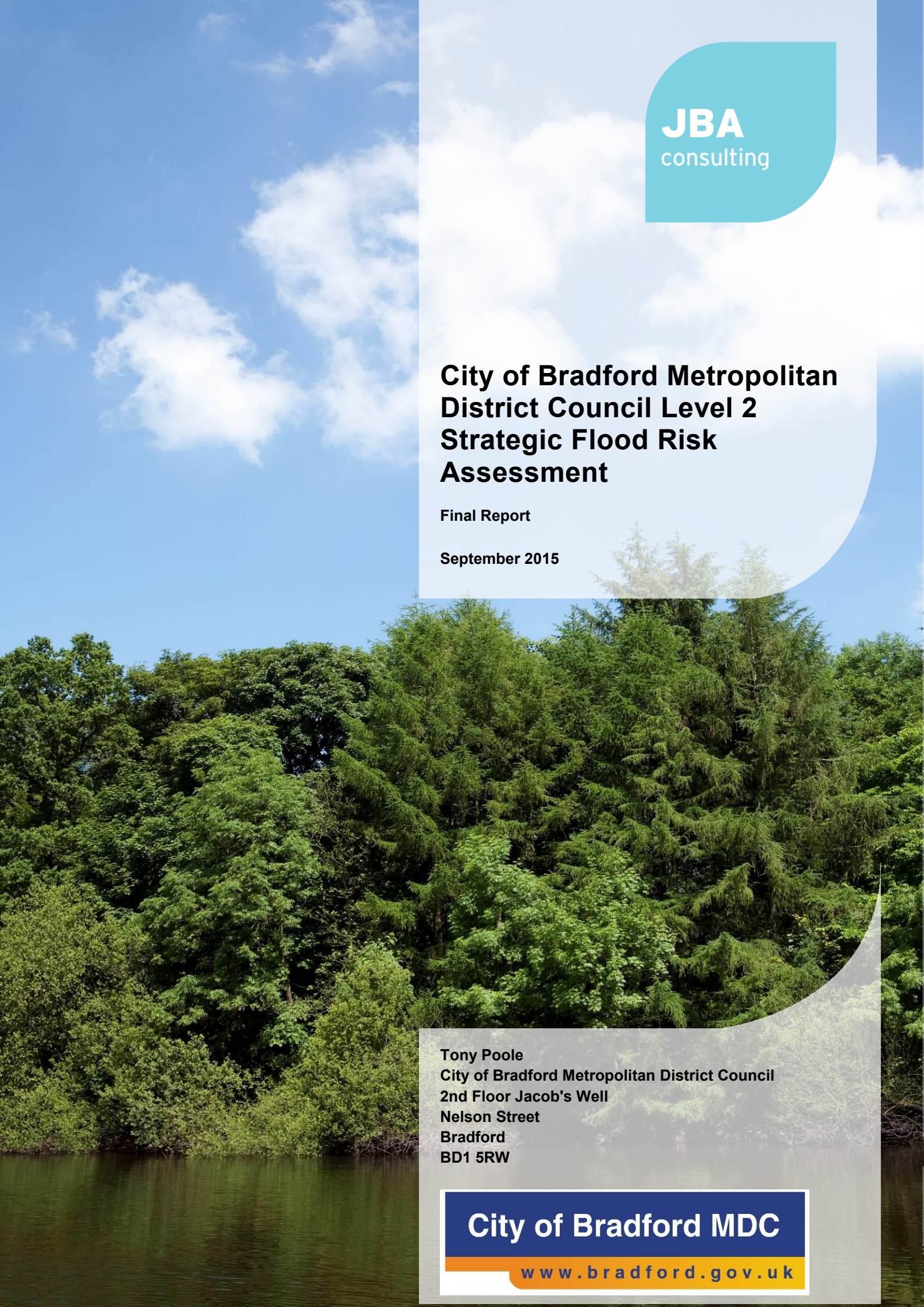

City of Bradford Metropolitan District Council Level 2 Strategic Flood Risk Assessment

Final Report

September 2015

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Revision History

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Contract

This report describes work commissioned by Mr Tony Poole, on behalf of City of Bradford Metropolitan District Council, by a letter dated 10/10/2014. City of Bradford Metropolitan District Council's representative for the contract was Mr Tony Poole. Mike Williamson of JBA Consulting carried out this work.

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Purpose

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Acknowledgements

JBA would like to thank all Council, Environment Agency, Yorkshire Water and Canal & River Trust staff, along with Will Shepherd at Sheffield University for their time and commitment to providing data and discussing the issues identified during the course of this study.

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Executive Summary

This Level 2 Strategic Flood Risk Assessment (SFRA) follows on from the Level 1 SFRA. The purpose of this report is to provide a more detailed assessment of all relevant sources of flood risk on key sites within The City of Bradford Metropolitan District Council's (the council) two priority regeneration areas. The council is developing Area Action Plans (AAP) for these two areas to guide future growth and development. The AAPs encompass the key growth areas of Bradford City Centre (BCC) and the Shipley and Canal Road Corridor (SCRC). The key sites within the AAP areas are comprised mainly of residential and mixed uses and are considered necessary for the council's wider sustainability objectives.

This Level 2 report will form part of the evidence base that informs and supports policies and proposals contained within the two AAPs and has been prepared in accordance with current best practice as set out in the National Planning Policy Framework[1] (NPPF) and the Flood Risk and accompanying Coastal Change Planning Practice Guidance[2] (FRCC-PPG).

A detailed assessment of flood risk is provided and the evidence required to facilitate the application of the Exception Test, whilst also informing the sequential approach to site acceptability and layout, in terms of avoiding and reducing flood risk, and the design of possible mitigation measures are also discussed. The Level 2 SFRA will support the council's Local Plan Core Strategy which sets out that an appraisal of flood risk issues will be undertaken as part of the AAP production.

The council are developing their Core Strategy Publication Draft as part of the Bradford District Local Plan of which the SCRC and BCC AAPs are required to inform. The Local Plan will guide future growth and development in the district for the next 15 - 20 years. The Core Strategy, once adopted, will set the strategic planning policies and broad development locations throughout the district.

A number of key proposed development sites are shown to be at risk from Bradford Beck and the River Aire. The Core Strategy Publication Draft states that these sites cannot be relocated to Flood Zone 1, due to the associated social and economic benefits of their location. There are also several sites at high risk from Bradford Beck and the River Aire, within Flood Zone 3b (the functional floodplain), zone 3a and zone 3ai. Risk from surface water flooding is also apparent at a number of sites. Surface water flood risk is examined using the Environment Agency updated Flood Map for Surface Water (uFMfSW) supported by historical evidence. Table 1-1 summarises the number of sites at risk from each fluvial flood zone.

Table 1-1: Fluvial Flood Risk Summary for Proposed Sites

			Flood Zone 1	Flood Zone 2	Flood Zone 3a	Flood Zone 3ai	Flood Zone 3b
Proposed Use	**No. Sites**	**Area (ha)**	**No. 100%**	**No.**	**No.**	**No.**	**No.**
Residential	38	52	27	11	5	3	1
Employment	7	5	4	3	2	1	1
Mixed use	23	74	12	11	9	2	3
Expansion area	1	1	1	0	0	0	0
TOTAL	**69**	**132**	**44**	**25**	**16**	**6**	**5**

Recommendations are made for each site at risk, broadly entailing the following:

- Development unlikely;
- Exception Test required as part of site-specific FRA;
- Exception Test, as part of site-specific FRA, required unless site layout can be adapted to avoid high flood risk;
- Site-specific FRA required to consider minimal risk or where site footprint area >1 ha;
- Development should be permitted.

