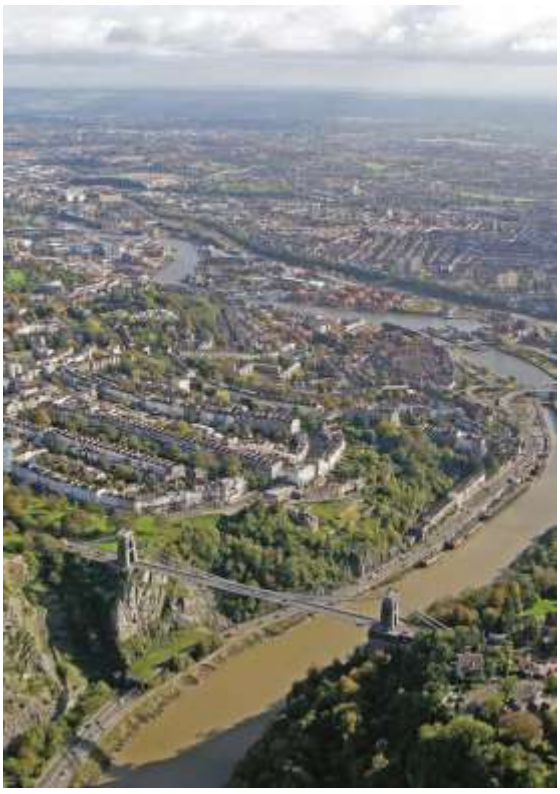
Level 1 – Citywide
Strategic Flood Risk Assessment



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Purpose of the document

The Bristol City Council (BCC) Level 1 Strategic Flood Risk Assessment (SFRA) provides a citywide assessment of flood risk from all sources assessing the risk now and in the future, taking in to account the predicted effects of climate change. The BCC Level 1 SFRA report assesses the impact that land use changes and development in the area will have on flood risk. The report contains important flood risk and drainage information and related data sources. The accompanying SFRA mapping provides flood extents and flooding records with area specific references. This Level 1 SFRA report has been prepared in accordance with the National Planning Practice Guidance (NPPG) and the Environment Agency's (EA) How to prepare a SFRA for Local Planning Authorities (LPA) available on the Gov.uk website. It is sufficiently detailed to allow the LPA to identify whether development can be allocated outside high and medium flood risk areas, based on all sources of flooding.

A separate Level 2 SFRA report will also be prepared. The Level 2 SFRA shall provide further detailed information on flood risk in locations such as Bristol city centre and Avonmouth where some development may be necessary in areas subjected to a greater risk of flooding, if appropriate.

1.0 Background and strategic planning

1.1 Introduction

Bristol has declared a climate and ecological emergency. The Bristol One City Plan and its accompanying Climate Strategy states that all aspects of city life and growth need to contribute to making Bristol a healthier, safer and more resilient city. This SFRA sets out how developments in the city can manage flood risks through a multiple benefit approach that will contribute towards meeting the objectives of the One City Plan.

This SFRA has been completed in line with the guidance for LPA's. It assesses the risk from all sources of flooding within the Bristol area. The SFRA aims to inform development plans in the current day and for the future, taking into account the projected effects of climate change. One of the main purposes of the SFRA is to define areas of Flood Zone 3a and 3b, as well as high risk areas from other sources of flooding, to inform sequential testing for new development. In addition to informing planning and development procedures, the SFRA can also be utilised for emergency planning, development control and to inform individual site's drainage strategies.

The SFRA has been prepared by the BCC Lead Local Flood Authority (LLFA), comprising internal BCC teams such as Flood Risk Management, Strategic City Planning (SCP) and the Civil Protection Unit (CPU) 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 EA, Wessex Water (WW) and the Lower Severn Internal Drainage Board (LSIDB). In conjunction with the other RMAs, BCC have undertaken a number of flood modelling studies in recent years which have improved the assessment of strategic flood risks posed to the city. This revised version of the Level 1 SFRA is therefore a more concise report reflecting these findings and refers to the associated study outputs that are readily available for usage. Further detail about the flood risks to the city can be seen in the Bristol Local Flood Risk Management Strategy (LFRMS).

1.2 Context

The purpose of this SFRA is to inform appropriate land use planning and ensure sustainable development within the BCC region takes into account flood risk, ensuring there is a sequential approach to development in the city. The SFRA report will be used to assess the flood risk within the BCC area, and the risks posed from surrounding areas. Surrounding areas include the neighbouring West of England (WoE) authorities: South Gloucestershire Council (SGC) to the north and east, Bath and North East Somerset Council (BaNES) to the east and south and North Somerset Council (NSC) to the south and west of the city of Bristol (see Figure 1 below). The catchments of these Local Authority areas all drain, at least in part, in to Bristol.

Figure 1 Local Planning Authority boundary map

Avonmouth, in the west of the BCC administrative area, is in part managed by the LSIDB. Further information of the LSIDB role and functions is provided in following sections. Figure 2 below indicates the area of coverage of the LSIDB via a map display.

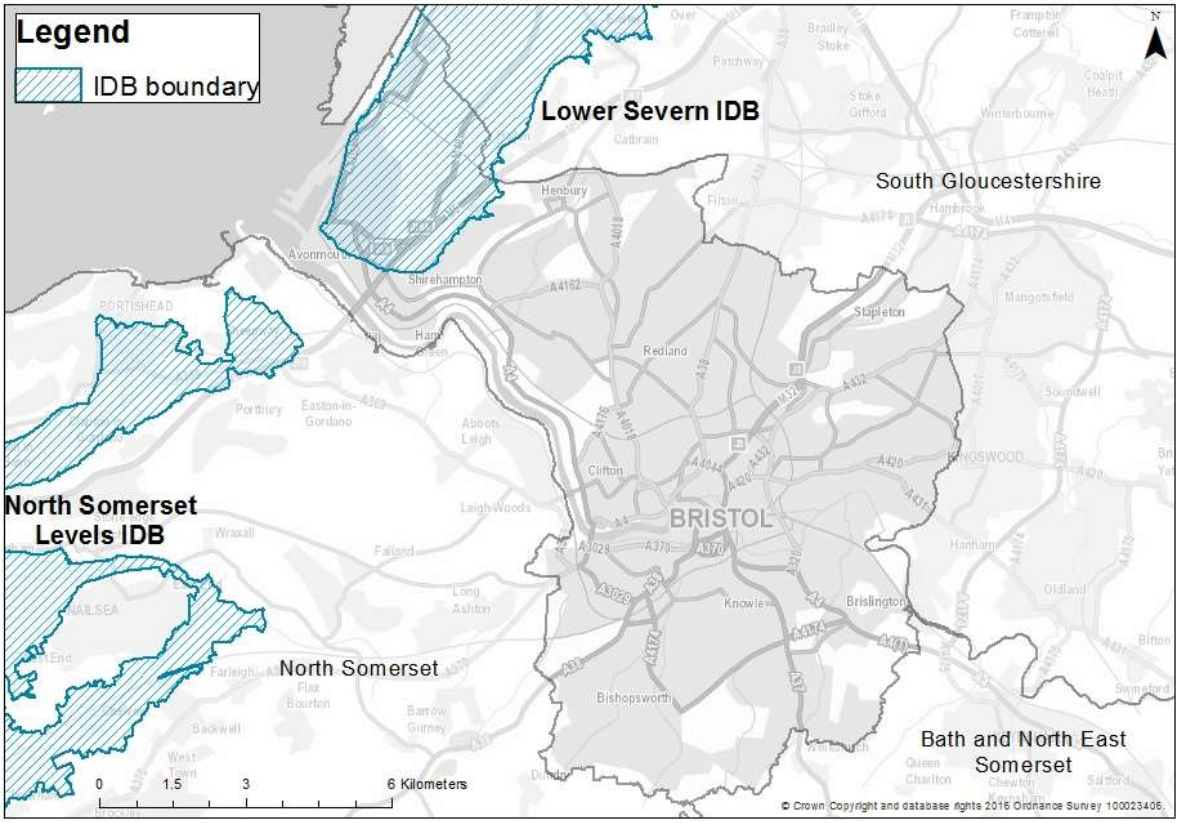

Figure 2 Internal Drainage Board areas and extent of the Lower Severn Internal Drainage Board (LSIDB) administrative area in Bristol

BCC falls within the further division of WW catchments of the Bristol Avon and South Gloucestershire Streams shown in Figure 3.

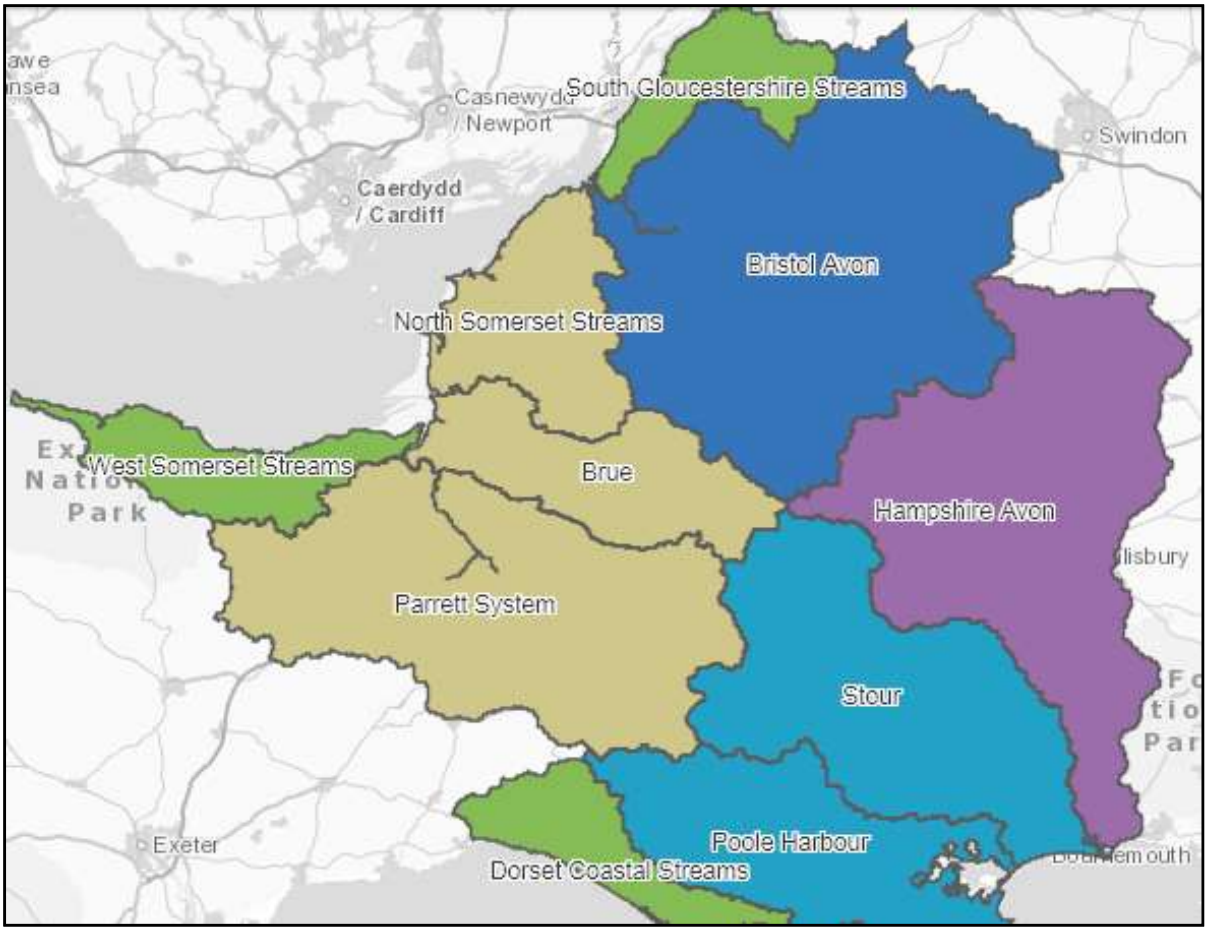

Figure 3 The Wessex catchment and sub catchments, indicating coverage of the sewerage undertaker Wessex Water

Other responsible RMAs operating on a wider catchment scale basis, containing Bristol within it, include the EA and WW, the sewerage undertaker for the Wessex region as illustrated in Figure 4 below. Figure 4 demonstrates the different RMA responsibilities for different sources of flooding.

Figure 4 Flood Risk Management Authorities and their responsibilities in Bristol

The main functions of the Level 1 SFRA are to:

- Provide the technical evidence base to support the Bristol Local Plan and its policies, including the Flood Risk Management and Infrastructure Delivery Strategy;
- Provide up to date flood mapping, defining Flood Zones 3a and 3b, areas of high risk and those that are benefitting from flood defences;
- Help apply the Sequential Test to the Site Allocations process;
- Inform site specific Flood Risk Assessments (FRAs), Sustainable Drainage Strategies, Sequential Test reports (where required) and Flood Evacuation Plans (FEPs);
- Identify ways to reduce flood risk through new development and land use planning;
- Confirm the coverage and extent of the Level 2 SFRA; and
- Confirm the BCC LLFA's approach as statutory consultee in respect of surface water and sustainable drainage, replacing the previous West of England Sustainable Drainage Developers (WoE SuDS) Guide in Bristol.

1.3 Planning Policy

As the SFRA is a planning evidence document, this section of the report identifies the relevant planning policies from a national through to local level that influence the SFRA and vice versa.

National Policy

The Planning Practice Guidance category 'Flood risk and coastal change' provides the guidance for developing an SFRA.

Section 14 of the National Planning Policy Framework relates to 'Meeting the challenge of climate change, flooding and coastal change'. The Planning and flood risk subsection is most applicable (paragraphs 155-165). In summary, the NPPF requires the LPA to try to avoid development in areas currently at risk of flooding or that are predicted to be at risk in the future. Where this is not possible, and there are other overriding sustainability benefits for instance, it must be ensured that new development is safe from flooding over its intended lifetime (i.e. inclusive of the projected impacts of climate change) and without increasing flood risk elsewhere. The NPPF describes this process as the Sequential and Exception tests. The Level 1 SFRA will provide the basis for applying the Sequential Test and aim to steer new development to areas with the lowest risk from any form of flooding.

Local Policy

Within the existing Bristol Local Plan, planning policy BCS16, contained within the Bristol Core Strategy (BCS), considers Flood Risk and Water Management. Policy BCS16 focuses on minimising the risk and impact of flooding. The policy is achieved by siting new developments in areas at lowest risk of flooding (where possible), requiring constructing of flood resistant or resilient design and by reducing surface water run-off. Sequential test reports and site-specific FRAs are required when development is proposed in areas at risk of flooding. At the time of writing the Local Plan is being updated and so parts of this section are subject to change.

The Bristol Central Area Plan (2015), contained within the Local Plan, considers development within the central area. The central area is a locality that will be explained further in this report which is subjected to a significant risk of flooding from combined tidal and fluvial sources. Policy BCAP5: Development and flood risk within the Central Area Plan acknowledges the risk from flooding and addresses the need for this to be appropriately balanced with the wider sustainability benefits of developing the city centre.

Also found within the Local Plan, the Bristol Site Allocations and Development Management Policies (2014) outline where there is the requirement for FRAs at certain sites as well as methods for reducing the risk of flooding in the built and natural environment. Flood mitigation can be achieved through green infrastructure for example. The process of completing the site allocations policies in 2014 utilised a sequential approach to locate development in the lowest flood risk zone possible.

