

Bristol City Council
Bristol Avon Flood Strategy
Economic Appraisal Technical
Report

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1 Introduction

This report outlines the work undertaken by Ove Arup and Partners Limited (Arup) on behalf of Bristol City Council in the economic appraisal for a Strategic Outline Case for the Bristol Avon Flood Strategy.

This report sets out the options appraised, the methodology used to estimate the benefits of each option and the findings. A proportionate cost benefit analysis has been completed.

1.1 The need for the strategy

The City of Bristol is centred on the historic Floating Harbour. The Floating harbour today is the heart of the city, providing a significant leisure amenity and containing many of the city's cultural and heritage highlights, as well as its commercial centre.

The Floating Harbour is however at risk of flooding from both tidal events and high flows on the River Avon (as well as inflows from other watercourses).

The Harbour's flood 'stop' gates are vulnerable to bypassing mechanisms and failure that, regardless of investment to the gates in isolation, would mean that the Harbour remains at high risk. Studies highlight the operational risk posed to harbour water level control infrastructure from boats, cars and other potential floating debris.

Climate change is increasing sea levels, storminess and peak river flows, all of which increase the risk of flooding. In the absence of investment (the theoretical "Do Nothing" scenario), the effects of climate change would lead to write-off of many cultural and commercial assets in the area of the Floating Harbour, massively impacting on the city's tourism and financial sectors. Future flood risks are a significant consideration for planning policy now. They influence, constrain and could potentially blight development and investor confidence.

Figure 1 shows the future climate 1 in 2 annual chance flood outline: under the rules set out in the Flood Hazard Research Centre's Multicoloured Manual, all properties within this area would be assumed written off.



Figure 1: Do Nothing 1 in 2 annual chance tidal flood outline, 2045 (dark blue) and 2125 (light blue).

Bristol has significant ambitions to grow, with key areas of growth and regeneration proposed for the Western Harbour, Bristol Temple Quarter and St. Philip's Marsh areas of the city, focused on providing housing, education, and a focus on science and technology.

The transport links provided by Bristol Temple Meads station are recognised as being a key component of these ambitions, not just in the area around the quays but for the whole city. The station and connecting transport links are however subject to disruption in flood events. Proposals to develop a flood defence also provide a Partnership Opportunity for the promotion of a sustainable travel route supporting sustainable growth and active green travel.

1.2 This assessment

This assessment looks at the economic case for the strategy; the basis for selection of the preferred strategy using the FCERM "Decision Rule"; and the case for "local choice" of an alternate strategy that facilitates Bristol's greater ambitions.

This study has assessed the main source of funding attributable to flood and coastal erosion risk management, which is DEFRA Grant in Aid, payable only up to the scale of strategy identified by the Decision Rule. Grant in Aid eligible benefits, which are predominantly attributable to the reduction of flood risk, reflect economic impacts on the nation (as opposed to benefits to the local region). The quantum of DEFRA Grant in Aid that may be available to the strategy is calculated using the Partnership Funding Calculator (PFC). The PFC provides different rates of payment for different kinds of outcomes, and higher payment rates are provided for moving residential properties out of high flood risk into lower risk, as well as for reductions in flood damages that affect people on a personal level.

The assessment has also analysed local benefits, reflecting the financial impacts on the City of Bristol of addressing flood risk. This may form the basis of bids to alternate sources of funding, further supporting the development of the strategy.

The following two sections set out the approach to the analysis of both these measures of benefit.

2 Grant in Aid eligible benefits

Floods' devastating economic costs to the nation stem from direct physical damage to property contents and fabric, indirect impacts on critical transport, communications, utilities or other essential services. The social impacts of flooding are widespread, interconnected and may be long-lasting; these intangible impacts are both direct and indirect.

Economic losses from the predicted flood risk have been estimated using the Flood Hazard Research Centre's Multi Coloured Manual (MCM) methodology¹. The following direct sources of damages have been estimated:

- Damages to residential and non-residential properties (including heritage properties)
- Emergency Services
- Utilities damages
- Indirect commercial impacts due to flooding to businesses
- Costs of evacuation
- Vehicle damages
- Risks to Life
- Mental health
- Rail disruption
- Traffic disruption
- Intangible Benefits

The avoidance of damage from flooding to residential and non-residential property fabric and contents is the principal benefit for the purposes of the economic assessment.

Predicted flood depths are estimated from the average ground level at each property, the modelled flood water level and an allowance for the property threshold height. MCM depth damage curves were used to derive property damages, based on hydraulic modelling of water level predictions for the modelled scenarios of the project phases.

2.1 Benefit areas

The study area was sub-divided into benefit areas to facilitate a more detailed breakdown of the results and data input parameters. Each of these benefit areas corresponds to a key area within the city region at risk of flooding. See Figure 2.

The benefit areas do not correspond to flood cells as such, which are technically hydraulic independent, but provide the necessary detail to be able to report (coarsely) on individual communities, reaches between key restrictive structures (eg between Netham weir and , and individual flood mechanisms (eg the River Frome).

¹ Flood and Coastal Erosion Risk Management: A Manual for Economic Appraisal, 2013 Flood Hazard Research Centre

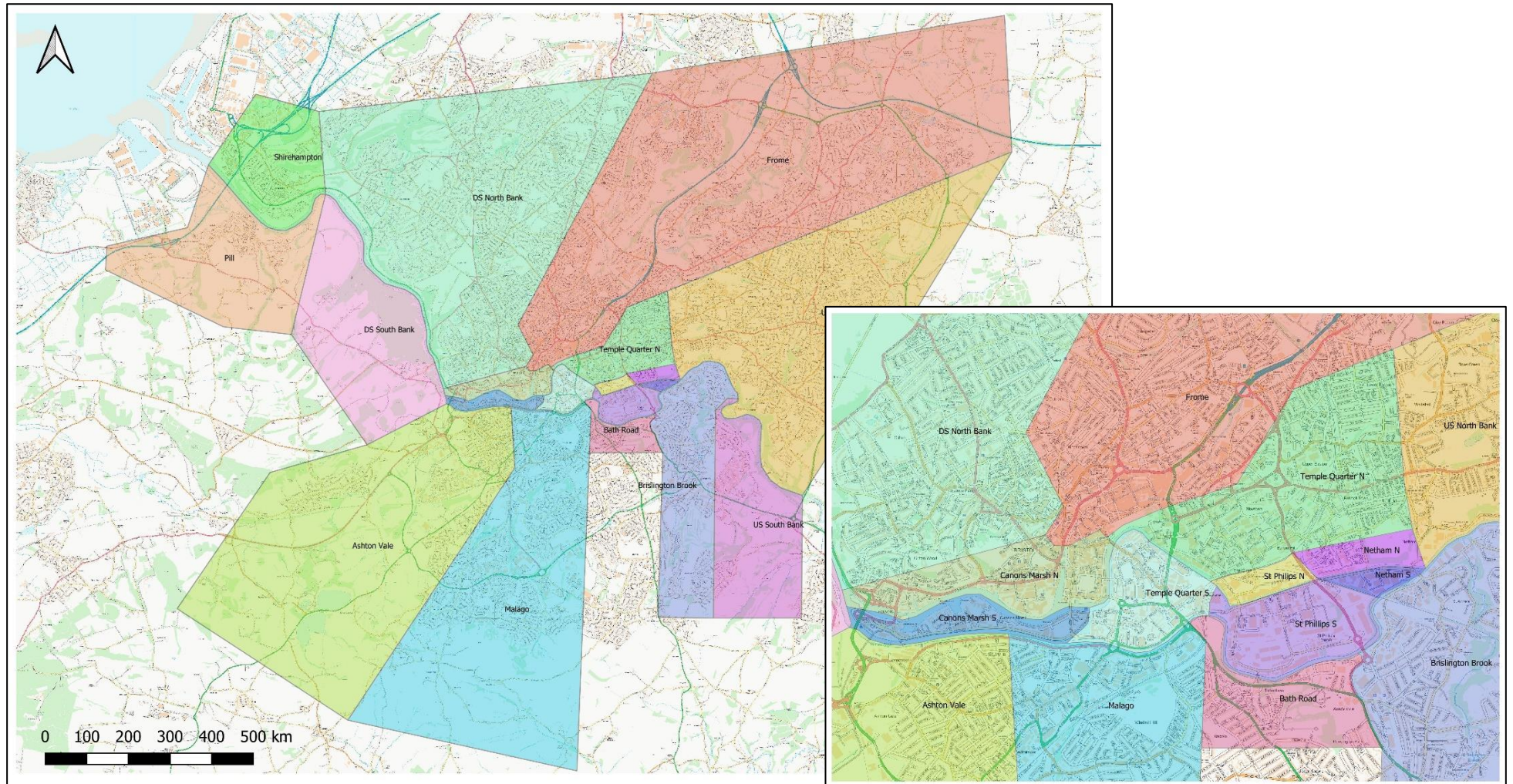


Figure 2. Benefit areas within the study area.

2.2 Property damages

2.2.1 Overview

The FHRC “Multicoloured Manual” provides many techniques for the evaluation of different types of flood damage at individual properties; these relate flood depths to flood damages for each individual flood event.

Property damages are calculated for a range of different event probabilities and integrated to find the annual average damage (AAD) over the appraisal period.

Climate change means that the relationship between probability and event magnitude changes over time, and this means that the AAD value also changes against time. AAD has been calculated for four different climate change epochs in line with current English guidance.

The damages accrued over the proposals’ lifetime have been calculated in Net Present Value (NPV) terms by interpolating between the values of AAD in each epoch and discounting into present day values based on the Treasury Green Book discount rates.

Properties are considered to be written off if they are flooded on average more than once every 3 years. The write off value of the property is converted to a Net Present Value also using Treasury Green Book Discount rates.

Finally, the NPV damages and Write off are capped so that they do not exceed the market value of that property in total. Uncapped damages in the Do Nothing are approximately 3 times as large as the capped damages, reflecting the high level of flood risk.

Benefits, represented by damages avoided, are then calculated by comparison of the damages observed during the baseline “Do Nothing” option with the damages observed during each of the Do Something options.

The damage estimates have been reviewed for potential sensitivity to individual properties. Only 4 properties comprise more than 1% of Do Nothing damages, and only 16 properties comprise more than 0.5% of Do Nothing damages. The top 50 properties are responsible for 25% of the Do Nothing damages. These properties have been inspected to see if any of their parameters appear particularly responsible for the magnitude of their influence – in general they simply reflect that these are large, high value properties at high risk of flooding.

2.2.2 Residential property

The MCM values flood damage to residential properties based on age, property type and social class (although this latter point is subsequently adjusted for by equity adjustment factors).

All residential buildings were listed within the NRD with an MCM code of “1”. Since this was insufficient information for quantifying damages, the codes were updated to match the category of the housing; detached, semi-detached, terraced,

flat or bungalow. Limited information about the age of the buildings was available, therefore historical maps, Consumer Data Research Centre² dwelling age maps and Google Street View were used. Properties post-dating 2012 construction have been removed from the analysis.

Only properties with ground level occupancy are included in the property damage calculation. These are classified as dG (definitely ground) or pG (possible ground) in the NRD dataset; the classifications dU and pU denote definitely upper and possible upper level respectively. Upper flood properties have been kept in for the assessment, but only Risk to Life and Vehicle damages are associated with these properties.

Assessment of higher damages associated with occupied basements has not been done. These properties are identified with a code of dB in the NRD dataset: only 74 such properties were identified in the 1000yr 2125 floodplain, and this approach does not have significant impacts on the study's conclusions.

2.2.3 Re-accommodation

The costs of evacuation and rehousing of residents during floods, and while their properties are restored following flooding are calculated based on the “Mid” value of the “Full Scale Evacuation Cost” tables from the MCM. These provide a cost based on the depth of flooding, and a given property type.

2.2.4 Non-residential properties

The study area includes non-residential properties (NRP). The MCM values flood damage to NRP building fabric and contents on the basis of various NRP categories and ground floor areas estimated from Mastermap. The area attributed to each property is based on the floor area of the building polygon. Where multiple NRD points fall within the same Mastermap building polygon the floor area of the building is divided evenly between them. This approach is best practice but nonetheless has limitations – for example an industrial factory may have a small ancillary office function.

2.2.5 Damages to heritage properties

Bristol is a city with a high number of heritage buildings within the floodplain. These structures often include elements of timber construction that might be considered more susceptible to flood conditions.

Prior assessment of this issue has drawn on a PARNASSUS research project³ by a University College London student on flood vulnerability of Bristol's listed buildings. This project however made erroneous assumptions regarding the potential water level difference between the interior and exterior of the buildings, and this meant its key conclusions greatly exaggerated the potential risk to the

² <https://maps.cdrc.ac.uk/#/metrics/dwellingage/default/BTTTTFFT/11.132837961736747/-2.5777/51.4782/>

³ Parnassus v2.0, “Vulnerability of Historic Buildings to Tidal Flooding in Bristol due to Climate Change”, Chee Check Foo and Christopher King-Wah Wong, University College London, 2016

buildings, at least in terms of the mechanisms considered. The report did however provide mapping of the heritage properties, and this has been used to identify the same properties within the damage assessment.

The MultiColoured Manual contains some provision to allow the susceptibility of a property to be altered. As a default, flood damages are calculated based on “indicative susceptibility”. For this analysis, the susceptibility factor of heritage properties was set to “High”. This will result in higher flood damages for these properties.

2.3 Risk to Life

The economic impacts of potential loss of life from a flood event have been assessed by application of the approach in “Assessing and Valuing the Risk to Life from Flooding for the Use in Appraisal of Risk management measures”⁴ Risk to life assesses the likely impact of floods of different severities on the properties affected.

The analysis defines a value for the number of fatalities likely, taking into account the severity of flooding defined by the flood hazard (based on depth, velocity and debris), as well as the demographics (the amount of population in the floodplain, and the vulnerability of the population based on census data) and characteristics of the area at risk (including speed of flood onset and available flood warning). This value is multiplied by the valuation of a life, over the appraisal period, listed in Table 1.

2.4 Vehicle damages

Economic losses associated with damage to vehicles are estimated for all residential properties, based on an average 1.15 vehicles per property. Guidance suggests that flood depths of greater than 35cm are almost certain to lead to a vehicle being written off (FCERM-AG, 2013)⁵. Damage equal to the write-off value of all vehicles at the property are therefore assumed for all properties where flood depth exceeds this threshold, minus an assumed 25% for vehicles that might be moved during a flood event.

2.5 Mental health damages

The impacts of mental health due to the higher rates of anxiety, depression and post-traumatic stress disorder after a flood event have been calculated using the latest guidance from Environment Agency⁶. The costs associated with these illnesses include the treatment costs and the loss of employment. Co-morbidity and the proportion of those seeking treatment have also been considered. The

⁴ Defra (2008),” Supplementary Notice to Operating Authorities – Assessing and Valuing the Risk to Life from Flooding for the Use in Appraisal of Risk Management Measures”

⁵ “FCERM: A Manual for Economic Appraisal”, 2013 Flood Hazard Research Centre and Environment Agency

⁶https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/879942/Mental_Health_Guidance.pdf

number of adults in each residential property was determined and this was then multiplied by the mental health costs per adult for each flood depth band.

2.6 Intangible health benefits

Intangible health benefits reflect the longer-term personal impact of flooding on the health and wellbeing of those affected; a reduction in flood risk is correlated with an approximate equivalent financial benefit.

The MCM 2013 methodology was used to estimate intangible benefits with flood risk management improvements at a property level. The basis of the estimation is that flooding of residential properties causes stress, disruption, illness and other losses that are not assigned a value in the main economic assessment. Rather than increase the losses in each flood event to include this, the Intangible Benefits assessment provides a positive benefit that can be added to the ‘damages avoided’ by each option. The magnitude of the benefit is dependent on the number of residential properties benefitting (i.e. with a reduced threshold of flooding), and the size of the change in threshold of flooding at each property.

2.7 Utilities

Utilities damages have been assumed equal to 5% of capped property damages., in line with “Learning Lessons from the 2007 Floods”, M. Pitt, 2008.

Correspondence between BCC and Bristol Water, Wales and West Utilities, and Western Power Distribution indicates that, while local networks may incur some disruption during events and damage, reasonable resilience measures have been taken, and few significant assets lie within the floodplain. The key assets noted are:

Hotwell Tunnel: Located next to Cumberland Basin. 760mm freshwater mains from Barrow Water Treatment Works to Bristol. Generally resilient if the tunnel is flooded but would be seriously affected if equipment was flooded. 80% of supply can be provided by re-routing from elsewhere in the event of damage.

Western Power Distribution: Feeder Road operational depot – staff take vehicles home with them and equipment could be supplied from elsewhere in the event of a flood.

2.8 Emergency services

Emergency services have been assumed at 5.6% of capped property damages (discounted at the health discount rate), based on the economies of scale of an urban environment.

It is however noted that most hospitals in Bristol are located to the north of the Avon and Floating Harbour; there would therefore be a significant increase in emergency response times for south Bristol while transport is impacted during a flood event. No monetary allowance has been made for this impact.

2.9 Assumptions

Present value damages have been estimated for a 100-year appraisal period, based on the assumed design life of the proposed works. The base date of the assessment is 2025.

The National Receptor Dataset (NRD) was supplemented with the OS Mastermap Topographic Area data to maximise the available information on each property, and then ‘cleaned’ to exclude those property points with no land-use categories or floor areas.

In the absence of survey information, a property threshold level has been assumed of LiDAR digital terrain ground level plus 300mm, as per guidance from MCM. Thresholds have been inspected in Google Streetview, and this value is considered broadly appropriate. Note that the hydraulic modelling adopted no increase in property elevation in order to preserve flood flow pathways, so there is no double counting of thresholds.

Non-commercial NRPs, including PO Boxes and telephone boxes, were excluded from the assessment by assigning an MCM code of 9 – which does not accrue any damages for any level of flooding. The assessment also does not value the impact of flooding to agricultural or amenity land.

Any properties with an MCM code of 999 were checked against Google aerial maps and street view imagery to determine whether a more appropriate value could be given or whether the property needed to be removed from the analysis (often garages, outbuildings, etc.). The same process was used to determine the correct MCM code when the NRD and MasterMap values did not correspond.

The assessment assumptions are summarised in the below table.

Table 1. Key Assumptions

Parameter	Assumed Value		
Properties			
Property Threshold	Residential	300 mm	Nominal assumed
	NRP	300 mm	Nominal assumed
Residential Property Value	Detached	Various – see Table 2.	
	Semi-Detached		
	Terraced		
	Bungalow		
	Flat		
NRP Rateable Value (£/m ²)	Factory	43.98	Taken from Valuation Office Agency, uplifted to 2020 values using CPI
	Retail	173.54	
	Office	160.47	
	Warehouse	85.58	

Parameter	Assumed Value	
	Other	85.58
NRP Rental Yield	Factory	4.875
	Retail	6.5
	Office	5
	Warehouse	6.25
	Other	6.25
	Taken from Knight Frank Investment Yield Guide July 2020	
CPI (Consumer Price Index)	108.6	CPI in April 2020 is 108.6, used to adjust the damage data used by the tool at which CPI was 108.11.
Flood Characteristics		
Flood Type	Fluvial (storm)	Tidal
Flood Duration	Over 12 hours	Under 12 hours
Flood Warning	Over 8 hours	Over 8 hours
Risk to Life Parameters		
Average number of people per property	2.25	Mean of all Benefit areas. Ranges from 2.22 to 2.44
Percentage elderly (> 75 yr)	2.8	Mean of all Benefit areas. Ranges from 2.06 to 12.53.
Percentage disabled or infirm	15.07	Mean of all Benefit areas. Ranges from 14.81 to 29.2
Reference value of a life (at 2020)	£1,753,002	
Flood warning	England – 2.15	
Speed of Onset	1 - Very gradual	
Nature of area	1 – multi-storey apartments / 2 – typical residential area, industrial and commercial areas	
Nature of catchment	Pasture or arable / Urban / Woodland	
Vehicle Damage		
Vehicles Per Household	1.15	Average
Threshold for vehicle write-off	350mm	As recommended by the Multi-Coloured Manual.