1 http://planningguidance.planningportal.gov.uk/blog/policy/achieving-sustainable-development/delivering-sustainable-development/10-meeting-the-challenge-of-climate-change-flooding-and-coastal-change/

2 http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/

Five sites, in both AAP areas, are at risk from the Flood Zone 3b. Of these five sites, only two are considered unlikely for development to proceed safely. These sites are Site DF4 in Shipley which is at significant risk from the River Aire and Site SG/1.2 at Britannia Mill in the City Centre. SCRC Sites CCF4 has extant planning permission therefore any development and flood risk recommendations are not provided as part of this SFRA.

Site DF4 is situated on an area of Brownfield land proposed for mixed use development of business and residential uses. The whole of this site is at some level of fluvial risk from the River Aire with 84.6% of the footprint within the Aire's functional floodplain meaning 84.6% of the site should be safeguarded for open space and for flood storage. 12.3 % is within Flood Zone 3a and a nominal amount is within Flood Zone 3ai and Flood Zone 2. The site area is small at 0.6 ha meaning any changes in layout to remove residential development from Flood Zone 3a would not be possible.

An option may be to review and update the 2005 Upper Aire model, through a detailed site-specific FRA, to assess whether the outputs may lower the risk to the site based on more up-to-date hydrological conditions and model components. Potential river modelling could assess the benefit of defences to the site with considerations as to whether the potential associated costs of defending the site would be justifiable when compared to the cost of development.

Site DF5 is located adjacent to this site on the south side of Dockfield Road. This site is also Brownfield land with the same proposed uses. Another option could be to combine sites DF4 and DF5 in such a way that all or most residential development is directed toward site DF5 and businesses are situated within the higher risk DF4 site, though situated outside of the functional floodplain. The Green Infrastructure Study, 2013, proposes that this area of land could incorporate areas of greenspace. In terms of reducing flood risk, this should be considered as part of the end use of the land.

Site SG/1.2 has been allocated for a sports and leisure complex including a swimming pool. This site was originally allocated for 200 residential units though having applied the Sequential Test, the council decided to change the proposed use. Any development type would require a detailed evacuation plan linked to a relevant flood warning alert.

27% of the site area is within the functional floodplain and therefore, according to the FRCC-PPG, cannot be developed. 18% is within Flood Zone 3a meaning just under half of the site is within the 1 in 100 AEP event floodplain. Land use allocated for leisure purposes falls within the Less Vulnerable category of Table 2 of the FRCC-PPG and therefore would be permitted for development, subject to a site-specific FRA. 29% of the site falls within Flood Zone 3ai. Any re-development of the existing structures in this zone must not exceed the current footprint and, where possible, should attempt to reduce the footprint or deal with the flood water on-site.

The site is also at high risk from surface water flooding with 76% within the 1 in 30 year surface water flood outline. At 1.2 ha in size, it may prove difficult to accommodate surface water on-site. Options would need to be assessed through the FRA using detailed surface water modelling including an appraisal of SuDS options. Access and egress should also be assessed as part of the FRA to ensure safe pedestrian and vehicular access routes during an extreme flood, for the lifetime of the development.

There are a number of sites within / partially within Flood Zone 3a. In order to mitigate the flood risk, considerations of layout design have been discussed along with a number of direct mitigation strategies. The mitigation measures would need to reduce flood risk to the new development, ensure flood risk does not increase to third parties downstream and if possible allow for some amenity benefit through Green Infrastructure.

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Abbreviations

AAP ..... Area Action Plan
AEP ..... Annual Exceedance Probability
BCC ..... Bradford City Centre
CBMDC ..... City of Bradford Metropolitan District Council
CC ..... Climate change
CDA ..... Critical Drainage Area
DTM ..... Digital Terrain Model
FCDPAG ..... Flood and Coastal Defence Project Appraisal Guidance
FCERM ..... Flood and Coastal Erosion Risk Management Network
FDGiA ..... Flood Defence Grant in Aid
FRA ..... Flood Risk Assessment
FRCC-PPG ..... Flood Risk and Coastal Change Planning Practice Guidance
FRMS ..... Flood Risk Management Strategy
FWMA ..... Flood and Water Management Act
GI ..... Green Infrastructure
LFRMS ..... Local Flood Risk Management Strategy
LLFA ..... Lead Local Flood Authority
LPA ..... Local Planning Authority
NPPF ..... National Planning Policy Framework
RMA ..... Risk Management Authority
SAB ..... SuDS Approving Body
SCRA ..... Shipley and Canal Road Corridor
SFRA ..... Strategic Flood Risk Assessment
SuDS ..... Sustainable Drainage Systems
SWMP ..... Surface Water Management Plan
uFMfSW ..... updated Flood Map for Surface Water
UKCP09 ..... UK Climate Projections

1 Introduction

This Level 2 Strategic Flood Risk Assessment (SFRA) follows on from the Level 1 SFRA. The purpose of this report is to provide a more detailed assessment of all pertinent sources of flood risk on key sites within The City of Bradford Metropolitan District Council's (the council) two priority regeneration areas. The council is developing Area Action Plans (AAP) for these two areas to guide future growth and development. The AAPs encompass the key growth areas of Bradford City Centre (BCC) and the Shipley and Canal Road Corridor (SCRC). The key sites within the AAP areas are comprised mainly of residential and mixed uses and are considered necessary for the council's wider sustainability objectives.

The Level 1 SFRA provides a comprehensive review of flood risk over the entire local authority area whilst also providing guidance for developers, and spatial planners. The Level 1 SFRA should therefore be referred to, alongside this Level 2 assessment, as it provides the context for flood risk and development throughout the area. This Level 2 report will form part of the evidence base that informs and supports policies and proposals contained within the two AAPs.

1.1 Background

JBA Consulting was commissioned in October 2014 by City of Bradford Metropolitan District Council (CBMBC) to undertake a Level 2 Strategic Flood Risk Assessment. This Level 2 SFRA has been prepared in accordance with current best practice as set out in the National Planning Policy Framework[3] (NPPF) and the accompanying Flood Risk and Coastal Change Planning Practice Guidance[4] (FRCC-PPG).

In assessing fluvial flood risk within the AAP areas, the outputs from the Bradford Beck Flood Modelling Study 2013[5], the Upper Aire 2005 Modelling Study and the Environment Agency Flood Map for Planning have been used.

At the time of finalisation of this Level 2 SFRA the outputs from the Bradford Beck model had not been used to update the Flood Map for Planning, however the Environment Agency has since agreed to include the 1 in 100 and 1 in 1000 AEP Bradford Beck model outputs within their next update. Throughout this report, the Bradford Beck outlines are referred to as the 1 in 100 and 1 in 1000 AEP event outlines rather than Flood Zones 3 and 2 due to the timing of the Flood Map for Planning updates.

It is advised by the Environment Agency that the Lead Local Flood Authority (LLFA) for CBMBC is consulted with regard to any development options that are influenced by Bradford Beck, being an ordinary watercourse.

The Upper Aire model 1 in 25 AEP flood event outline and Flood Zones 2 and 3 of the Flood Map for Planning will be used to assess risk to proposed sites north of Dockfield Road, Shipley, where the downstream boundary of the Bradford Beck model is located.

1.2 Scope and Objectives

This study is required to deliver a more detailed assessment of flood risk and to provide the evidence required to facilitate the application of the Exception Test whilst also informing the sequential approach to site acceptability and layout, in terms of avoiding and reducing flood risk, and the design of possible mitigation measures. This study will support the council's Local Plan Core Strategy which sets out that an appraisal of flood risk issues will be undertaken as part of the AAP production. This Level 2 SFRA should not be regarded as the Exception Test without the evidence for sustainability benefits and site-specific flood risk assessments.