1.4 Applying the Sequential Test

Information regarding flooding contained within this SFRA document can be utilised for applying the Sequential Test. The Sequential Test can be applied both in the site allocations process and through sequential test reports submitted with planning applications on sites not allocated in the local plan. The risk rating of sites proposed for development can be compared with other readily available sites in order to locate development in the areas of lowest flood risk.

This SFRA shows the relative areas at higher risk, determined as EA-defined Flood Zones 2 and 3 (subjected to higher risk from fluvial and tidal sources), BCC-defined areas of high surface water (pluvial) flood risk, or other areas with known flooding issues. The EA only shows areas of Flood Zones 2 and 3 on the Flood Map for Planning: Rivers and Sea and does not define areas of Flood Zones 3a and 3b which is one of the main purposes of the SFRA. All areas outside of the above designated areas (Flood Zones and areas of high surface water flood risk) will be defined either as Flood Zone 1 or deemed at lower flood risk from all other sources of flooding. Therefore, all sites located within the low flood risk zone will be deemed to pass the Sequential Test. Climate change should be applied as part of the Sequential Test in line with paragraphs 155, 157 and 158 of the NPPF. Further information for applying the Sequential Test in Bristol is available in the BCC Flood Risk Sequential Test Practice Note. Sites deemed appropriate and allocated for development will be included within the Bristol Local Plan. Such allocated sites are therefore deemed to have 'passed' the Sequential Test but may still require the Exception Test to be applied, as appropriate. Further information regarding applying the Exception Test in Bristol can be found in the Bristol Level 2 SFRA. Any unallocated sites would need to apply the Sequential Test using the information from this SFRA. The flood mapping and corresponding information available in this SFRA will assist in identifying alternative sites at lower risk of flooding if required.

The Sequential and Exception Tests are planning documents and as such, prospective developers or applicants should discuss the application of the tests with the BCC SCP and Development Management teams ahead of formal submission of the document.

1.5 Flood Risk Management Plan

The Bristol River Avon catchment falls within the wider EA Severn River Basin District Flood Risk Management Plan (FRMP). Specific actions applicable to Bristol can be found in the plan and are accessible via the link below.

1.6 Flood risk and water management policy and guidance

Key guidance and legislation that can help inform planning practice in the field of flood risk and water management includes the following:

- European Commission: Water Framework Directive; Brussels 2000
- European Commission: EU Floods Directive; Brussels 2007
- Sir Michael Pitt: Learning lessons from the 2007 floods; London 2008
- UK Government: The Flood Risk Regulations; London 2009
- UK Government: Flood and Water Management Act; London 2010
- Environment Agency: Bristol Avon Catchment Flood Management Plan; Exeter 2012
- CIRIA: The SuDS Manual (C753); London 2015
- Environment Agency: Severn river basin district flood risk management plan; Bristol 2016
- UK Government: The Water Environment (Water Framework Directive) (England and Wales) Regulations; London 2017
- Atkins: The Severn Estuary Shoreline Management Plan 2; Cardiff 2017
- Bristol City Council: Bristol Local Flood Risk Management Strategy; Bristol 2018
- UK Government Department for Food and Rural Affairs: A Green Future: Our 25 Year Plan to Improve the Environment; London 2018

2.0 Flood risk in Bristol

2.1 Sources of flooding

This SFRA considers the following sources of flood risk:

- Tidal – significant flood risk posed in the present day from the Severn Estuary and the tidal River Avon, predicted to increase further still with climate change and sea level rise;
- Fluvial – in the present day there are a few high risk locations, such as parts of the River Frome, the Brislington Brook and the River Avon east of Temple Meads such as at St Philips Marsh but giving a relatively low flood risk overall. The predicted increase in the future due to climate impacts is expected to increase this risk;
- Pluvial – significant flood risk posed from heavy rainfall events now and in the future. The risk of flooding from this source is already high in the current day and rainfall events are predicted to be more frequent and of higher intensity due to climate change. Areas of Ashton, Southmead, St George and those around the base of Dundry Hills are known to be particularly susceptible to this type of flooding, albeit this is a risk posed citywide;

- Sewer – closely linked with pluvial, with similar areas of risk. High flood risk in the present day, predicted to increase going in to the future due to the significant level of pluvial flood risk that directly relates to this;
- Groundwater – deemed relatively low flood risk in the current day although higher risk areas exist, particularly around Avonmouth. There are areas with known problems with springs such as Redland, Shirehampton, Horfield, Withywood and Whitchurch; these tend to be isolated areas or properties. This could increase in the future due to climate effects on rainfall that indirectly influences the water table and raised sea levels which could have an impact. A full groundwater flood risk study has not yet been conducted so not enough is known at this stage without further investigation;
- Reservoir – Deemed as relatively low flood risk in the present day due to high safety measures and regular routine inspections to prevent failures. The effects of climate change are not thought to increase the flood risk from this source considerably over time. As despite the increased inflow that would be anticipated the hotter climate and expanding population to serve would also result in a substantial increase in demand and subsequently outflow.

Approximate flood extents during extreme fluvial, tidal and pluvial events are available via the online flood risk management maps.

2.2 River systems and watercourses in Bristol

The aim of the section is to provide a high level summary and description of the principal river systems in Bristol, which will aid further understanding of the flood risks posed to the city that will be elaborated upon in further subsections.

The River Avon passes through Bristol from the east to west. Routed through BaNES, the River Avon flows towards Netham where a proportion of flows may enter the Feeder Canal into the Floating Harbour whilst the remainder and majority of flow continues along the River Avon, eventually becoming the River Avon New Cut at Totterdown. Flood gates at Netham Lock have paddles to restrict flow and limit the River Avon flows entering the Floating Harbour. The Floating Harbour level is regulated and has complex interactions between incoming tides and river flows, the water level is maintained by the presence of Netham Weir which prevents the outflow and draining down of the Harbour from Netham Lock. The Underfall sluices present at the downstream extent of the Harbour also pass flows to the New Cut, regulating the outflow from the Floating Harbour through an automated sluice system. Beyond central Bristol the River Avon continues westwards and eventually discharges into the Severn Estuary at Avonmouth. The Severn Estuary provides the tidal influence to the Avon. The tidal extent of the river extends through the entire BCC area. Tributaries of the River Avon within Bristol include the River Frome, River Trym, Longmoor Brook, Old Colliter's Brook, River Malago, Brislington Brook and Conham Vale Stream. The Avon represents the largest and longest stretch of

watercourse in Bristol. Figure 5 shows the extent of the Bristol river network that is defined as EA designated Main River (defined as those shown on the 'Main River' map but generally larger rivers and streams or those with higher risk)) and also represents other key watercourses in the city (discounting many of the smaller ordinary watercourses and drainage ditches deemed inappropriate for scale).

Water entering the low-lying Avonmouth area via rainfall or fluvial flows is managed by a network of drainage ditches that drain into the Severn Estuary. The drainage network is known as the Avonmouth Rhines and is shown in Figure 6. The LSIDB is responsible for managing the 'Viewed' Avonmouth Rhines system however there are other rhines, which are shown in Figure 6 and are owned and maintained by riparian owners. The Avonmouth area, along with the Bristol central area, is given further consideration in the separate Bristol SFRA Level 2 document where the flood risks of these areas is analysed in greater detail.

The other more significant watercourse that also eventually discharges to the Avon is the River Frome. The River Frome flows into Bristol from the north of the city on a south-westerly course entering the BCC administrative area in the Frenchay / Broomhill area. It is joined by the Horfield Brook/Boiling Wells Stream, Fishponds Brook and Coombe Brook along its course. Base flows in the River Frome discharge into the River Avon to the west of the Prince Street/Commercial Road junction via the Mylnes Culvert. During tide locked and/or flood flow scenarios, the Frome can overflow into the Floating Harbour via various flood relief culverts. High flows on the Bristol Frome are diverted away from the city centre at Eastville via the Northern Stormwater Interceptor Sewer (NSWI). The NSWI inlet structure (Eastville Sluices) is located adjacent to Junction 2 of the M32. The NSWI discharges high flows to the River Avon at the site of the former Black Rocks pumping station within the Avon Gorge. The NSWI was completed in 1962 in response to multiple flooding incidents in the Eastville area.

In the south of the city, the Southern Interceptor Tunnel (SIT) on Airport Road (see Figure 5) carries fluvial flood flows from the Brislington Brook onwards to Crox Bottom, adjacent to Hartcliffe Way on the Pigeonhouse Stream. The SIT then also diverts flood flows in the Pigeonhouse Stream and continues on to Manor Wood where it joins the River Malago and the Malago Interceptor that diverts all flow from the upper River Malago. The tidal outfalls of these interceptor systems all finally discharge in to the River Avon. The result of these interceptors, particularly the SIT and Malago Interceptor is that fluvial flood risk downstream of these assets is significantly reduced. The SIT and Malago Interceptors were constructed in the 1970s in response to the Great Flood of 1968 (see Section 2.4 Historic flooding incidents).

Figure 5 and Figure 6 below assist in helping explain the hydrology and tidal and fluvial interactions in Bristol.

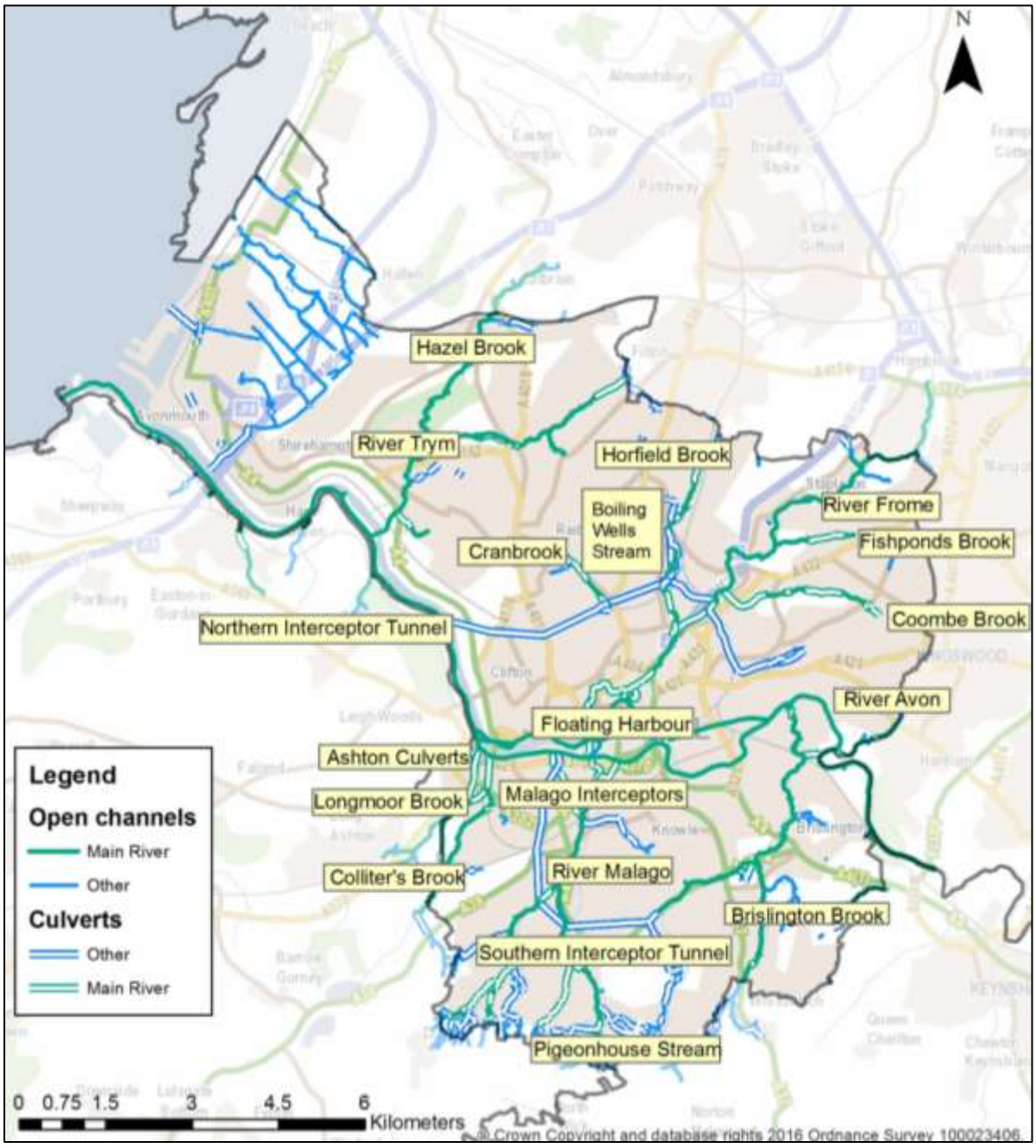

Figure 5 Map of main rivers, streams or significant bodies of water in Bristol

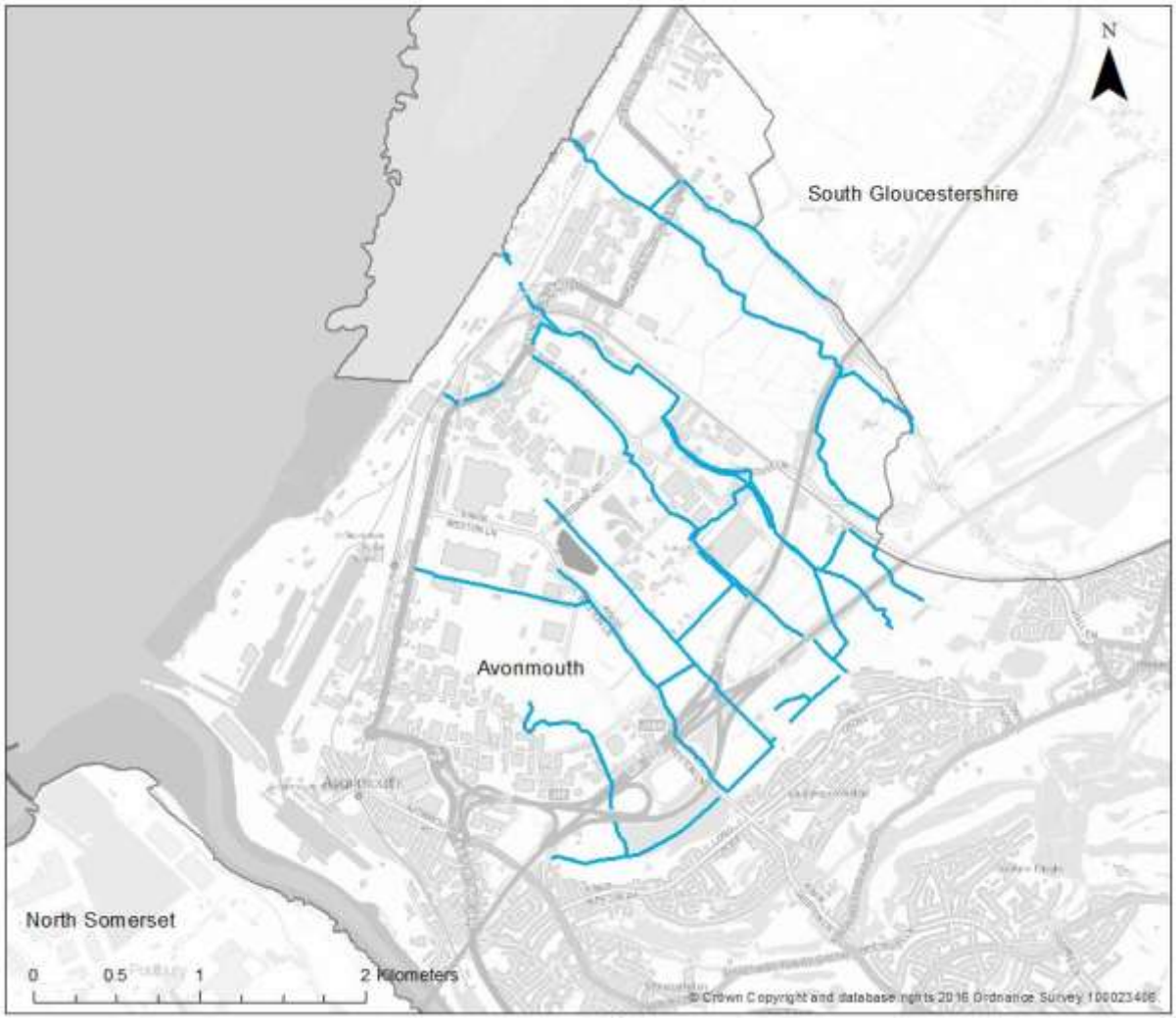

Figure 6 'Viewed' Avonmouth Rhine network maintained by the LSIDB

2.3 Geology

The geology underlying Bristol consists of mudstones and limestones. This gives a range of permeability across the city from little uptake to much faster permeation in cracked and fissured underlying bedrock strata and so site specific infiltration testing is the best method for the SuDS design.

