazardous floodwater. Therefore, residual flood risk mitigation is always required where there are existing or proposed defences. The rate of rise of flooding is used to estimate the speed of onset in Bristol due to the above flooding characteristics and time series flood modelling undertaken to reflect this. This is particularly useful when used in conjunction with the flood velocity and depth mapping.

6.2 Depth

Knowledge of the relative flood depths around a site will help in assessing whether a site is safe and help to inform such aspects as the site sequential layout, finished floor levels, internal and external building construction materials, and design. Hazardous flood depths should be designed out of developments so that occupants will be safe from flooding throughout the lifetime of the development. This can be done using passive flood resistance measures such as ground raising. Flood mitigations should prioritise passive measures (that are generally more reliable) over active measures (such as flood gates), that in general are less effective. Also flood management techniques will be dependent on the flood depths encountered. Installing property level protection, like flood doors and air brick covers for instance may be appropriate against shallower flood depths but become ineffective at greater depths. Flood resilient buildings that have raised electrics and avoid materials like plasterboard and carpet (using tiles and concrete instead for example), and therefore recover faster from flooding, can be used for greater flood depths. Positioning more readily damageable materials and services above the design flood event flood depths plus a freeboard allowance will help gain flood resilience in the building design but will not address the safety of occupants. A site will not be deemed safe if significant flood depths are anticipated that are not appropriately mitigated. In line with the Flood Risk Assessment

Guidance for New Development and Flood Risks to People Guidance Document and the supplementary note Sub-Guidance of Safe Access and Exit if there is a risk to life that cannot be adequately mitigated then development should be refused.

6.3 Velocity

Flood water moving at higher velocities is generally more hazardous than still water. The velocity of flood waters is often expressed in terms of metres per second (m/s). Flood velocity maps suggest where flood water flows will have gathered more speed and will naturally align. They can be utilised to aid the positioning of developments away from known flow paths. Flow path flood velocity maps can also be used for positioning green infrastructure, flood risk management assets and SuDS features. This blue corridor approach can help intercept flows. Variations in velocities can also pose a risk if a sudden relief of a blockage for instance or overflow initiates suddenly as restricted flows find new flow paths this may be a residual risk factor that can cause a potential threat through the redirecting of flood waters. This is also a factor to consider when siting a development, as intercepting such flow paths can not only create a risk to the new development itself but also to third party receptors. Access and egress points to a site from its surrounds should consider where faster flowing water could be problematic for entering and exiting the vicinity. If faster flood water velocities cannot be adequately mitigated that could cause a risk to life then development proposals would be refused, in line with the Flood Risk Assessment Guidance for New Development and Flood Risks to People Guidance Document.

6.4 Hazard

Flood hazard is a function of velocity and depth and debris factor. Differing combinations of these contributory factors can result in various repercussions with varying levels of severity. This is expressed in the correlating flood hazard rating. Debris content is considered within the flood hazard rating. Other hazardous materials and contamination concerns are further consequences acknowledged that can make the danger of flood water even more apparent, but these factors are not considered in further detail under the requirements of the SFRA. The flood hazard exposure advice ranges from caution to danger for some, danger for most to danger for all people, dependant on the depth velocity relationship. See Table 4 in the supplementary note (Sub-Guidance of Safe Access and Exit), displaying this classification which is in accordance with the Flood Risk Assessment Guidance for New Development. If a risk to life cannot be adequately mitigated, then development should be refused. A flood hazard that poses a danger for all or a danger for most should be avoided when designing a new development.

Table 5 DeFRA/Environment Agency Hazard to people Classification using Hazard rating

HR	Depth of flooding - d (m)												
	DF = 0.5				DF = 1								
Velocity v (m/s)	0.05	0.10	0.20	0.25	0.30	0.40	0.50	0.60	0.80	1.00	1.50	2.00	2.50
0.0	0.03 + 0.5 = 0.53	0.05 + 0.5 = 0.55	0.10 + 0.5 = 0.60	0.13 + 0.5 = 0.63	0.15 + 1.0 = 1.15	0.20 + 1.0 = 1.20	0.25 + 1.0 = 1.25	0.30 + 1.0 = 1.30	0.40 + 1.0 = 1.40	0.50 + 1.0 = 1.50	0.75 + 1.0 = 1.75	1.00 + 1.0 = 2.00	1.25 + 1.0 = 2.25
0.1	0.03 + 0.5 = 0.53	0.06 + 0.5 = 0.56	0.12 + 0.5 = 0.62	0.15 + 0.5 = 0.65	0.18 + 1.0 = 1.18	0.24 + 1.0 = 1.24	0.30 + 1.0 = 1.30	0.36 + 1.0 = 1.36	0.48 + 1.0 = 1.48	0.60 + 1.0 = 1.60	0.90 + 1.0 = 1.90	1.20 + 1.0 = 2.20	1.50 + 1.0 = 2.55
0.3	0.04 + 0.5 = 0.54	0.08 + 0.5 = 0.58	0.15 + 0.5 = 0.65	0.19 + 0.5 = 0.69	0.23 + 1.0 = 1.23	0.30 + 1.0 = 1.30	0.38 + 1.0 = 1.38	0.45 + 1.0 = 1.45	0.60 + 1.0 = 1.60	0.75 + 1.0 = 1.75	1.13 + 1.0 = 2.13	1.50 + 1.0 = 2.50	1.88 + 1.0 = 2.88
0.5	0.05 + 0.5 = 0.55	0.10 + 0.5 = 0.60	0.20 + 0.5 = 0.70	0.25 + 0.5 = 0.75	0.30 + 1.0 = 1.30	0.40 + 1.0 = 1.40	0.50 + 1.0 = 1.50	0.60 + 1.0 = 1.60	0.80 + 1.0 = 1.80	1.00 + 1.0 = 2.00	1.50 + 1.0 = 2.50	2.00 + 1.0 = 3.00	2.50 + 1.0 = 3.50
1.0	0.08 + 0.5 = 0.58	0.15 + 0.5 = 0.65	0.30 + 0.5 = 0.80	0.38 + 0.5 = 0.88	0.45 + 1.0 = 1.45	0.60 + 1.0 = 1.60	0.75 + 1.0 = 1.75	0.90 + 1.0 = 1.90	1.20 + 1.0 = 2.20	1.50 + 1.0 = 2.50	2.25 + 1.0 = 3.25	3.00 + 1.0 = 4.00	3.75 + 1.0 = 4.75
1.5	0.10 + 0.5 = 0.60	0.20 + 0.5 = 0.70	0.40 + 0.5 = 0.90	0.50 + 0.5 = 1.00	0.60 + 1.0 = 1.60	0.80 + 1.0 = 1.80	1.00 + 1.0 = 2.00	1.20 + 1.0 = 2.20	1.60 + 1.0 = 2.60	2.00 + 1.0 = 3.00	3.00 + 1.0 = 4.00	4.00 + 1.0 = 5.00	5.00 + 1.0 = 6.00
2.0	0.13 + 0.5 = 0.63	0.25 + 0.5 = 0.75	0.50 + 0.5 = 1.00	0.63 + 0.5 = 1.13	0.75 + 1.0 = 1.75	1.00 + 1.0 = 2.00	1.25 + 1.0 = 2.25	1.50 + 1.0 = 2.50	2.00 + 1.0 = 3.00	3.50	4.75	6.00	7.25
2.5	0.15 + 0.5 = 0.65	0.30 + 0.5 = 0.80	0.60 + 0.5 = 1.10	0.75 + 0.5 = 1.25	0.90 + 1.0 = 1.90	1.20 + 1.0 = 2.20	1.50 + 1.0 = 2.50	1.80 + 1.0 = 2.80	3.40	4.00	5.50	7.00	8.50
3.0	0.18 + 0.5 = 0.68	0.35 + 0.5 = 0.85	0.70 + 0.5 = 1.20	0.88 + 0.5 = 1.38	1.05 + 1.0 = 2.05	1.40 + 1.0 = 2.40	1.75 + 1.0 = 2.75	3.10	3.80	4.50	6.25	8.00	9.75
3.5	0.20 + 0.5 = 0.70	0.40 + 0.5 = 0.90	0.80 + 0.5 = 1.30	1.00 + 0.5 = 1.50	1.20 + 1.0 = 2.20	1.60 + 1.0 = 2.60	3.00	3.40	4.20	5.00	7.00	9.00	11.00
4.0	0.23 + 0.5 = 0.73	0.45 + 0.5 = 0.95	0.90 + 0.5 = 1.40	1.13 + 0.5 = 1.63	1.35 + 1.0 = 2.35	1.80 + 1.0 = 2.80	3.25	3.70	4.60	5.50	7.75	10.00	12.25
4.5	0.25 + 0.5 = 0.75	0.50 + 0.5 = 1.00	1.00 + 0.5 = 1.50	1.25 + 0.5 = 1.75	1.50 + 1.0 = 2.50	2.00 + 1.0 = 3.00	3.50	4.00	5.00	6.00	8.50	11.00	13.50
5.0	0.28 + 0.5 = 0.78	0.60 + 0.5 = 1.10	1.10 + 0.5 = 1.60	1.38 + 0.5 = 1.88	1.65 + 1.0 = 2.65	3.20	3.75	4.30	5.40	6.50	9.25	12.00	14.75