The council are developing their Core Strategy as part of the Bradford District Local Plan of which the SCRC and BCC AAPs are required to inform. The Local Plan will guide future growth

3 http://planningguidance.planningportal.gov.uk/blog/policy/achieving-sustainable-development/delivering-sustainable-development/10-meeting-the-challenge-of-climate-change-flooding-and-coastal-change/

4 http://planningguidance.planningportal.gov.uk/blog/guidance/flood-risk-and-coastal-change/

5 Flood Resilient City, Bradford Beck Flood Modelling, Developing an InfoWorks CS Model, V4.131008 - Final Draft Version. Simon Doncaster, Will Shepherd and John Blanksby. Pennine Water Group, University of Sheffield. October 2013.

and development in the district for the next 15 - 20 years. The Core Strategy, once adopted, will set the strategic planning policies and broad development locations throughout the district.

The Level 1 SFRA focused on key settlements within the local authority area rather than specific proposed development sites. The council carried out an initial scoping assessment of flood risk on the key sites within the AAP areas prior to the commissioning of this Level 2 study. This helped identify where further more detailed flood risk data and assessment would be required. The scoping assessment ascertained that the scale of proposed development in the AAP areas meant that it was not considered possible to allocate all development to areas of low flood risk following application of the Sequential Test.

The Core Strategy Publication Draft identifies that the wider sustainability benefits of delivering housing and economic growth within the AAP areas significantly outweighs the flood risk issues, and on this basis are deemed by the council to pass the first part of the Exception Test.

The council identifies the key objectives for this Level 2 SFRA are to:

- Provide a robust evidence base to support the policy approach to managing and mitigating flood risk in the AAP areas;
- Take forward the work of the Level 1 SFRA and scoping assessment to develop a detailed understanding of the nature of flood risk from all sources in specific development areas within the AAP areas;
- Provide guidance for the AAPs to ensure that proposed development would be safe from flooding and not increase flood risk elsewhere; and
- Identify the need and level of detail for site-specific flood risk assessments.

A number of key proposed development sites are shown to be within the 1 in 1000 AEP flood event outline from Bradford Beck and within Flood Zone 2 from the River Aire. As stated by the Core Strategy Publication Draft, these sites cannot be relocated to Flood Zone 1 due to the associated social and economic benefits of their location. Several proposed sites currently contain existing development and some are open land. There are also a number of sites at higher risk from the Bradford Beck model 1 in 20 AEP flood event and also the 1 in 25 AEP event from the Upper Aire model. These higher risk event outlines will be used to form the functional floodplain (Flood Zone 3b) and/or Flood Zone 3ai within the AAP areas.

A key objective of the Level 2 SFRA is to assess the proposed development sites at medium and high flood risk and to assist the council in establishing whether the requirements of the Exception Test can be met. In order to pass the Exception Test the NPPF (Para 102) states:

> a. *"It must be demonstrated that the development provides wider sustainability benefits to the community that outweigh flood risk, informed by a Strategic Flood Risk Assessment where one has been prepared; and*
>
> b. *A site-specific flood risk assessment must demonstrate that the development will be safe for its lifetime taking account of the vulnerability of its users, without increasing flood risk elsewhere, and, where possible, will reduce flood risk overall.*

Both elements of the test have to be passed for development to be allocated or permitted."

Following the work carried out by CBMDC in the Scoping Assessment and within the Core Strategy Publication Draft, part a of the Exception Test has already been evaluated by the council.

Whilst the Exception Test process makes it possible to identify areas where development can proceed safely, it must not be seen as an opportunity to situate inappropriate development in flood risk areas. It is a useful planning tool that can help to justify the acceptability of the residual risks remaining after the mitigation measures have been applied.

In order to establish whether applying the Exception Test is justified or can then be satisfied, the Level 2 SFRA considers the detailed nature of the flood hazard, taking account of the presence of flood risk management infrastructure. The detailed nature of the flood hazard (see Section 3.2.3) within a flood zone includes:

- Flood probability;

- Flood depth;
- Flood velocity; and
- Rate of onset of flooding.

By facilitating the application of the Exception Test, the Level 2 SFRA will also provide supporting evidence for the possible mitigation measures that would assist in enabling the development to proceed, thus attempting to satisfy the second part of the test, point b.

1.2.1 The Exception Test

The FRCC-PPG (Para 023) defines the Exception Test as:

"…a method to demonstrate and help ensure that flood risk to people and property will be managed satisfactorily, while allowing necessary development to go ahead in situations where suitable sites at lower risk of flooding are not available.

Essentially, the two parts to the Test require proposed development to show that it will provide wider sustainability benefits to the community that outweigh flood risk, and that it will be safe for its lifetime, without increasing flood risk elsewhere and where possible reduce flood risk overall."

Using this SFRA, the Exception Test should be carried out by the developer, alongside the council, as part of a site-specific FRA, undertaken as part of a planning application. The FRA should show that the second part of the test can be satisfied upon development.

1.3 Study Area

As mentioned previously, the study area for this Level 2 SFRA is split into two parts, namely Bradford City Centre and the Shipley and Canal Road Corridor with each area having its own Area Action Plan. These areas have been evaluated, in terms of strategic flood risk, in this SFRA.

The main source of risk comes from Bradford Beck which flows northwards, into the River Aire, directly through the city centre and the corridor. The beck is culverted throughout the city centre until it resurfaces at Bolton Woods before continuing through to the Aire. Flood risk to the city centre, from the beck, has been reduced by way of the Westbrook and Bradford Beck flood relief diversion tunnels, constructed in the 1990s, which divert flow away from the city centre. Several other tributaries feed into Bradford Beck in the city centre, namely Bowling Beck from the south, Westbrook from the south west and Eastbrook from the south east (see Figure 1-1). Each of these watercourses were included in the Bradford Beck Modelling Study, 2013. Risk is also apparent from the River Aire in the north of Shipley. For more information on the AAP study areas, see the Issues and Options Reports.[6] [7]