Limestone, mudstone and sandstone comprise the typical geology characterisation of the Bristol area. This is mostly overlain with clay soil. A map indicating the main geological bedrock composition in the Bristol area is shown in Figure 7 below. The areas of limestone and sandstone are much freer draining and allow greater permeability in contrast to the relatively impermeable mudstones, as shown in the corresponding infiltration potential map in Figure 8. Alluvial deposits are apparent adjacent to present and former river systems, such as where the River Avon flows from Bath in the east, it flows through flood plains and areas which were marshes in the past.

Soil type is a major factor in infiltration potential and only determined accurately through ground investigation. In general Bristol is typically underlain by Evesham deep clays which are described as ‘slowly permeable’. However, there are areas of higher infiltration in locations such as Stoke Bishop, Westbury-on-Trym, Brislington and Easton. The area is however heavily urbanised so drainage characteristics of brownfield sites and previously developed sites give a more realistic reflection. The impact of the varied geology is reflected in our sustainable drainage requirements in Section 4.3 Sustainable Drainage Systems (SuDS).

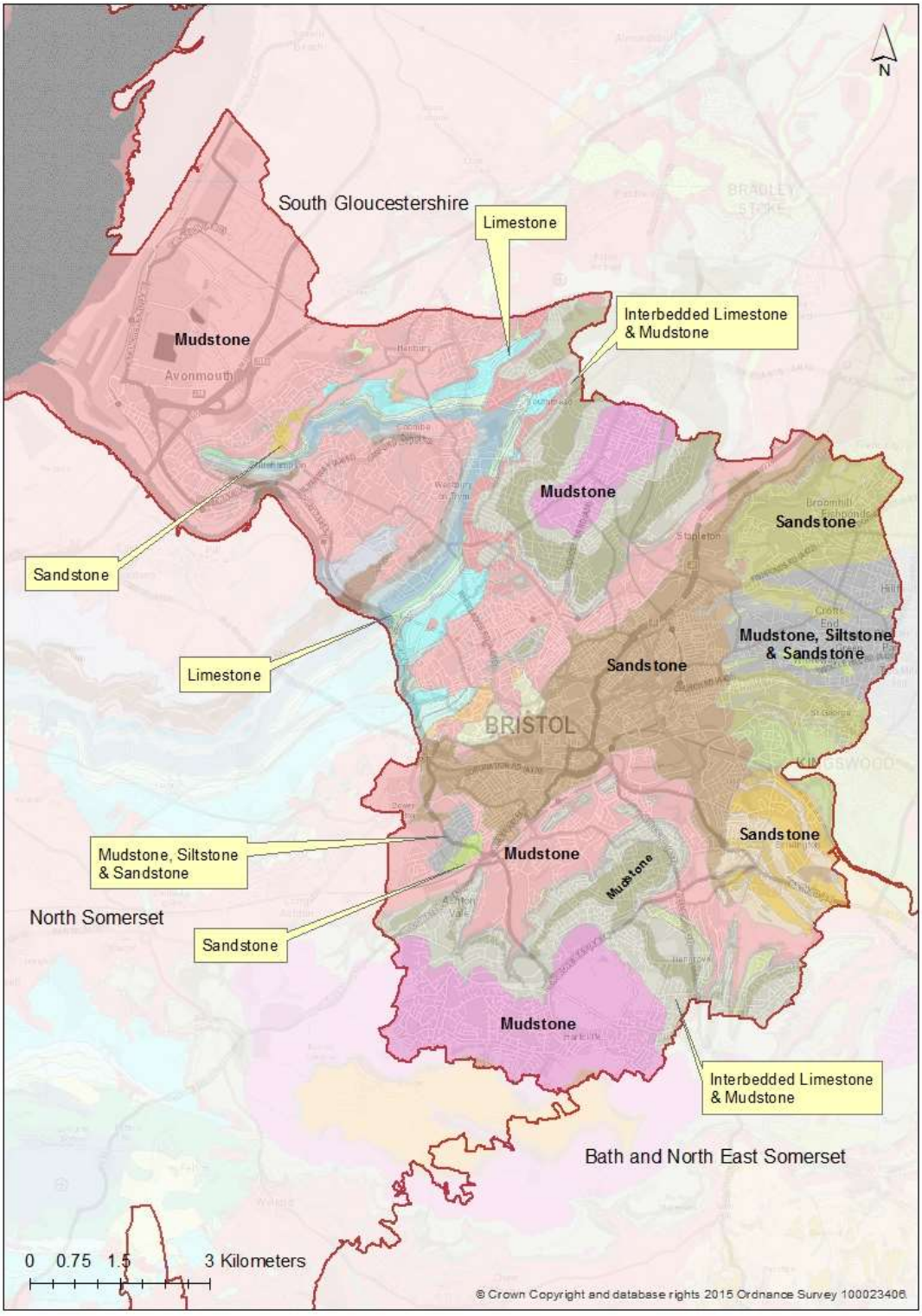

Figure 7 Geology of Bristol map

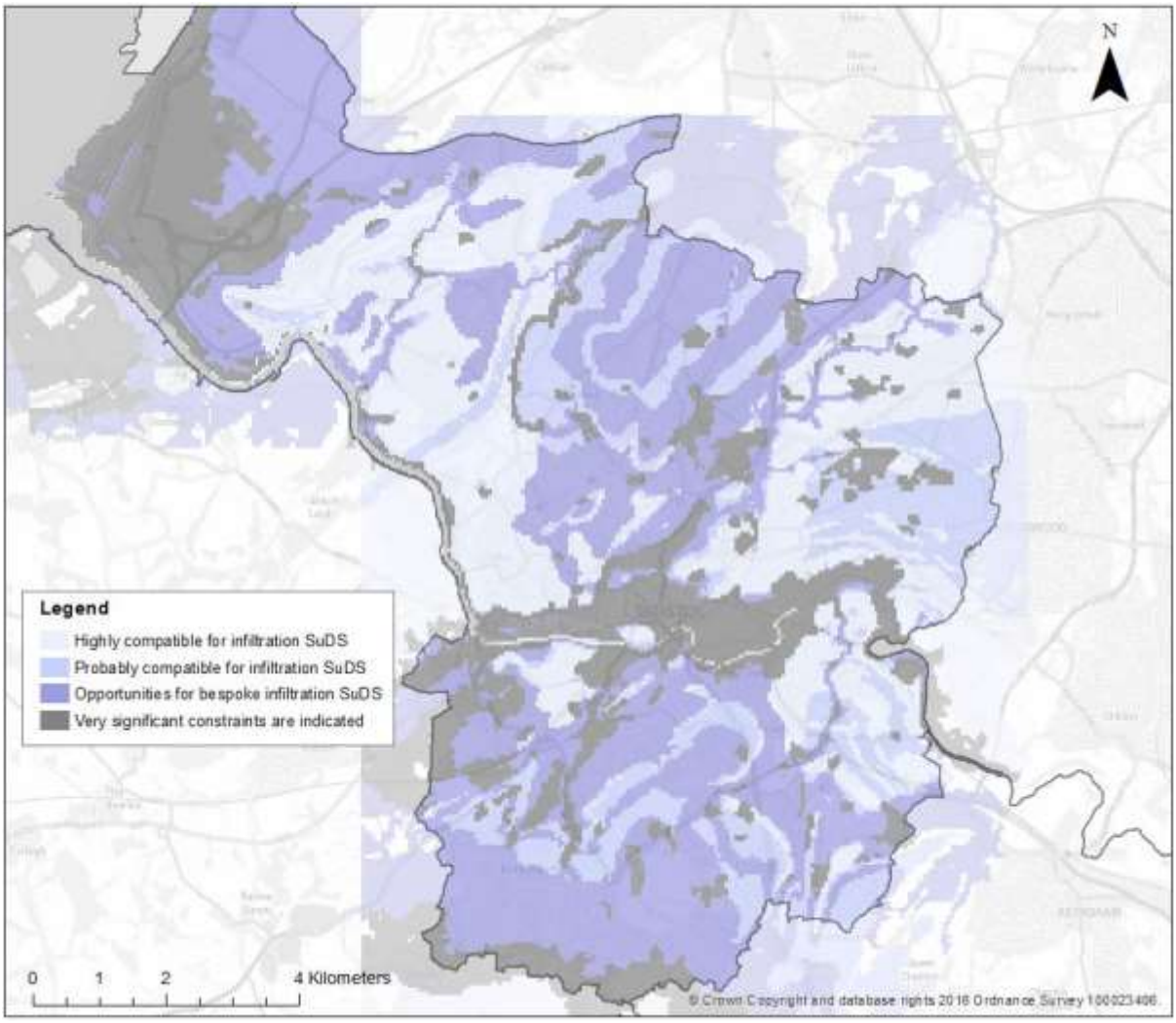

Figure 8 British Geological Society SuDS infiltration potential map

2.4 Historic flooding incidents

Please note the detail of older flood records is very limited and so therefore lacks certainty. Table 1 below summarises the flooding experienced in Bristol according to available historic records.

Table 1 Historic flood records for Bristol

Year	Flood event description
1607	Tidal storm surge coinciding with significant rainfall in the Severn Estuary passing through the Bristol Channel causing flood depths up to 3.5m.
1703	St Stephens Church recorded a flood depth 1.8m, presumed tidal flooding.
1809	Old King Street (now Merchants Street), Broadmead flood depth 1.8m, presumed tidal flooding.
1882	Stapleton Road recorded flood depth 1.2 – 2.4m. Estimated 1715 properties flooded from fluvial sources on the River Frome.
1889	Bedminster and St Agnes areas recorded flood depths between 1.5 – 1.8m from fluvial sources on the River Malago and Pigeonhouse Stream.
1896	A tidal flood affected the central area up to 1m depth.
1937	Ashton Gate, Sydney Street, Zetland Road, Lawrence Hill, Albert Road, Silver Street, Black Swan (PH) flood depths from 1.2 – 1.5m surface water flooding from heavy rainfall.
1960	Eastville Bristol Rovers' former football ground flood depth 2m surface water flooding from heavy rainfall.
1965	10 reported incidents of flooding around Stapleton from the River Frome.
1968	The 'Great Flood'. Pluvial flooding in Ashton, Bedminster, Brislington, St George, Westbury, Stapleton, Hartcliffe and Withywood. Approximately 3000 properties flooded.
1979	Surface water flooding following 40mm of rainfall in May effected areas around Whitchurch, Knowle, Redland and Westbury-on-Trym. In December 32mm of rain in south Bristol and 28mm in the north led to 33 flooding incidents in Hartcliffe and Horfield combined.
1980s	Various pluvial flooding incidents throughout the city in the North and West in particular.
1981	Storm surge of 1.6m causing tidal flooding, Station Road and Nibley Road, Shirehampton effected.
1982	Reports of numerous pluvial flooding incidents in Bishopsworth in March and 18mm in August causing flooding throughout the city.
1984	City wide surface water flooding experienced following a deluge of 86mm of rainfall.
1995	Pluvial flooding experienced throughout the city 73 properties flooded.
1999	Several smaller scale flood incidents recorded due to rainfall.
2000	Some properties near Stapleton Road and the Merchants Arms (PH) in Eastville flooded from the River Frome.
2012	Pluvial flooding of around 25 properties was experienced citywide following bouts of heavy rainfall in November. This was during the wettest year on UK records and the high groundwater levels contributed in causing increased runoff from Greenfield land. Those areas particularly badly effected included Highridge, Henbury, Brentry, Southmead, Bishopsworth and Hengrove. See Plate 1 below.
2014	A tidal storm surge causing flooding of low spots along the River Avon. See Plate 2 below.

Year	Flood event description
2016	Summertime thunderstorms resulted in flooding at Redland, Clifton and Cotham. Autumn leaf fall combined with heavy rainfall from Storm Angus resulting in blockages and flooding problems, particularly at Whitchurch Lane.
2018	New Year tidal flooding experienced in Bedminster due to blockage of a tide flap. Summer thunderstorms caused flooding in south Bristol. In November, rainfall and blockages of drainage infrastructure caused subsequent pluvial flooding at Cheltenham Road and a FWMA (2010) Section 19 Flood Investigation to be undertaken.
2020	In March 2020, tidal flooding led to one property being flooded internally at Sea Mills and significant flood depths under the Clifton Suspension Bridge, at Junction Lock and at Cattle Market Road.

Plate 1 Surface water flooding in Southmead in 2012

Plate 2 Tidal flooding at Cumberland Basin from the River Avon (looking downstream) in 2014

2.5 Supporting flood risk studies and evidence

The following flood risk studies have been conducted to gain a greater understanding of the flood risk posed in Bristol from various sources and for the reasons specified. Flood modelling to inform the project objectives has enhanced the understanding of the level of flood risk and flood mechanisms in these respective areas.

Central Area Flood Risk Assessment

The Central Area Flood Risk Assessment (CAFRA) conducted by BCC in partnership with the EA analysed combinations of varying magnitudes of tidal levels and river flows to establish the most significant risk of flooding posed to the Bristol central area. It concluded that the threat from a large tidal event was generally more of a concern than that from high fluvial flows or a combination of medium tidal and fluvial events occurring at the same time. The CAFRA model formed the basis for all subsequent modelling in the city centre, including this SFRA and as such the SFRA model will supersede the CAFRA model. *Therefore the SFRA modelling is deemed to be the best available information on tidal and fluvial flooding in the city centre.*

Avonmouth Severnside Enterprise Area (ASEA) Ecology Mitigation and Flood Defence Project

This ASEA Ecology Mitigation and Flood Defence Project is being run in partnership between SGC, BCC and the EA and focuses on managing the risk of flooding, inclusive climate change, to support growth of the ASEA and to protect existing communities in the area. The project is focussing on managing tidal risk of flooding to the area through the raising and improving of tidal flood defences along the coast. It will also entail some land raising of key development sites to manage residual tidal flood risk and fluvial flood risk. Given the scheme is currently in contract for construction (at the time of writing), this SFRA assumes the proposed defences are in place, which is reflected in the Level 2 SFRA and its associated modelling. *Therefore the ASEA Ecology Mitigation and Flood Defence project modelling is deemed to be the best available information on tidal flooding in Avonmouth to 2098.*

Ex-Critical Ordinary Watercourses (ex-COWs)

The EA have modelled various ex-COWs in Bristol which provides more up to date fluvial flood risk information about these watercourses. The ex-COWs included in the modelling are the Cranbrook, Coombe Brook, Conham Vale Stream, Fishponds Brook, River Trym, Horfield Brook and Boiling Wells Stream. *Therefore the ex-COWs modelling is deemed to be the best available information on fluvial flooding for the above watercourses*. Further information and flood modelling reporting is available upon request by contacting the EA Customers & Engagement team via: WessexEnquiries@environment-agency.gov.uk.