Flood Hazard Rating (HR)	Colour Code	Hazard to People Classification
Less than 0.75		Very low hazard - Caution
0.75 to 1.25		Danger for some – includes children, the elderly and the infirm
1.25 to 2.0		Danger for most – includes the general public
More than 2.0		Danger for all – includes the emergency services

The seriousness of implications based on the flood hazard rating can link to vulnerability classifications also; for example, the consequences of a flood event can be limited by avoiding certain land uses in areas that will be more susceptible to greater flood hazards. Predictions of the speed of flow that flood water is travelling at, combined with its relative depth is required to assess whether a site is safe and can also be helpful in planning the layout of new development, designing appropriate mitigation measures, emergency planning, formulating evacuation plans and planning diversionary routes for evacuees and those making journeys during a flood event to avoid the most hazardous flood conditions. Estimated flood damage to vehicles and buildings can also be surmised from the flood hazard assessment. Useful applications of the flood hazard analysis include:

- Demonstrate whether a development can be made safe and should form part of a site-specific FRA (part b of the Exception Test)
- Planning of safe access and egress for new developments
- Emergency planning advice for people at risk and the emergency services
- Development of household or community flood plans.

6.5 Duration

The time over which flooding is experienced will help devise the appropriate flood risk management methods to manage the flood over its duration. The length of time flood water needs to be managed or stored is also dependent upon the drain down time of the catchment and the wider area. Predictions on the duration of flooding can be used to infer the length of time building occupiers would have to vacate the premises, ahead of and during a flood event before being able to regain access and reoccupy that premises. This can help with evacuation plans, emergency services rescue plans and recovery plans. The duration of tidal flooding depends on the topography of the surrounding area. Subsequent tides in the tidal cycle may prove problematic though if water is still ponding in an area following the tidal regression of the first high tide. A concurrent tide can follow up in an inundated area and compile further tidal flood waters on top of this. In the tidal zone in Bristol the flood duration can be underestimated where flood models do not reflect local topography and assets or blockages. This has been apparent on the Portway and Cattle Market Road for example where flood waters can remain for quite some time after the peak of the tide. When the river Avon level remains or is sustained at a high level for a significant time this also means the Floating Harbour cannot empty or drain down. These implications are seen in the fluvial Upper End 2120 scenario where flooding appears constant over a more prolonged period.

Intense rainfall causing flash flooding can be relatively short-lived. Pluvial flooding is often more concentrated and localised, and water often recedes more quickly. However, subsequent storms can return the location to the flooded conditions instantly, especially in areas with high groundwater levels following lengthy wet spells. The sizing of SuDS features, such as detention basins for example, will be designed around storage requirements estimated to accommodate flood water up until it can pass over the entire flood event.

Fluvial flooding from larger rivers is generally more prolonged, maintaining a more persistent flood level over a longer time frame. Periods of sustained rainfall will raise groundwater levels and the higher water table level will help maintain a constant baseflow condition; this makes seasonality and precedent ground conditions influencing factors in this type of flooding. Flooding from the rivers Avon and Frome could be more prone to these longer flood durations. Fluvial flooding in the urban rapid response catchments, like the Brislington Brook, can be more sudden and shorter lived.

Where applicable, floodplain storage compensation will have to be calculated and accommodated for in equivalent terms of flood level and volume for the 1:100 chance flood event. This will need to be undertaken in accordance with the above gov.uk guidance with climate change allowances based on land uses in the affected areas. As well as an assessment of any off-site impacts as an implication of this will have to be made.