1.3.1 Valley Road Culvert, Bradford Beck, Shipley

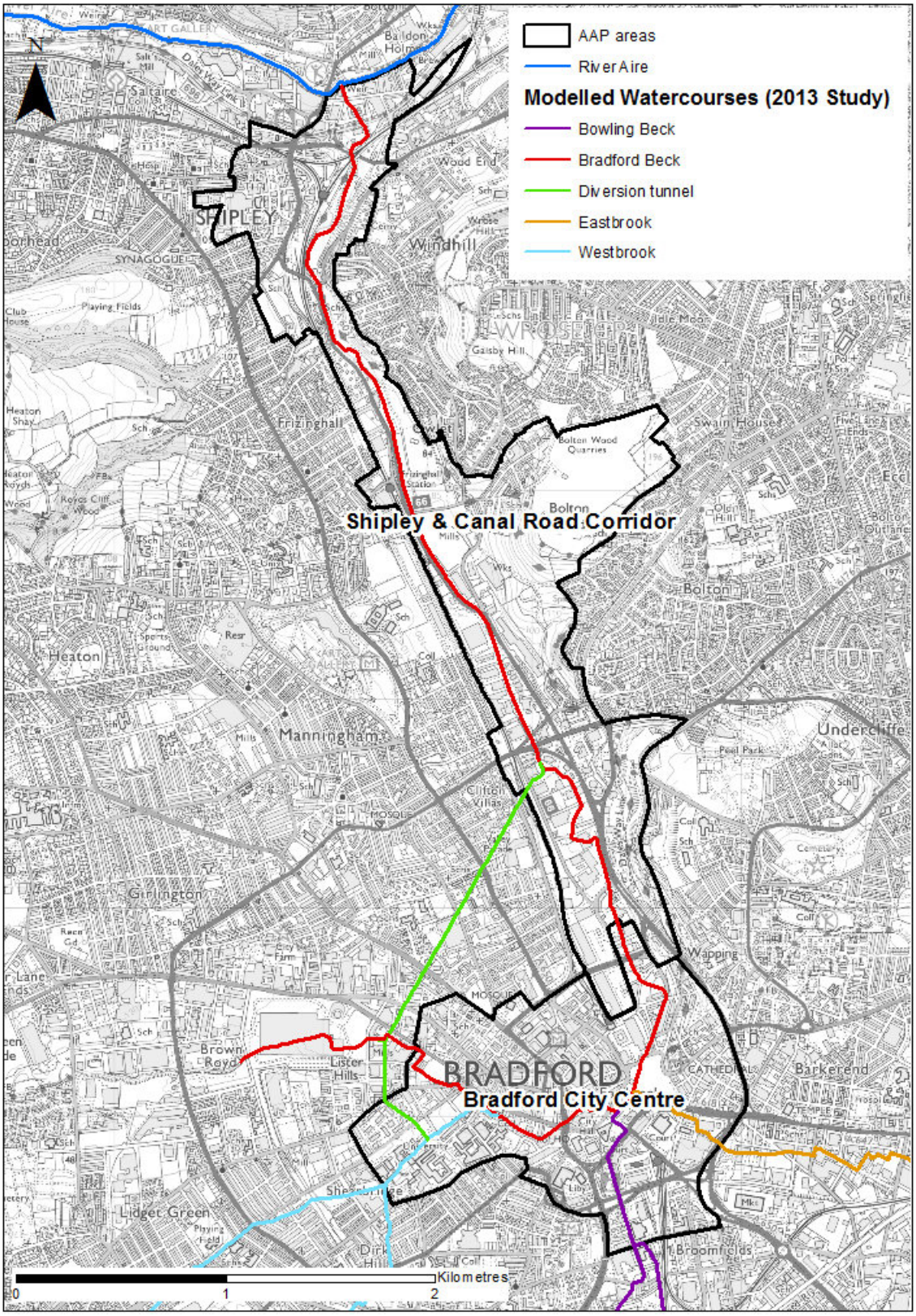
A condition assessment was carried out, by JBA Consulting, on the Bradford Beck culvert at Valley Road, Shipley. The condition assessment found the overall structure to be poor, mainly due to concrete spalling, corrosion of exposed reinforcements, cracking of culvert walls and debris build up. Various remedial measures have been assessed though the council's Highway Structures Unit consider the culvert to be beyond economic repair.

The council therefore propose the removal of the culvert with the area being left open for potential flood storage including the extension of the linear park. The council would then look to re-naturalise the Bradford Beck channel in this area.

6 http://www.bradford.gov.uk/bmdc/the_environment/planning_service/local_development_framework/shipley_action_plan_dpd

7 http://www.bradford.gov.uk/bmdc/the_environment/planning_service/local_development_framework/bradford_city_centre_action_plan.htm

Figure 1-1: AAP Areas and Modelled Watercourses



1.3.2 Bradford City Centre

Bradford City Centre, including its peripheral areas such as Little Germany, Goitside and the University campuses, is considered to be the top priority regeneration area for the district. The city centre has suffered decline over the previous few decades with 1960s developments abandoning the historical architectural heritage of other city buildings. The council considers the current city centre to have poor retail and leisure facilities and is in need of regeneration.

The BCC AAP Issues and Options Report, 2013 identifies six neighbourhoods within BCC, namely The Bowl, The Channel, The Market, The Valley, The Learning Quarter and The Southern Gateway.

1.3.2.1 Central Business and Leisure District (The Bowl)

This area aims to become the business core of the city centre with Grade A office space and late night leisure offerings centred around a City Park.

1.3.2.2 Cathedral Quarter and Little Germany (The Channel)

The Channel is based in the north east of the city centre and will focus on the development of the Broadway Shopping Centre which will expand on the city's retail outlets. The aim is to combine this with major residential areas.

1.3.2.3 Shopping and Markets Area (The Market)

Based in the central north of the city centre, The Market aims to offer small independent retailing and leisure facilities amongst the existing Kirkgate Shopping Centre and the Oastler Centre.

1.3.2.4 Goitside (The Valley)

The Valley neighbourhood covers the north west of the city centre and will focus on the provision of city centre living. Small scale leisure and retail enterprises will also be combined.

1.3.2.5 The Learning Quarter

This neighbourhood covers the current University and College campuses in the west of the city centre with the aim being to expand on student living accommodation and educational facilities.

1.3.2.6 The Southern Gateway

Currently industrial, this area in the south of the city centre is targeted to become a residential area aimed at city centre living.

1.3.3 Shipley and Canal Road Corridor

Stretching from Bradford City Centre to the River Aire at Shipley, the Shipley and Canal Road Corridor (SCRC) was identified for major regeneration schemes in 2006 when the council carried out feasibility studies for reinstating the Bradford Canal. The idea was that the corridor could capitalise on the regeneration and development opportunities that the reinstated canal would bring.

Three areas of opportunity exist within the SCRC, namely Shipley, New Bolton Woods and The City Centre Fringe.

1.3.3.1 Shipley

The Shipley area of opportunity includes Shipley Town Centre with supporting rail links and range of shops, restaurants and community infrastructure. Significant employment areas are also close by, as is the World Heritage Site of Saltaire. Shipley is in current need of regeneration with dated architecture, fragmented pedestrianised areas and the preference for new developments to locate on the outskirts of the town rather than in the town centre itself.

1.3.3.2 New Bolton Woods

This includes the New Bolton Woods Masterplan site and Bolton Woods Quarry which are each earmarked for major residential developments on previously used land together with employment uses, a school and playing fields. New Bolton Woods is currently characterised

by industry and major roads thus major regeneration is required in order to attract potential residents.

1.3.3.3 The City Centre Fringe

This area of opportunity links the SCRC to the Bradford City Centre AAP area thus is an important area for regeneration. The Fringe is within walking distance of the city centre and is characterised by large retail and employment areas. There are a number of currently vacant areas which would benefit from development.

1.3.4 Green Infrastructure Corridors

Green Infrastructure (GI) is a strategically planned and delivered network of high quality green spaces and other environmental features. It should be designed and managed as a multifunctional resource capable of delivering a wide range of environmental and quality of life benefits for local communities. GI includes parks, open spaces, playing fields, woodlands, allotments and private gardens. GI should be provided as an integral part of all new development, alongside other infrastructure such as utilities and transport networks.

GI can provide many social, economic and environmental benefits close to where people live and work including:

- Places for outdoor relaxation and play;
- Space and habitat for wildlife with access to nature for people;
- Climate change adaptation - for example flood alleviation and cooling urban heat islands;
- Environmental education;
- Local food production - in allotments, gardens and through agriculture;
- Improved health and well-being – lowering stress levels and providing opportunities for exercise.

Along the length of the SCRC AAP area is the sub-regionally important Spen Valley Greenway and Canal Road corridor, linking the River Calder Green Infrastructure Corridor in the south to the River Aire Green Infrastructure corridor in the north. The District important Pitty and Clayton Becks Green Infrastructure corridor runs within the BCC AAP area, westwards from the city centre, and has helped restrict development in this area.

The SCRC AAP Issues and Options Report, in relation to strategic GI, states the requirement for an integrated approach to flood risk and GI along the whole corridor which will be key in delivering sustainable development. The emerging approach in respect of GI and flood risk is based on the creation of a Linear Park along the length of Bradford Beck, restoring the natural character of the beck, retaining areas of natural floodplain, introducing new areas and enhancing existing areas of greenspace whilst incorporating sustainable drainage within new development. The GI strategy aims to reduce downstream flood risk along the corridor, stretching from Bradford City Centre to Shipley Town Centre. Suitable modelling has not yet taken place to review the impact that such proposed GI may have on flood risk. This would be required in order to confirm GI suitability.