Surface Water Management Plan (2018)

The Surface Water Management Plan (SWMP) was conducted by BCC in partnership with WW. This study utilised a computer model to simulate rainfall events over the entire city. The model was a 1D/2D integrated model and therefore included an interpretation of the ground surface and incorporated some of the underground surface water sewer network. Different rainfall scenarios were applied to identify areas at higher risk, which are those at potential high risk of surface/sewer (pluvial) water flooding. The key outputs and predicted pluvial flood extents derived from this are displayed in the surface water flood risk maps. The SWMP modelling results will also inform the EA's surface water flood maps on their long term flood risk information. Areas at higher risk identified from the SWMP include Ashton, Southmead, Hengrove and St George. *The SWMP modelling is deemed by this SFRA as the best available information to determine surface water and sewer flood risk in the city.*

The SWMP assumes a clean and functioning sewer and highway drainage system, so blockages or associated problems that can exacerbate the flooding are not modelled.

2.6 Fluvial flood risk

Despite the various flood relief assets described in section 2.2, there is still an element of risk from high river flows though that is still prevalent in many riverside areas throughout the city, as is shown in the SFRA fluvial flood mapping. The areas at highest potential risk from fluvial flooding are at Ashton, Bedminster, St Philips Marsh and on the Brislington Brook and River Frome. The catchments of these watercourses, as well as the River Trym and Conham Vale Stream discharge into the tidal River Avon. Therefore, as explained in the following section, the impacts of tidal ingress on the River Avon can have significant effects on areas adjacent to the river itself and its tributaries.

The various catchments can be significantly influenced by trash screen blockages, as well as tide locking from the tidal River Avon. Blockages of trash screens are major contributing factors towards the heightened risk in the lower reaches of these river catchments. The potential impact of debris blockages has been analysed in the

CAFRA and ex-COWs studies. Areas around Bristol that have suffered flooding problems due to blockages are widespread including, St Annes, Bedminster, Cheltenham Road and Whitchurch Lane highlighting the importance of quantifying the residual risk also. *Developments taking place downstream or upstream of vulnerable flood risk assets should consider the potential impacts of blockages. The Bristol Flood Risk Asset Register (*FRAR*) has further location details for such assets. Blockage information is available for the Bristol ex-COWs model through the EA Customers & Engagement Team available via: wessexenquiries@environment-agency.gov.uk.*

Different rivers around the city respond and react to rainfall in varying capacities. The Rivers Frome and Avon react slower through baseflow from prolonged rainfall in the wider catchment. All of the other watercourses in the city react very quickly and respond to rainfall landing on the immediate surrounds more rapidly. Lower sections of the rivers in Bristol can be tide-locked by the Severn Estuary influences of the tidal River Avon. Understanding this is of particular importance in surface water drainage assessments, where sites propose to discharge surface water to a watercourse, and flood emergency plans for new developments and should be considered in site specific FRAs.

There are two specific catchment areas within Bristol that are at higher risk from rapid response flooding following extreme rainfall events, the Brislington Brook and the River Trym. The nature of the Brislington Brook rapid response catchment reflects the steep terrain, underlying geology and predominant impermeable cover within this area. Due to the high inflow from surrounding areas this watercourse reacts fast and river levels rise quickly. The River Trym at Westbury-on-Trym has similar characteristics to the Brislington Brook. These watercourses are included in Section 4.2 for Flood Warning Areas. Areas susceptible to extreme flash flooding are usually very limited on time in order to respond quickly enough to issue Flood Warnings.

2.7 Tidal flood risk

The 14m tidal range of the Severn Estuary poses a significant tidal flood risk throughout the BCC area. The SFRA modelling shows that in addition to direct tidal flooding, the fluvial and tidal interactions on the River Avon and its tributaries pose a significant potential flood risk to the central area of Bristol and those low lying areas adjacent to the watercourse. In the current climate the transition from fluvial to tidal dominance occurs around Netham Weir for all return periods tested except for the 1000yr where the transition point is approximately 500m downstream of Netham Weir. For future climates, the transition point moves 1 to 2km downstream of Netham Weir. The flood modelling undertaken in the CAFRA indicates that tide locking during extreme high tides results in potentially more significant flood extents

than freely discharging high fluvial flows on the Longmoor Brook, Colliter's Brook and lower River Malago.

Due to the nature of the tidal Avon, tidal flood events have a fluvial component within them, and vice versa, thus flood events have a joint probability of these flooding sources combined. Table 2 below provides a breakdown of the various joint probability conditions that constitute different annual chance events. As a tidal watercourse the River Avon always has elements of tidal and fluvial affects to varying degrees. Those combined factors in variations shown below have been deemed appropriate for determining the corresponding magnitude of flood event.

Table 2 Joint probability tidal river flood events on the Bristol Avon

Annual Chance (AC) flood event	Tidal AC component	Fluvial AC component
1 in 20 fluvial dominant	Mean High Water Spring (MHWS)	20
1 in 100 fluvial	1	100
1 in 200 tidal dominant	200	2
1 in 1000 fluvial dominant	12	1000
1 in 1000 tidal dominant	1000	12

The tide-locking phenomenon is also apparent in Avonmouth and the rhine network where the outfalls are influenced by the tides, due to the network's low topographic level, locality and proximity adjacent to the Severn Estuary. The flood modelling undertaken for the ASEA Ecology Mitigation and Flood Defence project suggests the rhine system is sufficient to cope with the tide-locking of these outfalls.

It is recognised from historical events, recent studies and flood investigations that the greatest risk of flooding in central Bristol downstream of Netham weir occurs when a high spring tide coincides with a substantial storm surge component due to the concurrent weather systems. Upstream of Netham Weir, and in River Avon tributaries, fluvial dominant flood events are deemed to generate the most significant flood extents.

2.8 Functional floodplain

The Functional Floodplain is the land or areas where water has to flow or be stored in times of flooding. This SFRA defines the Functional Floodplain as the extent generated during a 1 in 20 annual chance fluvial flood event combined with a Mean High Water Spring (MHWS) tide. The aforementioned event reflects the most realistic flooding combination given the nature and flood mechanisms of the River Avon catchment. In certain parts of Bristol that are already developed upon, existing buildings would prevent the flow or storage of flood water on these areas. Therefore they are not defined as Flood Zone 3b (FZ3b), despite flood modelling initially

suggesting so. Areas of the city that are designated as FZ3b are indicated in the functional floodplain mapping including sections of the following areas:

- Longmoor Brook and Colliter's Brook at Ashton Vale;
- Boiling Wells Stream at Mina Road Park;
- Boiling Wells Stream and Watercress Stream at Boiling Wells;
- Brislington Brook at Nightingale Valley;
- River Avon at Eastwood Farm Open Space;
- River Trym at Sea Mills;
- River Frome at Napier Road, Glenfrome Road and Eastville Park;
- Hallen rhine network at Hallen Marsh 1;
- Hallen rhine network at Hallen Marsh 2;
- Newland rhine drainage network at Lawrence Weston 1; and
- Newland rhine drainage network at Lawrence Weston 2.

Development must be avoided within the areas mapped as FZ3b. At Avonmouth, Hallen Marsh Wetland Habitat area is an exception as it is also identified as FZ3b but is intended to be allocated for development in order to direct more water onto the proposed wetland area lying adjacent to here. The majority of the marsh will be retained as a wetland at Hallen Marsh though. Where this lies is highlighted in the ASEA planning application (BCC reference: 18/02847/FB) Area 4 ecological mitigation design unit plan (see accompanying Functional Floodplain 3b & wetland habitat area map also). Further consideration is given to this in the Bristol Level 2 SFRA (2020).

2.9 Ordinary Watercourse flood risk

A number of smaller rivers, streams and ditches, known as Ordinary Watercourses (OWs) present a risk of flooding, they are identified as watercourses in the Bristol FRAR and BCC are the RMA. These minor watercourses that are not designated as Main Rivers fall under the jurisdiction of the LLFA. Many of the OWs in Bristol can often respond quickly to rainfall events and the extent of flooding that they may cause is relatively unknown. Susceptibility to this type of flooding is known at the base of the Dundry Hills in south Bristol and around Henbury in the north of the city. OWs can be difficult to model on a strategic scale due to their size and scale. Modelling difficulty, the flashy nature of OWs in Bristol and the direct rainfall interaction means that surface water mapping in the SWMP can be the most effective way estimating the risk from OWs. *Therefore this SFRA determines the SWMP is the best available information for assessing the flood risk to developments potentially affected by these watercourses*.

2.10 Surface water (pluvial) and sewer flood risk

This section seeks to identify areas that are at risk from surface water/pluvial flooding, that are susceptible to flood during heavy rainfall events from short intense storms and those areas that have known drainage issues. This source of flooding is fairly sporadic and localised in nature, although some notably larger accumulations (areas at higher risk) of pluvial flooding have been identified. The heavily urbanised, or often clay composite soil and hilly terrain of the city are factors that contribute to this risk. Surface water runoff occurs generally more rapidly on such typically impermeable surface cover. Intense localised rainfall causes surface water run off to such an extent that drainage systems are unable to cope. The risk of surface water flooding increases when catchments are particularly dry, saturated, frozen or have large impermeable areas, and are unable to absorb excess water. Flooding can occur very rapidly and often without warning. The most significant risk is from intense rather than prolonged rainfall. The risk has been quantified on a strategic scale by our SWMP. Ashton, Southmead, Hengrove and St George are areas shown to be more susceptible to pluvial flooding according to the SWMP.

Low lying basement flats have often suffered from this type of flooding. This has been seen at various locations throughout the city but notably at higher elevations (e.g. in Redland and Clifton), demonstrating the localised nature of this type of flooding.

It has also been seen the flooding problems that occur following periods of prolonged rainfall, as was noted in 2012 when the UK experienced its wettest year on record. Areas adjacent to Greenfield land suffered due to unusually high ground water levels. The saturated ground would only permit very limited infiltration of preceding rainfall events. Nearby flooding was a resultant consequence of the increased run off and overland flow. Henbury, Southmead and areas at the base of Dundry Hills were again shown as vulnerable to this pluvial flood risk. The risk of surface water flooding increases when catchments are already saturated and are unable to absorb excess water. In general terms, the flooding that has affected the UK in recent times has resulted from surface water events. As explained there are locations within Bristol that are at risk from or have experienced this type of flooding.

Rapid snow melt could also potentially pose a flooding risk from overland flow, particularly in hillier catchments like from Dundry Hills. However due to the depth ratio of snow to water a substantial amount of snow and very rapid melt would be required to cause any flooding problems. There are also no known reported historical flooding problems of this kind, to any notable scale and so this is deemed very low risk and not considered in any further detail.

Sewer flooding occurs when the capacity of a sewer is exceeded, either as a result of surcharging during extreme rainfall or flows or because of an asset failure (blockage, damage or collapse). WW is the sewerage undertaker for the wider Wessex region which includes Bristol. Much of the sewer network in Bristol contains

combined foul and storm systems, particularly in older parts of the city like Clifton and Bedminster. Combined systems can have more limited capacity than separated ones. They can also pose an additional threat during flood conditions due to the associated health risks attached to sewage contaminated flood waters.

The SWMP represents the pluvial flood risk and also reflects the sewer flood risk since major components of the sewer network are incorporated into this flood model. The national Risk of Flooding from Surface Water (RoFSW) mapping on the EA website will incorporate SWMP data from BCC.

Section 4.3 Sustainable Drainage Systems (SuDS) of this SFRA report explains the BCC policy with regard to surface water management, flood risk and drainage for developers, which reflects the above explained risk.

WW is currently developing a Drainage and wastewater management plan (DWMP) that sets out a 25 year plan for future requirements and risks that should be considered for new developments. The DWMP includes catchment plans for the sewer network serving the Bristol Avon catchment area.

Areas which historically have had a greater quantity of sewer flooding problems include some of the surrounds of the Floating Harbour, Montpellier, just south of Westbury-on-Trym and north of Hengrove. This is possibly due to constraints in the sewer network in its capacity or due to degradation.

2.11 Areas with critical drainage problems

Bristol does not contain any Critical Drainage Areas as defined, identified and notified by the EA. As an alternative the areas at higher risk of surface water flooding identified can help infer areas that may experience drainage constraints. The Avonmouth region in particular is known for its poor drainage characteristics and there are implications with this when considering any water management techniques for new development proposed for the area.

2.12 Groundwater flood risk

According to the Bristol LFRMS and records with the BCC LLFA there have been few instances of flooding from groundwater sources in Bristol. It is recognised that the data used to assess this risk to date has been broad scale but is considered to be low in comparison to the risk of flooding from other sources.

In lower lying areas in Ashton in the south-west of the city and Avonmouth in the north, groundwater can get to within 1-2m of the ground surface. Specifically in Avonmouth, BCC records indicate that high water table has caused damage to suspended timber floors and flooded a number of basements in Avonmouth Village.

Groundwater flooding has been reported at locations throughout the city but this has tended to be in isolated basements, rather than groundwater rising above the ground surface to cause flooding on a large scale. In addition, there are areas where springs can form, causing localised above ground flooding. These areas are typically in Horfield, Redland, areas around Dundry Hills and Ashton (although less so here). These tend to be isolated pockets and as such do not cause a significant risk to the city. Whilst all developments need to manage groundwater flood risk in the areas mentioned that are known to have greater risk from natural springs there is the need to ensure a more robust assessment of this source of flooding.

There is an action in the LFRMS to conduct a full FRA of groundwater flood risk in Bristol to gain greater understanding of this complex source of flooding. Once completed this SFRA document should be updated to reflect the findings and outcomes. Figure 8 can give an indication as to where there may be greater likelihood of groundwater flooding issues where British Geological Society data suggests infiltration potential is more limited.

2.13 Reservoir flood risk

There are reservoir dams either in Bristol or located such that Bristol would suffer flooding if a collapse occurred. It is likely that there will be little or no warning of a reservoir breach and flooding would be almost instantaneous. Whilst the likelihood of a dam failure is low, the risk to life and damage to property in such an event is very likely to be significant. The raised reservoirs that pose a flood risk to Bristol consist of the Barrow reservoirs and Chew Valley Lake reservoir (to the south of Bristol) this risk would potentially impact the central Bristol area and surrounds. The reservoir flooding map (see Figure 10) outline the extent of this type of flooding, if a failure were to occur. North of Bristol Tubbs Bottom detention reservoir is located on the Bristol Frome, upstream of Frampton Cotterell. The reservoir is used for holding back high flows on the Bristol Frome to reduce the downstream flood risk and is included in the Flood Map for Planning/National flood risk assessment mapping as a formal flood defence. Agricultural land is flooded if this structure is exceeded. Also north of the BCC area the Cribbs Causeway Delaying Reservoir holds back run-off from this large development area. The outlets of the above mentioned reservoirs avoid Bristol, even if inadvertently, emergency drawdown of these structures is therefore not considered to present an increase in flood risk. Impounding reservoir flood risk evaluations have also not been deemed as the appropriate requirements for these types of structures.