Parameter	Assumed Value	
Average Value Per Vehicle	£3,424	Based on 2013 figure, brought up to date for 2020 using CPI.
Additional Assumptions		
Susceptibility	Indicative / High	Indicative assumed as default. For specifically identified “Heritage” properties, set to High
Social Class Distribution	Class AB	13%
	Class C1	24%
	Class C2	52%
	Class DE	11%
National Average Assumed		
Emergency Service allowance	5.6% of direct property damages ⁸	
Utilities damage allowance	5% of direct property damages ⁹	
Green Book Discount Rates	0-30 years	3.5%
	31-75 years	3.0%
	76-100 years	2.5%
Green Book Discount Rates (Emergency Services, mental health, intangible benefits, Risks to Life)	0-30 years	1.5%
	31-75 years	1.3%
	76-100 years	1.1%

2.9.1 Residential Property Values

Residential property values were taken from Zoopla estimates. Table 2 shows the residential property value per benefit area for each house type.

Table 2. Residential Property Values

Benefit areas	Postcode	Detached	Semi-detached	Terraced	Bungalow	Flat
Ashton Vale	BS3	£384,875	£333,596	£358,809	£205,437	£205,437
Bath Road	BS4	£351,249	£260,461	£294,163	£175,664	£175,664
Brislington Brook	BS4	£351,249	£260,461	£294,163	£175,664	£175,664
Canons Marsh N	BS1	£566,664	£443,489	£559,000	£309,998	£309,998

⁸ FCERM: A Manual for Economic Appraisal, 2013 Flood Hazard Research Centre and Environment Agency

⁹ “Learning Lessons from the 2007 Floods”, M. Pitt, 2008

Canons Marsh S	BS1	£566,664	£443,489	£559,000	£309,998	£309,998
DS North Bank	BS9	£867,294	£565,663	£382,718	£337,251	£337,251
DS South Bank	BS8	£1,336,410	£997,293	£741,480	£399,695	£399,695
Frome	BS6	£782,768	£733,555	£616,555	£352,667	£352,667
Malago	BS3	£384,875	£333,596	£358,809	£205,437	£205,437
Netham N	BS2	£451,720	£350,413	£347,408	£230,832	£230,832
Netham S	BS2	£451,720	£350,413	£347,408	£230,832	£230,832
Pill	BS20	£486,279	£316,525	£318,037	£233,266	£233,266
Shirehampton	BS11	£464,250	£232,695	£223,550	£167,345	£167,345
St Phillips N	BS2	£451,720	£350,413	£347,408	£230,832	£230,832
St Phillips S	BS2	£451,720	£350,413	£347,408	£230,832	£230,832
Temple Quarter N	BS1	£566,664	£443,489	£559,000	£309,998	£309,998
Temple Quarter S	BS1	£566,664	£443,489	£559,000	£309,998	£309,998
US North Bank	BS5	£326,473	£252,135	£272,071	£166,726	£166,726
US South Bank	BS4	£351,249	£260,461	£294,163	£175,664	£175,664

2.10 Railway Disruption

Bristol Temple Meads station itself is relatively well elevated compared to the local floodplain. However, the passageway that allows passengers to access different platforms is subject to flood risk, and if flooded, the station would be unable to operate. The station is also the changeover point for train crews, and therefore disruption to the station also impacts services to the southwest. In major flood events, while the track itself may remain dry, the station itself would be isolated and inaccessible. This also would have a knock-on effect for connecting transport services.

Potential damages and disruption caused by the flooding of Bristol Temple Meads station were estimated using the MCM methodology on delays and monetary compensation for rail services. Flooding of the rail track and associated

infrastructure will cause some services to be cancelled and others to be delayed. The more severe the flooding the more severe will be the disruption and the larger the number of services cancelled.

The number of services impacted and/or the passenger journeys for the rail asset at risk from flooding shown in model results in a 24-hour period was obtained from the Office of Rail and Road Statistics¹⁰. Estimates were then made on the number of services affected and the disruption was quantified using the Network Rail indicative compensation and value of time methods.

The station had 11.4m passenger exits and entries in 2019, and 1.5m interchanges. This gives an average of 35,100 journeys per day. Based on the past 7 years, usage is increasing at approximately 5% a year, and the stated ambition is for usage to have reached 22m exits and entries by 2030.

	Business	Commuters	Leisure
Percentage	28%	23%	49%
Value of time (£/hr)	138.17	19.02	16.74

Cost per hour of delay = 51.26 £/hr/ delay

	Delay	Cancellation
Percentage	40%	60%

In present day terms, delays would cost potentially £720k per day of disruption.

At an estimated 216 trains / day, with an assumed compensation value of £2,591 (assumed high because of the high percentage of business journeys), cancellations would cost £336k per day of disruption.

Considering the low direct impact of flood events on the rail infrastructure, it is assumed the duration of disruption per flood event is 24hours at full effect, and a further day at half the impact.

The costs associated with disruption are increased over time proportionate to increases in passenger numbers to 2030 (although it is likely that numbers will also increase beyond this time), and the Department for transport WebTag “Value of Time Index” (to 2066). This means that the cost of a flood event increases over time from £2.0m in 2025 to £6.3m in 2125.

The combination of fluvial and tidal flood mechanisms gives the station a potential frequency of disruption of 1 in 7.5 years in the present day, worsening to an annual event in 2125, in both the Do Nothing and Do Minimum scenarios (although the Do Nothing rate of degradation is faster).

¹⁰ <https://dataportal.orr.gov.uk/statistics/usage/estimates-of-station-usage/>

2.11 Traffic Disruption

Disruption to the road network of Bristol caused by flooding was calculated using the MCM value of time method.

A traffic analysis was conducted in 2016 by CH2M Hill¹¹, based on the tidal flood risk outlines available at the time. That study used the BATS4M transport model of the greater Bristol area to test flood impact scenarios in the a.m. peak, Inter-peak (IP) and p.m. peak models for both 2015, and a forecast year of 2036. The model contained assumptions about planned developments and strategies within the model area, in accordance with Department for Transport (DfT) guidance.

Monetary impacts were identified for a single day, using the DfT TUBA software, which uses Value of Time parameters to vary the costs of travel.

Daily monetary impacts were estimated for four tidal flood scenarios: the 1 in 5, 1 in 20 and 1 in 200 annual chance tidal events, and the 1 in 200 annual chance, with flood walls.

Arup's more recent modelling shows differences in flood outlines, as well as the influence of fluvial flood events. Most notably, the current strategy does not protect the Portway road along its entire length, and therefore the benefits of protecting this road should not be claimed. To make use of the outputs from the CH2M Hill study, we have attributed the approximate contribution that each major impacted road would have made to the flood scenarios assessed, based on the relative ratios of their traffic counts (from DfT Road traffic statistics). Costs have been updated using DfT VoT data to obtain appropriate costs for disruption in each given year.

Table 3: Estimated cost of transport impact due to flood risk to each road over time (£/day)

Road	2025	2045	2065	2125
Brunel Lock Road	42,900	70,600	104,200	216,300
Cumberland basin Road	42,900	70,600	104,200	216,300
Clarence Road	42,900	70,600	104,200	216,300
Albert Road	128,800	211,600	312,700	648,800
Feeder Road	8,400	13,900	20,500	42,500

¹¹ CH2M Hill, April 2016 "Tidal Flood Risk Transport Modelling"

Cumberland Road	16,900	27,800	41,000	85,000
Welsh Back	111,900	183,800	271,600	563,400
Redcliffe Street	111,900	183,800	271,600	563,400

Not included:

- Portway Road (not included as not protected along its length)
- Bedminster Parade, East Street (not included as not protected)

We have then assessed the flood frequencies to these roads based on the more recent flood risk mapping and assumed only 24 hours impact on transport for any event. More extreme events could reasonably be assumed to have a longer impact due to clear up times, but the reduced frequency associated with these events mitigates potential sensitivity to this assumption.

Table 4: Estimated Annual Average and Net Present Value impacts of flooding.

Road	AAD 2025 (£k)	AAD 2045 (£k)	AAD 2065 (£k)	AAD 2066 (£k)	AAD 2125 (£k)	NPV (£m)
Do Nothing	487	863	1,312	1,312	2,722	31.3
Do Minimum	273	493	755	755	1,924	18.9
Op6 75yr	4	8	18	8	57	0.4
Op7 100yr	4	8	12	6	52	0.3
Op8 200yr	3	5	7	6	36	0.2

2.12 Treatment of climate change

Current English government guidance¹² on the impact of climate change is to build on the assessment of current risk, and to incorporate resilience and flexibility based on an assessment of potential future sensitivities as quoted in Table 5 and Table 6. The hydraulic model inputs to the economic model assume the Central allowance for fluvial events, and the Higher Central allowance for tidal events.

¹² <https://www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances>

Table 5 climate change guidance for fluvial events, % changes to 1961-1990 baseline

Estimates	Total potential change anticipated for the 2020s	Total potential change anticipated for the 2050s	Total potential change anticipated for the 2080s
Upper End	25%	40%	70%
Higher Central	15%	25%	35%
Central	10%	20%	25%

Table 6 climate change guidance for tidal events, % changes to 1981-2000 baseline

Estimates	2000 to 2035 (mm)	2036 to 2065 (mm)	2066 to 2095 (mm)	2096 to 2125 (mm)	Cumulative rise 2000 to 2125 (metres)
Upper End	7 (245)	11.4 (342)	16 (480)	18.4 (552)	1.62
Higher Central	5.8 (203)	8.8 (264)	11.7 (351)	13.1 (393)	1.21

2.13 Flood Mechanisms

Each tidal scenario was run for the 1yr, 2yr, 12yr, 20yr, 75yr, 100yr, 200yr, and 1000yr return period flood events. These events assumed generally to coincide with 1yr return period inflow, except for the 200yr event (coinciding with a 2yr flow on local water courses) and the 1,000yr event (coinciding with a 12yr flow).

Similarly, fluvial scenarios were run for the 1yr, 2yr, 12yr, 20yr, 75yr, 100yr, 200yr, and 1000yr return period flood events. These events assumed generally to coincide with a 1year return period tidal flood event, except for the 200yr event (coinciding with a 2yr tidal event) and the 1,000yr event (coinciding with a 12yr tidal event).

The coincident events from these mechanisms were highlighted in the Central Area Flood Risk Assessment CAFRA (“CAFRA”, BCC, 2016), and updated by Arup following a review of joint probability.

The annual average damage (AAD) for these two mechanisms were calculated separately and combined to give an estimate of the overall flood risk. A third “mechanism” was also assessed: this adjusted for potential double counting of tidal flooding within the set-up of the fluvial mechanism for the 200yr and 1000yr events. The AAD for this mechanism was subtracted from the sum of the other two AAD values.

The same process was completed for the future epoch modelling to account for climate change and produce AAD figures for the NCC, 2020s, 2050s and 2080s future epochs.

2.14 Options

The shortlisted options for the economic assessment were as follows:

- Do Nothing
- Do Minimum
- Defend

2.14.1 Do Nothing

Background to the operation of the Harbour

Downstream of the Floating Harbour the River Avon is tidal. At low tide, harbour water levels are maintained at a normal level of 6.1mOD by two pairs of lock gates at the Entrance Lock to Cumberland Basin, at the western end of the basin. A pair of lock gates at Junction Lock (Junction Upper Gates)) at the eastern end of Cumberland Basin act as back up to the Entrance Lock gates to ensure that water levels are maintained in the Floating Harbour. The Junction Upper Gates are also closed approximately twice a month to retain water in the Floating Harbour when Cumberland Basin is scoured at low tide to remove accumulated silt.

Fluvial flow enters the harbour from the River Avon via the Feeder Canal at Netham Lock, and from the River Frome which passes through the centre of Bristol. Flows discharge from the harbour via four culverts at Underfall Yard Sluice, located close to Junction Lock.

Spring high tides are prevented from entering the Floating Harbour by two pairs of flood-stop gates located in Junction Lock. – the 1992 and 2010 stop gates. The function of the outer pair of lock gates at Netham lock is to restrict high river flows from entering the Floating Harbour. During high tides, neither the lock gates at Cumberland Basin nor the Junction Upper Gates can be used to prevent tidal inflows because they are mitred in the opposite direction. The Cumberland Basin gates are opened when the flood stop gates close to avoid damage due to reverse loading.

When a surge tide level is predicted to exceed the normal operational level of the Floating Harbour (by Environment Agency flood forecasting models), the decision is taken to close a pair set of the Junction Lock gates, which are mechanically operated using Hydraulic Pump Units (HPU). The Harbour Authority is obliged to notify the Environment Agency Flood Incident Duty Officer that the gates have been closed. The gates are typically operated 200 times each year.

As such, the deployment of the gates on demand is dependent on: Environment Agency services, a power supply, and staff with appropriate flood-risk training and decision support. While a mobile HPU is available for back up in the event of failure to the main units, this would also need maintenance, and deployment by appropriately trained staff. In the peak of major flood events, water levels will cut off access to the lock gates for their operation.

The installation of the gates was funded by Environment Agency GiA. The Harbour Authority is paid £150/closure by the Environment Agency for their operation.

Modelling of the Do Nothing

Under the Do Nothing scenario, the flood gate protective structures at Netham Lock and Junction Lock are no longer powered, funded, supported or maintained. In the absence of proactive management of the gates, they would not be closed on time; the lock gates managed by the Harbour Master are not constructed to hold back flooding. The lock gates / flood gates are modelled as being static and open.

The Avon through Bristol is not subject to active maintenance, increases to roughness or bed levels have not been assumed in the Do Nothing scenario.

2.14.2 Do Minimum

The Do Minimum option assumes that the lock gate and flood gate protective structures at Netham Lock and Junction Lock are maintained and refurbished over the appraisal period so that, *if operated successfully*, they provide a significant reduction in flood risk in flood events.

The default modelled scenario in the Do Minimum is therefore that the locks are managed in a timely fashion prior to a flood event, and are managed proactively during the event so that the levels of fluvial events entering the Floating Harbour do not cause flooding by being prevented from leaving the docks. Fluvial flood events have been noted to last for the duration of multiple tidal cycles.

However, there are several resilience concerns with regards to the locks, relating to risks of operational failure due to equipment failure, electrical failures, and traffic disruption impacting on staff availability. The Central Area Flood Risk Assessment (“CAFRA”, BCC, 2016) identified the susceptibility of the Netham Lock gates to flooding as “Moderate to High”. The Failure Mode Analysis identified a 5-20% likelihood of both gates failing open, noting a past incident (2016) where staff were unable to access the gate on time due to traffic.

Tidal surge events have been shown to tend occur during concurrent high tides, and, at present, are not reliably forecast. Notably, the need for proactive management during a flood event requires real time response to the complex interaction of river flow volumes and tidal levels: a fluvial event may last two tidal cycles. This interplay between the two mechanisms does not allow deployment of the gates to be limited to a single operation in advance of a flood.

In the largest tidal and fluvial events, the tide has been witnessed carrying significant volumes of debris, (including vehicles), which may impair the function of the gates. The Failure Mode Effect Analysis (Arup, 2015) identified a 20-50% likelihood of vandalism or debris on the cill preventing closure of one of the Junction Lock gates, an event that is noted as having happened 3 times in 20 years, although the risk of this occurring to both sets of gates is considered “low” in a Do minimum scenario.

In flood events greater than a present day 12 year fluvial event, or a 20 year tidal event, flood flows bypassing the lock gates via the quays on either side are fast and deep, achieving hazard ratings of “*dangerous to most*” or above; and it may reasonably be considered that there is a very significant chance of failure to close the gates (see Picture 1).

The Do Minimum economic modelling reflects this by reverting to the outputs of the Do Nothing modelling in these events.



Picture 1: Flood flows bypassing the lock gates.

2.14.3 Defend

The construction of flood defences along the Avon and tying into the floodgate / lock structures would prevent flooding from entering the Floating Harbour up to a given standard. To promote such a strategy it is also necessary to undertake any works necessary to mitigate detrimental flood risk impacts of the proposals.

A range of standards of protection have been considered in the assessment, to facilitate assessment of the Decision Rule and to allow identification of a range of options for the development of the “Local Choice” preferred option, particularly with a view to management of climate change.

Defences have been modelled without freeboard but have been costed including freeboard (with the exception of the Local Choice options).

2.14.3.1 Development of flood defence options

Defence options have been developed around the need to address climate change through a managed adaptive approach. This reflects the likely potential for sea level rise to drive dramatic changes in the standard of protection over time.

As a starting point, scenarios have been built around the concept of constructing a strategy in 2025 on a precautionary basis, the standard of which will decline against time to meet a given standard in 2065, at which point the defence would be raised again to a higher level, the standard of which will decline against time to meet the given standard in 2125 at the end of strategy life.

Figure 3 shows an example of this in action.

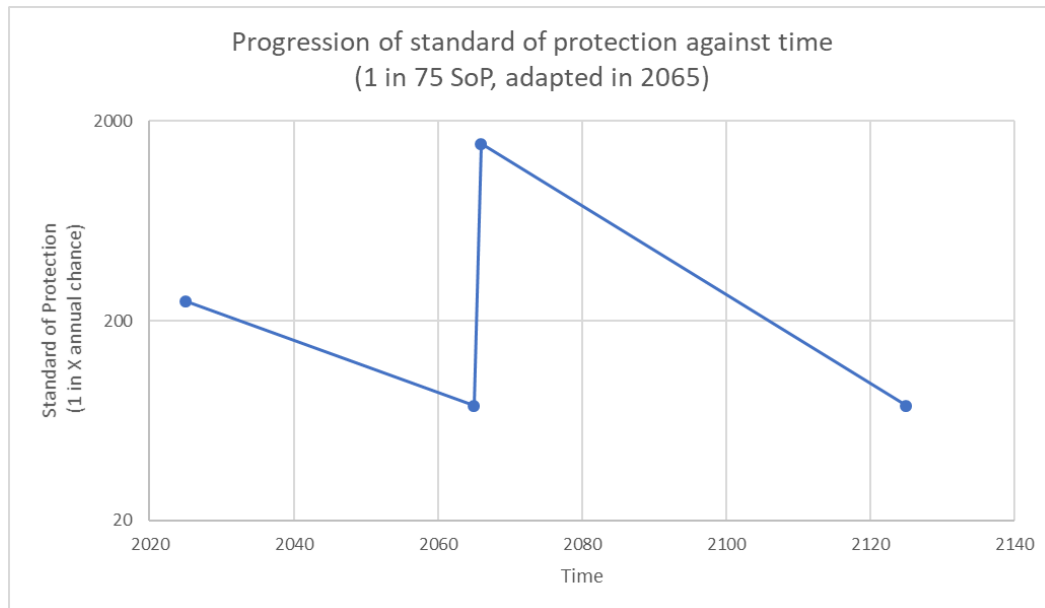


Figure 3: Progression of the standard of protection against time, for a strategy designed to a 1 in 75 annual chance, and uplifted in 2065

To provide a 75year standard of protection (SoP) on this basis (and considering only the tidal component for now), the strategy would need to be built to the equivalent of a ~250year strategy in 2025. Over time, this SoP would decline, reaching a 75year SoP in 2065. At this point in time, the strategy would be raised to what would be, in 2065, the equivalent of 1540 year standard of protection. However, over time, this too would decline to a 75 year standard of protection by the end of strategy life.