1.4 Outline Methodology

As mentioned in Section 1.1, the outputs from the Bradford Beck Modelling Study, October 2013, will be used to assess fluvial risk from the beck, and will be used to update the Environment Agency Flood Map for Planning. The Bradford Beck model takes account of the sewer system and the impact of the flood relief diversion channels mentioned in Section 1.3. The outputs from the Upper Aire Modelling Study, 2005, along with Flood Zones 2 and 3 of the Flood Map for Planning will also be used to assess fluvial risk in Shipley, north of Dockfield Road where the Bradford Beck model domain ends. Neither model has been amended nor updated further as part of this SFRA.

The assessment of flood risk to key development sites within the AAP areas will entail the following:

- Fluvial assessment using existing outputs, for multiple return periods including 1 in 20, 1 in 100 and 1 in 1000 AEP events, from the Bradford Beck Modelling Study, 2013; the 1 in 25 AEP event from the Upper Aire FRMS, 2005; and Flood Zones 2 and 3 from the Flood Map for Planning including:
    - Flood outlines - assessment of area and percentage coverage of proposed site footprints;
    - Flood depths (Bradford Beck only) - assessment of flood levels;
    - Flood velocities (Bradford Beck only) - assessment of flow velocities;
    - Flood hazard (Bradford Beck only) - assessment of flood hazard to people as a function of flood depth and flow velocity; and
    - Climate change (Bradford Beck only) - assessment of possible future flooding by increasing flows by 20%.
- Surface flooding assessment of proposed sites using the third generation updated Flood Map for Surface Water (uFMfSW) including area (ha) and percentage area coverage of proposed site footprints. Identification of possible Critical Drainage Areas (CDA) where required;
- Delineation of functional floodplain (see Section 1.4.1) and a Flood Zone 3ai (see Section 1.4.2);
- Assessment of historic flood incidents using data provided by CBMDC;
- Assessment of Green Infrastructure opportunities;
- Assessment of mitigation options and recommendations on site layouts in order for development to proceed;
- Tabulated evidence of risk (see Appendix B) and recommendations for site-specific Flood Risk Assessments and requirements for passing the Exception Test, where required.

1.4.1 Functional Floodplain (Flood Zone 3b) Delineation

The functional floodplain for this study is delineated from the 1 in 20 and 1 in 25 AEP event outlines produced from the Bradford Beck Model, 2013 and the Upper Aire FRMS, 2005 respectively. Appendix C details the delineation process.

The functional floodplain comprises land where water has to flow or be stored in times of flood. Areas of functional floodplain, within the AAP areas, will be identified as part of this Level 2 SFRA. The identification of functional floodplain should take account of local circumstances and not be defined solely on rigid probability parameters. It should be finalised through consultation between the Environment Agency and the Lead Local Flood Authority (LLFA). A functional floodplain is a very important planning tool in making space for flood waters and safeguarding development when flooding occurs. Generally, development is directed away from these areas.

Land which would naturally flood with an annual probability of 1 in 20 (5%) or greater in any year should provide a starting point for consideration and discussions to identify the functional floodplain. Areas which would naturally flood, but which are prevented from doing so by existing defences and infrastructure or solid buildings, will not normally be identified as functional floodplain. Land which is designed to flood (such as through a flood attenuation scheme) in an extreme flood (1 in 1000 AEP event), should be incorporated into the functional floodplain. If an area is intended to flood, e.g. an upstream flood storage area designed to protect communities further downstream, then this should be safeguarded from development and identified as functional floodplain, even though it may not flood very often.

1.4.2 Flood Zone 3ai

The Flood Zone 3ai approach was implemented by the council across the local authority area during the Level 1 assessment. The Level 1 report defines Flood Zone 3ai as:

"Developed land within Flood Zone 3 where water would flow or be stored in times of flooding if not already constrained by development. In NPPF terms these areas would constitute Flood Zone 3a, however following discussion with the Environment Agency it was agreed that Flood Zone 3a should be subdivided so as to indicate those areas of higher risk. Identification of zone 3ai allows the council to assess risk within 3a in more detail showing areas where existing development is likely to be restricting flood flows and water storage. Should sites in Flood Zone 3ai become available for new or further development (e.g. as brownfield sites) then both the risk at the sites and their role in managing flood risk in the surrounding area should be carefully considered. Flood Zone 3ai includes the areas of land that would be in Flood Zone 3b if not already developed. Flood Zone 3ai should therefore be used as an indicator of flood risk, from a modelled 1 in 20 year event, to existing development sites".

Flood Zone 3ai has therefore been defined, within the AAP areas, through the 1 in 20 and 1 in 25 AEP event outlines produced from the Bradford Beck Model, 2013 and the Upper Aire FRMS, 2005 respectively. The most up-to-date available MasterMap data and OS mapping, supplied by the council, along with aerial photography[8] were used to define currently developed land.

1.4.3 Green Infrastructure Opportunities

This Level 2 study will focus on any Green Infrastructure opportunities for flood risk management by referring to areas of proposed Green Infrastructure identified in the council's Green Infrastructure studies for the AAPs. The NPPF explains that open space can perform many functions, including flood risk mitigation, and that Local Plans should account for increased flood risk, resulting from climate change, through the planning of Green Infrastructure (GI). GI can have an important role to play in reducing the likelihood of flooding by providing space for flood storage, reducing runoff and increasing infiltration, whilst also providing wildlife habitats and recreational land.

Alongside GI should be the implementation of Sustainable Drainage Systems (SuDS), specifically within proposed development sites, where possible. The suitability of GI and SuDS should be informed by this SFRA through utilisation of open space for water in the areas of greatest flood risk. The December 2014 announcement from the Department for Communities and Local Government (DCLG) that Local Planning Authorities will be responsible for the delivery of SuDS, will offer opportunities to increase GI within the AAP areas and to quality control all new drainage schemes for new and redeveloped large sites. See Section 4.4.1 for more information on SuDS.

The Bradford City Centre Green Infrastructure Study[9] and the Shipley and Canal Road Corridor Green Infrastructure Study[10] provide more detail on GI within the AAP areas. These GI studies indicate that in the highest flood risk areas, space can be created for flooding through the safeguarding of areas of open space and Green Infrastructure. Proposed areas of GI, output from these GI studies, are shown on the SFRA mapping.

The Town and Country Planning Association together with The Wildlife Trusts produced a guidance document for Green Infrastructure[11]. The guidance states that the Local Plan should identify funding sources for GI and provision should be made for GI to be adequately funded as part of a developments core infrastructure. For new developments, GI assets can be secured from a landowner's 'land value uplift' and as part of development agreements. The LPA could include capital for the purchase, design, planning and maintenance of GI within its Community Infrastructure Levy programme.

Section 3.4 discusses the possible opportunities for GI integration within the planning of proposed sites, relative to flood risk.

8 Copyright:© 2013 Esri, DeLorme, NAVTEQ, TomTom

9 Bradford City Centre Green Infrastructure Study, Gillespies, October 2014

10 Shipley and Canal Road Corridor Green Infrastructure Study, Gillespies, October 2014

11 Planning for a Healthy Environment - Good Practice Guidance for Green Infrastructure and Biodiversity, Published by the Town and Country Planning Association and The Wildlife Trusts, July 2012

2 Flood Risk Review

2.1 Previous Studies

As mentioned previously, fluvial flood risk has been assessed using the outputs from the Bradford Beck Flood Model, 2013, the Upper Aire FRMS, 2005 and the Environment Agency's Flood Map for Planning.