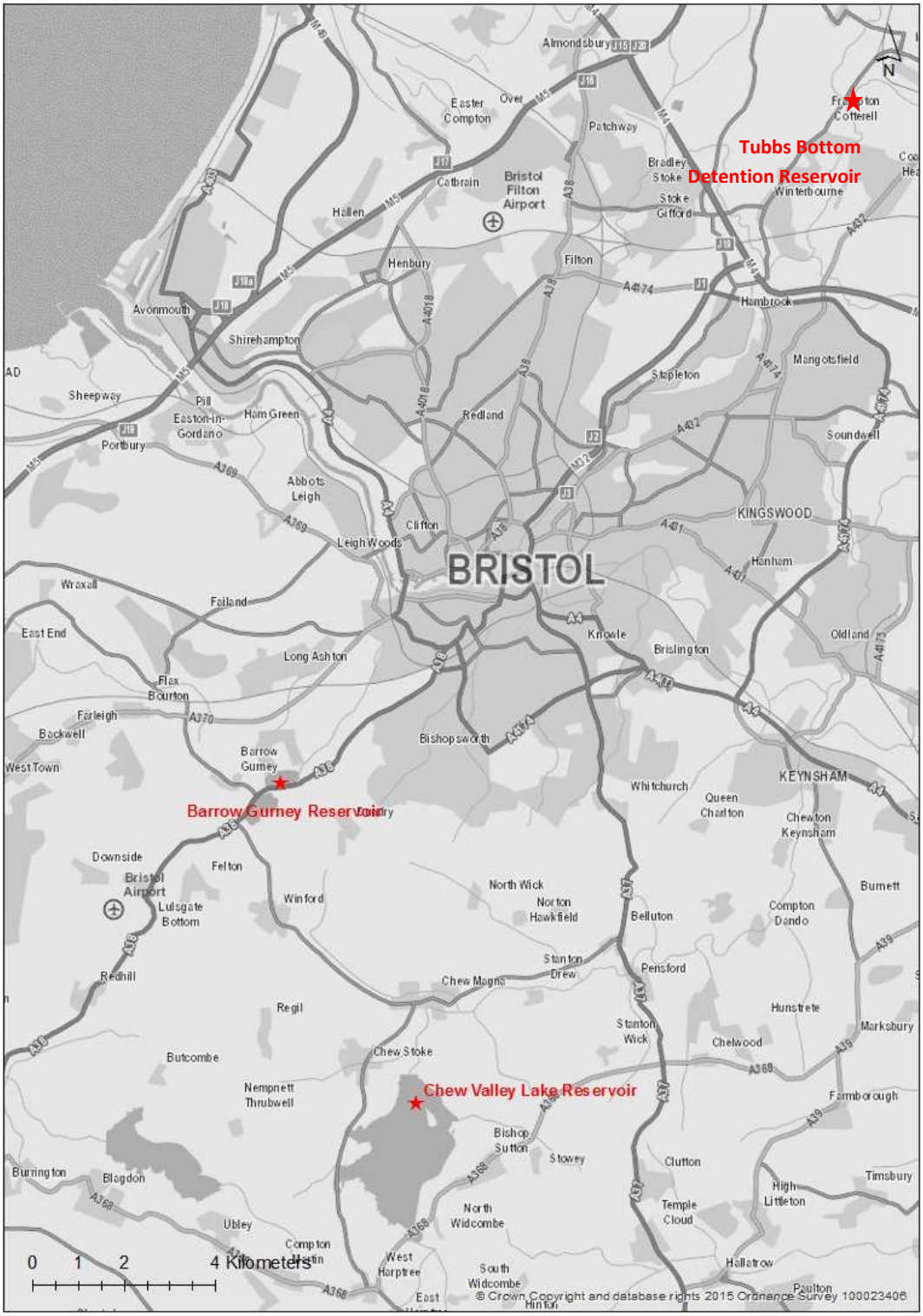

Figure 9 Reservoirs in close proximity to BCC posing a potential flood risk

Figure 10 Reservoir flood map for Bristol

2.14 Other artificial water retaining structures

The Floating Harbour is a significant body of retaining water in one of the areas of greatest flood risk in central Bristol. A complex arrangement exists with the harbour in that it has direct influence and interaction with the tidal River Avon and River Frome fluvial flows. The SFRA fluvial and tidal flood maps have taken into account the Floating Harbour operations, further details of which are available within the full CAFRA report. For planning purposes the SFRA Flood Zone modelling assumes the Harbour flood gates are open, representing a flood defence failure (inability to close the flood gates) and providing a conservative approach for the purpose of the Flood Map for Planning.

North of Henbury, on the River Trym, a railway culvert also acts as a flood retention structure holding back high flows and reducing the downstream flood risk. The Trym railway culvert and embankment are not formal flood defence structures and therefore are not designated and shown as such on the Flood Map for Planning (whereas Tubbs Bottom Reservoir is).

The NSWI diverts high river flows from the River Frome near the M32 at Junction 2. Spanning from here to the Black Rocks area, where it discharges into the River Avon, downstream of central Bristol. The NSWI represents not only an effective conveyance and diversionary channel for the river flows but also offers significant amounts of water storage potential. Its operation through the opening of sluice gates and a system of penstocks and flaps at Eastville Sluices enables the function of conveying high volumes during increased flows in the Frome. The NSWI also takes flows from the Horfield Brook, Cranbrook, and Boiling Wells Stream.

In the Flood Map for Planning, the flood modelling has assumed that the NSWI sluice gates are shut representing a failure to open or be operated. The assumption that the operation of flood assets (where required) could be hindered has been taken as a precautionary measure for all non-passive assets in the city including Netham Lock, Junction Lock and the NSWI.

In the south of the city, the SIT and Brislington Brook interceptor tunnel also offer flood storage potential. The inflow to these assets is passive and therefore doesn't require intervention. Therefore, unlike the Harbour gates and Eastville Sluices, the SIT and Brislington Brook interceptor are represented as fully operational in the Flood Map for Planning.

2.15 Wider catchment flood assessment

This section assesses the flood risk within Bristol due to impacts from surrounding areas. Since the wider flood catchments and neighbouring authorities all drain into and flow towards Bristol the flood risk posed to surrounding areas from BCC is deemed negligible and not given further consideration with in this report. See the topographic map in Figure 11 below indicating the local topography with lighter shaded areas showing higher elevations and darker ones low points. The Bristol flood models that generate the flood maps extend into the immediate catchment, so represent cross boundary flows. Inflows pass into Bristol across the LA boundaries from the north, east and south. The River Avon also acts as a natural catchment divide from much of NSC. Therefore from a development management perspective it is important that BCC work with our colleagues in neighbouring WoE authorities to ensure downstream risk from new developments that border the county boundaries are managed appropriately.

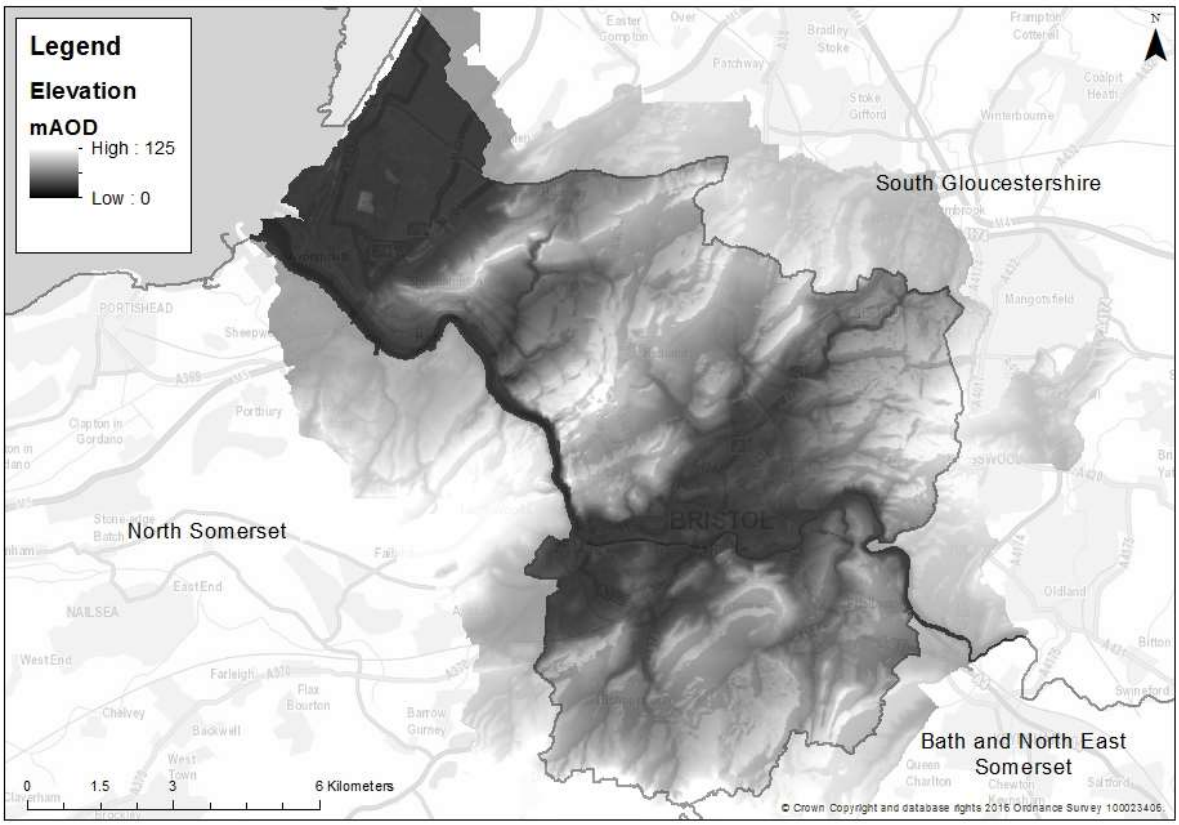

Figure 11 Topographic map of Bristol and neighbouring Local Authorities

2.16 Climate change

The predicted effects of climate change are well documented and those that directly impact on flood risk include sea level rise, increased rainfall and river flows. This consequently causes a predicted increase in flood depths, levels, durations, velocities, hazard and extents in the future. We have used the climate change parameters in NPPF in our models to assess the risk of climate change to the city from tidal, fluvial and surface water sources. The fluvial and tidal flood modelling for the central area undertaken for this SFRA was conducted in accordance with UKCP09 recommendations as the latest UKCP18 were unavailable through national policy at the time the flood models were run. This was the best available data at the time and the most up to date climate change recommendations will be used in any subsequent SFRA revisions and updated when necessary. The December 2015 climate change allowances contained in the NPPF were current and applied at the time of the model runs. The Bristol SFRA will be updated on a five yearly cycle in order to keep up to date with such crucial changes. The tidal / fluvial SFRA model is approved and adopted by BCC and the EA as the best available information to assess this risk in the central area of Bristol at the time of writing. The tidal / fluvial SFRA model results will therefore be used for both development management, data requests and as the basis for future flood and coastal risk management schemes.

When used for the aforementioned purposes model limitations most be considered, notably:

- It is a strategic scale model so it should be reviewed for its fitness for purpose for site specific modelling;
- The appropriateness of the hydrology, particularly climate change hydrology, will need to be considered by the user;
- Sea Level Rise has not been updated in line with UKCP18 and is therefore underestimating the increased tidal flood risk due to climate change. We would therefore recommend that developers run the model with latest UKCP18 uplifts or include an additional allowance of at least 300mm on top of the climate change level plus a 300mm freeboard allowance on top of this.

For the 1 in 100 annual chance fluvial event Higher Central and Upper End climate change allowance categories have been applied, corresponding to scale factors of 35% and 70%. These allowances correspond to the requirements of Table 1 of the NPPF FRA: climate change allowances. These scenarios are run in conjunction with the appropriate joint probability estimate for the downstream tidal/surge boundary.

1 in 200 annual chance tidal dominant flood events have been run over three climate epochs and the 1 in 1,000 year tidally dominated event over one, run in conjunction with the appropriate joint probability estimate for the fluvial boundaries. The three epochs are defined as the years 2020, 2080 and 2120. These tidal events were run in conjunction with the appropriate joint probability estimates for the fluvial boundaries, themselves with appropriate climate change uplifts.

The appropriate fluvial climate change allowance and tidal / surge scenarios (including the rise in sea level) are combined with the relevant epoch as outlined in the NPPF. The combinations of fluvial and tidal return periods used are detailed in the corresponding climate change flood maps. All models were run to produce peak to peak matching of fluvial and tide / surge waves. Sea level rise estimates at the time of the model runs corresponds with the figures in Table 3 below.

Table 3 Sea Level Rise in mm

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

Flood modelling at Avonmouth has taken a similar approach to the central area in that it combines a high tide element in the fluvial model up to 2098 with a +40% increase. However since tidal flooding becomes the dominant source of flooding beyond a certain point of time in the future a purely tidal inundation model is used with projections up to 2116.

The ex-COWs, purely fluvial modelling, were conducted in line with the South West River Basin District allowances of +40% and +85%, for Higher central and Upper end NPPF Allowance categories respectively up until 2080 and 2115.

Please note that there are inconsistencies between the levels of climate change applied for different watercourses throughout the city. This is since the flood mapping for Bristol is composed of flood modelling from a range of projects according to different time scales. Thus climate change allowances differ in places due to changing guidance or related to the original purpose of the modelling being conducted. Where climate change modelling was not available the existing EA Flood Zone 2 was used as the best estimate for the future case Flood Zone. The most up to date and best available data has been used throughout the city to give the best representation for the 2080 epoch, for a 60 year commercial development lifetime and the 2120 epoch, for a 100 year residential development lifetime. If however site specific modelling can be proven to be deemed more appropriate than the SFRA flood mapping then this can be contested.

Within the SWMP model, peak rainfall intensity allowances to forecast the estimated magnitude of future pluvial flood events have been run in accordance with the NPPF 2050s, 2080s and 2110s epochs with the relative rainfall and tidal (to account for tide locked systems) uplifts corresponding to Table 1 in the NPPF referenced 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. In combination with population expansion, increased rainfall puts an increased future strain on the capacity of the existing sewer network.

Additional information concerning the flood modelling conducted is available through: flood.data@bristol.gov.uk.

3.0 Managing flood risk

3.1 Main flood defences

The following section gives an explanation of flood defence assets providing a flood risk management function in Bristol. It seeks to explain their locality, function they serve, area they protect and the related level or standard of protection if available. The list is quite extensive so for specific features of interest not mentioned below the Bristol FRAR can be referred to and further details derived from BCC Flood Risk and Data Management team via: flood.data@bristol.gov.uk, or through the EA Customers & Engagement team via: WessexEnquiries@environment-agency.gov.uk. Figure 12 indicates the location of some of the key flood risk assets in the city, a brief explanation of each of them follows.