This example is a good illustration of why this adaptive approach is necessary. Had the strategy not been raised in 2065, the 75 year strategy would have continued to decline such that by 2125, it would have had a SoP equivalent to 3.5years – the property it protected would be at risk of being written off.

On the other hand, to construct on a fully precautionary basis to the 2125 75year standard of protection would have meant that, when constructed, the strategy would have had a SoP equivalent to the 2025 5250year event. This would be potentially excessive, and it is noted that the defence heights in some locations are significant: their visual and amenity impact is reduced by deferring construction to the 2125 standard. The difference between 2065 and 2125 defence heights is typically 0.50- 0.60m.

2.15 Overlaps

There are several overlapping initiatives and mechanisms within the Bristol Avon Flood Strategy; these are managed by adjustments within the calculation of Net Present Value.

2.15.1 Local economy

The analysis into impacts on the local economy by its nature overlaps the area of flood damage assessment. Where proposals are being assessed for their potential to unlock future development, care has been taken to manage overlaps.

For properties overlapped by proposed developments set out in the “Economic Development Needs Assessment (“EDNA”) dataset (see Section 3 for further details), it is assumed that damages are only accrued outside of the build out timeline of the EDNA properties. This is because the imminent development of those sites will lead to replacement of the properties on those sites with National Planning Policy Framework compliant construction. None-the-less it is acknowledged that, without an adopted Bristol Avon Flood Strategy, even allocated sites are struggling in some locations to obtain planning permission because they are contrary to national planning policies regarding flood risk.

The EDNA properties build-out timeline is 5 years, and there is an allowance within the calculation of the impacts on the local economy for a 10% chance that the developments do not go ahead. Flood damages for properties within this outline are therefore assumed to be accrued for the first 5 years, and 10% are accrued for the rest of the appraisal period.

In some cases, it has been noted by comparison with alternate sources, or by direct information from BCC staff, that the provided polygons of the EDNA site encompass properties that will in fact be retained. These polygons have been updated so that those properties can still accrue damages.

For properties overlapped by Bristol’s more extensive areas of growth and regeneration (Bristol Temple Quarter and St. Philip’s Marsh), the timelines of the proposed development have been considered, such that damages are accrued up till the expected delivery of the development. Properties can still be written off before the delivery date if at high risk in the Do Minimum and Do Nothing scenarios. The timelines are uncertain and should be subject to review: some elements of each of these proposals may be carried out in advance; others may lag behind. Nonetheless, the assumed timelines are as follows:

Area for growth and regeneration	Bristol Temple Quarter	St. Philip’s Marsh	Frome Gateway
Assumed delivery date	2035	2040	2045
Percentage of uncapped damages	21%	26%	30%

The development proposals for the area of Western Harbour are noted not to include any replacement / demolition of existing properties, and because of this, no adjustment is made for them.

2.15.2 Pluvial flood risk

Properties that are within the Environment Agency's Risk of Flooding from Surface Water 1% annual chance flood outline were identified – over the lifetime of the scheme, the risk associated with this flooding will increase to a 3.3% AEP. The Net Present Value damages of these properties were then reduced by 25%, thereby avoiding claiming benefits that might be required to justify funding to address risks to these properties.

2.15.3 River Frome flood risk

The benefit area of the Bristol Avon Flood Strategy (BAFS) has considerable overlap with that of the Environment Agency's flood alleviation proposals for the Lower Frome, particularly in the more extreme flood events. It is currently understood that those proposals amount to refurbishment of existing defences at Eastville, preventing deterioration rather than improving the standard of protection.

As such, it is reasonable for the BAFS to claim benefits in this location, particularly as they act directly on the residual risk of the Lower Frome strategy. OM2 scores can also be claimed provided they move properties from one risk band to another.

3 Impacts on the local economy

Figure 4, extracted from the “Frontier methodology”¹³, illustrates the areas of overlap between Flood and Coastal Erosion Risk Management benefits, and impacts to the local economy.

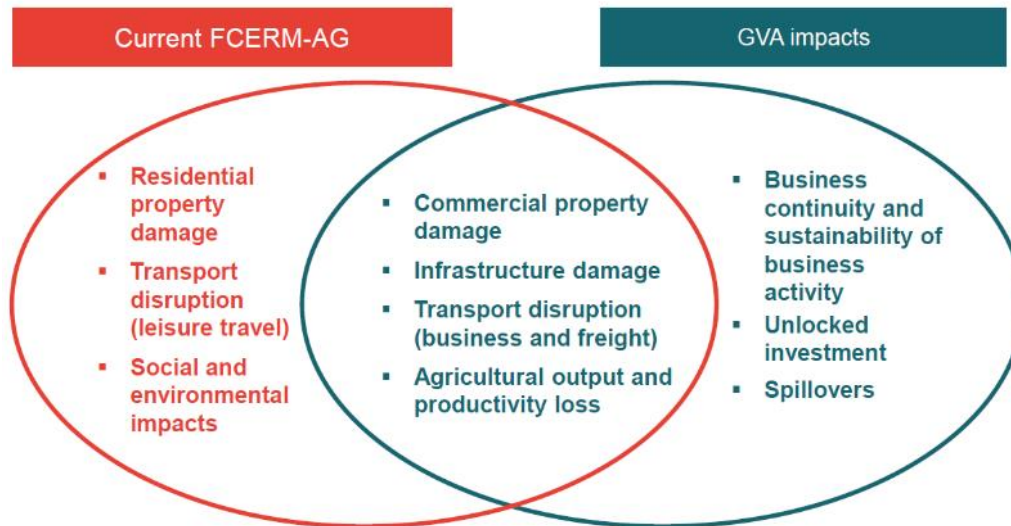


Figure 4: Overlaps between Grant in Aid eligible impacts, and impacts to the local economy

Future growth benefits would be generated by all the shortlisted options. The future growth benefits do not contribute to the calculation of FCERM Grant in Aid. However, these future growth benefits align with the HM Treasury Green Book Approach, and in order to provide a robust justification for the investment of Bristol City Council funding they are included and presented in Table 19, below.

These benefits have been calculated in-line with HM Treasury Green Book principles and the Homes and Communities Agency (HCA, now Homes England) Additionality Guidelines, as well as the Frontier methodology, as detailed in **Appendix B**. The unit of impact is a monetary measure of the value added by businesses to the local economy termed Gross Value Added, GVA.

The benefits assessed include

- Direct impacts on commercial property and infrastructure
- GVA losses saved through reduced flood risk to existing businesses
- GVA earned through jobs created by the unlocking of development on the floodplain
- GVA earned through jobs created by construction of the flood strategy and the unlocked development.

¹³ Defra / EA project FD2662, “Flood and Coastal erosion risk management and the local economy,” March 2014.

- GVA saved through the reduced flood risk to Bristol's tourism industry.
- Potential health and amenity benefits generated through enabling the creation of a sustainable transport network next to the River Avon.

3.1.1 Direct impacts on commercial property and infrastructure

This is calculated using the approaches outlined elsewhere in this report. The relevant aspects are; disruption to road and rail; direct damages to non-residential properties; utility damages and indirect commercial losses.

3.1.2 GVA loss saved through reduced flood risk to existing businesses

Reducing the flood risk to existing businesses reduces losses as a result of:

- Incurring losses due to business disruption
- Incurring costs spent on adapting their properties to be flood proof
- Going out of business or moving out of the area

The approach for calculating these losses is prescribed in the "Frontier" methodology, a joint Defra/EA flood and coastal erosion risk management (FCERM) research and development programme – project FD2662. This method identifies the likelihood of the above scenarios, based on the Location Dependence and Adaptive Capacity of the business. Location Dependence and Adaptive Capacity of the business are in turn identified from the Business Type and Business Size. The economic impacts of flooding are based on the lost earnings of staff (FTE) employed by each business, multiplied by the duration of impact and the frequency of flooding.

The benefits of the intervention are calculated from the impacts avoided, and a range of different standards of protection have been assessed.

This calculation has been carried out at a high level, using available datasets, and generic assumptions of business response to flooding. Improvements in the calculations of disruption could be made using surveys of individual businesses.

3.1.3 GVA from unlocking of development

The net economic gain to Bristol as a result of land use changes from the sites potentially unlocked by reduced flood risk through this strategy is captured by adjusting the gross impacts for additionality, that is "the net, rather than the gross impact of an intervention after making allowances for what would have happened in the absence of the intervention". The assessment therefore adjusts the gross impacts by considering the following additionality assumptions:

- Deadweight: the level of economic activity that would have occurred without the intervention.

- Leakage: the level of benefits (i.e. jobs on these sites) that are likely to go to residents outside of Bristol who commute in.
- Displacement: the proportion of economic benefits that are displaced from elsewhere in the region
- Multiplier impacts: additional impacts within the economy from supply linkages due to purchases made as a result of the intervention and further purchases with linked firms along the supply chain (indirect effects) and income effects associated with local expenditure as a result of those who derive incomes from the direct and supply linkage impacts (induced effects).

The GVA benefits are calculated based on Net Present Value: however, a range of periods are assessed, depending on the impacts being considered. GVA earned through unlocking development

The delivery of the BAFS will be an influence in unlocking development within the floodplain – both through expansion with existing sites, and development of brownfield sites.

Where possible, existing data from specific assessments relating to individual sites has been used. The overview of the method is

- Estimate the internal floor area associated with a development
- Identify the proposed uses
- Estimate the gross number of FTE jobs created from the internal floor area, the proposed use, and assumed occupancy rates.
- Apply leakage, displacement and multipliers to calculate net FTE.
- Use assumed values of GVA / FTE, multiplied by an assumed time profile of construction, occupancy, and decaying benefits.

3.1.4 GVA earned through the jobs created by construction

Construction jobs are created through two sources on this project

- The construction of the strategy itself
- The construction of development unlocked by the strategy.

The benefits of the created jobs have been estimated at £10m for delivery of the strategy, and £29m for construction of development unlocked by the strategy.

3.1.5 GVA saved through the reduced flood risk to Bristol's tourism industry

The 2013 report “Bristol Floating Harbour EIA Final Report” identified annual visitor spending associated with the Floating Harbour of £14.9m, based on

assumed spend per adult, and apportioned visitor numbers of 1.4m (including 2 children to 1 adult).

However, that study is notably conservative in some of its assumptions, and its scope. It adjusted for double counting of visitors by assuming that they attend 3 attractions a day, and this adjustment is particularly conservative given that shorter visits comprise a high proportion of overall visitor numbers. Assuming that visitors attend 2 attractions a day increases apportioned visitor numbers to 2.1m visitors, and this seems like a more reasonable proportion of Bristol's overall annual visitors (18m per annum according to Visit Bristol, although this is noted to be a high estimate from comparison with Visit Britain's statistics. On this basis, and adjusting for uplifts in spend based on Visit Britain statistics, the annual spend can be estimated at £23m per annum today, or £63k per day, based on 2.1m annual visitors (including children). Even this estimate focusses on "attractions" and overlooks the value of spend in local hotels and restaurants as part of Bristol's leisure industry.

Four different scales of flood event can be identified, impacting on variously:

- The quays and the harbour railway
- SS Great Britain
- All quays and attractions except for M Shed
- All quays and attractions

Estimates of the costs and frequencies of these events have been built up by reference to visitor surveys and the modelled flood extents. This has allowed the following estimates of impact to the local economy, based on Net Present Value.

It is considered that some of these attractions are fundamentally unmoveable from their current locations; as such they would either continue to incur disruption, adapt or go out of business. Even with adaptation, flooding to the quays on a 2 year (as per the Do Nothing 2065 scenario) would likely make their position untenable. As such, it is expected that a significant portion of Bristol's tourism industry in the Floating Harbour would be written off long term in the Do Nothing scenario.

3.1.6 Potential health and amenity benefits from enabling the creation of a sustainable transport route

The concept of a sustainable transport route built beside the River Avon, and beside the Feeder Road has been promoted for several years, originally as the "New Cut Greenway". The construction of a flood defence along these same routes creates an opportunity for partnership to enable such a proposal.

A green infrastructure transport route for improved cycling and walking beside the river, would provide significant transport and amenity benefits. The benefits of such a route were assessed in 2017 using Arup's "Green Infrastructure Valuation Estimation Tool." The tool draws on the methods of the UK National Ecosystems Assessment 2010, and HM Treasury guidance on carbon pricing. The

tool identified two core benefits of the greenway: Health and Recreation, valued at £3.6m / year, and Amenity, valued at £8.4m / year. Updating these figures to 2020 using CPI, they can be valued at £3.8m/year and £8.8m/year.

Over a ten year period, this is a Net Present Value of £117.2m. Accepting that the BAFS may only be one of the factors by which such an investment could be enabled, it is suggested that only 15% of this could be claimed as a benefit of the strategy. Nonetheless, this would still be £17.6m benefit attributable to the strategy.

The assessment undertaken in the Green Infrastructure Valuation Estimation Tool highlights that Floating Harbour docks in their current condition may provide a similar level of amenity. It would be reasonable to argue that in the Do-Nothing scenario, with extensive flooding to the quays in the 2 year return period tidal event, this amenity would be significantly impacted, and therefore the strategy proposals provide a similar order of benefit in terms of amenity protected.

4 Flood damages results

4.1 Annual Average Damages

Annual Average Damages associated with the design phases are shown for each epoch in the tables below. Emergency services and utilities are derived by multiplying the Annual Average Property Damages by the factors listed in Table 1.

These tables are presented based on all benefit areas, without adjustment for overlaps. As discussed in Section 2.15, “Overlaps”, adjustments for overlapping area and mechanisms are addressed at the stage of calculating the Net Present Values.

Table 7. Annual Average Damages for 2025

Option	Total Annual Average Property Damage (£)	Emergency Services (£)	Utilities (£)	Annual Average Vehicle Damage (£)	Annual Average Risk to Life (£)	Total AAD (£)
Do Nothing	41,903,514	2,346,597	2,095,176	514,997	1,175,574	48,035,857
Do Minimum	12,738,641	713,364	636,932	119,858	517,959	14,726,754
75yr SoP	2,631,070	147,340	131,554	38,881	98,029	3,529,943
100yr SoP	2,626,054	147,059	131,303	38,299	94,265	3,519,165
200yr SoP	2,345,185	131,330	117,259	36,935	87,038	3,191,857

Table 8. Annual Average Damages for 2045

Option	Total Annual Average Property Damage (£)	Emergency Services (£)	Utilities (£)	Annual Average Vehicle Damage (£)	Annual Average Risk to Life (£)	Total AAD (£)
Do Nothing	52,491,424	2,939,520	2,624,571	729,613	1,373,992	60,159,120
Do Minimum	18,976,283	1,062,672	948,814	217,758	686,970	21,892,497
75yr SoP	3,938,184	220,538	196,909	57,938	141,074	5,133,754
100yr SoP	3,944,507	220,892	197,225	55,997	134,197	5,136,959
200yr SoP	3,535,733	198,001	176,787	52,716	124,378	4,658,931

Table 9. Annual Average Damages for 2065

Option	Total Annual Average Property Damage (£)	Emergency Services (£)	Utilities (£)	Annual Average Vehicle Damage (£)	Annual Average Risk to Life (£)	Total AAD (£)
Do Nothing	69,492,750	3,891,594	3,474,638	1,026,686	1,800,178	79,685,845
Do Minimum	41,254,148	2,310,232	2,062,707	529,175	1,293,393	47,449,656
75yr SoP	4,702,164	263,321	235,108	67,040	155,134	6,126,364
100yr SoP	4,603,180	257,778	230,159	63,834	148,115	6,011,171
200yr SoP	3,810,477	213,387	190,524	55,696	129,535	5,091,044

Table 10. Annual Average Damages for 2066 (ie immediately after Options 6,7,8 have been raised to reduce vulnerability to climate change)

Option	Total Annual Average Property Damage (£)	Emergency Services (£)	Utilities (£)	Annual Average Vehicle Damage (£)	Annual Average Risk to Life (£)	Total AAD (£)
Do Nothing	69,492,750	3,891,594	3,474,638	1,026,686	1,800,178	79,685,845
Do Minimum	41,254,148	2,310,232	2,062,707	529,175	1,293,393	47,449,656
75yr SoP	3,575,719	200,240	178,786	74,278	130,443	5,276,734
100yr SoP	3,902,260	218,527	195,113	68,123	122,900	5,614,184
200yr SoP	3,431,429	192,160	171,571	57,719	120,974	5,060,457

Table 11. Annual Average Damages for 2125

Option	Total Annual Average Property Damage (£)	Emergency Services (£)	Utilities (£)	Annual Average Vehicle Damage (£)	Annual Average Risk to Life (£)	Total AAD (£)
Do Nothing	178,318,519	9,985,837	8,915,926	2,407,383	3,498,039	203,125,705
Do Minimum	157,505,375	8,820,301	7,875,269	2,001,071	4,152,034	180,354,049
75yr SoP	7,698,905	431,139	384,945	105,997	222,332	10,053,229
100yr SoP	7,203,322	403,386	360,166	101,507	210,881	9,458,510
200yr SoP	6,371,010	356,777	318,550	91,763	176,681	8,522,488

4.2 Present Value Damages

Capped present value damages associated with the options are shown in and Table 13.

Table 12 Capped Present Value Damages (£m)

	Do Nothing	Do Minimum	75yr SoP	100yr SoP	200yr SoP
Residential write-offs	112	4	-	-	-
Non-residential write-offs	250	49	-	-	-
Residential property damages (including write-offs)	224	158	16	15	6
Non-residential property damages (including write-offs)	473	367	48	44	14
Emergency Services	67	86	11	11	9
Utilities	35	26	3	3	3
Indirect Commercial losses	16	23	2	2	2
Traffic disruption	31	27	0	0	0
Rail Disruption	94	85	1	1	0
Relocation costs	16	23	2	2	2
Car damages	14	13	2	2	1
Risk to Life	60	73	6	6	5
Mental health	18	22	8	8	6
Intangible health benefits	0	5	28	28	29
OM1a qualifying damages*	1,045.9	886.2	65.5	65.4	51.6
OM1b qualifying damages*	108	126	-10	-10	-15

* Intangible health benefits have been treated as a negative damage in both OM1a and OM1b

Some dis-benefit can be noted between the Do Minimum and Do Nothing for certain elements of the scheme. This is because of property write-offs, which are applied when flood risks exceeds a 1 in 3 annual chance, and these have an overall impact on the scheme funding as well.

Other elements of damages (emergency services, utilities, indirect commercial losses, relocation costs, car damages, risk to life and mental health) are all similarly stopped from being accrued when a property is written off. This means that their values are also lower than normal in the Do Nothing and Do Minimum – and this means that the proportion of OM1b qualifying damages is much lower than normal.

Property damages are further limited by capping, so that the value of property damages, plus the write off value does not exceed the total value of a property – Even if write-offs were ignored, property capping would halve the admissible

property damages in the Do Nothing case. This also further limits the potential values of those other elements of damage.