6.6 Sources

The type of flooding encountered will help determine the mitigation measures. Pluvial flood risk, for example can be managed in part at least through source control SuDS, catching rainfall where it lands. It is however more difficult to predict in sufficient time to take precautionary actions as there is no flood warning service for this type of flooding. Surface water flooding will be patchier in nature, while in contrast tidal flooding will have a more constant flood extent in comparison.

Although the astronomical tidal tide heights are known well in advance, the surge element of tidal flooding is hard to predict, particularly the scale and timing of the surge in relation to the astronomical peak. This means that we cannot guarantee that a timely or accurate flood warning would be issued. Tidal flood warnings are based on predicted forecast levels, rather than actual levels and as such contain a high level of uncertainty.

With most fluvial flooding, there is the benefit of river level monitoring being available to track levels and warn of the likelihood of the water levels exceeding bank heights. The EA Flood Warning systems available in Bristol (specified in the BCC Level 1 SFRA) utilise information from these monitoring stations and often issue flood warnings based on actual river levels upstream. Anyone with a UK postcode can sign up to receive free Flood Warnings. With enough notification prior to a potential flood event the necessary measures can be put into action to help manage this. However, although the EA aims to issue a flood warning two hours in advance of a fluvial flood event, this will not always be possible, especially in rapid response catchments and there is no guarantee that a flood warning will be issued at all. There is also the residual risk that there could be a failure in the flood forecasting or warning system or an issue with them being communicated effectively or them being acted upon.

6.7 Flood mechanisms

Understanding of how flooding occurs in different localities is vital in determining the appropriate flood management measures and actions. Considering the source and circumstances, be that from antecedent weather conditions or due to infrastructural failure, it is important in assessing how best to manage this risk. Using the detailed flood mapping in conjunction with the recommendations within this report, combined with background on flood defences where applicable, will help identify the site-specific mitigations necessary.

7.0 Development plans

This section describes different types of development sites within the planning process and provides flood risk requirements for certain areas of Bristol.

The Bristol Development Framework Core Strategy (BCS) was adopted in June 2011. One of the Spatial Visions of the BCS is to balance industrial renewal with environmental protection at Avonmouth. It states “Avonmouth will maintain its status as a regionally important industrial and warehousing business location.

The key economic sectors of environmental technologies, distribution and logistics, advanced engineering and aerospace and manufacturing will be encouraged.

• There will be an expanded role for the Port.

• Development will be carefully managed to avoid increased flood risk.

• Internationally important biodiversity will be safeguarded.

Policy DM18 of the Site Allocations and Development Management Policies document states “The Avonmouth and Kingsweston Levels area as shown on the Policies Map will remain primarily undeveloped.

Development proposals consistent with the areas undeveloped status may be acceptable, where they would be in accordance with all other relevant development plan policies”.

Please note the above policies are subject change and will be superseded when updated in due course but are current at the time of writing.

It is proposed in the latest revision of the draft Local Plan to release parts of the levels, considering the protection that the ASEA scheme offers.

In the central area, Bristol Temple Quarter, Western Harbour, Frome Gateway, and St. Philips Marsh were included in the Bristol Local Plan Review 2019, as areas of growth and regeneration. These areas each face their own challenges with respect to flood risk which is described in section 3.3. A Development Framework for Bristol Temple Quarter is in place, and a framework for Frome Gateway is under preparation. Similar frameworks and / or master plans are expected to follow for Western Harbour and St Phillips Marsh.

7.1 Site allocations

The Sequential Test search area for allocating sites for development is determined by regeneration objectives for the specific area as set out in the Local Plan, or the redevelopment of brownfield sites where the benefits of regeneration cannot be achieved elsewhere. A site may be allocated if development is deemed as passing the Sequential Test due to there being no other reasonably available sites on which a comparable development could be achieved. This is explained in the BCC Flood Risk

Sequential Test Practice Note. Sites still need to pass the Exception Test within higher risk areas though and a preference should be made for existing brownfield sites, over greenfield land.

Flood mitigation measures that assist in passing the Exception Test for allocated sites include the following:

- Change of land use
- Strategic land raising
- Recommendation of local scale land raising on a plot-by-plot basis
- New / improved access routes
- Property resilience / resistance measures
- Flood warning / flood event management
- Improvements to the rhine network (local & strategic) within the Avonmouth area
- Passive measures, such as flood doors, over active measures, like temporary and demountable defences (that are not appropriate for new-build developments)

7.2 Windfall sites

The Sequential Test will need to be applied to windfall sites since they would not have followed this process. As they are unallocated, planning applications will have to carry out the sequential approach since the land would not have been previously designated for this purpose.

7.3 Safeguarding land

Making sure flood risk assets are properly implemented and appropriately maintained is essential in ensuring their ongoing functioning and running effectively over their intended lifetime. Designating areas of land solely for this purpose is important to ensure they are constructed in line with their specification and for the continued access, monitoring, inspection and required maintenance. The initial on site works and post site access tracks for maintenance staff, equipment and vehicles must all be factored in. See the ‘Land safeguarded from development that is required for current and future flood management’ map outlining where this applies for new or planned flood defences. These maps will be updated as plans progress, but in the meantime please contact the city council and the Environment Agency if your site is near to any of these areas. Development will be resisted within these areas if they would fetter the delivery of future flood defences.

It must also be ensured that other existing flood risk assets, which do not appear on the ‘Land safeguarded from development that is required for current and future flood management’ map, are enabled to continue the ongoing access, monitoring, inspection, and maintenance they require. If a flood risk asset is identified in close vicinity to a proposed development site, via the Flood Risk Asset Register for instance, the asset owner identified responsible for this should be contacted through the planning process.

8.0 Exception Test

Where the Exception Test needs to be applied it's two component parts must be satisfied to pass the test. The two components are to demonstrate that:

- development that has to be in a flood risk area will provide wider sustainability benefits to the community that outweigh flood risk; and
- the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.

Providing wider sustainability benefits to the community that outweigh flood risk

Justification must be provided that other sustainability criteria outweigh the flood risk issues posed to help support the decision-making process to enable development in areas at high flood risk. This report does not consider wider sustainability benefits that might contribute towards outweighing flood risk. Applicants should engage with the planning authority on this matter.

Demonstrating development will be safe for its lifetime taking account of the vulnerability of its users

To demonstrate that a development is safe for its lifetime, the flood risk planning practice guidance (PPG) should be applied. However, it is recognised that it in some circumstances, it may be possible to demonstrate that a development is safe without necessarily satisfying every paragraph of the flood risk PPG. As such, locally specific guidance for development in Bristol is provided in section 9 of this report – Managing the risk of flooding to development.