The following definitions provide clarification on the certain types of flood maps available which have inclusion of flood defences or alternatively do not include the presence of such defences:

- Flood Map for Planning: Rivers and Sea – contains several layers of information including aspects like: land at risk of flooding, areas benefiting from defences and Flood Storage Areas;
- EA Flood Zones - refer to the probability of river and sea flooding, ignoring the presence of defences. They deliberately do not include raised defences because they are intended for strategic planning purposes.
- Risk of Flooding: Rivers and Sea map (NaFRA) – takes into account the presence of defences;

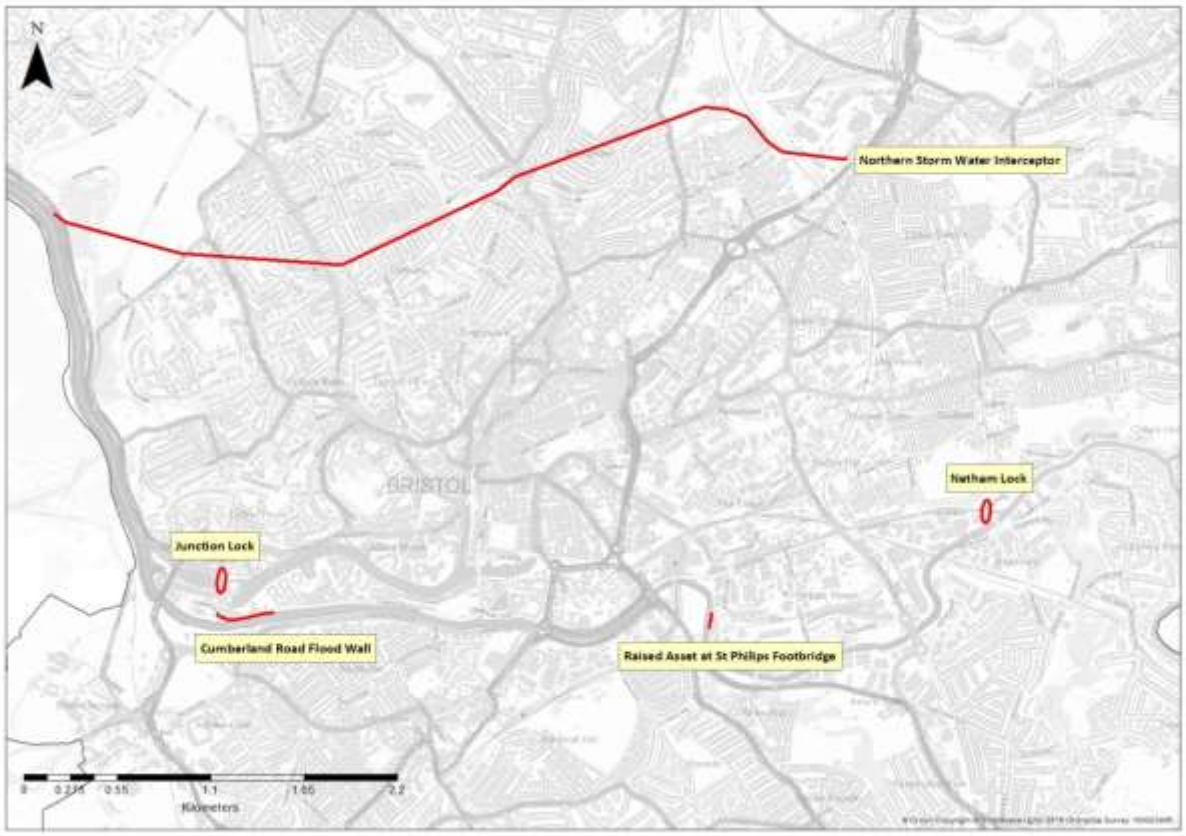

Figure 12 Critical flood risk assets in Bristol

Floating Harbour – Junction Lock flood gates

Junction Lock flood gates (see Plate 3) on the Floating Harbour have been shown through the CAFRA modelling as critical in mitigating the risk of flooding to the Bristol central area. This flood risk asset is managed by BCC Harbour Authority on behalf of the EA. Junction Lock failure as open is shown on the flood map for planning to give the most conservative picture of flooding conditions, allowing flood water to pass through the gates, opposed to if closed and preventing this. Manual operation

of these defences is possible however in the event of mechanical power failure. The flood modelling carried out as part of this SFRA considers the impact of gates being operational and also not operating to quantify the impacts of failing flood defences and inform the Flood Zone mapping. The same is applicable to the Netham Lock flood gates also. The CAFRA studies have further detailed information about the central Bristol flood defences.

Plate 3 Junction Lock flood gates

Totterdown defences

The raised asset at St Philip's footbridge incorporates an upstand wall with crest level of 9.5m AOD which steps down to the pre-existing EA flood wall adjacent to Victor Street, at the upstream end, and tapers down to ground level at the downstream end. The EA flood wall has a crest level of 9.1m AOD with the ground downstream having a varied level of approximately 9.5 – 9m AOD. The new and existing walls provide localised protection to the industrial area behind and ties in to / replaces part of pre-existing EA defences (known as the Totterdown flood defence scheme). The assets would only have a very low standard of protection. The low protection standard is due to the defence being overtopped or outflanked at both ends and more widely through the St Philips Marsh area during flood events with an annual chance of approximately 1 in 10 or greater.

Cumberland Road wall

The Cumberland Road flood defence wall (see Plate 4 below) has reduced the tidal flood risk to approximately 170 properties in and around the Floating Harbour area and most notably those at Avon Crescent. It has a crest level of 9.2m AOD, which is just under the 1 in 100 annual chance tidally dominant level. The EA Flood Map for Planning does not consider its presence but it is considered in the defended scenario of the SFRA flood mapping and in the SFRA functional flood plain mapping also. The EA will use the SFRA flood mapping to update the Risk of Flooding Rivers and Sea map which includes defences.

Plate 4 Cumberland Road flood defence wall

Northern Storm Water Interceptor

As described in section 2.2 the NSWI diverts high flows from the River Frome at the Eastville intake down towards the River Avon before they reach central Bristol, offering some protection to this area. The NSWI is only opened when necessary and therefore the default position for the sluices is shut. During high flows and when a certain pre-defined level is reached the NSWI penstock sluices are manually opened and will take most of the flow from the River Frome. The majority of the time the River Frome flows through trash screens into the M32 culvert. Should the sluices feeding into the NSWI fail an overflow system exists to make sure flows are diverted once reaching a set level. An overflow channel also exists in the NSWI in case of exceedance or tide-locking. The NSWI provides a level of flood protection to downstream areas, including Eastville, the emerging Frome Gateway regeneration area as well as the City Centre Framework area.

ASEA Flood Defences

BCC is working in partnership with SGC and the EA to deliver the ASEA Ecology Mitigation and Flood Defence Project to help promote future sustainable growth and development within the area. Once complete it will provide a 1 in 200 year SoP against a tidal flood event for the Avonmouth area. The scheme will consist of a combination of raising the height of existing flood banks and building new, higher embankments as well as concrete and steel sheet pile flood defences and flood gates. The flood defences have been designed to include an allowance for at least 60 years of climate change. The scheme will tie into the existing high ground in Shirehampton, within the vicinity of the Shirehampton Tidal Defence Scheme. Please see the ASEA Ecology Mitigation and Flood Defence Project for further information.

Bristol Flood Strategy

A Bristol Flood Strategy to assess the feasibility of options for flood protection for the central area is also underway with BCC and the EA. The Strategy's objectives include managing flood risk to the city centre until the year 2120, inclusive of the projected impacts of climate change. The strategy is required to mitigate the existing and future flood risk to the city centre, as well as the adverse impacts of future development.

The ASEA defences and the Bristol central area flood defences are given further consideration in the Bristol Level 2 SFRA (2020) report.

3.2 Flood risk reduction schemes

A number of minor flood reduction schemes have been completed across the city of Bristol designed to reduce the risk to specific properties or streets and are not strategic defences that can be relied upon for development management purposes. During completion of site-specific FRAs, the LLFA strongly recommend the use of the online flood risk management maps to identify schemes in the vicinity of their sites and contact the LLFA to establish if the scheme is likely to reduce the risk to the site. Contact also the EA Customers & Engagement Team via: wessexenquiries@environment-agency.gov.uk for EA asset data.

The following paragraphs provide an outline of some of the minor flood schemes implemented in Bristol. Please note though this is not inclusive of all works that have been undertaken in the area, specifically those on a much smaller scale. It is also worth noting that these schemes do not necessarily offer a level of SoP in line with current day planning standards. Nor does it give sufficient protection when consideration of required climate change allowances is factored in for future development.

Dundry flood alleviation scheme involved a series of measures including localised drainage ditch improvements and flood proof fencing, as indicated in Plate 5. The

aim of this was to reduce the flood risk in south Bristol and areas lying adjacent to the base of the Dundry Hills. Approximately 20 properties in the Hartcliffe, Whitchurch Park, Bishopsworth, Stockwood, and Hengrove areas benefitted from the scheme. To evaluate if a nearby development proposal could also benefit from this scheme contact BCC Flood Risk and Data Management team via: flood.data@bristol.gov.uk for further information.

Plate 5 Flood proof fencing in south Bristol

Fonthill Park attenuation basin, located in Southmead, utilises a SuDS method to hold rain water back in the park area, reducing the downstream flood risk. This flood storage basin, shown in Plate 6 below, offers up to a 1 in 75 year return period SoP to surface water flooding impacts in the surrounding area. This SuDS feature reduces the pluvial flood risk to areas such as Stanton Road.

Plate 6 Flood storage attenuation basin in Fonthill Park, Southmead

3.3 Land use changes

Increases in impermeable area coverage through new development can, without mitigation, increase water run-off and consequently increase the risk of flooding. It must be ensured there is no increased risk to third parties derived from new developments. The management or mitigation of potential increases in flood risk arising from development is the main objective of BCS16 and this SFRA.

Different types of land use are deemed appropriate in certain Flood Zones and areas at risk to flooding. The Gov.uk website, within the Flood risk and coastal change the Flood Zone and risk tables section contains Table 2: Flood risk vulnerability classification which classifies different development types and categorises them based on different vulnerability ratings. Different development types are compatible with varying degrees of flood risk. Table 3: Flood risk vulnerability and flood zone 'compatibility' should be followed in determining if a development proposal is acceptable on flood risk grounds or whether the Sequential Test or Exception Test should be applied. The SFRA maps are to be used for making the Flood Zone assessment. The intended development lifetime duration should factor in the predicted impacts of climate change on flood risk.

A typical example of where these changes to land use occur in Bristol that affects the flood risk vulnerability of the development dependent on how it has been categorised is in the case of commercial usage changing to residential. As the lifetime of a commercial development is often less than the 100 year intended design lifetime of a residential development the effects of climate change are worse when switching to this alternative use. More vulnerable uses, like for residential purposes, will have to ensure that flood risk is therefore managed over a far more extended period of time than previously.

Changes to land use and vulnerability can have an impact on FEPs. As statutory consultees to the planning process, the CPU and LLFA advise the LPA on flood evacuation and egress, following the information set out in the NPPF. The CPU and LLFA have confirmed with the LPA that for sites, regeneration areas or developments that significantly alter the vulnerability of that area (for example, changing an area dominated by industrial development to predominantly residential), the applicant will be expected to meet the NPPF Flood Risk Planning Guidance paragraphs 039, 040 and 057. Developments, sites or regeneration areas that are not significantly increasing the vulnerability of an area need only address paragraphs 040 and 057.

3.4 Cumulative impacts

Strategically planned development aimed to house future population expansion and hit housing targets will increase surface water flows if impermeable land use coverage and the associated runoff is not compensated for through adequate drainage provision. Building in flood prone areas may also have the consequence of redirecting flood waters subsequently creating a new or enhanced risk to third parties. Occupants should also not be subjected to an existing or projected future risk as shown in the SFRA climate change flood maps. Increased numbers of people in higher risk areas can put an additional strain on emergency services and affect safe access and egress. Flood modelling, either available or specially commissioned can help identify if new large scale development sites are in flood risk areas or will be in the future. This SFRA and the accompanying mapping should be the developer or strategic planner's first reference point.

Windfall development sites could increase the risk of flooding to third parties or those inhabiting the new development if site specific FRA requirements as detailed in this report for certain areas are not adhered to properly. Following the requirements set out in NPPF and this SFRA report appropriately will reduce such impacts by recognising the flood risk posed to a site to deem it appropriate or not on flood risk grounds and by making recommendation for any necessary mitigation measures.

Where permitted developments do not take flood risk and effective water management into account in the planning process this could cause an increase in the risk of flooding in new developments or in contributing surface water runoff. Localised flooding issues can occur if development layouts do not consider relative

topographic levels or exclude factoring in adequate drainage provision, such as through use of non-permeable materials used for driveways or in the paving over of gardens for instance. Although the impacts on an individual level could be minor the urban expansion and urban creep effect on the whole also has very detrimental effects, in particular with regards to flood risk. Revisions of the SFRA modelling and parameters used in the model estimates are intended to capture the current landscape cover and reflect this as accurately as possible. It should be ensured however that local and national planning guidance is readily followed to avoid such related impacts.

Significant changes in land use are already apparent in areas such as Ashton for instance where paving over of domestic gardens is a common occurrence in an area that is already subjected to significant flood risk issues. This urban creep effect increases the chance of flooding in the area due to the additional contribution to surface water runoff. The implementation of SuDS techniques would comprise part of the solution here. The combined impact of many small elements of nature based solutions and green space can have a profound impact on reducing the urban heat island effect, improving mental health and in reducing water volumes entering the urban drainage and river networks. Examples of such features that can be incorporated into new developments include; planters, swales, rain gardens, grassed verges and green roofs. Section 4.3 of this report elaborates further on ways to manage surface water flooding impacts through utilisation of SuDS.

An assessment of the impacts of new connections discharging to receiving watercourses, considering existing flow rates and post development flow rates must be made. The reasoning for this is due to the cumulative effects of multiple connections over time and ensuring the receiving water bodies have sufficient capacity to take additional flows. An evaluation of this will be made by contacting the responsible organisation dependent on where you are carrying out work on a watercourse. Follow the link to find whether permission to carry out work on or near the river, stream, flood defence or other watercourse in question is required and which RMA to contact.

The impact of cumulative development in all areas at risk of river flooding must ensure that flood risk is not worsened within that respective area and surrounds. Sites that displace fluvial floodwater will be required to mitigate these impacts and not just make an account of it. For matters concerning rivers or the sea, where this is applicable, the EA Customers & Engagement Team should be contacted at: wessexenquiries@environment-agency.gov.uk.

The displacement of flood water is a factor needing consideration for all newly proposed development sites located within any area at risk of river flooding. The ASEA flood defences scheme has taken land raising, and its potential impacts on third party land, into account for sites identified within the Enterprise Area and Economic Development Strategy. Such sites are therefore deemed to not require

further assessment of third party impacts. However, other 'windfall' sites in Avonmouth need to consider third party impacts, which may include hydraulic modelling as an evidence base. The ASEA flood modelling is available for third parties to use to test the impact of their proposals in an FRA. Early liaison with the EA would be required to clarify the requirements for managing impacts on third parties. The ASEA scheme is to facilitate development of "less vulnerable" commercial development in the enterprise area only. Minor residential development would only be supported provided a site specific FRA including flood evacuation plan can demonstrate the site meets the requirements of this SFRA and NPPF, commensurate with the lifetime of the development.