The irony is that these effects are greatest because the flood damages are so high. Bristol is particularly subject to high capping and write-off ratios because it is subject to high flood risk, caused by the city centre being subject to two sources of flood risk (fluvial and tidal), rather than just one. Fluvial flood damages comprise approximately 40% of the overall property damages in the Do Nothing. This greatly increases the frequency of flooding. The changes in frequency associated with climate change are a sensitivity for tidal flood risk, leading to increased likelihood of write off.

The calculator in its latest form (released April 2020) is relatively untested, and the circumstances of Bristol are relatively unique and extreme. We would welcome further discussions with LPRG to explain how Bristol's circumstances are potentially leaving it at a disadvantage to other areas and explore how the underlying guidance could be applied to maximise funding to Bristol.

Table 13 Capped Present Value Damages and Benefits

Option	Net PV Damages (£m)	OM1a Benefits (Total Benefits, £m)	OM1b qualifying damages (£m)	OM1b Benefits (£m)
Do Nothing	1045.9	-	108	-
Do Minimum	886.2	160.0	126	-18
75yr SoP	65.5	980.4	-10	118
100yr SoP	65.4	980.5	-10	118
200yr SoP	51.6	994.4	-15	123

4.3 Risks to Property

The potential increases in flood risk to property if the status quo continues is shown below in Table 14, below. This count does not include upper floor properties within the floodplain, or properties constructed since 2012.

Table 14: Property at risk in the Do Minimum scenario, assuming Floating Harbour flood gates are successfully operated.

	Do Minimum present day							Sum
	Tidal 200		Fluvial 100		Total, avoiding double counting			
	Residential	Non-residential	Residential	Non-residential	Residential	Non-residential		
Near the city centre	228	499	381	483	510	615	1125	
Downstream	129	40	72	13	129	40	169	

Upstream	9	7	22	12	22	12	34
Sub-total	366	546	475	508	661	667	1328
Total		912		983		1328	

Do Minimum 2125							
Tidal 200		Fluvial 100		Total, avoiding double counting			
Residential	Non-residential	Residential	Non-residential	Residential	Non-residential	Sum	
Near the city centre	1730	1693	1649	1490	2253	1880	4133
Downstream	223	51	168	44	223	51	274
Upstream	26	19	32	20	32	20	52
Sub-total	1979	1763	1849	1554	2508	1951	4459
Total		3742		3403		4459	

The distribution of these properties is shown in Figure 5, overleaf.

4.3.1 Grant in Aid property counts

Property counts (used later in calculations of Grant in Aid) have identified property numbers by their risk bands (in accordance with the Partnership Funding Calculator) and their threshold of deprivation based on the Super Output Area Index of Multiple Deprivation. These are shown in Figure 6 and Figure 7, overleaf.

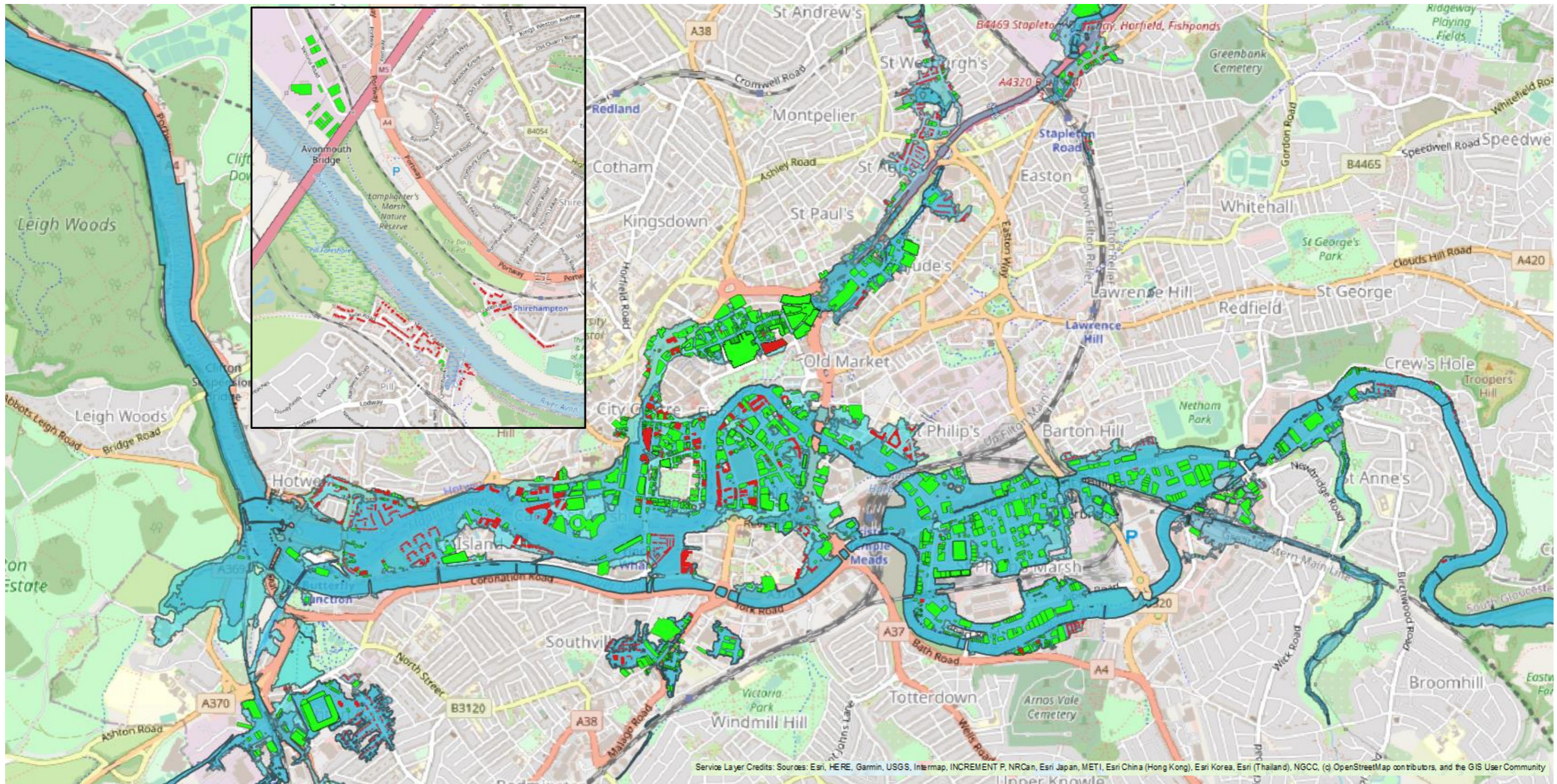


Figure 5: Residential (red) and Non-residential (green) properties within the 2125 200yr tidal (pale blue) and 100yr fluvial (dark blue) flood extents. Inset: Pill & Shirehampton (flood extents not mapped at this location)

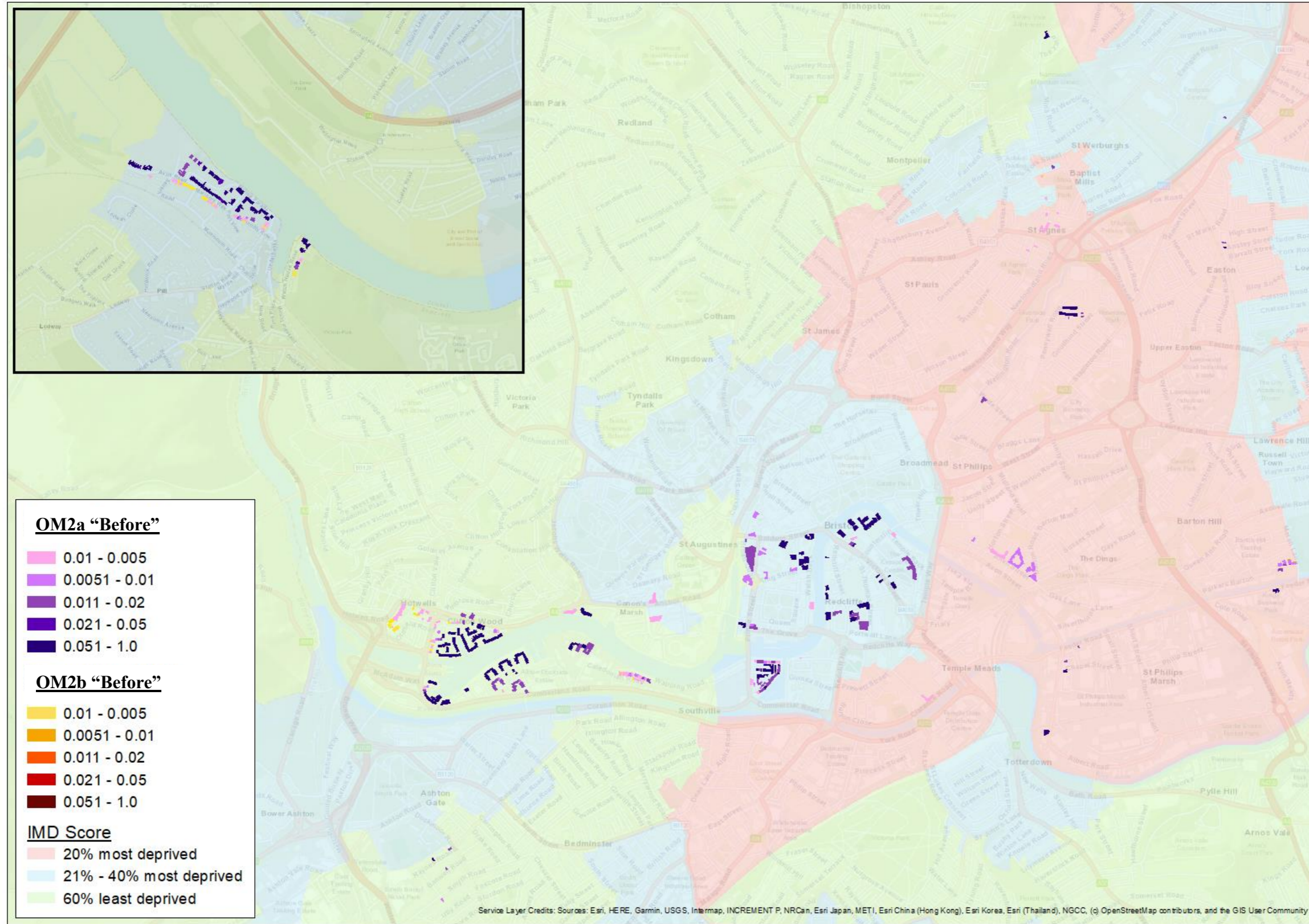


Figure 6: OM2a and OM2b before flood strategy

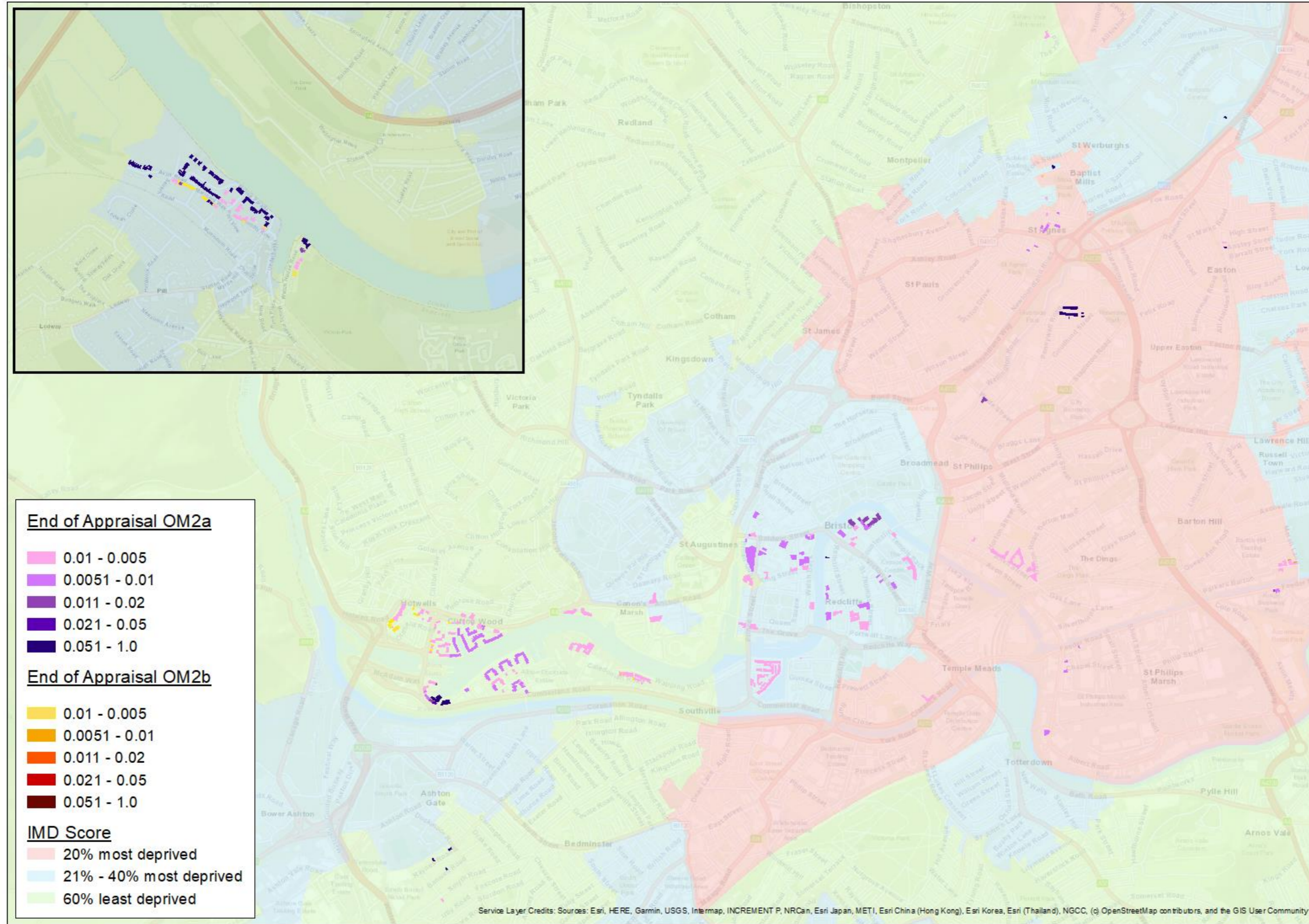


Figure 7: Distribution of OM2a and OM2b eligible properties at the end of the appraisal period, assuming implementation of 75yr Standard of Protection.

4.4 Critical Infrastructure

Over the 100-year appraisal period a total of 112 electrical substations are at risk in the Do-Nothing scenario. This suggests a disruption to the local electrical infrastructure across the city.

Several educational properties are at risk over the 100-year appraisal period for the Do-Nothing scenario. This includes 3 primary schools and 2 nurseries.

- St. Philips Marsh nursery school
- St. Nicholas of Tolentino RC primary school
- St. Mary Redcliffe & Temple C of E school
- Holy Cross Catholic Primary School
- Teddies Nursery

Community centres at risk over the 100-year appraisal period for the Do Nothing (DoN) scenario:

- TS Adventure Sea Cadets
- The Meriton Education and Support for Young Parents
- Redcliffe Children's Centre
- Parkway Parent and Child Project
- Broad Plain Boys Club
- Marksbury Road Library

Emergency service centres at risk over the 100-year appraisal period for the DoN scenario:

- Avon Fire & Rescue Service (Hartcliffe Way & Temple back)
- Avon & Somerset Constabulary (Clanage Road)

5 Strategy costs

The costs of the Strategy have been developed across the 2 Phases of development in detail, down to the type of construction considered for each defence, and how / when each component would be designed to allow for raising to 2125 standard.

Some components of the costs allow for elements of “Placemaking”, The table below, for the purposes of Grant in Aid eligible costs, does not include these components. Placemaking costs amounted to approx. £20m of the strategy costs.

Maintenance costs take account of two major repairs to defences or locks over the lifetime of the strategy, assumed to occur at year 33 and year 67 of strategy life, as well as annual maintenance to both.

Table 15: Net Present Value strategy costs (NPV to a base year of 2025)

Option	Capital works, 2025 (£m)	Capital works, 2065 (£m)	Whole life maintenance costs (£m)	Total Whole Life Cost (£m)
Do Nothing	0	0	0	0
Do Minimum	14	0	5	19
2065 75yr SoP in 2025, uplift to 2125 75yr SoP in 2065	213.7	7.9	24.1	245.7
2065 100yr SoP in 2025, uplift to 2125 100yr SoP in 2065	215.3	7.9	25.2	248.5
2065 200yr SoP in 2025, uplift to 2125 200yr SoP in 2065	223.3	7.9	25.5	256.7
2065 NPPF Standard in 2025, uplift to 2125 Standard SoP in 2065	216.0	9.1	24.3	249.3

6 Application of the Decision Rule

6.1 Results

Capped PVD damages, the net benefit of implementing each of the options, and the project costs are used to calculate the benefit cost ratios shown in Table 16 below.

Table 16 Benefit cost ratios for each phase

Option	Damages (£m)	Intangible benefits (£m)	Benefits (£m)	Costs (£m)	Benefit Cost Ratio	Incremental Benefit Cost Ratio to next option
Do Nothing	1046	0	0	0	-	9.0
Do Minimum	886	5	160	19	8.4	3.62
75yr SoP	65.5	28	980.4	245.7	4.0	0.04
100yr SoP	65.4	28	980.5	248.5	4.0	1.27
200yr SoP	51.6	29	994.4	256.7	3.9	-

Application of the Decision Rule

From the Do Minimum, an IBCR > 1 is required to progress to a subsequent option. The analysis indicates an IBCR > 3.

From the 75yr SoP, an IBCR > 1 is required to progress to consideration of the next option, and this is not achieved.

Therefore, the strategy that the calculation of Grant in Aid should be based on is a 75year strategy, constructed to the 2065 200yr standard in 2025 and uplifted to the 2125 75yr standard in 2065.

The benefits of the 75yr and 100yr standard are unusually close in value, so this has been investigated in greater depth.

- The strategy comprises a mix of core benefit areas, around which the strategy design has been developed, and areas that are protected from detriment. For the areas that are protected from detriment, it happens to be the case that higher flood defences at the core benefit area result in higher water levels (when compared with lower flood defences) at the areas protected from detriment. Essentially, higher flood defence levels reduce the relieving mechanisms that would have applied in exceedance events.
- This does not mean that those areas are at worse flood risk, but it does mean that the relationship between their residual damages and the standard of protection is inverted when compared with the core benefit areas. The overall impact on residual benefits is however a balance between the direct protection provided by the detriment flood defences, and the raised residual risk, and it is the tipping of this balance back in

favour of the effect of the protection that results in higher benefits for the 200year standard.

6.2 Grant in Aid

It has been assumed in the calculator that, to allow for pluvial flood risk, only 90% of properties can be claimed. 90% reflects the ratios of residential flood damages before capping with and without the pluvial adjustment. The property counts are given below in **Error! Reference source not found.** and **Error! Reference source not found.**. These properties can be seen in Figures 6 and 7.