2.1.1 Bradford Beck

The Level 1 SFRA reviews the flood modelling studies that have been completed and includes a review of flood history and general flood risk within the Bradford local authority area. The most recent study concerning Bradford Beck is the Bradford Beck Flood Modelling Study, 2013[6]. The Bradford Beck study used InfoWorks CS modelling software as this software is considered effective at modelling piped drainage networks such as culverts and sewers. This extract is taken from the InfoWorks modelling report[6]:

"Based on a 1D sub-surface (pipes and culverts) model linked to a 2D surface model (DTM), detailed data on culvert, pipe and open channel sections can be included in the InfoWorks model. This includes culvert, pipe and channel shapes and dimensions, sub-surface and surface elevations, inlet and outlet data, flood level data and energy loss data. By including sub-surface drainage structures within the model, the transport and storage capacity of these structures can be accounted for in modelling scenarios. Modelled surface flows and flood extents are therefore more likely to indicate actual flood extents and flows, rather than potentially exaggerated surface-only flows".

There is a marked difference between Flood Zones 2 and 3 of the Flood Map for Planning (version August 2014) and the Bradford Beck model outputs for the 1 in 1000 (1000 year) and 1 in 100 (100 year) AEP events respectively. Northwards through the Canal Road Corridor from Bolton Woods, Flood Zone 3 is invariably larger than the 100 year event from the Bradford Beck model. Western parts of the city centre are shown to be virtually flood free for the Bradford Beck 100 year event compared to Flood zone 3 thus illustrating the benefits of the flood diversion tunnel. In the city centre around Eastbrook, risk from the 100 year event appears greater than that shown by Flood Zone 3, however, due to minimal details regarding Eastbrook, the flood extents are considered to be unpredictable.

Comparisons between Flood Zone 2 and the Bradford Beck 1000 year event show that the Bradford Beck output is larger than Flood Zone 2 throughout both AAP areas, with the exception being in the west of the city centre around the university, again most likely due to the diversion tunnel. As discussed in Section 1.4, the Bradford Beck 2013 model has been reviewed by the council and, in agreement with the Environment Agency, is considered to be the best source of information when reviewing fluvial flood risk from Bradford Beck thus will be used to update the EA Flood Map for Planning in due course.

The 2013 study InfoWorks model is designed to be a 'live' model that can be updated and edited as and when required if and when new information becomes available or to model certain scenarios such as the effect of floodplain removal on flood risk elsewhere. This model may be made available by the council for any site-specific Flood Risk Assessments that may be required as a result of development.

2.1.2 River Aire

The Upper Aire FRMS was completed in 2005. There has since been a review and update of this study in 2008, however, there was minimal change in the modelled outputs. The influence of the River Aire on the SCRC AAP area is confined to the area north of Dockfield Road so only affects three of the proposed development sites in the Dockfield Road area.

3 AAP Flood Risk Review and Assessment

3.1 Introduction

The BCC AAP boundary includes the main shopping, civic, entertainment and central business district of the city centre and also more peripheral areas such as Little Germany, Goitside, and the College and University campuses[12].

As discussed in Section 1.3.2, Bradford City Centre is made up of six neighbourhood areas based on differing development focuses:

- The Bowl - proposed as business core, predominantly employment uses, minimum expected residential units of approximately 500. Currently car parking, vacant and occupied buildings;
- The Channel - proposed retail, namely new Broadway Shopping Centre, residential led mixed use developments, minimum expected residential units of approximately 1,010. Currently car parking, vacant land / buildings;
- The Market - proposed small retail, some residential; currently car parking, vacant mills and market space;
- The Valley - proposed focus on residential with minimum expected units of approximately 500, some retail. Currently car parking, vacant mills and shops;
- The Learning Quarter - proposed mainly residential for student accommodation; currently car parking areas;
- The Southern Gateway - proposed for residential with minimum expected approximately 740 units. Currently industrial.

The SCRC AAP boundary extends from the northern edge of Bradford City Centre to Shipley. It includes Shipley town centre and areas of housing, open space, industry and employment located alongside Canal Road[13].

As stated in Section 1.3.3, the SCRC has been further subdivided into three areas of opportunity:

- Shipley - emerging residential development opportunities within the town centre (50 - 100 units), Shipley East (100 - 150 units) and Dockfield Road (300 - 400 units) with mixed use residential and employment proposals. Current uses include industrial and vacant land;
- New Bolton Woods - proposed residential development concentrated around the New Bolton Woods Masterplan site (1,000 - 1,200 residential units) including retail and business developments, a school and playing fields. Bolton Woods Quarry proposed for several areas of open space, in addition to residential (1,000 units) and employment uses. Current uses are predominated by open space and existing quarry, with some industrial and residential areas;
- The City Centre Fringe - proposed residential equating to around 100 - 150 units, employment uses and open space enhancement considered in the areas of Boars Well and Canal Road.

As previously discussed in Section 1.2, this Level 2 SFRA was required to inform on both AAP areas due to the fact that a number of proposed development sites are shown to be at some level of fluvial risk from Bradford Beck or the River Aire. As the economic and social importance of these sites are considered to outweigh the level of flood risk, this Level 2 assessment helps to inform application of the second part of the Exception Test.

12 City Centre Area Action Plan, Further Issues and Options Report, City of Bradford MDC, March 2013

13 Shipley and Canal Road Corridor Area Action Plan, Further Issues and Options Report, City of Bradford MDC, March 2013

3.2 Fluvial Flooding - Existing Risk

3.2.1 Fluvial Flood Flow Pathways

Bradford Beck has been modelled, as part of the 2013 study, from the culvert at Princeroyd Way, Brown Royd, where the beck descends underground and through the city centre, northwards to the downstream model boundary at Dockfield Road in Shipley.

For the 1 in 100 AEP event, the beck starts surcharging when the tributaries of Bowling Beck and Eastbrook enter Bradford Beck around Broadway and Bank Street. Surcharging from Bowling Beck is limited to this area and also to land adjacent to Nelson Street south of the Bus Station. Eastbrook is shown to surcharge along its whole length within the BCC AAP area however the outputs from Eastbrook are considered unpredictable.

Within the SCRC AAP area, surcharging of the culvert at Cape Street is apparent for the 1 in 100 AEP event with flooding continuing downstream through the works before ceasing at the gas holders. A small pocket of flooding occurs at the confluence of Bradford Beck and the Diversion Tunnel where the beck opens up before descending under Station Road. Minor flooding from both banks of the beck occurs where the beck opens up again along the boundary of King George V Memorial Playing Fields and Canal Road. North of Gaisby Lane the flood extent from the right bank increases and also from the left bank at Owlet and along Valley Road. The 1 in 100 AEP flood extent is shown to overtop banks again around Briggate.

The downstream boundary of the Bradford Beck model is at the bridge on Dockfield Road. The Flood Map for Planning is then used to assess the risk from the River Aire. The 1 in 100 AEP flood event (Flood Zone 3) is shown to breach the right bank of the Aire immediately downstream of the A6038 flooding several industrial buildings.

Refer to the SFRA Maps in Appendix A to view the fluvial flood outlines.

3.2.2 The Functional Floodplain (Flood Zone 3b)

A requirement of this SFRA is to define the functional floodplain and Flood Zone 3ai outlines. These outlines have been finalised through discussion and agreement between JBA Consulting, CBMDC and the Environment Agency.

The functional floodplain is represented by the 1 in 20 and 1 in 25 AEP events produced from the Bradford Beck 2013 and Upper Aire FRMS 2005 models respectively. The BCC AAP area contains only a small area of functional floodplain due to the density of development and infrastructure in the city centre meaning, on the whole, there is not a reasonable amount of space for storage of flood water.

Bradford Beck mostly flows sub-surface in the city centre though the 1 in 20 AEP event outline is shown to flow above ground on land between Caledonia Street and Croft Street in the Southern Gateway Neighbourhood. Within the SCRC area, the 1 in 20 AEP event outline appears to surcharge the culvert at Cape Street causing flooding to the land around Singleton Street and Valley Road. Valley Road then forms a flood pathway before land around the Works becomes inundated. Land around Owlet is also within the 1 in 20 year outline, as is a small area south of Briggate. The River Aire 1 in 25 AEP event outline displays a similar coverage to that of Flood Zone 3 without extending quite so far south and downstream.