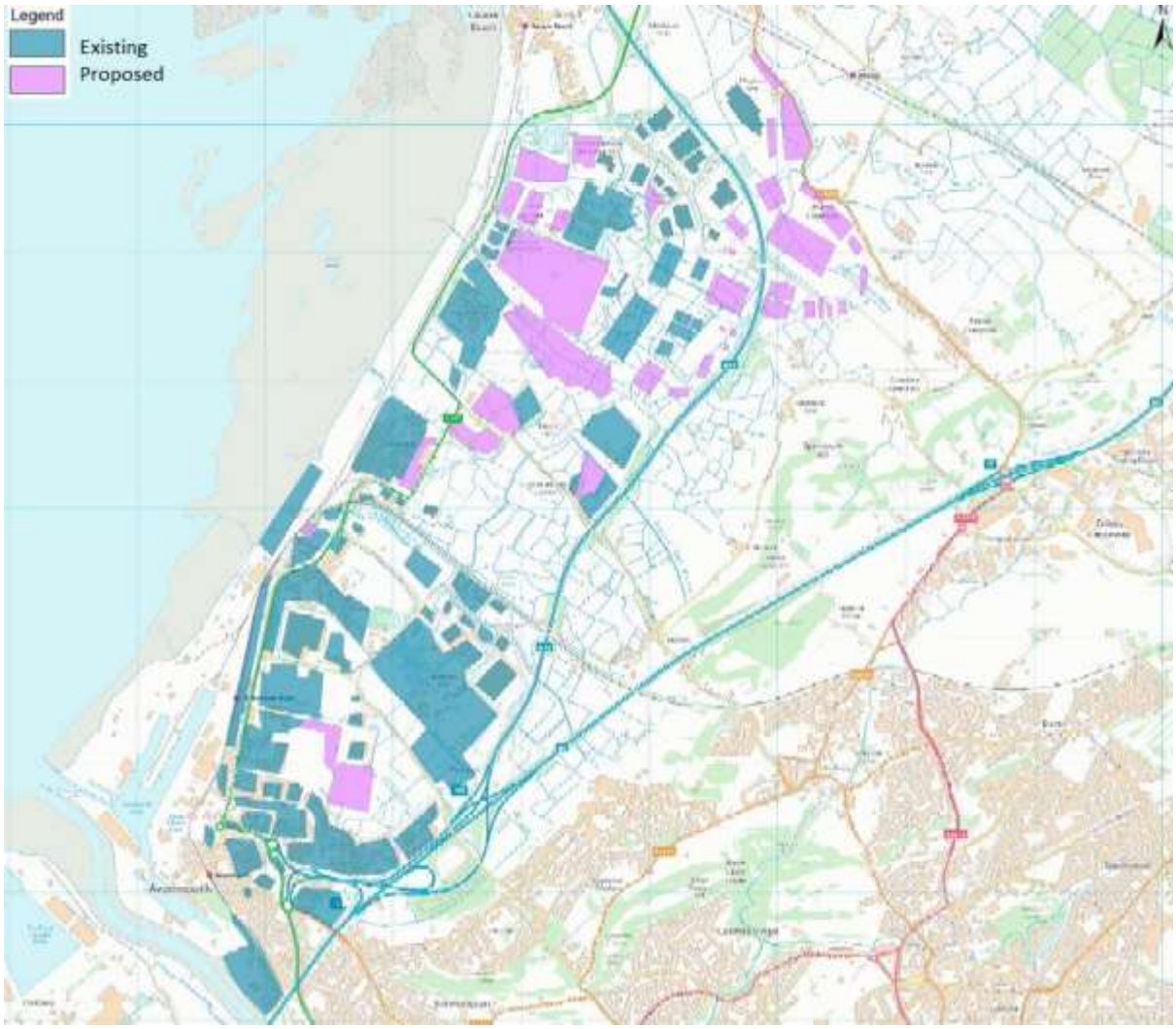

Figure 13 Areas of land raising in Avonmouth, either existing or proposed

With regards to surface water, development in or around areas at higher risk may displace the pluvial flood extents and this must be accounted for via a site specific FRA. This may be achieved by extra drainage provision accommodating additional

flood water volumes for instance or by restricting discharge rates to receiving water systems.

For central Bristol our recent studies such as CAFRA and the emerging Avon Flood Risk Management Strategy have demonstrated a funnelling effect on the flood tide of the Avon meaning land raising possibly displaces flood water elsewhere so FRAs in the centre promoting land raising or other flood resistant designs need to make an account of displacing flood water.

For assessment of flood water displacement if developing in higher risk areas or contribution areas, consultation with the applicable RMA is pertinent. If relevant, following review of the SFRA mapping of your site, please start by contacting BCC FRM team via: flood.data@bristol.gov.uk to progress this further.

3.5 Opportunities to reduce causes and impacts of flooding

It is clear from the flood mapping in the SFRA that there is a need for a Bristol Flood Strategy for the central area. The Strategy aims to help protect the central area against the current risk of flooding and projected future impacts of climate change and sea level rise on stretches of the tidal River Avon. To ensure the longevity and in particular to sustain growth and maintain the livelihood of the main central business hub of the city a means of protecting this area from future tidal and fluvial flood risk on this key watercourse and main river is vital. Key regeneration plans that could benefit from such flood defences include Western Harbour, Temple Quarter and Frome Gateway. As noted previously, this SFRA has assumed the Bristol Flood Strategy is not in place and as a result FRAs in the central area should also assume that no strategy has been confirmed until the strategy has been endorsed and approved with a reasonable certainty of delivery.

The flood defences proposed through the ASEA Ecology Mitigation and Flood Defence Project is another essential element to deliver future protection to tidal flooding in the Avonmouth area. Again this will be vital for sustaining future growth in the area and to protect existing business and communities. As noted previously, this SFRA and its associated modelling, assumes the ASEA defences are in place.

Implementing a varying array of SuDS techniques citywide, adapted dependent on the locality and surrounds will help reduce pluvial flood risk impacts on a cumulative basis. Surface water storage areas in areas of green space or those at low risk such as car parks will also assist and contribute towards achieving this overall benefit. The removal of surface water from combined sewers will be an additional benefit associated with applying widespread SuDS wherever possible in BCC. BCC continue to work with partners to promote schemes to reduce surface water flood risk. As mentioned earlier, unless a relevant scheme can demonstrate a standard of protection of 1 in 100 annual chance or greater, these scheme is not considered by the SFRA. FRAs within the vicinity of such schemes should assess any localised benefits from such schemes.

Large sections of watercourses are culverted in Bristol as is evident in the Bristol FRAR. De-culverting certain sections to provide open channels could be possible to provide benefits including enhanced amenity value, reduced restrictions on flow, give potentially larger capacities and flood storage areas. This would need scoping out on a site by site basis with key RMAs including BCC, the EA and WW if pursued.

The Bristol Local Flood Risk Management Strategy outlines plans within BCC and partner organisations for managing the risk of flooding in the city that may be a useful reference point. Developments proposed in close proximity to the above areas or that are influenced by aspects in this section can seek further input from: flood.data@bristol.gov.uk to scope flood reduction opportunities in more detail.

3.6 Locations vulnerable to an increased risk of flooding from further development

Different sources of flooding affect certain areas in Bristol and this section seeks to identify what risk potential developments could be subjected to and aims to identify suitable means to mitigate the flood risk posed. It highlights some of the particular areas in the city that are more prone to and subjected to the type of flooding described. This text should be read with the corresponding flood mapping available.

Surface water

Critical Ordinary Watercourse flood risk can also be inferred from the surface water flood risk maps (SWMP), areas particularly susceptible in this respect lie at the base of Dundry Hills in south Bristol where the rapid runoff from the steep clay composition hills leads to flashy flooding from such sources.

In north Bristol the Southmead, Henbury and Brentry surface water HRAs are located downstream of the Filton area in SGC within which future development is proposed. Impacts could therefore be felt if increased surface water flows were contributed from this development. There are flood mitigations and SuDS established in FRAs to be incorporated within the development plans for the Cribbs Patchway New Neighbourhood. BCC engagement with neighbouring authorities (SGC in this case) and the EA is therefore crucial to ensure all measures are properly implemented and that additional volumes entering receiving watercourses (such as the Hazel Brook and River Trym) are regulated so that no impacts are felt in surrounding areas. The consideration of additional upstream fluvial flows contributing towards the flood risk in these localities is however advised.

Other surface water flood risk areas in Southmead could also be subjected to additional flows due to ongoing developments and wider urban expansion within this area. Again these matters need to be factored in and addressed through site specific FRAs with review of the applicable RMAs including BCC and WW. Enhanced surface water management and drainage can be critical in such areas.

Parts of Hengrove and Ashton are other localities showing an increased risk of surface water flooding where future development will require enhanced flood mitigation measures.

Recommendations:

- Site development out of higher risk areas, away from natural flow paths and out of blue corridors unless there are wider sustainability needs to locate development accordingly;
- Ensure site layouts do not interrupt the flow of water across the site;
- Utilise a designing for exceedance approach to ensure management of surface water to and from the development;
- Where the above is unavoidable, raise FFLs above the 1 in 100 annual chance design flood level, inclusive of the impacts of climate change and flood resilient construction below;
- Consideration of flood events from sources of fluvial and surface water flooding taking in to account upstream development and wider contribution areas;
- Incorporate enhanced SuDS strategies, especially accounting for downstream impacts and contribution flows towards areas at risk; and
- Consideration of tidal or fluvial impacts on relevant discharge outlets.

Tidal flooding

There is significant threat from tidal flooding to development in parts of central Bristol, Spike Island, Hotwells, St Philip's Marsh and areas neighbouring Bower Ashton.

Recommendations:

- Site development out of the tidal extent, inclusive of climate change (2080 commercial, 2120 residential) denoted in the flood mapping;
- Where the above is unavoidable raise FFLs or ground levels above the design 1 in 200 annual chance (0.5% AEP) flood level including the appropriate allowance for climate change, plus freeboard of 300mm, and flood resilient construction;
- Assess the impact on 3rd parties and mitigate if necessary.
- The effects of tide-locking must be duly considered in drainage strategies;
- Devise FEPs where required;
- Sign up to Flood Warning systems where available.

Future developments proposed for the Avonmouth area could potentially increase the risk of tidal flooding in the area unless managed appropriately. The ASEA Ecology Mitigation and Flood Defence Project will help address this through new coastal defences. The project has tested what impact ground raising of strategic

sites will have on the wider area in a new coastal inundation model. Additional specific considerations for Avonmouth follow.

Avonmouth**;**

- Consideration of groundwater flood risk, now and into the future including the projected impacts of climate change;
- No basement dwellings due to the high groundwater table;
- Basement or underground units to only be promoted with robust and appropriate mitigation proposals due to high groundwater table;
- Consideration of joint probability flood events from various combined sources of fluvial, tidal and groundwater flooding;
- Consultation with the LSIDB to agree appropriate fluvial flood plain compensation ;
- Where surface water will be discharging to the rhine network, consultation with the LSIDB to agree surface water drainage strategy; and
- Land raising impact testing (via hydraulic modelling) is to be undertaken in support of FRAs of areas outside of the Enterprise Zone (see related map in Figure 13 indicating areas of land raising in Avonmouth).

Fluvial flooding
For development sited around the watercourses described in Sections 2.2 and 2.6 fluvial flood risk could be more apparent.

Recommendations:

- Site development outside of the fluvial flood extent, inclusive of climate change (2080 commercial, 2120 residential) denoted in the fluvial flood mapping;
- If the above is unavoidable raise FFLs above the 1% AEP (1 in 100 annual chance) design flood level including an appropriate allowance for climate change, plus freeboard of 300mm, and flood resilient construction;
- Provide suitable floodplain compensation for the loss of flood storage;
- Consideration of high tide impacts on downstream discharge points to tidal waterbodies;
- Devise FEPs where required;
- Sign up to Flood Warning systems where available.

Combination flood events
The interactions of the water systems in Bristol mean that flooding will often occur due to sources of flooding combining at the same time. This is perhaps most evident around the Ashton and south central areas of Bristol, particularly around the Ashton Gate area. Precautionary flood mitigation measures to consider in FRAs for sites on land adjoining (or affected by) the tidal River Avon include:

- Consideration of joint probability flood events from various combined sources of fluvial, tidal and surface water flooding. In respect of combined fluvial/tidal flooding much of this is considered and available in the SFRA modelling. With respect to areas prone to combined tidal/pluvial flooding and its influences on flood risk, flood mitigation measures and drainage strategies the following combinations are applicable and need further consideration:
    - 1 in 30 year rainfall event in combination with a 1:2 year tide (both including climate change)
    - 1 in 2 year rainfall event in combination with a 1:200 year tide (both including climate change)
- The effects of tide-locking must be duly considered in drainage strategies. Tidal outlet levels above 8.0mAOD are advised as the forcing shut of tide flaps and consequently backing up of the system often occurs because these levels are exceeded during the higher Spring tides in the current day and will be more frequently in the future;
- For existing and new outfalls estimates of the tide-locking time duration can be obtained from the tidal curve generated at Bedminster Bridge river level tide gauge available on request from: flood.data@bristol.gov.uk;
- Where development cannot be sited outside of flooded areas raised FFLs above the 1% AEP fluvial or 0.5% AEP tidal flood events, dependent on which shows the worst predicted flooding is an essential requirement.
- Assess the impact on 3rd parties and mitigate if necessary.

In the far reaches of the downstream catchments of River Avon tributaries the effects of tide-locking on outfalls can impact drainage systems from surcharging and increase risk from joint probability tidal and fluvial combination flood events. Ashton for example is seen as having a multitude of flood risks posed to it from various sources. Future development plans are proposed here that will have to consider the complex interactions between the open channel and culverted fluvial watercourses that are also subjected to the influences of the tidal River Avon that they discharge to. As well as that surface water risk is also highlighted as at significant risk in the Ashton area.

Bedminster, like Ashton, lies adjacent to the River Avon and much of the higher catchment feeds down into this point meaning fluvial and tidal flood risk combined is at a substantial level. Potential developments are proposed to regenerate this area, which assists in passing the Sequential Test, but if passed flood mitigations identified through the Exception Test will then in turn have to be satisfied.

3.7 Land safeguarded from development required for current and future flood management

For areas designated as Flood Zone 3b in Section 2.8 and indicated as such in the FZ3b mapping, development must be avoided within these areas. As previously

stated this includes: Longmoor Brook and Colliter's Brook at Ashton Vale, Boiling Wells Stream at Mina Road Park, Boiling Wells Stream and Watercress Stream at Boiling Wells, Brislington Brook at Nightingale Valley, River Avon at Eastwood Farm Open Space, River Trym at Sea Mills and River Frome at Napier Road, Glenfrome Road and Eastville Park.

Wetland areas as part of the ASEA Ecology Mitigation and Flood Defence Project are designed to pond during winter months, with regular flooding from the nearby rhines encouraged and as such no development will be sited in the ASEA planning application Area 4 ecological mitigation design unit plan. The flood defences along the Avonmouth coastline confirmed and outlined in planning permission: 18/02847/FB (BCC reference) under the ASEA Ecology Mitigation and Flood Defence Project are also safeguarded for fulfilling their tidal flood defence purpose for now and future years.