Table 17: Outcome measure 2a- households at risk today that are better protected against flood risk by this project

N° households in deprived areas		at risk today				
20% most deprived		96	17	0	34	
21% to 40% most deprived		89	100	0	222	
60% least deprived		114	105	0	232	
		low risk	moderate risk	intermediate risk	significant risk	very significant risk
N° households in deprived areas		at risk after duration of benefits				
20% most deprived		85	13	17	0	32
21% to 40% most deprived		200	95	48	0	68
60% least deprived		258	114	62	4	13
		low risk	moderate risk	intermediate risk	significant risk	very significant risk

Table 18: Outcome measure 2b- additional households at risk in 2040 that are better protected against flood risk by this project

N° households in deprived areas		at risk in 2040				
20% most deprived		2	1	0	0	0
21% to 40% most deprived		12	0	0	0	0
60% least deprived		23	0	0	0	0
		low risk	moderate risk	intermediate risk	significant risk	very significant risk
N° households in deprived areas		at risk after duration of benefits				
20% most deprived		2	1	0	0	0
21% to 40% most deprived		3	0	1	0	8
60% least deprived		23	0	0	0	0
		low risk	moderate risk	intermediate risk	significant risk	very significant risk

Future costs of maintenance and the uplifts to raise the scheme to a higher standard of protection at a later stage are less than 20% of the upfront costs. This

allows the same funding period for the strategy to be assumed as the appraisal period, 100 years.

The Grant in Aid calculator shows that present value FCERM Grant in Aid contributions to up-front costs should be £68.6m (Appendix A).

6.3 Local Choice

Bristol City Council’s ambitions for Western Harbour, Bristol Temple Quarter and St. Philip’s Marsh merit the consideration of a National Planning Policy Guidance compatible standard of protection. Such a strategy would be constructed to the greater of the 100year fluvial, or 200year tidal SoP, with greater allowances for climate change. The defences however would not need to be constructed with freeboard, because uncertainty in flood risk can be managed by development behind the defences through their own application of freeboard in their floor levels.

Comparison of such a strategy suggests that the first phase would have defence heights lower than a 200year strategy. but that the second phase would be very comparable in level to the 200year strategy.

The cost analysis suggests that in Net present terms, the NPPF strategy would cost £225m NPV capital works (compared to £222m for the grant eligible strategy).

However the Phase 1 capital cost would be £216m. This would require additional funding of approx. £147.5m on top of the £68.5m Grant in Aid funding.

The remaining decision for the council is around the placemaking costs, which would elevate the NPV capital costs of the strategy to approx. £253m. These additional £21m costs will help to make these very significant civil works fit into the context of the city, aiding visual amenity an accessibility in this very visible setting. Including placemaking, this would require additional funding of approx. PV £184.5m on top of the Grant in Aid funding.

7 The case for funding by Bristol City Council

The potential local benefits, of the Local Choice “NPPF-Compliant” strategy, are shown in Table 19, below.

Table 19: Local benefit of the Local Choice

	NPPF Compliant strategy		Other standards of protection	
	Benefit compared to Do Nothing	Benefit compared to Do Minimum	Minimum Benefit compared to Do Nothing	Minimum Benefit compared to Do Minimum
Commercial property damage and infrastructure disruption avoided	£405m	£281m	£405m	£281m

Disruption to businesses avoided	£250m	£250m	£250m	£250m
Growth enabled at unlocked sites (EDNA sites)	£5,635m	£5,635m	>0	>0
Growth enabled at unlocked sites (Growth and Regeneration sites)	£1,513m	£1,513m	>0	>0
Jobs created through construction	£25m	£25m	£10m	£10m
Disruption to the tourism sector avoided	£263m	£21m	£263m	£21m
Benefit of enabling green transport infrastructure	£18m	£18m	£18m	£18m
TOTAL	£8,109m	£7,743m	£946m	£580m

Clearly the bulk of these benefits are associated with the growth enabled at unlocked sites, particularly associated with delivery of an NPPF-compliant scheme. At lesser standards of protection, not compliant with NPPF, a flood strategy will still have some influence in enabling development to proceed to planning consent earlier, or at lesser expense, however it may be much reduced. Nonetheless, because they would have that influence, the overall benefits presented above for “Other standards of Protection” are a minimum.

It is important to recognise that identification of the potential local benefit of the strategy is not the same as claiming all these benefits toward a funding application. Flood risk is not the only infrastructure issue to be resolved to enable the unlocked sites or the greenway, and the benefits identified above would need to be apportioned across several infrastructure investments. However, without resolving flood risk, it is true to say that these developments will only proceed with significant delay or cost.

Further work would be necessary to resolve this analysis in greater detail, and this should focus on assessing the potential benefits associated with unlocking the Growth and Regeneration sites and resolving the potential overlapping claims to infrastructure funding associated with these sites.

8 Phase 1 Build stages

The first phase of the strategy may be delivered over several years and could progress as one package or as a number of discrete packages. There may be key elements in different areas that need to progress in advance, and more complex areas that are likely to be delivered by BCC, with support from the Environment Agency.

The interactions of the different elements of the scheme need to be worked through in greater detail at Outline Business Case: the flood gates at Entrance Lock and Netham risk impacting on ongoing navigation; defences interface with existing EA assets, raised defences along the New Cut interface with highways, the railway and other BCC assets.

Sections of the strategy could be delivered by developers. A review of the following impacts on the timing of the key reach areas has been assessed.

- Reliance on other projects
- Abortive work
- Construction inefficiency
- Impairment of development opportunities
- Detriment implications

Components with a low risk of impact have been prioritised, leading to the initially suggested build priority of the Phase 1 works below. Supporting Partnership Funding Calculations can be found in Appendix A.

Key points of this approach

- Detriment mitigation addressed upfront, so that strategy is flood risk assessment compliant.
- Each stage is cost beneficial

Table 20: Suggested build priority of Phase 1 works.

	Components	Benefits (£m)	Capital works (£m)	Estimated Grant in Aid funding (£m)	Funding required (£m)
First Build	Entrance & Netham Lock flood gates Detriment mitigation works	228	89	14	75 (84% of build)
Second Build	The remainder of Phase 1.	753	127	55.3	72 (57% of build)

This suggested staging should be considered in greater detail to see if smaller ‘sub-stages’ can be identified prior to proceeding to Outline Business Case (OBC). These stages have not been explicitly modelled, and separate OBC documents will be necessary to bring out the nuances / detail of each of these stages.

9 Sensitivity Analysis

Decision Rule

The cost of the 75yr SoP strategy would have to more than triple for the Decision Rule to find the Do Minimum as the preferred option. Similarly the benefit of the 75yr SoP would have to be more than halved.

The benefit of the 100yr SoP strategy would only need to increase 1% to become the preferred option, and this seems eminently possible given the subtleties around increasing residual damages at the detriment mitigation benefit areas (see Section 6.1). The high sensitivity is driven by relatively low costs differences between the different standards.

Given the interplay between residual damages and the direct protection, it is also possible for the 200yr SoP strategy to become the preferred option, if the benefits of that strategy increased by 1.5%, but those of the 100yr SoP did not change (the 100yr SoP would be said to be “dominated”). The associated changes in Grant in Aid could be relatively minor however – at a 1.5% increase in benefits, the 200yr SoP would yield a £2m increase in Grant in Aid.

Available funding

Estimates of GiA funding are dependent on the relative ratio of up front and future costs, overall estimates of funding, and property numbers.

It is notable that the Partnership Funding Calculator is providing a **very low rate of return on benefits**: £68.6m GiA compared to £980m benefits is a 1:14 return.

OM	Damage type	Qualifying benefits (£m)	%age of benefits	Payment rate (p/£)	Eligible Grant in Aid
OM1a	Overall damages	844	86.1%	6	50.6
OM1b	People related	118	12%	20	23.6
	Deprivation				
OM2	20% most deprived	0.25	0.0%	45	0.1
	21% to 40% most deprived	7.5	0.8%	30	2.3
	60% least deprived	10.7	1.1%	20	2.1
TOTAL		980.4		Pv. max eligible GiA	78.7

The pv max. eligible GiA is scaled down to £68.5m because the calculator adjusts for the proportion that future costs make of the overall scheme cost.

As discussed in Section 4.2, Bristol is subject to a very high level of property write-off: write-offs account for approximately 50% of property damages in the Do Nothing case. This is driven by tidal flooding (for which frequencies of flooding are very sensitive to the effects of climate change), but also by properties being at risk of flooding from both tidal and fluvial mechanisms at once.

Not only is this significantly limiting the amount of benefits claimable as overall benefits (OM1a), it also reduces the proportion that OM1b makes up of the whole. If the routine that calculates write-offs is turned off within our calculations, OM1a

is increased by 6% (because property capping is still a very strong influence), but OM1b is increased by 57%. This would increase Grant in Aid by £10.5m.

The paradox that the property write-offs present is that higher benefits (and higher returns on Grant in Aid) would be achieved by under-representing flood risk. The write-off also potentially incentivises presentation of the business case over a shorter time scale, eg for the appraisal period to end in 2065. This would allow future costs to be reduced (hence increasing the proportion of the funding), as well as reducing the proportion of benefit lost to capping or write-offs. The irony here is that in locations such as this, subject to high flood risk and sensitive to climate change, strategies should be focussed on longer timescales.

It is also notable that the OM2 percentage of the benefits is low compared to the overall percentage that residential benefits make-up of the whole. This suggests low residential property counts. One of the challenges of the property counts is the amount of floodplain within the modelling that does not directly benefit from the interventions – particularly upstream on watercourses like the Malago and Longmoor / Colliter's Brook. Properties in these locations potentially move into worse risk bands over time, counteracting the scheme's benefit moving other properties out of flood risk. Effort has been made to remove these properties from the OM2 counts, but some may remain, and it is recommended that this matter is considered in detail at OBC.

10 Conclusion

10.1.1 Preferred strategy

A preferred flood strategy has been identified for Bristol Avon. This is a strategy, based on an NPPF compliant defence, constructed (in Phase 1) with an allowance for climate change up to 2065, and raised in 2065 (Phase 2) to include an allowance up to 2125.

10.1.2 Grant in Aid eligible benefits

The strategy would deliver Grant in Aid eligible benefits to the nation through flood damage avoided of £980m. It moves some 553 residential properties at flood risk today to a lower risk band at the end of the appraisal, and a further 28 that would have become at risk by 2040 because of climate change.

10.1.3 Grant in Aid Funding

This strategy has an estimated capital cost for Phase 1 of £223m. The Grant in Aid funding identified for this strategy has been identified at a maximum of £68.5m, requiring funding of £147.5m to be secured for Phase 1 to proceed.

Present Value maintenance costs, and the capital works to uplift the defence in Phase 2 are estimated at £33.4m.

10.1.4 The case for other sources of funding

In terms of the local economy, the strategy would help deliver significant benefits through avoided damage to businesses and infrastructure (£400m), avoided disruption to local businesses (£250m) and the creation of construction jobs (£25m).

There are proposed developments capable of generating an estimated (£7.1bn) GVA located in the benefitting floodplain of the strategy – and while it's true to say that the progression of these developments is not solely dependent on delivery of a flood strategy (and therefore the strategy could not 'claim' all these benefits), it is also true to say that delivery of the strategy will enable these to progress to a faster timescale and lower cost.

The city's ambitions for growth outside of the floodplain require an effective integrated transport network linking it to the city centre, and Bristol Temple Meads rail station is seen as the key hub of that network. However, the station, and routes to and from the station are at risk of disruption from flooding, and the strategy proposals would form a key part of making this ambition effective.

The Bristol tourist industry is centred on the Floating Harbour as an aesthetic heritage site. Failure to protect the Harbour could effectively lead to a significant portion of this industry being written off, and the estimated benefit of protecting the Harbour is valued at approx. £260m.

10.1.5 Further considerations

The costs and benefit values presented in this report are estimates based on information available prior to its preparation. Values should continue to be refined at Outline Business Case stage in consultation with the Environment Agency Large Project Review Group (LPRG) to confirm the economic case for the strategy.

The Build Stages outlined in this report should be considered in greater detail to see if smaller 'sub-stages' can be identified prior to proceeding to Outline Business Case (OBC). These stages have not been explicitly modelled, and separate OBC documents will be necessary to bring out the nuances / detail of each of these stages.

The approach to strategic consideration of flood risk has made reasonable allowances for pluvial flood risk within the overlapping area to reduce the risk of double counting. However, this element of the analysis will need to be progressed through a greater level of interaction with BCC's emerging surface water flood risk management plan, its proposals and the latest surface water risk mapping.

The amount of Grant in Aid indicated by the Partnership Funding Calculator seems low compared to the overall damages, and this seems that Bristol's particularly high flood risk is in fact limiting the potential return on benefits due to high levels of write-offs and property capping. This seems counter intuitive, and it is recommended that the economic effects of wide scale property write-off are explored in greater depth to understand whether further benefits can be claimed.

The calculator in its latest form (released April 2020) is relatively untested, and the circumstances of Bristol are relatively unique and extreme. We would welcome further discussions with LPRG to explain how Bristol's circumstances are potentially leaving it at a disadvantage to other areas and explore how the underlying guidance could be applied to maximise funding to Bristol.

Regardless of the above effect due to capping and write-off, the build-up of costs and benefits should remain under review at OBC, and further sources of Grant in Aid eligible benefit should be explored, for instance reductions in the carbon footprint associated with flood damage.

Planning and development is an evolving process, and the benefit case for funding leveraged against the identified developments in the floodplain will need to evolve with those developments. It is recognised that the flood strategy is not the only component of enabling works, and the attribution of benefits / funding across different initiatives will need to be managed at a city level to avoid double counting. This means that the local funding element of this analysis will need to be kept up to date with this evolving situation.

Flood and Coastal Erosion Risk Management (FCERM)

Partnership Funding (PF) calculator 2020 for Flood and Coastal Erosion Risk Management Grant-in-Aid (FCERM GiA)

Version 1: March 2020 (for use by projects delivering FCERM outcomes after 1 April 2021)

Key	input	selection
	calculated cells	

SECTION 1: Project details

Project Name	Bristol Flood Strategy
National Project number	
Date of PF Calculator	28 July 2020
Lead RMA	Bristol City Council
FCERM GiA applicant type	Local Authority

Project stage	
Option reference	Preferred option 75yr SoP

Benefit:Cost ratio	4.0 to 1
Effective return to taxpayer:	14.3 to 1
Effective return on contributions:	6.6 to 1

All values in £ (pound Sterling)

Figures in blue to be included in the national FCERM capital programme for the chosen option

SECTION 2: Prospect of eligibility for FCERM GiA

Confirmed strategic approach?	Yes	See guidance. Evidence provided in the business case		
Raw PF Score	32%	Adjusted PF Score	100%	Review maturity of the risk contingency and any contributions to minimise the risk of exceeding FCERM GiA limits
Minimum pv contribution/saving required	£ 147,466,930	pv FCERM GiA up-front costs	£ 68,585,070	
pv maximum eligible FCERM GiA	£ 78,743,376	pv FCERM GiA future costs	£ -	Other RMAs not eligible for FCERM GiA towards future costs

SECTION 3: Costs and contributions for the PREFERRED OPTION (over the duration of benefits period)

Project costs	Towards qualifying outcomes	Contributions secured to date	towards pv appraisal costs	towards pv qualifying outcomes up-front	towards pv qualifying outcomes future	Contributor(s) or Fund(s)
pv appraisal costs	£ 2,352,000	pv Local Levy				
pv design and construction costs	£ 133,562,500	pv other public sector	£ 1,417,000	£ 145,665,930		BCC
pv risk contingency	£ 80,137,500	pv private and voluntary sector				
pv costs for approval	£ 216,052,000	pv other Environment Agency	£ 384,000			
pv future costs	£ 32,000,000	pv sub-total	£ 1,801,000	£ 145,665,930	£ -	
pv WLC (over duration of benefits)	£ 248,052,000	pv total contributions	£ 147,466,930			

Contributions to future costs are not included in GiA calculation. Other RMAs are encouraged to secure contributions towards future costs, separately

SECTION 4: Outcome Measure 1 - economic benefits arising from FCERM

pv WLB (appraisal period)	£ 980,400,000	Economic summary sheet completed	
Duration of benefits (DoB) period	100	Economic data included in business case?	
pv WLB (DoB = OM1A)	£ 980,400,000		
People related impacts - due to measures proposed (DoB = OM1B)	£ 118,000,000		

SECTION 5A: Outcome Measure 2A (today) - households at risk today that are better protected against flood risk by this project (over the duration of benefits period)

N° households in deprived areas	at risk today					change due to project					pv qual. benefits	
	low risk	moderate risk	intermediate risk	significant risk	very significant risk	low risk	moderate risk	intermediate risk	significant risk	very significant risk	£	£
20% most deprived	96	17	0	0	34	85	-83	0	0	-2	£ 240,704	
21% to 40% most deprived	89	100	0	0	222	200	6	-52	0	-154	£ 7,751,713	
60% least deprived	114	105	0	0	232	258	0	-43	4	-219	£ 10,647,185	

N° households in deprived areas	at risk after duration of benefits					Annual damages avoided (£) compared with a household at low risk				
	low risk	moderate risk	intermediate risk	significant risk	very significant risk	low risk	moderate risk	intermediate risk	significant risk	very significant risk
20% most deprived	85	13	17	0	32	0	59	294	1000	1589
21% to 40% most deprived	200	95	48	0	68					
60% least deprived	258	114	62	4	13					

The deprivation categories are taken from the Index of Multiple Deprivation, available through gov.uk (see guidance and version sheet for links)

SECTION 5B: Outcome Measure 2B (2040) - households at risk in 2040 that are better protected against flood risk by this project (over the remaining duration of benefits period)

Year when measures are ready for service Gateway 4	2025
--	------

N° households in deprived areas	at risk from 2040					change due to project					pv qual. benefits	
	low risk	moderate risk	intermediate risk	significant risk	very significant risk	low risk	moderate risk	intermediate risk	significant risk	very significant risk	£	£
20% most deprived	2	1	0	0	0	2	-1	-1	0	0	£ 6,123	
21% to 40% most deprived	12	0	0	0	0	3	-12	1	0	8	-£ 213,289	
60% least deprived	23	0	0	0	0	23	-23	0	0	0	£ 23,472	

N° households in deprived areas	at risk after duration of benefits					Annual damages avoided (£) compared with a household at low risk				
	low risk	moderate risk	intermediate risk	significant risk	very significant risk	low risk	moderate risk	intermediate risk	significant risk	very significant risk
20% most deprived	2	1	0	0	0	0	59	294	1000	1589
21% to 40% most deprived	3	0	1	0	8					
60% least deprived	23	0	0	0	0					

The deprivation categories are taken from the Index of Multiple Deprivation, available through gov.uk (see guidance and version sheet for links)

SECTION 6: Outcome Measure 3 - households better protected against coastal erosion

N° households in deprived areas	at risk today		Damages per household avoided:		pv qual. benefits	
	long-term loss	medium-term loss	Annual damages avoided	Loss expected in	£	£
20% most deprived			£ 6,800	£ 6,800	£ -	£ -
21% to 40% most deprived			50	20	£ -	£ -
60% least deprived			£ 1,341	£ 3,417	£ -	£ -

Present value of Year 1 loss (i.e. first year damages, discounted based on when loss is expected)

SECTION 7: Outcome Measure 4 - environmental improvements

Type of habitat (OM4A)	'before' condition (Ha)			'after' condition at end of DoB (Ha)			pv qual. benefits	Length of river habitat enhanced (OM4B)		pv qual. benefits
	Poor	Moderate	Good	Poor	Moderate	Good		Comprehensive restoration	Partial restoration	
Intertidal habitat							£ -		£ -	
Woodland							£ -		£ -	
Wet woodland							£ -		£ -	
Wetlands/wet grassland							£ -		£ -	
Grassland							£ -		£ -	
Heathland							£ -		£ -	
Ponds/lakes							£ -		£ -	
Arable land							£ -		£ -	