Reducing flood risk overall where possible (causes and impacts)

Site specific flood mitigation measures should be applied where there is the requirement, but developer contributions to wider flood reduction schemes will also be sought where this is necessary and from those benefitting from this. Higher risk areas will be most prevalent in this regard and developments that could be subjected to a heightened risk of flooding or those that could potentially worsen the effects on the surrounding areas will have to compensate alternative ways of managing this. In site specific FRAs it will need to be demonstrated that the flood risk factors in section 6.0 Detailed flood modelling have each been appropriately considered.

9.0 Managing the risk of flooding to development

The guiding principle for making development safe from the risk of flooding should be to minimise the potential for people to be exposed to hazardous flood water. Hazard is defined in accordance with the DeFRA/Environment Agency Hazard to people Classification using Hazard rating as seen in Table 5 above and explained in section 6.4 of this report. Consistent with the process set out in national flood risk PPG, exposure to hazard should follow a hierarchy of avoiding, controlling, mitigating, and managing the risk. The following sections provide further advice on making a development safe from the risk of flooding by minimising the potential for people to be exposed to hazardous flood water.

Ensuring safe development over its intended lifetime

9.1 The Design Flood

To inform the measures needed to make a development safe for its lifetime, the design flood first needs to be determined. The design flood is defined as:

- River flooding likely to occur with a 1% annual probability (a 1 in 100 chance each year); or
- tidal flooding with a 0.5% annual probability (1 in 200 chance each year); or
- surface water flooding likely to occur with a 1% annual probability (a 1 in 100 chance each year),
- plus, an appropriate allowance for climate change.

The design flood must be used when considering the potential for exposure to hazardous flood water. It may also be useful to consider how the potential for exposure to hazardous flood water changes over time, for example by assessing the flood hazard at various points in time over the lifetime of the development. Guidance on appropriate allowances for climate change when determining the design flood is provided in the following section 9.2.

9.2 Climate change allowances

Site specific flood risk assessments should refer to Environment Agency guidance on when and how to use climate change allowances Flood risk assessments: climate change allowances - GOV.UK (www.gov.uk).

Bristol is vulnerable to the increased risk of flooding due to climate change, so we consider it essential that this guidance is adhered to. The impact of sea level rise is particularly important in Bristol, as such we draw attention to the guidance on sea level allowances as follows.

Sea level allowances

There are a range of allowances for each river basin district and epoch for sea level rise. The:

- higher central allowance is based on the 70th percentile
- upper end allowance is based on the 95th percentile

The Environment Agency guidance advises that for flood risk assessments **both** the higher central and upper end allowances should be assessed. To help decide which allowances to use to address flood risk for a development, consider the:

- likely depth, extent, speed of onset, velocity, and duration of flooding for each allowance of climate change over time
- vulnerability of the proposed development types to flooding
- 'built in' measures used to address flood risk, for example, raised floor levels
- capacity or space in the development to include measures to manage flood risk in the future, using an adaptive approach.

Due to Bristol's vulnerability to rising sea levels, we recommend using the upper end allowance as a precautionary approach in the central area.

It should also be noted that mitigating measures such as raised floor levels is not a binary choice between the two allowances. It may be appropriate for example to set floor levels somewhere between the two levels.

Speak to the Environment Agency and the planning authority at the earliest opportunity when considering these matters. Tension between flood risk and design considerations is not a reason to allow unsafe development.

9.3 Avoid, control, mitigate, manage

To make a site safe, use a suite of measures that complement each other following the hierarchy of avoid, control, mitigate, and manage, to minimise the potential for exposure to hazardous flood water.

Avoid

Firstly, apply the Sequential Test and, if needed, the Exception Test. For larger sites locate all buildings in areas at lowest risk of flooding where possible, then design the layout of the site such that more vulnerable uses are sited in areas of lower risk. For smaller sites and / or where the flood risk is uniform across the site, place more vulnerable uses on higher floors.

Separate commercial areas from residential areas so that each can be considered with different lifetimes (typically 75 years for commercial and 100 years for residential).

Avoid lowering ground levels. Lowering ground in areas at risk of flooding increases potential flood depths, and as such increases the risk of exposure to hazardous flood water. If unavoidable, then use ramps and / or barriers to protect them from hazardous flood depths.

Consider the lifetime of the development and the potential for a time limited use where appropriate such that a permitted use is ceased at a point in time before potential flooding becomes hazardous.

Control

The council in partnership with the Environment Agency have a long-term plan to manage the risk of flooding from the river Avon. The Bristol Avon Flood Strategy sets out our vision. Where development is in an area that will benefit from these defences, please contact us to discuss how to use this in any Flood Risk Assessment. Where development lies near to or within the footprint of the strategy, speak to us to consider ways in which development could be integrated with our plans to manage the risk. See section 9.5 for further details.

Mitigate

Raise floor levels or consider landscaping and ground raising above the design flood using the upper end climate change allowance for residential uses in the central area. Consider and provide suitable floor levels for other uses.

Locate plant that is critical to the safe use of the building above the future case flood defence failure scenario appropriate for the development type (the upper end climate change allowance in the central area). This is so that it can remain operational in times of flooding.

Incorporate flood resistance measures such as flood doors or barriers to stop water from entering buildings up to a safe structural limit. Typically, these measures can be effective for resisting short duration flooding up to a depth of approximately 0.6m. Use passive measures in preference to active measures wherever possible.

Incorporate flood resilience measures such as resilient building materials to minimise damage and allow faster cleaning, drying, repairing and re-occupancy of the building after a flood. Have plans in place to move sensitive equipment or belongings to upper floors when flooding is expected.

Manage

Provide safe access and escape routes that are above the design flood level. See section 9.4 for further advice regarding safe access and escape routes.

Prepare a Flood Warning and Evacuation Plan (FWEP) using the council's templates for commercial and residential developments, and with consideration to the flood risk PPG. Give careful attention to the thresholds for implementation of various aspects of the plan and avoid over-reliance on the Environment Agency's flood warning service. Minimise reliance on emergency services.

Incorporate areas of safe refuge within buildings at a level above design flood levels and residual flood risk levels. Ensure areas of refuge provide necessary facilities such as clean running water, heating, and electricity that can operate during a flood event. Consider the duration of flooding when considering the suitability of safe refuge areas.