The ongoing Bristol Flood Strategy could result in areas of the city that will require safeguarding for flood defences. Consideration will be given to the safeguarding of land once the strategy is fully developed.

The flood risk management functions performed by the flood mitigation measures and SuDS features at Dundry Hills and Fonthill Park described in section 3.2 are important aspects in managing flooding to the surrounding areas. Development that hinders their ability to operate effectively should therefore not be permitted.

4.0 Sustainable development

4.1 Advice for conducting Flood Risk Assessments

See the Flood risk assessment for planning applications guidance on the GOV.UK website for general advice. The requirement for an FRA, and the detail contained within it, will vary dependent on the type of development, its locality and its associated flood risk rating. For advice on the requirements for various types of planning applications see FRA for planning applications. For the appropriate climate change allowances to apply see FRA: climate change allowances (please note BCC is located within the Severn River Basin District). Flood risk studies and assessments conducted within the BCC region that may be of use are available at: BCC Planning Evidence. Information about surface water risk and drainage is available via: Flood risk and drainage for developers. Refer to Section 3.0 of this report for area based guidance, specific land use requirements and existing or emerging flood management schemes throughout the city.

In Bristol there are requirements for an FRA to accompany development proposed within high pluvial risk areas. Local List Items 9, 17 and 18 of the BCC Planning Application Requirements Local List 1st December 2017 specify what types of planning applications require FRAs, Sustainable Drainage Strategies and how

BCS16 should be addressed. Standing advice for drainage also exists which considers flood risk and the scale of development proposed. Further detail to inform this is provided within the SuDS requirements confirmed in this SFRA (Section 4.3).

Flood risk information and online mapping for Bristol is available in the online flood risk management maps.

The SFRA tidal / fluvial model is essentially a revised version of the CAFRA model, a CAFRA summary report of which is available. To obtain EA Product four information for your site of interest which includes; in-channel and site specific flood levels and depths from rivers and the sea where available, asset data and historic flooding information, email the EA at: WessexEnquiries@environment-agency.gov.uk. For the full SFRA model contact BCC via: flood.data@bristol.gov.uk.

Flood levels derived from the SFRA modelling will be available via a webmap (currently in process of being built) or through: flood.data@bristol.gov.uk. To obtain the ASEA Ecology Mitigation and Flood Defence Project model and/or associated product 4 information email the EA at: WessexEnquiries@environment-agency.gov.uk.

For further information concerning the SWMP please contact: flood.data@bristol.gov.uk.

Planning recommendations

- Developments located in Flood Zone 2, 3 or at high surface water flood risk inclusive of climate change over its intended lifetime will require a site specific FRA (in line with NPPG and NPPF requirements);
- Development sites shown in areas benefitting from defences will require an FRA in case of defence failure;
- National and local EA standing advice should be followed and applied where relevant;
- Third party impacts must be considered and new development must be safe without increasing the risk elsewhere. This includes an analysis of what the increase in flood risk to third parties is if utilising flood resistant measures, raising ground levels;
- Raised Finished Floor Levels above the 1 in 100 annual chance fluvial and 1 in 200 annual chance tidal, inclusive of climate change, design flood level plus 300mm freeboard allowance;
- 150mm raised Finished Floor Levels in areas at high risk to surface water flooding, inclusive of climate change allowances. To ensure the development is safe over its intended lifetime;
- Flood Warning and Evacuation Plans are required for proposed developments in areas shown to be at higher risk, inclusive of climate change. The evacuation plan will need to demonstrate how the site complies with NPPF (see Section 3.3). FEP templates are available in the BCC Flood risk strategy

and responsibility for Developers FEP and for Owners FEP and these will need consultation with the BCC CPU and LLFA;

- Flood resistant construction where new development needs to take place below the 1 in 100 fluvial, 1 in 100 pluvial and 1 in 200 year tidal annual chance flood events. Flood resilient construction above this level. As according to the design flood levels indicated in the SFRA flood mapping in order to help post-flood recovery time. This must include future occupants and therefore must also include the future flood risk, inclusive of climate change predictions. FRA's should also consider including flood resistant measures too and conclude what are the most appropriate forms of flood management for the development in question;
- SuDS to serve the site designed in accordance with the SuDS Manual to reflect the BCC requirements. To make sure of no increased flood risk to third parties caused by new developments; and
- Site specific FRAs within the Avonmouth area should use the revised ASEA model for the region which factors in land raising around the area in the coastal inundation model.

4.2 Flood Warning Areas

A Flood Warning system exists in Bristol that is provided by the EA for anticipated flooding from rivers and the sea. The EA data and information is available via: WessexEnquiries@environment-agency.gov.uk. Flood Alerts are issued when flooding is possible, in attempt to give some forewarning of expected conditions. Flood Warnings are issued when flooding is expected and immediate action should be taken. Severe Flood Warnings are issued when there is a risk to life. Surface water flooding has no official Flood Warning service or facility, due in part to being extremely difficult to forecast due to the high intensity, sporadic nature of the storms that could result in flooding. Nor are there any formal flood warning services for any other sources of flooding in Bristol.

Further information regarding Flood Alerts and Flood Warning areas in Bristol is available in the Flood warnings for England. The BCC Flood Plan sets out actions and processes for responding to potential flooding, it is managed by BCC CPU and for further information please contact them via: emergency.planning@bristol.gov.uk. The CPU initiates the Flood Plan, in line with certain Flood Warning levels, to respond to potential flood events once activation trigger levels have been reached to orchestrate an organisational response in combination with other key RMAs and services. The Flood Plan identifies specific actions, communication needs, planned recovery processes and links to other emergency plans and multi-agency response plans that could be enacted. A range of Actions could be carried that could include (but are not limited to): recording, investigating flood incidents, clearing gully blockages, placing road diversions, providing notification through networks, deploying flood barriers, lowering Floating Harbour levels, conducting emergency

traffic management procedures, maintaining critical services, opening emergency rest centres and places of safety and coordinate waste management processes in flood recovery clear up. The CPU is also the responsible body within the BCC LPA for reviewing FEPs for planning purposes and as such it is imperative that applicants liaise with the CPU during preparation of evacuation plans.

4.3 Sustainable Drainage Systems (SuDS)

This section provides the BCC approach to SuDS for all developments within the Bristol LPA area and supplements BSC16. It therefore will supersede the WoE SuDS Guide upon publishing of this Level 1 SFRA report. This section will be referenced by the LLFA when it reviews drainage strategies for new developments.

The planning process, informed by the SFRA evidence base, aims to steer development away from areas at higher risk of flooding but it must also ensure that there is no increased risk to third parties caused by a new development. New developments can increase flood risk through an increase in impermeable surface cover and/or misdirecting the flow of water run-off inappropriately, affecting downstream receptors. Managing the potential risk to third parties caused by new development is achievable in part through appropriate drainage solutions and adequate surface water management (as referenced in BCS16). Early engagement with the LLFA, including producing a proof of concept drainage design and utilising green infrastructure to aid the climate and ecological emergency aims is strongly advised. A range of different SuDS applications are suitable throughout the Bristol area. The British Geological Society map in Figure 8 above for example indicates the varying degrees of infiltration potential for utilising infiltrating SuDS across the city.

This SFRA deems SuDS designed in accordance with the CIRIA SuDS Manual Version 2 report (2015) as appropriate. This document will help in the SuDS feature selection criteria, determining the appropriate SuDS component dependent on the site constraints and opportunities.

In line with the four pillars of SuDS design highlighted in the SuDS Manual three of the four benefits below shall be provided in the drainage system to make the development acceptable:

- Improve water quality
- Enhance amenity value
- Increase biodiversity

There needs to be a compulsory 50% reduction on brownfield rates water quantity.

Major development

BCC, designated as the LLFA for the area have the responsibility as statutory consultee for all major development in respect of surface water management. According to the ministerial statement and national policy major developments consist of 10 dwellings or more; or equivalent non-residential or mixed development (as set out in Article 2(1) of the Town and Country Planning (Development Management Procedure) (England) Order 2010). The requirement is to ensure that SuDS for the management of run-off are put in place, unless demonstrated to be inappropriate. A fully detailed SuDS strategy is required for every major application.

Minor developments

Table confirms when to consult BCC LLFA on a planning application and therefore expects SuDS details to be included with the planning application documents.

Table 4 Bristol Standing Advice and consultation matrix

Development Type/Size	Development located in a surface water flood risk area	Development NOT located in a surface water flood risk area	Development in IDB Area
Change of Use	No advice given	No advice given	Consult IDB for all development proposals within Lower Severn IDB area. Consultation with LLFA not required
Increase of impermeable area to a single dwelling or single plot of residential land LESS THAN 25m²	No advice given	No advice given	
Increase of impermeable area to a single dwelling or single plot of residential land GREATER THAN 25m²	Follow Standing Advice	Follow Standing Advice	
Development of 1 new dwelling	Follow Standing Advice	Follow Standing Advice	
Development of 2-4 new dwellings	Consult LLFA	Follow Standing Advice	
Development of 5-9 new dwellings	Consult LLFA	Consult LLFA	
Commercial development where the increase in impermeable area is LESS THAN 250m²	Follow Standing Advice	Follow Standing Advice	
Commercial development where the increase in impermeable area is GREATER THAN 250m²	Consult LLFA	Follow Standing Advice	
All Major Developments	Consult LLFA	Consult LLFA	Consult LLFA & IDB

If after applying the SuDS hierarchy non-infiltrating SuDS are not feasible the following method is appropriate. A discharge rate of five litres per second per site will be suitable for minor developments if accompanied with 25 litres of storage per square metre also. Table 6 shows these parameters. This will be deemed acceptable by the LLFA and save completing a full detailed drainage strategy for smaller sites.

Table 5 Minor development drainage requirements summary

Development size	Discharge rate	Storage requirement
1-9 dwellings or 1000m^2 floor space	5l/s	25l per m^2

Outlet connections

Any discharge outlets will need approval from the relevant governing body, such as WW for sewer connections, the EA for main river connections, BCC for ordinary watercourse connections and the LSIDB for connections to the Avonmouth Rhine Network. Advice on the appropriate organisation to contact, dependent on the type of watercourse consent required, can be found on the Carrying out work on a watercourse section of the BCC website.

Adoption and maintenance

The following adoption options for SuDS features are potentially available, dependent on the type of SuDS feature and what it is draining. There are conditions of the SuDS specification that will need to be confirmed according to the adoptable body's requirements. The list below sets out whom to contact for differing SuDS features.

BCC will adopt green-infrastructure based SuDS serving the highway, such as, but not limited to, swales or bio retention features, subject to technical details and appropriate commuted sum for maintenance being agreed. This can include highway drainage features that are allowed on to private land. If applicable contact for enquiries: highways.traffic@bristol.gov.uk or flood.data@bristol.gov.uk. BCC will not adopt permeable paving on adopted highways.

For SuDS in parks areas and on public open space contact: flood.data@bristol.gov.uk.

The recently revised Sewers for Adoption 8 will mean more SuDS will potentially be adoptable by WW as the sewerage undertaker for the region. Please see the Sewers for Adoption report for further guidance but please note this is still in the process of implementation. Contact: development.north@wessexwater.co.uk.

Where the above are not feasible, for SuDS serving private developments management companies can offer the SuDS maintenance service.

4.4 Site Allocations

BCC SCP team undertake a GIS analysis of the SFRA flood maps contained within this suite of documents in order to inform the site allocations process. For development sites that have been allocated in the Bristol Local Plan please see the Site Allocations and Development Management Policies Annex: Site Allocations Information. See also the associated Site Allocations and Development Management Policies Map. The Bristol Central Area Plan also has sites allocated within it, with the corresponding Bristol Central Area Policies Map and the Local Plan Review will be proposing new sites. The basis of allocating development at the locations has considered the flood risk posed to these respective areas from all sources of flooding and so these sites are deemed as having passed the Sequential Test. Where a certain level of flood risk still exists however, that is not quite yet up to an acceptable standard, the Exception Test will have to be applied. This is to ensure a new development and its surrounding area is safe from flooding, without increasing flood risk elsewhere, over its intended lifetime. Advice for flood risk requirements on specific site allocations is indicated in the above linked documentation.

5.0 Monitoring and review

This Level 1 SFRA and the BCC Level 2 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. Those aspects that would constitute the requirement for review and revision of the document include 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 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.

6.0 Summary and recommendations

This SFRA provides key information on flood risk within the city of Bristol. The accompanying SFRA maps can be used to identify the risk posed to a specific potential development site in any area 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.

For areas identified as subjected to a greater risk that fall outside the scope of the Level 1 report please refer to the Level 2 report.

7.0 SFRA mapping data

The following flood maps are available to fulfil the purposes described in this SFRA document. The majority of these maps are not contained within this document and can be found in a separate related section. Further explanation or additional information pertaining to the flood mapping in Table below can be obtained from BCC FRM team via: flood.data@bristol.gov.uk.

Table 6 SFRA mapping data sources

SFRA Map	Data source
Local Planning Authority boundary map	BCC contactable via: flood.data@bristol.gov.uk
Bristol Main rivers	Download the Main River line from https://data.gov.uk/
Other rivers, streams or significant bodies of water	Contact relevant Bristol RMA as applicable Download the detailed river network from https://data.gov.uk/
Avonmouth Rhine network	LSIDB contactable via: admin@lowersevernidb.org.uk Download the detailed river network from https://data.gov.uk/
Wider catchment map	BCC LiDAR topography: contactable via: flood.data@bristol.gov.uk Download LiDAR from https://data.gov.uk/
Historic flood outlines	Contact relevant Bristol RMA as applicable Download Environment Agency recorded flood outlines from https://data.gov.uk/
EA Flood Zones	Download Flood Zones 2 and 3 from https://data.gov.uk/
eX-COWs	EA Customers & Engagement Team available via: wessexenquiries@environment-agency.gov.uk
Functional floodplain maps	BCC contactable via: flood.data@bristol.gov.uk

SFRA Map	Data source
Surface water flood maps	BCC contactable via: flood.data@bristol.gov.uk Download Risk of Flooding from Surface Water mapping from https://data.gov.uk/
Fluvial, tidal and pluvial climate change maps	BCC contactable via: flood.data@bristol.gov.uk
Sewer flood incidents	WW contactable via: development.north@wessexwater.co.uk
Reservoir flood maps	Download the Risk of Flooding from Reservoir mapping from https://data.gov.uk/
Depth, duration (flood extent at time), level, velocity and hazard for fluvial, tidal and pluvial	BCC contactable via: flood.data@bristol.gov.uk EA Customers & Engagement Team available via: wessexenquiries@environment-agency.gov.uk
Areas benefitting from defence	Download from https://data.gov.uk/
Infiltration potential for SuDS	See BGS data
Bristol site allocations	BCC contactable via: blp@bristol.gov.uk
Bristol flood defences	BCC contactable via: flood.data@bristol.gov.uk EA Customers & Engagement Team available via: wessexenquiries@environment-agency.gov.uk
Flood defence failure mapping breach, overtopping and blockage	BCC contactable via: flood.data@bristol.gov.uk EA Customers & Engagement Team available via: wessexenquiries@environment-agency.gov.uk
Flood Warning areas	EA Customers & Engagement Team available via: wessexenquiries@environment-agency.gov.uk
Critical infrastructure mapping	See National Receptor Database
Groundwater flooding	BCC records available via: flood.data@bristol.gov.uk

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