SECTION 8: Qualifying benefits and eligible FCERM GiA arising from project

OM	deprivation	Qualifying benefits	%age benefits	Payment rate	Eligible FCERM GiA	%age
OM1a	overall	£ 843,944,092	86.1%	6	£ 50,636,646	64.3%
OM1b	people related	£ 118,000,000	12.0%	20	£ 23,600,000	30.0%
OM2	20% most	£ 246,827	0.0%	45	£ 111,072	0.1%
	21% to 40%	£ 7,538,424	0.8%	30	£ 2,261,527	2.9%
	60% least	£ 10,670,657	1.1%	20	£ 2,134,131	2.7%
OM3	20% most	£ -	0.0%	45	£ -	0.0%
	21% to 40%	£ -	0.0%	30	£ -	0.0%
	60% least	£ -	0.0%	20	£ -	0.0%
OM4	habitat	£ -	0.0%	20	£ -	0.0%
	ivers	£ -	0.0%	20	£ -	0.0%
Total		£ 980,400,000		pv max. eligible GiA	£ 78,743,376	

Example sensitivity analyses

Test	Raw score	Contributions required	%age of whole life costs
PF Calculator (above)	32%	£ 147,466,930	68%
SA1: pv WLC - Affordability	25%	£ 201,479,929	65%
SA2: OM2 - Flood risks lower than assumptions made	31%	£ 148,224,583	60%
SA3: OM3 - Erosion risks lower than assumptions made	N/A	No OM3 contribution	n/a
SA4: Duration of benefits - Option choice is conservative	32%	£ 147,466,929	59%
SA5: Duration of benefits - Option choice is optimistic	32%	£ 147,637,368	60%
SA6: Strategic considerations not demonstrated	14%	£ 185,188,718	75%
SA7: Change in environmental habitat is optimistic	N/A	No OM4 contribution	n/a

Flood and Coastal Erosion Risk Management (FCERM)

Partnership Funding (PF) calculator 2020 for Flood and Coastal Erosion Risk Management Grant-in-Aid (FCERM GiA)

Version 1: March 2020 (for use by projects delivering FCERM outcomes after 1 April 2021)

Key	input	selection
	calculated cells	

SECTION 1: Project details

Project Name	Bristol Flood Strategy
National Project number	
Date of PF Calculator	28 July 2020
Lead RMA	Bristol City Council
FCERM GiA applicant type	Local Authority

Project stage	
Option reference	75yr SoP Build Stage 1

Benefit:Cost ratio	2.2 to 1
Effective return to taxpayer:	16.1 to 1
Effective return on contributions:	3.0 to 1

All values in £ (pound Sterling)

Figures in blue to be included in the national FCERM capital programme for the chosen option

SECTION 2: Prospect of eligibility for FCERM GiA

Confirmed strategic approach?	Yes	See guidance. Evidence provided in the business case		
Raw PF Score	16%	Adjusted PF Score	100%	Review maturity of the risk contingency and any contributions to minimise the risk of exceeding FCERM GiA limits
Minimum pv contribution/saving required	£ 75,845,531	pv FCERM GiA up-front costs	£ 14,153,753	
pv maximum eligible FCERM GiA	£ 16,517,755	pv FCERM GiA future costs	£ -	Other RMAs not eligible for FCERM GiA towards future costs

SECTION 3: Costs and contributions for the PREFERRED OPTION (over the duration of benefits period)

Project costs	Towards qualifying outcomes	Contributions secured to date	towards pv appraisal costs	towards pv qualifying outcomes up-front	towards pv qualifying outcomes future	Contributor(s) or Fund(s)
pv appraisal costs	£ 823,200	pv Local Levy				
pv design and construction costs	£ 55,735,053	pv other public sector	£ 495,950	£ 75,215,181		BCC
pv risk contingency	£ 33,441,032	pv private and voluntary sector				
pv costs for approval	£ 89,999,284	pv other Environment Agency	£ 134,400			
pv future costs	£ 15,031,942	pv sub-total	£ 630,350	£ 75,215,181		
pv WLC (over duration of benefits)	£ 105,031,226	pv total contributions	£ 75,845,531			

Contributions to future costs are not included in GiA calculation. Other RMAs are encouraged to secure contributions towards future costs, separately

SECTION 4: Outcome Measure 1 - economic benefits arising from FCERM

pv WLB (appraisal period)	£ 227,750,000	Economic summary sheet completed	
Duration of benefits (DoB) period	100	Economic data included in business case?	
pv WLB (DoB = OM1A)	£ 227,750,000		
People related impacts - due to measures proposed (DoB = OM1B)	£ 20,000,000		

SECTION 5A: Outcome Measure 2A (today) - households at risk today that are better protected against flood risk by this project (over the duration of benefits period)

N° households in deprived areas	at risk today					change due to project					pv qual. benefits	
	low risk	moderate risk	intermediate risk	significant risk	very significant risk	low risk	moderate risk	intermediate risk	significant risk	very significant risk	£	
20% most deprived	14	1	0	0	0	15	-14	-1	0	0	£	33,382
21% to 40% most deprived	24	16	0	0	62	37	-24	-15	0	2	£	79,063
60% least deprived	10	6	0	0	22	18	2	-4	0	-16	£	790,633

N° households in deprived areas	at risk after duration of benefits					Annual damages avoided (£) compared with a household at low risk				
	low risk	moderate risk	intermediate risk	significant risk	very significant risk	0	59	294	1000	1589
20% most deprived	15	0	0	0	0					
21% to 40% most deprived	37	0	1	0	64					
60% least deprived	18	12	2	0	6					

The deprivation categories are taken from the Index of Multiple Deprivation, available through gov.uk (see guidance and version sheet for links)

SECTION 5B: Outcome Measure 2B (2040) - households at risk in 2040 that are better protected against flood risk by this project (over the remaining duration of benefits period)

Year when measures are ready for service - Gateway 4	2025
--	------

N° households in deprived areas	at risk from 2040					change due to project					pv qual. benefits	
	low risk	moderate risk	intermediate risk	significant risk	very significant risk	low risk	moderate risk	intermediate risk	significant risk	very significant risk	£	
20% most deprived	1	0	0	0	0	0	-1	1	0	0	-£	4,082
21% to 40% most deprived	12	0	0	0	0	3	-12	1	0	8	-£	213,289
60% least deprived	10	0	0	0	0	0	-10	0	0	10	-£	265,335

N° households in deprived areas	at risk after duration of benefits					Annual damages avoided (£) compared with a household at low risk				
	low risk	moderate risk	intermediate risk	significant risk	very significant risk	0	59	294	1000	1589
20% most deprived	0	0	1	0	0					
21% to 40% most deprived	3	0	1	0	8					
60% least deprived	0	0	0	0	10					

The deprivation categories are taken from the Index of Multiple Deprivation, available through gov.uk (see guidance and version sheet for links)

SECTION 6: Outcome Measure 3 - households better protected against coastal erosion

N° households in deprived areas	at risk today		Damages per household avoided:		pv qual. benefits	
	long-term loss	medium-term loss	Annual damages avoided	Loss expected in	£	£
20% most deprived			£ 6,800	£ 6,800	£	-
21% to 40% most deprived			50	20	£	-
60% least deprived			£ 1,341	£ 3,417	£	-

Present value of Year 1 loss (i.e. first year damages, discounted based on when loss is expected)

SECTION 7: Outcome Measure 4 - environmental improvements

Type of habitat (OM4A)	'before' condition (Ha)			'after' condition at end of DoB (Ha)			pv qual. benefits	Length of river habitat enhanced (OM4B)	pv qual. benefits
	Poor	Moderate	Good	Poor	Moderate	Good			
Intertidal habitat							£ -	Comprehensive restoration Partial restoration A single, major physical improvement	£ -
Woodland							£ -		£ -
Wet woodland							£ -		£ -
Wetlands/wet grassland							£ -		£ -
Grassland							£ -		£ -
Heathland							£ -		£ -
Ponds/lakes							£ -		
Arable land							£ -		

SECTION 8: Qualifying benefits and eligible FCERM GiA arising from project

OM	deprivation	Qualifying benefits	%age benefits	Payment rate	Eligible FCERM GiA	%age
OM1a	overall	£ 207,329,628	91.0%	6	£ 12,439,778	75.3%
OM1b	people related	£ 20,000,000	8.8%	20	£ 4,000,000	24.2%
OM2	20% most	£ 29,300	0.0%	45	£ 13,185	0.1%
	21% to 40%	£ 134,225	-0.1%	30	£ 40,268	-0.2%
	60% least	£ 525,297	0.2%	20	£ 105,059	0.6%
OM3	20% most	£ -	0.0%	45	£ -	0.0%
	21% to 40%	£ -	0.0%	30	£ -	0.0%
	60% least	£ -	0.0%	20	£ -	0.0%
OM4	habitat	£ -	0.0%	20	£ -	0.0%
	ivers	£ -	0.0%	20	£ -	0.0%
Total		£ 227,750,000		pv max. eligible GiA	£ 16,517,755	

Example sensitivity analyses

Test	Raw score	Contributions required	%age of whole life costs
PF Calculator (above)	16%	£ 75,845,531	84%
SA1: pv WLC - Affordability	13%	£ 98,345,351	75%
SA2: OM2 - Flood risks lower than assumptions made	16%	£ 75,980,725	72%
SA3: OM3 - Erosion risks lower than assumptions made	N/A	No OM3 contribution	n/a
SA4: Duration of benefits - Option choice is conservative	16%	£ 75,845,530	72%
SA5: Duration of benefits - Option choice is optimistic	16%	£ 75,844,926	72%
SA6: Strategic considerations not demonstrated	7%	£ 83,630,095	80%
SA7: Change in environmental habitat is optimistic	N/A	No OM4 contribution	n/a

Flood and Coastal Erosion Risk Management (FCERM)

Partnership Funding (PF) calculator 2020 for Flood and Coastal Erosion Risk Management Grant-in-Aid (FCERM GiA)

Version 1: March 2020 (for use by projects delivering FCERM outcomes after 1 April 2021)

Key	input	selection
	calculated cells	

SECTION 1: Project details

Project Name	Bristol Flood Strategy
National Project number	
Date of PF Calculator	28 July 2020
Lead RMA	Bristol City Council
FCERM GiA applicant type	Local Authority

Project stage	
Option reference	75yr SoP Build stage 2

Benefit:Cost ratio	5.2 to 1
Effective return to taxpayer:	13.6 to 1
Effective return on contributions:	10.3 to 1

All values in £ (pound Sterling)

Figures in blue to be included in the national FCERM capital programme for the chosen option

SECTION 2: Prospect of eligibility for FCERM GiA

Confirmed strategic approach?	Yes	See guidance. Evidence provided in the business case		
Raw PF Score	43%	Adjusted PF Score	100%	Review maturity of the risk contingency and any contributions to minimise the risk of exceeding FCERM GiA limits
Minimum pv contribution/saving required	£ 72,997,558	pv FCERM GiA up-front costs	£ 55,307,122	
pv maximum eligible FCERM GiA	£ 62,617,669	pv FCERM GiA future costs	£ -	Other RMAs not eligible for FCERM GiA towards future costs

SECTION 3: Costs and contributions for the PREFERRED OPTION (over the duration of benefits period)

Project costs	Towards qualifying outcomes	Contributions secured to date	towards pv appraisal costs	towards pv qualifying outcomes up-front	towards pv qualifying outcomes future	Contributor(s) or Fund(s)
pv appraisal costs	£ 1,528,800	pv Local Levy				
pv design and construction costs	£ 79,234,925	pv other public sector	£ 921,050	£ 71,826,908		BCC
pv risk contingency	£ 47,540,955	pv private and voluntary sector				
pv costs for approval	£ 128,304,680	pv other Environment Agency	£ 249,600			
pv future costs	£ 16,959,430	pv sub-total	£ 1,170,650	£ 71,826,908		
pv WLC (over duration of benefits)	£ 145,264,110	pv total contributions	£ 72,997,558			Contributions to future costs are not included in GiA calculation. Other RMAs are encouraged to secure contributions towards future costs, separately

SECTION 4: Outcome Measure 1 - economic benefits arising from FCERM

pv WLB (appraisal period)	£ 752,650,000	Economic summary sheet completed	
Duration of benefits (DoB) period	100	Economic data included in business case?	
pv WLB (DoB = OM1A)	£ 752,650,000		
People related impacts - due to measures proposed (DoB = OM1B)	£ 98,000,000		

SECTION 5A: Outcome Measure 2A (today) - households at risk today that are better protected against flood risk by this project (over the duration of benefits period)

N° households in deprived areas	at risk today					change due to project					pv qual. benefits	
	low risk	moderate risk	intermediate risk	significant risk	very significant risk	low risk	moderate risk	intermediate risk	significant risk	very significant risk	£	
20% most deprived	70	26	2	34	70	-57	-9	-2	-2		£	333,823
21% to 40% most deprived	19	102	0	187	162	76	-55	0	-183		£	9,030,781
60% least deprived	102	92	0	215	238	1	-32	4	-211		£	10,169,291

at risk after duration of benefits					
low risk	moderate risk	intermediate risk	significant risk	very significant risk	
70	13	17	0	32	
162	95	47	0	4	
238	103	60	4	4	

Annual damages avoided (£) compared with a household at low risk					
low risk	moderate risk	intermediate risk	significant risk	very significant risk	
0	59	294	1000	1589	

The deprivation categories are taken from the **Index of Multiple Deprivation**, available through gov.uk (see guidance and version sheet for links)

SECTION 5B: Outcome Measure 2B (2040) - households at risk in 2040 that are better protected against flood risk by this project (over the remaining duration of benefits period)

Year when measures are ready for service - Gateway 4	2025
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N° households in deprived areas	at risk from 2040					change due to project					pv qual. benefits	
	low risk	moderate risk	intermediate risk	significant risk	very significant risk	low risk	moderate risk	intermediate risk	significant risk	very significant risk	£	
20% most deprived	7	0	0	1	8	-7	0	0	-1		£	34,698
21% to 40% most deprived	0	0	0	0	0	0	0	0	0		£	-
60% least deprived	0	0	0	1	1	0	0	0	-1		£	27,554

at risk after duration of benefits					
low risk	moderate risk	intermediate risk	significant risk	very significant risk	
8	0	0	0	0	
0	0	0	0	0	
1	0	0	0	0	

Annual damages avoided (£) compared with a household at low risk					
low risk	moderate risk	intermediate risk	significant risk	very significant risk	
0	59	294	1000	1589	

The deprivation categories are taken from the **Index of Multiple Deprivation**, available through gov.uk (see guidance and version sheet for links)

SECTION 6: Outcome Measure 3 - households better protected against coastal erosion

N° households in deprived areas	at risk today		Damages per household avoided:		pv qual. benefits	
	long-term loss	medium-term loss	Annual damages avoided	Loss expected in	£	years
20% most deprived			£ 6,800	£ 6,800	£	-
21% to 40% most deprived			50	20	£	-
60% least deprived			£ 1,341	£ 3,417	£	-

Present value of Year 1 loss (i.e. first year damages, discounted based on when loss is expected)

SECTION 7: Outcome Measure 4 - environmental improvements

Type of habitat (OM4A)	'before' condition (Ha)			'after' condition at end of DoB (Ha)			pv qual. benefits	Length of river habitat enhanced (OM4B)	pv qual. benefits
	Poor	Moderate	Good	Poor	Moderate	Good			
Intertidal habitat							£ -	Comprehensive restoration Partial restoration A single, major physical improvement	£ -
Woodland							£ -		£ -
Wet woodland							£ -		£ -
Wetlands/wet grassland							£ -		£ -
Grassland							£ -		
Heathland							£ -		
Ponds/lakes							£ -		
Arable land							£ -		

SECTION 8: Qualifying benefits and eligible FCERM GiA arising from project

OM	deprivation	Qualifying benefits	%age benefits	Payment rate	Eligible FCERM GiA	%age
OM1a	overall	£ 635,053,854	84.4%	6	£ 38,103,231	60.9%
OM1b	people related	£ 98,000,000	13.0%	20	£ 19,600,000	31.3%
OM2	20% most	£ 368,520	0.0%	45	£ 165,834	0.3%
	21% to 40%	£ 9,030,781	1.2%	30	£ 2,709,234	4.3%
	60% least	£ 10,196,846	1.4%	20	£ 2,039,369	3.3%
OM3	20% most	£ -	0.0%	45	£ -	0.0%
	21% to 40%	£ -	0.0%	30	£ -	0.0%
	60% least	£ -	0.0%	20	£ -	0.0%
OM4	habitat	£ -	0.0%	20	£ -	0.0%
	ivers	£ -	0.0%	20	£ -	0.0%
Total		£ 752,650,000		pv max. eligible GiA	£ 62,617,669	

Example sensitivity analyses

Test	Raw score	Contributions required	%age of whole life costs
PF Calculator (above)	43%	£ 72,997,558	57%
SA1: pv WLC - Affordability	34%	£ 105,073,727	58%
SA2: OM2 - Flood risks lower than assumptions made	43%	£ 73,682,228	51%
SA3: OM3 - Erosion risks lower than assumptions made	N/A	No OM3 contribution	n/a
SA4: Duration of benefits - Option choice is conservative	43%	£ 72,997,557	50%
SA5: Duration of benefits - Option choice is optimistic	43%	£ 73,190,143	50%
SA6: Strategic considerations not demonstrated	19%	£ 103,416,475	71%
SA7: Change in environmental habitat is optimistic	N/A	No OM4 contribution	n/a

Bristol City Council
Bristol Avon Flood Strategy
Economic Appraisal Technical
Report Appendix B – Local flood
risk benefits

Issue 1 | 30 September 2020

This report takes into account the particular instructions and requirements of our client.

It is not intended for and should not be relied upon by any third party and no responsibility is undertaken to any third party.




Job number 260498-00

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Document Verification

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1 Introduction

1.1.1 Objective of this report

Ove Arup and Partners Limited (Arup) have undertaken an economic appraisal for the Bristol Avon Flood Strategy on behalf of Bristol City Council (BCC).

This technical appendix sets out the data and methods used, and results attained to estimate the benefit to the Bristol City Region of the flood risk management options being considered. The unit of impact is a monetary measure of the value added by businesses to the local economy termed Gross Value Added, GVA.

1.1.2 Background

The Environment Agency / Defra Flood and Coastal Erosion Risk Management Grant in Aid (GiA) fund is determined based on the national economic benefits flood damages avoided. The effects on the local economy, of interest to BCC will not necessarily be considered in such an assessment, and these effects are set out in this report.

Figure 1, extracted from the “Frontier methodology”¹, illustrates the areas of overlap between Flood and Coastal Erosion Risk Management benefits, and impacts to the local economy.