Flood Warning Systems

See section 4.2 Flood Warning Areas of the BCC Level 1 SFRA report for further details of flood warning systems functioning in the area. EA water level gauges are located at several locations along the Bristol Frome and Bristol Avon rivers, including upstream of Netham Weir and Avonmouth, and a BCC monitor is positioned at Bedminster Bridge. Data from these resources can be provided upon request by contacting BCC via: flood.data@bristol.gov.uk and the EA Customers & Engagement Team via: wessexenquiries@environment-agency.gov.uk. This data can be viewed on Bristol – River and sea levels online.

9.4 Safe access and escape routes

Flood risk PPG states that "Access routes should allow occupants to safely access and exit their dwellings in design flood conditions". In Bristol, this is often difficult to achieve in practice because of existing ground levels that are significantly lower than the design flood. This leads to the requirement for the provision of offsite infrastructure such as raised walkways or raised ground that tie into higher ground, which is often not a viable or desirable solution.

If a site is in an area that will benefit from the Bristol Avon Flood Strategy, please contact us to discuss how safe access and egress might be considered.

If it is not possible to provide safe access for the duration of a design flood, a detailed assessment of the likelihood and duration of the possibility of being trapped and / or unable to enter a dwelling must be made to consider the overall site safety. In this case there must always be a safe refuge area to provide safe living accommodation for the duration of the flood event when access is restricted.

Reducing flood risk and not increasing flood risk elsewhere

Floodplain compensation

Where this applies floodplain storage compensation will have to be calculated and accommodated for in equivalent terms of flood level and volume for the 1:100 flood event. This will need to be undertaken in accordance with the gov.uk guidance with climate change allowances based on land uses in the affected areas. As well as this an assessment of any off-site impacts as an implication of this will have to be made.

9.5 Bristol Avon Flood Strategy

The 2023 draft Local Plan publication version policy FR2 – Bristol Avon Flood Strategy, sets out that flood risk from the river Avon will be addressed on a strategic basis consistent with the Bristol Avon Flood Strategy. Our aim is to avoid piecemeal development proposals with negative consequences arising because of site-specific flood risk management proposals. Instead, we aspire to a position whereby new development can rely on the future delivery of the strategic defences to manage flood risk from the river Avon, reducing the burden of site-specific flood risk mitigation.

Development in an area that benefits from a reduction in flood risk by the future delivery of the Bristol Avon Flood Strategy will be expected to:

- Incorporate adequate mitigation measures to make the site safe from flooding in the period up to the delivery of strategic flood defences.
- Respond to the residual risk of flooding associated with the potential for existing and planned flood defences failing or being overtopped.
- Facilitate the delivery of future flood defences and enhanced multi-purpose greenway along the river Avon frontage, including financial contributions where appropriate.

The exact area that will directly benefit from reduced flood risk because of the future delivery of the strategy will evolve as plans progress. However, the strategy's preferred option standard of protection is the 1 in 100 fluvial and 1 in 200 tidal including allowances for climate change. As such, areas within the SFRA central area maps for these two scenarios including climate change are likely to benefit from the proposals.

Any new development proposals within these areas should engage with the city council and Environment Agency at the outset of any proposals. Pre-application advice is strongly encouraged. As of October 2023, there is some uncertainty over both funding and the timeframe for the future delivery of defences. As such a precautionary approach is required to ensure that adequate mitigation measures to make the site safe from flooding in the period up to the (assumed) delivery of strategic flood defences are included. Engage with the council and Environment Agency early on to agree a suitable period.

Even when new development proposals can rely on the future delivery of flood defences, a residual risk associated with those future defences being over-topped and / or breached remains. See section 10 for details of how to manage residual flood risk.

The delivery of future flood defences will only be realised with additional financial contributions from yet un-secured sources, including private sector contributions. As such financial contributions to the future delivery of the defences will be sought from new development over and above Community Infrastructure Levy (CIL) contributions where appropriate. Early engagement with the city council and Environment Agency is required.

Development located within or adjacent to areas that are essential for the delivery of future flood defences are particularly important to the realisation of delivering the required flood protection and enhanced multi-purpose greenway. The upcoming 2023 Local Plan policies map FR2 – Bristol Avon Flood Strategy, identifies these areas. Development in those areas will be expected to:

- Accommodate space for and / or deliver flood protection infrastructure required as part of the development of the area, including enhanced greenway.

The amount of space required for the delivery of the proposed flood protection infrastructure including enhanced greenway will vary along the river corridor as constraints also vary. The Bristol Temple Quarter Development Framework (Planning in Bristol Temple Quarter) guiding principles sets out the need for an integrated design and placemaking approach to flood defence provision. It states that flood defence design along the river Avon corridors must incorporate habitat enhancement, landscaped public realm, public walkways, and cycle path facilities. The river Avon Greenway is identified as a 15-25m wide traffic free corridor.

It is vitally important to engage with the city council and Environment Agency as early as possible to agree a suitable approach that complies with policy FR2 – Bristol Avon Flood Strategy and our July 2022 planning position statement on Development in areas of flood risk (bristol.gov.uk).

10.0 Residual Flood Risk

The risk of flooding can never be eliminated in entirety. The risk of flooding that remains once any site-specific flood mitigation measures are considered is known as residual risk. Consideration of how to deal with extreme events or catastrophic failures, even if less likely to occur, is needed in combination with the plans made for managing the risk in a design flood event.

To consider residual risk analyse the detailed flood maps flood defence failure scenarios including climate change. Also analyse the 1 in 1,000 tidal and fluvial defended scenarios. Plan how such scenarios will be managed to reduce their impacts. Follow the same approach to Avoid, Control, Mitigate and Manage.

In all instances where a residual flood risk remains:

- A minimum floor level of 300mm above existing ground levels is required (note that mitigating the design flood may mean the required floor level is greater than this anyway).
- Significant flood depths may justify further raising of ground or floor levels (above the design flood).
- Safe refuge areas must be incorporated.
- Basements should be avoided and lowering existing ground levels will be resisted.
- Resilient construction such as raised services and flood resilient materials should be incorporated.
- Flood warning and evacuation plans must be put in place.

Rapid inundation from faster moving flood waters may make a safe evacuation less possible, as such safe refuge arrangements will always be necessary but should never be relied on as the only form of mitigation.

Note: in due course, flood maps that examine the residual risk of planned future defences for the central area failing or being over-topped will be produced. In the absence of those plans, the existing flood defence failure scenarios should be used to examine residual risk. This is a precautionary approach as those scenarios consider all the city's existing strategic flood management infrastructure failing simultaneously, but necessary in the absence of more realistic or up to date residual risk information. Updated residual risk maps for Avonmouth Severnside will also be produced in due course.