The SFRA mapping shows the extent of the functional floodplain alongside Flood Zone 3ai and the 1 in 100 and 1 in 1000 AEP event outlines.

The road network that is utilised by the Bradford Beck 1 in 20 year outline as a flood flow pathway has not been defined as functional floodplain. Also, much of the area around the Works and Singleton Street is currently developed and has therefore been designated as Flood Zone 3ai. Several areas of Owlet have been included within the functional floodplain as much of the land is currently undeveloped or used for allotments or parkland. The 1 in 20 AEP event outline south of the Briggate road (A657) includes areas of open space and woodland thus has been designated as functional floodplain.

3.2.3 Fluvial Flood Depths and Hazards

The SFRA mapping shows the Bradford Beck modelled flood depths and hazard ratings for the 1 in 100, 1 in 100 + climate change (+cc) and 1 in 1000 AEP flood events. Depth and hazard information has not been made available for the River Aire. Consideration of flood depth is an important factor in development planning as it provides an indication as to the scale of flood risk to people and whether mitigation options will be viable.

In general, flood depths are low for the majority of proposed sites though there are exceptions. As discussed throughout Section 3.4, it is recommended that, for most sites, development may be possible if a sequential approach to site layout is applied thus removing development, especially those proposed for residential uses, from Flood Zones 3b, 3a and 3ai where possible. If this approach can be achieved at all sites then the depth of flooding from Flood Zone 3a would be less of an inhibition to development.

Table 3-1, taken from the Flood Risks to People document, produced by Defra,[14] whereby flood hazard represents risk to people as a function of a design flood's depths and velocities.

Table 3-1: Flood Hazard Thresholds

Flood Hazard d x (v+0.5)	Description	Alternative Name / Hazard Class
0	Safe (dry)	None
0 to 0.75	Caution	Low
0.75 to 1.5	Dangerous for some	Moderate
1.5 to 2.5	Dangerous for most	Significant
Over 2.5	Dangerous for all	Extreme

As can be seen on the SFRA Maps in Appendix A, flood hazard within proposed sites is generally low to moderate for Flood Zone 3a, though larger areas of significant hazard are apparent within site NBW1. There are no extreme hazard areas within any site apart from along the immediate channel banks of Bradford Beck in site SE1. Sites CH/1.1, CH/1.2 and SG/1.2 contain areas of significant hazard, particularly Site SG/1.2 where the whole central portion of the site is with the significant hazard outline.

If the recommendations discussed in Section 3.4 are adhered to then the flood hazards should not pose an insurmountable issue to development. However, if it is necessary to build within the flood zones then depth and hazard information should be investigated more closely and appropriate mitigation measures should be sought.

3.3 Surface Water Flooding

The updated Flood Map for Surface Water (uFMfSW) has been used to assess surface water risk to each site. It can be seen from the SFRA Maps that the high risk 1 in 30 AEP event is confined to small areas, mainly within New Bolton Woods and the City Centre Fringe of the SCRC AAP area. There are large areas at risk from the 1 in 30 AEP event, mainly around Portland Street and Britannia Street in the Southern Gateway and around Eastbrook in The Channel Neighbourhood. Thornton Road, running through The Valley Neighbourhood, is utilised as a flood flow pathway by surface water flows.

The medium risk 1 in 100 AEP event outline is similar to the 1 in 30 year extent in terms of coverage of the city centre with the exception of the north end of The Channel around the A6181. In the SCRC, the 1 in 100 outline extends over a much larger area in the City Centre Fringe and parts of the Hallam Court Industrial Estate. The medium risk event is localised to small areas in and around the periphery of Shipley.

The low risk 1 in 1000 AEP extreme event inundates large areas of both AAP areas, especially to the west of the Canal Road in the SCRC. In the city centre, a lot more roads are used as flood flow pathways, causing floodwaters to be directed around the city centre.

Section 4 discusses the possibilities for Critical Drainage Area (CDA) designation, where surface water risk is considered significant enough to warrant such a designation.

14 Flood Risks to People, Phase 2, The Flood Risks to People Methodology, Defra. March 2006

3.4 Implications for Proposed Development

This section discusses the implications of flood risk to proposed sites and recommends options and solutions in order for development to proceed safely.

3.4.1 Development Site Summary

The following tables summarise the conclusions drawn from the analysis of each site following assessment of both fluvial and surface water flood risk. More detailed information can be found within the site assessment spreadsheets in Appendix B. Figure 3-1 shows a colour coded map of the proposed sites, based on the recommendations formulated from this SFRA.

SCRC Site CCF4 has extant planning permission thus is not included in the sites summary.

Table 3-2 applies to any site whereby development is discouraged and serious consideration should be given to removing the site from the council's list of allocated sites. This recommendation applies to two sites.

Table 3-2: Sites where development will prove difficult

Site Reference	AAP	Comments
DF4	SCRC	The fact that 80% of this relatively small site is within the functional floodplain effectively rules out development. This site should be used as open greenspace. A possible scenario could be to combine this site with Site DF5 across the road whereby the residential part of the two sites is located within the DF5 boundary
SG/1.2	BCC	75% of the site within Flood Zone 3 of which 27% is within Flood Zone 3b and cannot therefore be developed. 76% is within the high risk 1 in 30 year surface water flood outline.

Table 3-3 lists three sites, each within the BCC AAP area that will have to pass the second part of the Exception Test, through a site-specific FRA, in order for development to proceed. For these sites, changes in site layout are unlikely to be possible due to the scale of risk. As discussed throughout this report, to pass the Exception Test development must show that flood risk to people and development would be managed satisfactorily and be safe for its lifetime without increasing risk elsewhere and where possible reducing overall risk.

Table 3-3: Sites which must pass Exception Test

Site Reference	AAP	Comments
B/1.5	BCC	Due to the number of residential units required and the location of Flood Zone 3a on-site means it is unlikely that all residential can be situated outside of Flood Zone 3a.
CH/1.1	BCC	81% of proposed residential site within Flood Zone 3a. Significant risk from surface water flooding
CH/1.13	BCC	59% of proposed residential site within Flood Zone 3a. Risk from surface water flooding

Table 3-4 presents the six sites that would be required to pass the second part of the Exception Test, unless, following the sequential approach to development, site layout takes account of the requirements of the FRCC-PPG by directing any residential uses outside of Flood Zone 3a. Each site would be subject to a detailed site-specific FRA.

Table 3-4: Sites which require the Exception Test, dependant on site layout

Site Reference	AAP	Comments
CH/1.2	BCC	Proposed mixed use site therefore may be possible to locate residential uses outside of Flood Zone 3a. Surface water risk should be assessed as part of FRA
DF2	SCRC	Proposed mixed use site with only 8% within Flood Zone 3a therefore should be possible to locate residential uses outside of Flood Zone 3a.
DF5	SCRC	Proposed mixed use site with only 3% within Flood Zone 3a therefore should be possible to locate residential uses outside of Flood Zone 3a.
NBW1	SCRC	Proposed mixed use site with 3% in Flood Zone 3b and 5% in Flood Zone. 84% of this 49 ha site is within Flood Zone 1 therefore it should be possible to locate all

Site Reference	AAP	Comments
		development outside of any flood zones and to use the proposed Greenway to cover risk area
NBW5	SCRC	Proposed residential site with 1% in Flood Zone 3b and 3% within Flood Zone 3a. All residential development should be directed away from these areas.
SE1	SCRC	Proposed mixed use site incorporating GI with under 10% of the site area within Flood Zone 3b and 7% within Flood Zone 3a. With a site area of 8 ha it should be possible to locate development outside of these risk areas.