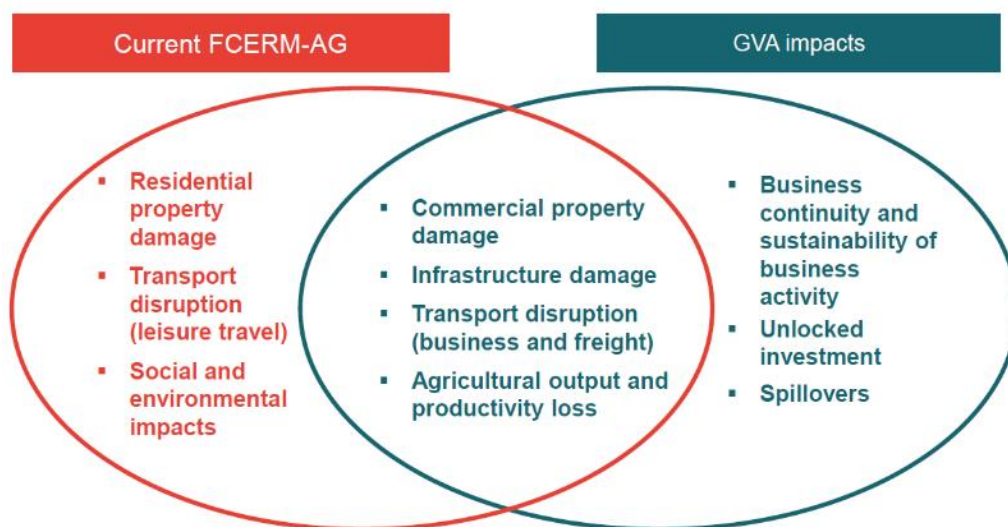


Figure 1: Overlaps between Grant in Aid eligible impacts, and impacts to the local economy

This assessment presents an assessment of the Gross Value Added (GVA) impacts, presented in the right-hand circle of Figure 1.

¹ Defra / EA project FD2662, “Flood and Coastal erosion risk management and the local economy,” March 2014.

2 Methodology

2.1 Overview

The benefits assessed include

- The “first order” losses associated with direct flood impacts on commercial property
- GVA losses saved through reduced flood risk to existing businesses
- GVA earned through jobs created by the unlocking of development on the floodplain
- GVA earned through jobs created by construction of the strategy and the unlocked development.
- GVA losses saved through reduced flood risk to the tourist industry
- Potential health and amenity benefits generated through enabling the creation of a sustainable transport network next to the River Avon.

These benefits have been calculated in-line with HM Treasury Green Book principles and the Homes and Communities Agency (HCA, now Homes England) Additionality Guidelines, as well as the “Frontier methodology”, as detailed in Section 3.

The net economic gain to Bristol as a result of land use changes from the sites potentially unlocked by the reduced flood risk through this strategy is captured by adjusting the gross impacts for additionality, that is “the net, rather than the gross impact of an intervention after making allowances for what would have happened in the absence of the intervention” . The assessment therefore adjusts the gross impacts by considering the following additionality assumptions:

- Deadweight: the level of economic activity that would have occurred without the intervention.
- Leakage: the level of benefits (i.e. jobs on these sites) that are likely to go to residents outside of Bristol who commute in.
- Displacement: the proportion of economic benefits that are displaced from elsewhere in the region
- Multiplier impacts: additional impacts within the economy from supply linkages due to purchases made as a result of the intervention and further purchases with linked firms along the supply chain (indirect effects) and income effects associated with local expenditure as a result of those who derive incomes from the direct and supply linkage impacts (induced effects).

3 First order losses to infrastructure and commercial property

First order losses have been taken from the direct damage calculations presented in the main body of the report, as shown here in Table 1.

Table 1: First order losses to infrastructure and commercial property (£m)

	Do Nothing	Do Minimum	75yr SoP	100yr SoP	200yr SoP
Non-residential properties	473	367	48	44	14
Utilities	35	26	3	3	3
Indirect Commercial losses	16	23	2	2	2
Traffic disruption	10*	9*	0	0	0
Rail Disruption	31*	29*	0	0	0
TOTAL 1st order Losses	565	454	53	49	19

*Commercial traffic and rail disruption estimated at 1/3 of overall disruption

4 GVA loss saved through reduced flood risk to existing businesses

Reducing the flood risk to existing businesses reduces losses as a result of:

- Incurring losses due to business disruption
- Incurring costs spent on adapting their properties to be flood proof
- Going out of business or moving out of the area

The approach for calculating these losses is prescribed in the “Frontier” methodology, a joint Defra/EA flood and coastal erosion risk management (FCERM) research and development programme – project FD2662. This method identifies the likelihood of the above scenarios, based on the Location Dependence and Adaptive Capacity of the business.

Location Dependence and Adaptive Capacity of the business are in turn identified from the Business Type (from National Receptor Dataset) and Business Size (determined from building area in OS Mastermap Data). The economic impacts of flooding are based on the lost earnings of staff (FTE) employed by each business, multiplied by the duration of impact and the frequency of flooding.

The benefits of the intervention are calculated from the impacts avoided, and a range of different standards of protection have been assessed.

This calculation has been carried out at a high level, using available datasets, and generic assumptions of business response to flooding. Improvements in the calculations of disruption could be made using surveys of individual businesses.

4.1 Assumptions

Average duration of disruption:

20 weeks (directly flooded properties). Source: Frontier methodology

3 weeks (disrupted properties). Source: Frontier methodology “with FCERM”

One of the major distinctions made is between properties that flood in an event, and properties that are disrupted by a flood event (eg due to property level protection). This is particularly relevant to more recently developed properties, where while the property itself may be considered raised out of the floodplain, but the road may flood to such a depth that properties along the road may be isolated, and local utilities may be disrupted. Where this is the case, the duration of flood impact is assumed to be an average of 3 weeks (in line with the Frontier methodology’s guidelines on properties with Flood Risk Management measures).

Displacement, Leakage, Multiplier

The Frontier methodology (and the worked examples embedded in the guidance) makes little to no reference to the economic concepts of displacement, leakage or multipliers. Indeed, it notes *“There is little evidence available on the degree of business displacement and additionality. This refers to the fact that new investment facilitated by FCERM could be a net addition to the national economy, as well as the local economy, or it could just be the latter.”* Notwithstanding this statement, it is considered that these effects should apply to assessment of Gross Value Added from FCERM benefits just the same as they would to other any other economic analyses.

- 1) Leakage represents the degree to which the benefits of an intervention are felt outside the study area, and typically reflects how far a workforce may travel to get to its place of employment. This concept remains, regardless of the effect being assessed. The magnitude of leakage tends to reflect the specialism of a role, and how well rewarded it is. Leakage has been assumed at 25%.
- 2) Displacement has been assumed as 25%, reflecting the Regional Level “all observations median” for displacement from the “Research to Improve the Assessment of Additionality.”
- 3) Multipliers represent the indirect and induced impact on the local economy. The assumed multipliers are: Retail, Leisure: 1.3; Financial services, Specialist manufacturing: 1.7; others: 1.5.

Assumed percentage “Move away or Shut Down”:

3% (Range from Frontier = 1.5 – 5%)

Assumed percentage “Stay and Adapt”:

50% (Range from Frontier = 25 – 75%)

Persistence of benefits: 10 years.

Decay (% per annum): 0. The economic benefits are directly attributable to flood risk to existing properties calculated as a probabilistic effect; they do not decay against time due to declining influence of the intervention.

Years over which benefits build: 0. The economic benefits are to existing properties but calculated as a probabilistic effect; they do not build against time.

Percentage vacant: 3% of buildings are assumed to be vacant at any one time.

Deadweight: Deadweight is calculated explicitly, by using a baseline scenario based on the current level of flood risk.

4.1.1 Calculation of assumed earnings per sector

There are 5 key sectors used to define staff earnings: Industry, Retail, Office, Other, and Mixed Business. Annual pay for these sectors has been built up from 2019 census data for the South West from the following sectors:

Table 2: Annual earnings per industry Sector, South West region, 2019.

Industry	25,988	£/yr	Based on weighted average of 5, Skilled Trades, and 8, "Process plant and machine operatives"
Office	32,658	£/yr	Based on weighted average of 1 "Managers, Directors and Senior Officials";2, "Professional Occupations";3,"Associate professional and technical occupations"; 4, "Administrative and secretarial occupations"
Other	26,668	£/yr	Taken from region average
Retail	14,580	£/yr	Taken from "retail"
Mixed B	26,668	£/yr	Taken from region average

These figures have in run been weighted by the ratio between the 2019 mean wage in the South West (£26,668), and the 2019 mean wage in Bristol (£30,768) and uplifted to take account of CPI to 2020 (factor of 1.021). This is an overall uplift of 18% on the figures above, giving:

Table 3: Annual earnings per industry sector, Bristol 2020.

Industry	30,613	£/yr
Office	38,470	£/yr
Other	31,414	£/yr
Retail	17,175	£/yr
Mixed B	31,414	£/yr

4.2 Results

Table 4: Net Gross Value Added (in £m present value) of avoided disruption to businesses.

Option	Lost Net Gross Value Added (£m NPV)	Benefit (£m NPV)
Do Nothing	254.7	0
Do Minimum	254.7	0
Option 6C 75yr adaptive	8.9	244
Option 7C 100yr adaptive	1.2	253
Option 8C 200yr adaptive	0.9	253

4.2.1 Sensitivity testing

Bristol city centre has a high number of heritage buildings to which there may be particular constraints to adaptation. In contrast to this, it also has a number of buildings that would be considered the national or regional headquarters of financial organisations, and these would be considered to have high capacity to adapt.

Sensitivity testing has therefore been undertaken on the assumed percentages of businesses taking up the “Stay and Adapt” strategy (higher percentages of “Stay and Adapt” will conversely result in lower percentages of “Stay and Do Nothing”)

Table 5: Sensitivity testing of “Stay and Adapt” assumption

Option	Benefit Net Gross Value Added (£m NPV)		
	Stay and Adapt = 25%	Stay and Adapt = 50%	Stay and Adapt = 75%
Do Nothing	0	0	0
Do Minimum	0	0	0
Option 6C 75yr adaptive	377	244	112
Option 7C 100yr adaptive	386	253	120
Option 8C 200yr adaptive	386	253	120

5 GVA earned through unlocking development

Developments in central Bristol which are at risk of flooding must be consistent with the ‘sequential approach’ and comply with the ‘exception test’. That means they should deliver sustainable development benefits which outweigh the flood risk and will be safe for their lifetimes without increasing flood risk elsewhere. At present, and without an adopted Bristol Avon Flood Strategy, in practice this is can be impossible to achieve in some locations, including on some sites already allocated for development in the local plan. In such circumstances planning applications will be recommended for refusal because they would be contrary to national planning policies regarding flood risk

The adoption of the Local Choice strategy, which provides a National Planning Policy Framework compatible standard of protection, would therefore be an influence in unlocking development within the floodplain – both through expansion with existing sites, and development of brownfield sites. For lesser standards of protection, this benefit would not accrue.

The method used to assess unlocked development considers:

- Estimate the internal floor area associated with a development

- Identify the proposed uses
- Estimate the gross number of FTE jobs created from the internal floor area, the proposed use, and assumed occupancy rates.
- Create an assumed time profile of construction, occupancy, and decaying benefits to understand how the numbers of jobs are created against time.
- Apply leakage, displacement and multipliers to calculate net FTE.
- Use assumed values of GVA / FTE based on the proposed usage

Where possible, existing data from specific assessments relating to individual sites has been used.

Two core pieces of information have been made available: The Economic Development Needs Assessment (EDNA) dataset, which relates to specific sites that have been allocated and are progressing through the planning system, and BCC's Areas of Growth and Regeneration, identified in the March 2019 consultation of the Bristol Local Plan Review. There are some areas of overlap between the two datasets, and grossly different levels of detail. Two separate assessments have been carried out as part of this study to identify potential volumes of development, and areas of overlap have been identified and resolve where necessary.

Explicit information regarding the areas of Growth and Regeneration has only been available from late in this project: in view of the potential overlaps between these areas, and the EDNA data, the associated benefits of unlocking the Areas of Growth and Regeneration have not been calculated at the time of writing.

5.1 The EDNA calculation

The Economic Development Needs Assessment (EDNA) dataset identifies:

- The gross footprints of different usages in each development. These have been converted to internal floor area by a) an allowance of 15% to convert from external to internal floor area, and b) assumptions regarding the number of floors to each development
- The planning status of each development

The dataset has been filtered to identify properties within the future climate 1% annual change fluvial and 0.5% annual chance tidal flood outline, that have not yet been granted planning permission. This amounts to 30 sites (Figure 2).

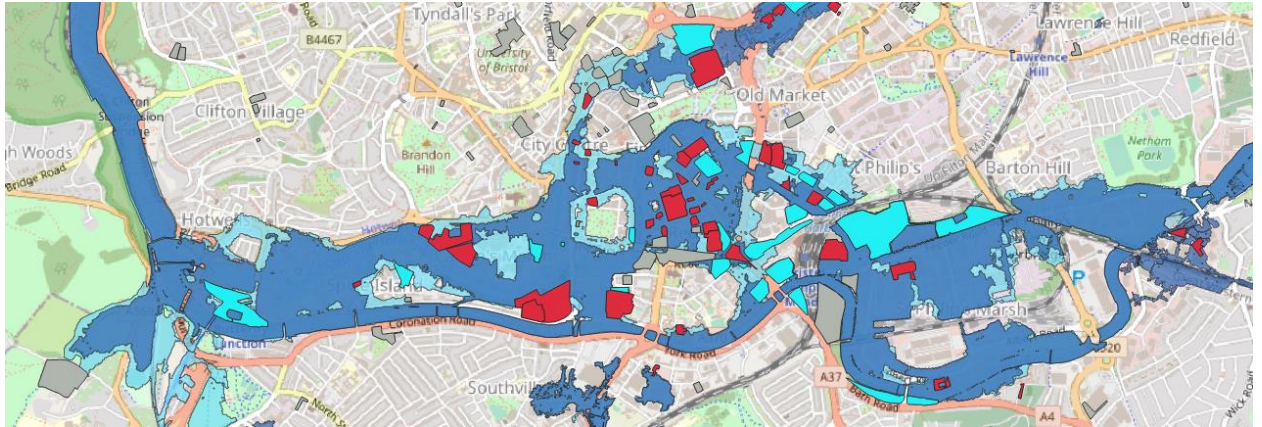


Figure 2: “EDNA Properties” in the floodplain. Red indicates sites already granted planning permission; green indicates allocated sites at flood risk.

In some cases, it has been noted by comparison with alternate sources, or by direct information from BCC staff, that the provided polygons of the EDNA site encompass properties that will in fact be retained. These polygons have been updated so that those properties can still accrue damages, and this is reflected in Figure 2.

The following assumptions have been made for each development type:

Table 6: Assumptions made behind cost build up for each development.

	Industry	Office	Other	Retail	Mixed Businesses
Multiplier	1.7	1.5	1.3	1.2	1.3
m2 / FTE	36	12	90	19	90
Average earnings / FTE (£)	30,613	38,470	31,414	17,175	31,414
Gross/ net floorspace adjustment	0.85	0.85	0.85	0.85	0.85
Assumed number of floors	1	3	2	1.5	2

The average earnings have been derived from Office of National Statistics Census Table 3.7a “Annual pay – Gross (£) for all employee jobs: United Kingdom 2019” This gives pay in individual sectors in the South West region.

Table 7: Calculated sector wage per business type.

Business type	South West Average Pay (£)	Derivation
Industry	25,988	Based on weighted average of 5, Skilled Trades, and 8, "Process plant and machine operatives"
Office	32,658	Based on weighted average of 1 "Managers, Directors and Senior Officials";2, "Professional Occupations";3,"Associate professional and technical occupations"; 4, "Administrative and secretarial occupations"
Other	26,668	Taken from region average
Retail	14,580	Based on "Retail" sector
Mixed Business	26,668	Taken from region average

These has further been converted to rates suitable for Bristol by using the ratio between the South West region and Bristol in Table 7.7a "Annual pay – Gross (£) for all employee jobs: United Kingdom 2019", which gives pay statistics at regional and city levels. This was a ratio of 1.15.

These have further been adjusted to 2020 by the Consumer price Index between 2019 and 2020.

Properties have been filtered to select only those in the 100yr fluvial or 200yr tidal floodplain that do not yet have planning permission. This resulted in a list of 30 sites, with capacity for approx. 30,000 FTE staff.

An allowance of 10% was made for developments that do not progress.

Construction of the proposals is expected to build linearly over a 5-year period from completion of the strategy: i.e. all development will be 100% complete in 2029. The estimated GVA associated with filling the developments was discounted against time using Treasury Green Book rates (3.5%). The assumed duration of benefits is out to 2036, reflecting the Planning Period that the EDNA dataset was based on.

It is assumed that any of these developments require a flood strategy to be in place to go ahead. This is not the same as saying that they are only dependent on a flood strategy to proceed; they may all be subject to other infrastructure requirements.

The calculated benefit of unlocking these developments would be £5,635m.

5.2 Bristol Local Plan Growth and Regeneration areas

The following key developments, shown in Figure 3 below, are noted:

- **Western Harbour**
- **Temple Quarter**
- **St. Philips Marsh**
- **Frome Gateway**

These polygons represent the areas of the corresponding Masterplans, minus areas of the Temple Quarter and St. Philip’s Marsh where we are aware that existing buildings will be retained, from reference to the Bristol Temple Quarter Spatial Framework² (Figure 4) and the draft Bristol Temple Quarter Masterplan Delivery Strategy³.

In addition to these developments, we are aware of **Bedminster Green**, however this development has planning approval in principle, subject to CIL funded works to address flood risk⁴: this site is therefore excluded from the assessment of benefits.

² Bristol Temple Quarter Spatial Framework, <https://www.bristoltemplequarter.com/key-projects/spatial-framework/> Bristol City Council 2016.