11.0 Monitoring and review

This BCC Level 2 SFRA and the BCC Level 1 SFRA will be updated in combination and periodically in line with the Bristol Local Plan updates on a five yearly cycle or whenever significant changes are required, as set out in the gov.uk guidance. The requirement for review and revision of the document may come when there is improved understanding of climate science and predicted future weather impacts, or if Bristol were to experience an extreme flood event.

To measure the success of the report and its intended aims in reducing and managing flood risk effectively, planning consultations with BCC will be monitored internally and with the EA and statistics collated for developments deriving flood risk benefits. That is avoiding developing in higher risk areas or incorporating measures into the development to help reduce flood risk and the impacts of climate change.

12.0 Summary and recommendations

This Level 2 SFRA provides detailed flood risk information on areas within the city of Bristol that are subjected to greater risk. The accompanying Level 2 SFRA maps can be used to analyse the risk posed to a specific site in those areas exposed to a higher risk of flooding throughout the city. Further information dependent on the type or source of flooding experienced (if relevant) can then be derived from the main report or from the LLFA or other applicable RMA via initial contact through: flood.data@bristol.gov.uk.

13.0 SFRA mapping data

The following accompanying flood maps are available to fulfil the purposes described in this SFRA document. Further explanation or additional information pertaining to the flood mapping in Table 6 below can be obtained from BCC FRM team via: flood.data@bristol.gov.uk.

Table 6 SFRA mapping data

SFRA Map	Data source
Depth, duration (flood extent at time), velocity, rate of rise and hazard for fluvial and tidal sources inclusive of climate change	BCC contactable via: flood.data@bristol.gov.uk EA Customers & Engagement Team available via: wessexenquiries@environment-agency.gov.uk
Depth, duration (flood extent at time), rate of rise, velocity, and hazard for pluvial sources inclusive of climate change	BCC contactable via: flood.data@bristol.gov.uk
Flood defence failure inclusive of climate change mapping breach, overtopping and blockage (this data is limited to certain flood risk assets only and not available for all locations)	BCC contactable via: flood.data@bristol.gov.uk EA Customers & Engagement Team available via: wessexenquiries@environment-agency.gov.uk
Functional floodplain maps	BCC contactable via: flood.data@bristol.gov.uk
Land safeguarded from development that is required for current and future flood management	BCC contactable via: flood.data@bristol.gov.uk

14.0 List of flood maps

Avonmouth 1 in 200 Tidal Flood Defended Scenario

Avonmouth 1 in 200 Tidal Flood Defended Scenario 2098

Avonmouth 1 in 200 Tidal Flood Defended Scenario 2098 - Duration

Avonmouth 1 in 200 Tidal Flood Defended Scenario 2098 - Rate of Rise

Avonmouth 1 in 200 Tidal Flood Defended Scenario 2116 – Duration

Avonmouth 1 in 200 Tidal Flood Defended Scenario 2116 - Rate of Rise

Avonmouth 1 in 200 Tidal Flood Undefended Scenario 2116 Duration

Avonmouth 1 in 200 Tidal Flood Defended Scenario 2120

Avonmouth 1 in 200 Tidal Flood Defended Scenario 2120 – Duration

Avonmouth 1 in 200 Tidal Flood Defended Scenario 2120 - Rate of Rise

Avonmouth 1 in 200 Tidal Flood Undefended Scenario 2080 Duration

Avonmouth 1 in 200 Tidal Flood Undefended Scenario 2080 Rate of Rise

Avonmouth 1 in 200 Tidal Flood Defence Failure Breach Scenario 2098

Avonmouth 1 in 200 Tidal Flood Defence Failure Breach Scenario 2120

Avonmouth 1 in 1000 Tidal Flood Defended Scenario

Avonmouth 1 in 1000 Tidal Flood Defended Scenario – Duration

Avonmouth 1 in 1000 Tidal Flood Defended Scenario - Rate of Rise

Avonmouth 1 in 1000 Tidal Flood Defended Scenario 2098

Avonmouth 1 in 1000 Tidal Flood Defended Scenario 2098 – Duration

Avonmouth 1 in 1000 Tidal Flood Defended Scenario 2098 Rate of Rise

Avonmouth 1 in 1000 Tidal Flood Defended Scenario 2116 – Duration

Avonmouth 1 in 1000 Tidal Flood Defended Scenario 2120

Avonmouth 1 in 1000 Tidal Flood Defended Scenario 2120 – Duration

Avonmouth 1 in 1000 Tidal Flood Defended Scenario 2120 - Rate of Rise

Avonmouth 1 in 1000 Tidal Flood Undefended Scenario – Duration

Avonmouth 1 in 1000 Tidal Flood Undefended Scenario - Rate of Rise

Avonmouth 1 in 1000 Tidal Flood Undefended Scenario 2080 – Duration

Avonmouth 1 in 1000 Tidal Flood Undefended Scenario 2080 - Rate of Rise

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defended Scenario – Depth

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defended Scenario – Hazard

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defended Scenario – Velocity

Central Area 1 in 100 Fluvial (1 in 1 tidal) Flood Defended Scenario – Duration

Central Area 1 in 100 Fluvial (1 in 1 tidal) Flood Defended Scenario - Rate of Rise

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defence Failure Scenario – Depth

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defence Failure Scenario – Hazard

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defence Failure Scenario – Velocity

Central Area 1 in 100 Fluvial (1 in 1 tidal) Flood Defence Failure Scenario – Duration

Central Area 1 in 100 Fluvial (1 in 1 tidal) Flood Defence Failure Scenario - Rate of Rise

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defended Scenario 2080 - Higher Central – Depth

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defended Scenario 2080 - Higher Central – Hazard

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defended Scenario 2080 - Higher Central – Velocity

Central Area 1 in 100 Fluvial (1 in 1 tidal) Flood Defended Scenario 2080 Higher Central – Duration

Central Area 1 in 100 Fluvial (1 in 1 tidal) Flood Defended Scenario 2080 Higher Central - Rate of Rise

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defended Scenario 2080 - Upper End – Depth

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defended Scenario 2080 - Upper End – Hazard

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defended Scenario 2080 - Upper End – Velocity

Central Area 1 in 100 Fluvial (1 in 1 tidal) Flood Defended Scenario 2080 Upper End – Duration

Central Area 1 in 100 Fluvial (1 in 1 tidal) Flood Defended Scenario 2080 Upper End - Rate of Rise

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defended Scenario 2120 - Higher Central – Depth

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defended Scenario 2120 - Higher Central – Hazard

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defended Scenario 2120 - Higher Central – Velocity

Central Area 1 in 100 Fluvial (1 in 1 tidal) Flood Defended Scenario 2120 Higher Central – Duration

Central Area 1 in 100 Fluvial (1 in 1 tidal) Flood Defended Scenario 2120 Higher Central - Rate of Rise

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defended Scenario 2120 - Upper End – Depth

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defended Scenario 2120 - Upper End – Hazard

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defended Scenario 2120 - Upper End – Velocity

Central Area 1 in 100 Fluvial (1 in 1 tidal) Flood Defended Scenario 2120 Upper End – Duration

Central Area 1 in 100 Fluvial (1 in 1 tidal) Flood Defended Scenario 2120 Upper End - Rate of Rise

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defence Failure Scenario – Depth

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defence Failure Scenario – Hazard

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defence Failure Scenario – Velocity

Central Area 1 in 100 Fluvial (1 in 1 tidal) Flood Defence Failure Scenario – Duration

Central Area 1 in 100 Fluvial (1 in 1 tidal) Flood Defence Failure Scenario - Rate of Rise

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defence Failure Scenario 2080 - Higher Central – Depth

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defence Failure Scenario 2080 - Higher Central – Hazard

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defence Failure Scenario 2080 - Higher Central – Velocity

Central Area 1 in 100 Fluvial (1 in 1 tidal) Flood Defence Failure Scenario 2080 Higher Central – Duration

Central Area 1 in 100 Fluvial (1 in 1 tidal) Flood Defence Failure Scenario 2080 Higher Central - Rate of Rise

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defence Failure Scenario 2120 - Higher Central – Depth

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defence Failure Scenario 2120 - Higher Central – Hazard

Central Area 1 in 100 Fluvial (1 to 1 Tidal) Flood Defence Failure Scenario 2120 - Higher Central – Velocity

Central Area 1 in 100 Fluvial (1 in 1 tidal) Flood Defence Failure Scenario 2120 Higher Central – Duration

Central Area 1 in 100 Fluvial (1 in 1 tidal) Flood Defence Failure Scenario 2120 Higher Central - Rate of Rise

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defence Failure Scenario 2120 - Upper End – Depth

Central Area 1 in 100 Fluvial (1 to 1 Tidal) Flood Defence Failure Scenario 2120 - Upper End – Hazard

Central Area 1 in 100 Fluvial (1 in 1 Tidal) Flood Defence Failure Scenario 2120 - Upper End – Velocity

Central Area 1 in 100 Fluvial (1 in 1 tidal) Flood Defence Failure Scenario 2120 Upper End – Duration

Central Area 1 in 100 Fluvial (1 in 1 tidal) Flood Defence Failure Scenario 2120 Upper End - Rate of Rise

Central Area 1 in 200 Tidal (1 in 2 Fluvial) Flood Defended Scenario – Depth

Central Area 1 in 200 Tidal (1 in 2 Fluvial) Flood Defended Scenario – Hazard

Central Area 1 in 200 Tidal (1 in 2 Fluvial) Flood Defended Scenario – Velocity

Central Area 1 in 200 Tidal (1 in 2 fluvial) Flood Defended Scenario – Duration

Central Area 1 in 200 Tidal (1 in 2 fluvial) Flood Defended Scenario - Rate of Rise

Central Area 1 in 200 Tidal (1 in 2 Fluvial) Flood Defended Scenario 2080 – Depth

Central Area 1 in 200 Tidal (1 in 2 Fluvial) Flood Defended Scenario 2080 – Hazard

Central Area 1 in 200 Tidal (1 in 2 Fluvial) Flood Defended Scenario 2080 – Velocity

Central Area 1 in 200 Tidal (1 in 2 fluvial) Flood Defended Scenario 2080 – Duration

Central Area 1 in 200 Tidal (1 in 2 fluvial) Flood Defended Scenario 2080 - Rate of Rise

Central Area 1 in 200 Tidal (1 in 2 Fluvial) Flood Defended Scenario 2120 – Depth

Central Area 1 in 200 Tidal (1 in 2 Fluvial) Flood Defended Scenario 2120 – Hazard

Central Area 1 in 200 Tidal (1 in 2 Fluvial) Flood Defended Scenario 2120 – Velocity

Central Area 1 in 200 Tidal (1 in 2 fluvial) Flood Defended Scenario 2120 – Duration

Central Area 1 in 200 Tidal (1 in 2 fluvial) Flood Defended Scenario 2120 - Rate of Rise

Central Area 1 in 200 Tidal (1 in 2 Fluvial) Flood Defence Failure Scenario – Depth

Central Area 1 in 200 Tidal (1 in 2 Fluvial) Flood Defence Failure Scenario – Hazard

Central Area 1 in 200 Tidal (1 in 2 Fluvial) Flood Defence Failure Scenario – Velocity

Central Area 1 in 200 Tidal (1 in 2 fluvial) Flood Defence Failure Scenario – Duration

Central Area 1 in 200 Tidal (1 in 2 fluvial) Flood Defence Failure Scenario - Rate of Rise

Central Area 1 in 200 Tidal (1 in 2 Fluvial) Flood Defence Failure Scenario 2080 – Depth

Central Area 1 in 200 Tidal (1 in 2 Fluvial) Flood Defence Failure Scenario 2080 – Hazard

Central Area 1 in 200 Tidal (1 in 2 Fluvial) Flood Defence Failure Scenario 2080 – Velocity

Central Area 1 in 200 Tidal (1 in 2 fluvial) Flood Defence Failure Scenario 2080 – Duration

Central Area 1 in 200 Tidal (1 in 2 fluvial) Flood Defence Failure Scenario 2080 - Rate of Rise

Central Area 1 in 200 Tidal (1 in 2 Fluvial) Flood Defence Failure Scenario 2120 – Depth

Central Area 1 in 200 Tidal (1 in 2 Fluvial) Flood Defence Failure Scenario 2120 – Hazard

Central Area 1 in 200 Tidal (1 in 2 Fluvial) Flood Defence Failure Scenario 2120 – Velocity

Central Area 1 in 200 Tidal (1 in 2 fluvial) Flood Defence Failure Scenario 2120 – Duration

Central Area 1 in 200 Tidal (1 in 2 fluvial) Flood Defence Failure Scenario 2120 - Rate of Rise