³ Draft Bristol Temple Quarter Masterplan Delivery Strategy, Bristol City Council, 2020

⁴ <https://democracy.bristol.gov.uk/ieDecisionDetails.aspx?AIId=15476>

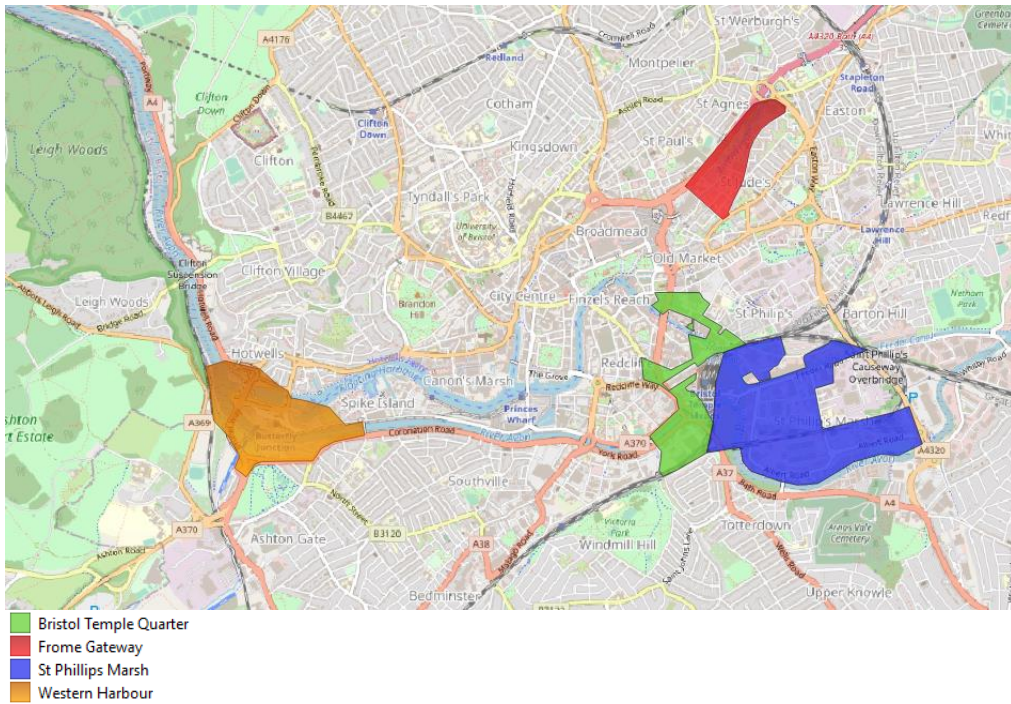


Figure 3: Proposed areas for Growth and Regeneration

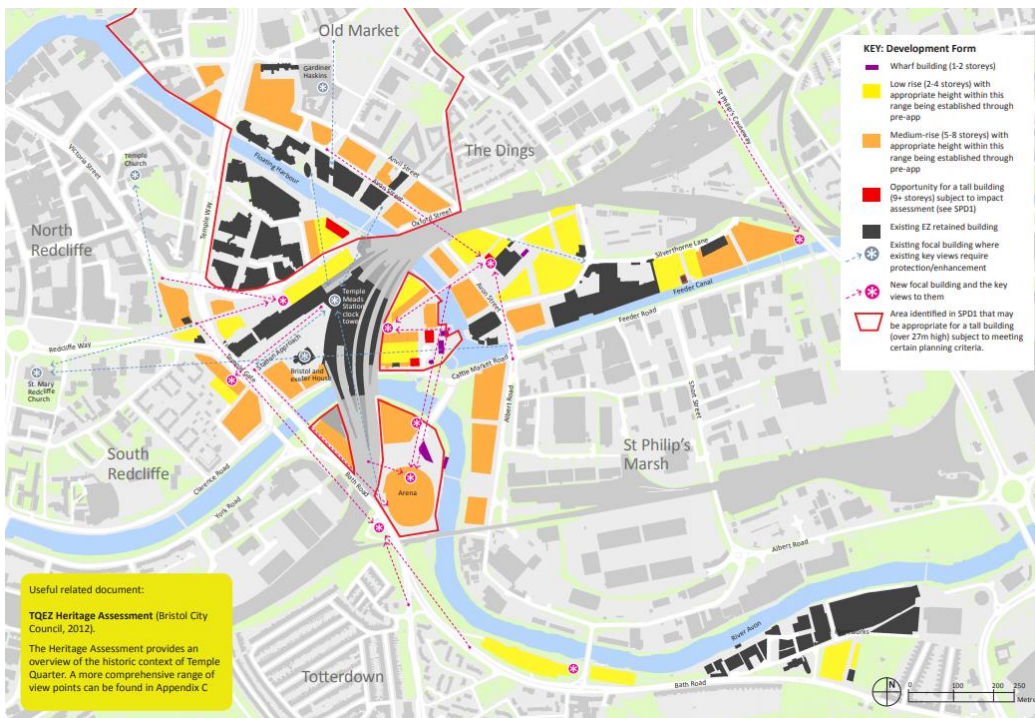


Figure 4: Temple Quarter Development Form (from BTQ Spatial Framework report)

5.3 Assessment of potential Gross Value Added from Growth and Regeneration areas

The plans behind these areas have evolved over different time frames, and because of this, some plans have a greater level of supporting data than others. It is also notable that the definition of the outlines of these areas and underlying data continues to evolve. Therefore, the estimates below are snapshots based on “best available” data at the time of writing, and should be subject to sensitivity testing.

It is important to note that the flood strategy is not the only initiative enabling the development of these areas. A range of additional enabling infrastructure (amongst other investments) is necessary for these sites to progress and will also be trying to raise funding based on the outcomes presented below. It will be necessary at a city level to resolve any double counting that this might result in.

5.3.1 Frome Gateway

The Strategy benefits the area of growth and regeneration identified as the Frome Gateway by reducing extreme harbour water levels which help convey River Frome flows and reduce peak water levels. Proposals are at a very early scoping stages and a masterplan for the area has yet to be developed, with no information on GVA benefits available. Significant reduction in extreme tidal flood risk in the Lower Frome is predicted. However, flood risk to the area during extreme fluvial events remains significant and further flood risk management measures are likely to be required. On this basis, GVA gain for the area has been excluded from this assessment.

5.3.2 Western Harbour

The Strategy benefits the area of growth and regeneration identified as Western Harbour by containing flood risk from the River Avon and reducing extreme harbour water levels.

The Cumberland Basin area, for example, already includes an allocation for development through the Bristol Central Area Plan and was included in the Economic Development Needs Assessment polygon. As such the GVA benefit of this development is embedded in the EDNA calculation covered in Section 4.1.

However, the council’s proposals for regeneration of the Western Harbour would reveal additional areas of development land through the reconfiguration of existing road infrastructure. This represents an additional source of potential above and beyond the capacity identified by this study. Proposals are at a very early scoping stages and a masterplan for the area has yet to be developed, with no information on GVA benefits available. On this basis, GVA gain for the area should be considered a conservative value.

5.3.3 Temple Quarter & St. Philip's Marsh

The Gross Value Added associated with the Temple Quarter, and St Philip's Marsh has been extracted from the draft Bristol Temple Quarter Masterplan. This identifies 4 core components to the Masterplan:

- Bristol Temple Meads station development
- City Gateway / Friary North / Temple gate
- Mead Street
- St. Philip's Marsh

Previous versions of the masterplan included the **TQEC campus** (east of Bristol Meads station, west of St. Philips Marsh), and that this is no longer present in the Masterplan document. It appears on further research that this site has been granted planning permission, and therefore the flood strategy is not considered to contribute to its success.

Previous versions also included the **Silverthorne** Lane development, but this has been included in the EDNA analysis, so is not revisited here.

Bristol Temple Meads station development

The development comprises £218m of works to improve circulations and transport links to the station, including transport interchanges, retail and car parking. The proposals were assessed as providing £347m Present Value benefit (based on a 60-year appraisal period). This benefit, calculated using the Government Transport Appraisal Guidance (TAG), derives from

- Changes in end-to-end journey times and costs
- Time savings for users accessing the station by foot, car and bus
- Modal shift impacts, reducing traffic accidents, greenhouse gas emissions
- Station quality and urban realm improvements.

Wider Economic Impacts associated with the impacts of these changes on the Bristol City Region's economy were not calculated.

The station itself is at elevation, and therefore it may initially be considered that efficiency improvements within the station and increased station capacity are not impacted by mitigation of flood risk (notwithstanding the direct flood risk impacts presented in the main economics report of *this* study). However, the £347m benefits identified above are unlikely to be fully realised if access routes to the station are regularly cut-off by flooding.

City Gateway / Friary North and Temple Gate, Mead St.

The developments within these areas have been declared by BCC planners as “not requiring a flood strategy to proceed.” Whilst the majority of these development areas are at low flood risk, it is noted that plots G,N,O,P,Q & R lie within either the 2025 1% AEP fluvial or 0.5% AEP tidal flood outline. They it therefore not

unreasonable to assume that they may therefore experience some difficulty achieving planning consent.

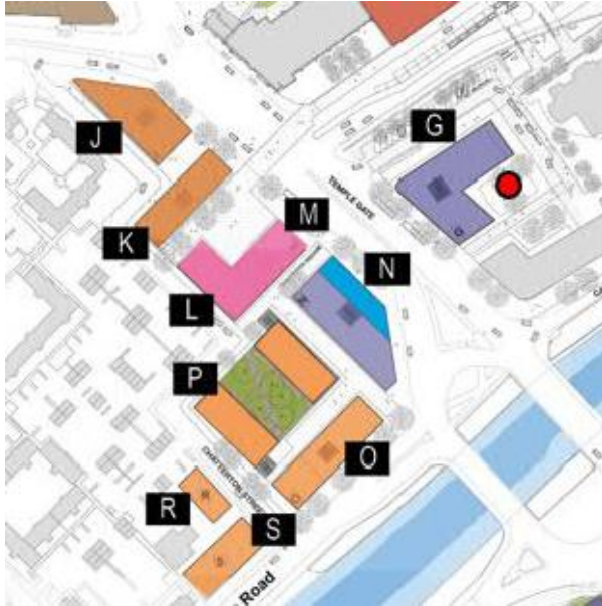


Figure 5: Friary North development sites.

The annual Total Gross GVA for plots, G, J-P, Q R and S is given as £20.4m pre-development, compared to £57.2m at full buildout, an uplift of £36.8m. Taking account of J and K, it is estimated that development within the 2025 1% AEP fluvial or 0.5% AEP tidal flood outline achieves an uplift in annual Total Gross GVA of £31.1m.

St. Philip' Marsh

BCC, working in partnership with WECA, Network Rail and Homes England are currently working on a long-term plan to guide how Temple Quarter and St Philip's Marsh develop in future. Delivery of the plan is constrained, both physically and by the needs of multiple landowners. Regeneration is therefore planned over several decades. At full build-out, the St. Philip's Marsh masterplan would achieve an uplift of £585m Total Gross GVA per annum. This has been initially evaluated as providing £1.51bn over a 31-year period.

The development of the BTQ site will be limited if a city-wide flood risk management strategy is not approved and implemented. At St. Philip's Marsh, resolving flood risk is recognised as being a key part of making the development viable. Precautionary planning assessments of residual flood risk, considering the risk of defence/gate failure, also led to an emerging concept of a raised Resilient Access Network. However, flood risk infrastructure is only part of making the development work. An additional £148m of enabling infrastructure is also identified as being necessary, and therefore flood risk may only be able to claim a component of this. For comparison, the cost estimate for Phase 1 defences associated with St. Philip's Marsh comes to £38m; approx. 20% of the overall infrastructure investment.

6 Construction jobs

6.1 Direct calculation

The construction of the flood strategy, and of the development that it unlocks, creates jobs that will generate GVA. These can be calculated from the cost of the strategy and the developments, as shown in Table 9, below.

The cost of the strategy has been taken directly from the cost estimates for this project. Construction costs of EDNA developments have been estimated from the assumed floor area of development calculated in Section 4 and multiplied by the rates in Table 8.

Table 8: Assumed construction cost per m2 of internal floor space.

	Industry	Office	Other	Retail	Mixed Business
Cost per m2 (£)	1,100	2,000	1,750	1,500	1,750

Table 9: Calculation of GVA associated with Construction Jobs.

	Flood Strategy	EDNA Developments
Capital works	£ 223,000,000	£ 626,941,361
% of cost spent on salaries	29%	29%
Salary expenditure	£ 64,670,000	£ 181,812,995
Average mean salary	£ 29,782	£ 29,782
Direct job years supported	2,171	6,105
1 FTE = 10 employment years	10	10
Direct jobs supported	217.1	610.5
Leakage	25%	25%
Net direct FTEs	162.86	457.87
Composite multiplier	1.3	1.3
Indirect & induced jobs	48.9	137.4
Total net jobs supported	211.7	595.2
Average GVA per construction worker ⁵	£ 48,750	£ 48,750
Total GVA supported	£ 10,321,310	£ 29,017,292

⁵ House of Commons Briefing Paper, Dec 2018, “Construction Industry, statistics and policy”. There are 2.4m jobs in the construction industry, contributing £117bn to the economy.

Area	Present Value GVA from construction jobs (£m)	% attributable to flood strategy	Construction jobs GVA attributable to flood strategy (£m)
Flood Strategy	10.3	100	10.3
EDNA sites	29.0	It is assumed that only 20% of enabling infrastructure costs are attributable to flood risk in these sites	5.8

6.2 Costs from secondary sources

The draft Bristol Temple Quarter Masterplan Delivery Strategy presents economic impacts associated with the construction of the Masterplan, as follows:

Area	Present Value GVA from construction jobs (£m)
Station development	9.1
City Gateway / Friary North / Temple Gate & Mead Street	17.8
St. Philip's Marsh	31.7 ⁶

6.3 Estimates of Construction jobs GVA attributable to flood strategy

The indicative contribution of the flood strategy to the value and likelihood of progression of these individual projects allows approximate percentages of the construction job estimates to be claimed. As per 5.3, it will be necessary at a city level to resolve any potential double counting between different projects 'laying claim' to these benefits.

⁶ Value adjusted from source material to avoid double counting of construction GVA associated with the Flood Defence works.

Table 10: Estimates of construction jobs GVA attributable to flood strategy

Area	Present Value GVA from construction jobs (£m)	% attributable to flood strategy	Construction jobs GVA attributable to flood strategy (£m)
Flood Strategy	10.3	100	10.3
EDNA sites	29.0	It is assumed that only 20% of enabling infrastructure costs are attributable to flood risk in these sites	5.8
Station development	9.1	0	0
City Gateway / Friary North / Temple Gate & Mead Street	17.8	10%	1.8
St. Philip's Marsh	31.7 ⁷	20%	6.3
TOTAL	97.9		25.2

7 GVA saved through the reduced flood risk to Bristol's tourism industry

The 2013 report “Bristol Floating Harbour EIA Final Report”⁸ identifies annual visitor spending associated with the Floating Harbour of £14.9m. Using VisitBritain statistics, this can be uplifted to £15.3m today, or £42k per day, based on 1,095,000 visitors.

However, the 2013 study is notably conservative in some of its assumptions, and its scope. It adjusted for double counting of visitors by assuming that they attend 3 attractions a day, and this adjustment is particularly conservative given that shorter visits comprise a high proportion of overall visitor numbers. Assuming that visitors attend 2 attractions a day, increases apportioned visitor numbers to 2.1m visitors, and this seems like a more reasonable proportion of Bristol's overall annual visitors (18m per annum according to Visit Bristol⁹, although this

⁷ Value adjusted from source material to avoid double counting of construction GVA associated with the Flood Defence works.

⁸ “Economic Impact of Bristol's Floating Harbour”, Bristol City Council, 2013.

⁹ The Economic Impact of Bristol's Visitor Economy (Visit Bristol, 2014)

is noted to be a high estimate from comparison with Visit Britain’s statistics). On this basis, and adjusting for uplifts in spend based on Visit Britain statistics, the annual spend can be estimated at £23m per annum today, or £63k per day, based on 2.1m annual visitors (including children). Even this estimate focusses on “attractions”, and overlooks the value of spend in local hotels and restaurants as part of Bristol’s leisure industry.

Key attractions include

- The Harbour Railway – 25,000 visitors (Andy King (BCC Senior Curator) 2015)
- SS Great Britain– 236,500 visitors (SS Great Britain trust)
- M Shed – 555,000 visitors (www.alva.org.uk)

If these attractions account for a 1/2 of a visitor day each, their approximate contribution to the Floating Harbour visitor numbers can be apportioned as follows:

- The Harbour Railway – 0.8%
- SS Great Britain – 7.2%
- M Shed – 16.9%

It can be assumed that for any attraction directly flooded, they may suffer 20 week’s disruption to business (based on the data of the Frontier methodology). In some major events, M Shed is not flooded directly, but it is considered that disruption to the local environs, and access might still induce 3 weeks disruption (as per Frontier methodology). For general flooding to the quays, 1 week’s disruption is assumed.

This information can be used in conjunction with flood risk to the quays to build up an estimate of flood impacts as follows:

Table 11: Build-up of economic impact of flooding on tourist facilities beside the Floating Harbour

	Duration of lost earnings			Allowance for displacement (%)	Economic impact per event (£m)
	1 week	3 weeks	20 weeks		
Minor events (quays, Harbour railway)	99.2		0.8	50	0.3
SS Great Britain directly flooded	92		8	30	0.8

All attractions except M Shed flooded		16.9	83.1	20	6.0
All attractions directly flooded			100	10	7.9
Do Nothing – in future climate events, flooding reaches the 2 year return period, leading to year – round loss of Harbourside tourism. However it is assumed that a high level of displacement would occur				50	7.7

Coupling this data with observed flood risk from the modelling allows us to build up an assessment of the annual average disruption per option. These can in turn be built into a Net Present Value, as follows:

Table 12: Annual Average and net present value impact on tourism due to flooding.

Option	Annual average Damages (£k)				Net present Value (£m)	
	2025	2045	2065	2125	10yrs	100yrs
Do Nothing	2,606	11,483	11,483	11,483	43.5	267
Do Minimum	314	686	864	2,787	3.7	24.4
75yr	67	131	285	159	0.8	3.6
100yr	53	98	141	61	0.6	2.7
200yr	40	59	79	37	0.4	1.6

8 Potential health and amenity benefits from enabling the creation of a sustainable transport route

The concept of a sustainable transport route built beside the River Avon, and beside the Feeder Road has been promoted for several years, originally as the “New Cut Greenway”. The construction of a flood defence along these same routes creates an opportunity for partnership to enable such a proposal.

A green infrastructure transport route for improved cycling and walking beside the river, would provide significant transport and amenity benefits. The benefits of such a route were assessed in 2017 using Arup’s “Green Infrastructure Valuation Estimation Tool.” The tool draws on the methods of the UK National Ecosystems Assessment 2010, and HM Treasury guidance on carbon pricing. The tool identified two core benefits of the greenway: Health and Recreation, valued at £3.6m / year, and Amenity, valued at £8.4m / year. Updating these figures to 2020 using CPI, they can be valued at £3.8m/year and £8.8m/year.

Over a ten year period, this is a Net Present Value of £117.2m. Accepting that the flood strategy may only be one of the factors by which such an investment could be enabled, it is suggested that only 15% of this could be claimed as a benefit of the strategy. Nonetheless, this would still be £17.6m benefit attributable to the strategy.

The assessment undertaken in the Green Infrastructure Valuation Estimation Tool highlights that Floating Harbour docks in their current condition may provide a similar level of amenity. It would be reasonable to argue that in the Do-Nothing scenario, with extensive flooding to the quays in the 2-year return period tidal event, this amenity would be significantly impacted, and therefore the strategy proposals provide a similar order of benefit in terms of amenity protected.

9 Summary

The potential local benefits of the Local Choice “NPPF-Compliant” strategy are compared with other standards of protection in Table 13, below. Clearly the bulk of these benefits are associated with the growth enabled at unlocked sites, associated with an NPPF complaint strategy.

Table 13: Local benefit of the Local Choice

	NPPF Compliant strategy		Other standards of protection	
	Benefit compared to Do Nothing	Benefit compared to Do Minimum	Minimum Benefit compared to Do Nothing	Minimum Benefit compared to Do Minimum
Commercial property damage and infrastructure disruption avoided	£405m	£281m	£405m	£281m
Disruption to businesses avoided	£250m	£250m	£250m	£250m
Growth enabled at unlocked sites (EDNA sites)	£5,635m	£5,635m	0	0
Growth enabled at unlocked sites (Growth and Regeneration sites)	£1,513m	£1,513m	0	0
Jobs created through construction	£25m	£25m	£10m	£10m

Disruption to the tourism sector avoided	£263m	£21m	£263m	£21m
Benefit of enabling green transport infrastructure	£18m	£18m	£18m	£18m
TOTAL	£8,109m	£7,743m	£946m	£580m

At lesser standards of protection, not compliant with NPPF, a flood strategy will still have some influence in enabling development to proceed to planning consent earlier, or at lesser expense, however it may be much reduced. Nonetheless, because they would have that influence, the overall benefits presented above for “Other standards of Protection” are a minimum.

It is important to recognise that identification of the potential local benefit of the strategy is not the same as claiming all these benefits toward a funding application. Flood risk is not the only infrastructure issue to be resolved to enable the unlocked sites or the greenway, and the benefits identified above would need to be apportioned across several infrastructure investments. However, without resolving flood risk, it is true to say that these developments will only proceed with significant delay or cost.

Further work would be necessary to resolve this analysis in greater detail, and this should focus on assessing the potential benefits associated with unlocking the Growth and Regeneration sites and resolving the potential overlapping claims to infrastructure funding associated with these sites.