Central Area 1 in 1000 Fluvial (1 in 12 Tidal) Flood Defended Scenario – Depth

Central Area 1 in 1000 Fluvial (1 in 12 Tidal) Flood Defended Scenario – Hazard

Central Area 1 in 1000 Fluvial (1 in 12 Tidal) Flood Defended Scenario – Velocity

Central Area 1 in 1000 Fluvial (1 in 12 tidal) Flood Defended Scenario – Duration

Central Area 1 in 1000 Fluvial (1 in 12 tidal) Flood Defended Scenario - Rate of Rise

Central Area 1 in 1000 Fluvial (1 in 12 Tidal) Flood Defence Failure Scenario – Depth

Central Area 1 in 1000 Fluvial (1 in 12 Tidal) Flood Defence Failure Scenario – Hazard

Central Area 1 in 1000 Fluvial (1 in 12 Tidal) Flood Defence Failure Scenario – Velocity

Central Area 1 in 1000 Fluvial (1 in 12 tidal) Flood Defence Failure Scenario – Duration

Central Area 1 in 1000 Fluvial (1 in 12 tidal) Flood Defence Failure Scenario - Rate of Rise

Central Area 1 in 1000 Tidal (1 in 12 Fluvial) Flood Defended Scenario – Depth

Central Area 1 in 1000 Tidal (1 in 12 Fluvial) Flood Defended Scenario – Hazard

Central Area 1 in 1000 Tidal (1 to 12 Fluvial) Flood Defended Scenario – Velocity

Central Area 1 in 1000 Tidal (1 in 12 fluvial) Flood Defended Scenario – Duration

Central Area 1 in 1000 Tidal (1 in 12 fluvial) Flood Defended Scenario - Rate of Rise

Central Area 1 in 1000 Tidal (1 in 12 Fluvial) Flood Defence Failure Scenario – Depth

Central Area 1 in 1000 Tidal (1 in 12 Fluvial) Flood Defence Failure Scenario – Hazard

Central Area 1 in 1000 Tidal (1 in 12 Fluvial) Flood Defence Failure Scenario – Velocity

Central Area 1 in 1000 Tidal (1 in 12 fluvial) Flood Defence Failure Scenario – Duration

Central Area 1 in 1000 Tidal (1 in 12 fluvial) Flood Defence Failure Scenario - Rate of Rise

Flood defence failure

Functional floodplain FZ3b – Duration

Functional floodplain FZ3b - Rate of Rise

Land safeguarded from development that is required for current and future flood management

Risk of Flooding from Surface Water - Medium Risk – Depth

Risk of Flooding from Surface Water - Medium Risk Hazard

Risk of Flooding from Surface Water - Medium Risk – Velocity

Risk of Flooding from Surface Water - Medium Risk - Depth 2080

Risk of Flooding from Surface Water - Medium Risk - Velocity 2080

Risk of Flooding from Surface Water - Medium Risk - Depth 2115

Risk of Flooding from Surface Water - Medium Risk - Velocity 2115

Risk of Flooding from Surface Water - High Risk – Depth

Risk of Flooding from Surface Water - High Risk Hazard

Risk of Flooding from Surface Water - High Risk – Velocity

Risk of Flooding from Surface Water - High Risk - Depth 2080

Risk of Flooding from Surface Water - High Risk - Velocity 2080

Risk of Flooding from Surface Water - High Risk - Depth 2115

Risk of Flooding from Surface Water - High Risk - Velocity 2115

15.0 References

Atkins: The Severn Estuary Shoreline Management Plan 2; Cardiff 2017

Bristol City Council: Bristol City Docks Bye-Laws; Bristol 2009

Bristol City Council: Conservation Area 17, City Docks, Character Appraisal & Management Proposals; Bristol 2011

Bristol City Council. Bristol Harbour. Available online: https://www.bristol.gov.uk/streets-travel/bristol-harbour (accessed on 14/09/2023)

Bristol Port: General Byelaws; Bristol 2005

Bristol City Council: Bristol Local Flood Risk Management Strategy; Bristol 2023

CIRIA: The SuDS Manual (C753); London 2015

Defra/Environment Agency Gov.uk Guidance. Flood Risk Assessment Guidance for New Development. Available online: https://assets.publishing.service.gov.uk/media/602d040fd3bf7f721a23a993/Flood_risk_assessment_guidance_for_new_development_-_phase_2_technical_report_Full_Documentation_and_Tools.pdf (accessed on 14/09/2023)

Defra/Environment Agency Gov.uk Guidance. Flood Risk to People. Available online: https://assets.publishing.service.gov.uk/media/602bbc3de90e07055f646148/Flood_risks_to_people_-_Phase_2_Guidance_Document_Technical_report.pdf(accessed on 14/09/2023)

Environment Agency: Bristol Avon Catchment Flood Management Plan; Exeter 2012

Environment Agency: Shirehampton Flood Defence Scheme booklet; Bristol 2019

European Commission: EU Bathing Water Directive; Brussels 2006

European Commission: EU Floods Directive; Brussels 2007

European Commission: Water Framework Directive; Brussels 2000

Halcrow Group Limited: Bristol City Council, Strategic Flood Risk Assessment Level 1 SFRA - Final Report; Exeter 2009

Gov.uk Guidance. Flood risk assessments: climate change allowances. Available online: https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances (accessed on 14/09/2023)

Gov.uk Guidance. How to prepare a strategic flood risk assessment. Available online: https://www.gov.uk/guidance/local-planning-authorities-strategic-flood-risk-assessment (accessed on 14/09/2023)

Gov.uk Guidance. Flood risk and coastal change. Available online: https://www.gov.uk/guidance/flood-risk-and-coastal-change#Strategic-Flood-Risk-Assessment-section (accessed on 14/09/2023)

JBA Consulting: Bristol Preliminary Flood Risk Assessment; Newport 2011

National Planning Policy Framework. Available online: https://www.gov.uk/government/publications/national-planning-policy-framework--2 (accessed on 14/09/2023)

Sir Michael Pitt: Learning lessons from the 2007 floods; London 2008

UK Government Department for Food and Rural Affairs: A Green Future: Our 25 Year Plan to Improve the Environment; London 2018

UK Government: National Planning Policy Framework; London 2018

UK Government: The Flood Risk Regulations; London 2009

UK Government: Flood and Water Management Act; London 2010

UK Government: The Water Environment (Water Framework Directive) (England and Wales) Regulations; London 2017