Table 3-5 is made up of 22 sites that are either wholly located outside of Flood Zone 3a or whereby only a nominal area is within Flood Zone 3a and / or Flood Zone 3b. It is assumed that these nominal areas can be avoided and residential and mixed use development directed away to lower risk zones thus avoiding the requirement for the Exception Test. Sites proposed for employment do not require the Exception Test.

These sites may have some part of their boundary within Flood Zone 2, be at risk from climate change or be at risk from surface water, therefore a site-specific FRA would be required to ensure safe development. Also listed are sites that may be wholly in Flood Zone 1 and without any perceived surface water risk, but are greater than 1 ha in size. According to FRCC-PPG, all sites with an area greater than 1 ha are subject to a site-specific FRA.

Table 3-5: Sites permitted subject to FRA

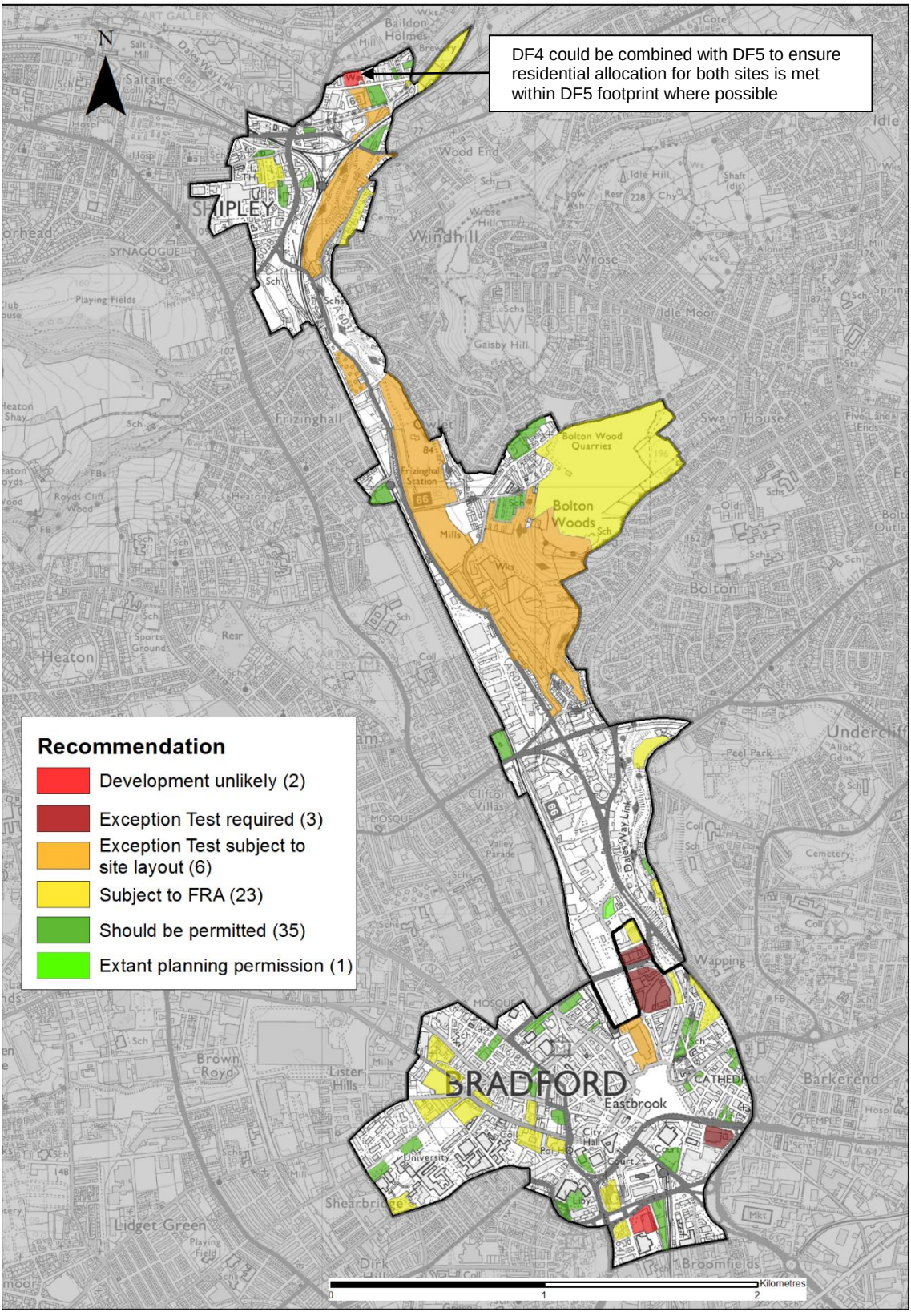
Site Reference	AAP	Comments
B/1.3	BCC	Proposed employment site with minimal fluvial and surface water risk.
B/1.6	BCC	Proposed mixed use site with 80% of its area within Flood Zone 2. Nominal area within Flood Zone 3a. Significant surface water risk
CH/1.4	BCC	Site area >1 ha
CH/1.8	BCC	Proposed residential site wholly outside of Flood Zone 3a but at risk from Flood Zone 2
CH/1.12	BCC	Proposed residential site with nominal area within Flood Zone 3a and Flood Zone 2. 22% of the site is within Flood Zone 3ai. This current development footprint within this 29% area must not change or could be demolished and left as open space
LQ/1.3	BCC	Proposed employment site with minimal fluvial risk
SG/1.1	BCC	Proposed residential site wholly outside of Flood Zone 3a but at risk from Flood Zone 2
V/1.1	BCC	Proposed residential use site wholly outside of Flood Zone 3a though with 98% within Flood Zone 2
V/1.2	BCC	Proposed mixed use site wholly outside of Flood Zone 3a but at risk from Flood Zone 2
V/1.3	BCC	Site area >1 ha
V/1.5	BCC	Proposed residential site wholly outside of Flood Zone 3a but at risk from Flood Zone 2
V/1.6	BCC	Proposed residential site wholly outside of Flood Zone 3a but at risk from Flood Zone 2. Surface water risk
V/1.7	BCC	Proposed residential site wholly outside of Flood Zone 3a but at risk from Flood Zone 2
V/1.8	BCC	Proposed mixed use site with nominal area within Flood Zone 3a. Nominal risk from surface water
V/1.10	BCC	Proposed residential site wholly outside of Flood Zone 3a but at risk from Flood Zone 2. Surface water risk
DF7	SCRC	Significant area at risk from extreme surface water flood event
CCF3	SCRC	Significant area at risk from extreme surface water flood event
BWQ	SCRC	Site area >1 ha, minimal surface water risk
CCF1	SCRC	Site area >1 ha
DF1	SCRC	Site area >1 ha, minimal surface water risk
SE2	SCRC	Site area >1 ha, minimal surface water risk
STC2	SCRC	Site area >1 ha, minimal surface water risk

Table 3-6 includes sites that are wholly within Flood Zone 1 and are less than 1 ha in area. Surface water risk may exist though is considered minimal. There are 34 sites fulfilling this criteria.

Table 3-6: Sites should be permitted

Site Reference	AAP	Comments
B/1.1	BCC	Nominal surface water risk
B/1.2	BCC	Nominal surface water risk
B/1.4	BCC	Nominal surface water risk
CH/1.3	BCC	Nominal surface water risk
CH/1.5	BCC	No perceived risk
CH/1.6	BCC	No perceived risk
CH/1.7	BCC	Nominal surface water risk
CH/1.9	BCC	Nominal surface water risk
CH/1.10	BCC	Nominal surface water risk
CH/1.11	BCC	Nominal surface water risk
LQ/1.1	BCC	Nominal surface water risk
LQ/1.2	BCC	Nominal surface water risk
M/1.1	BCC	Nominal surface water risk
M/1.2	BCC	Nominal surface water risk
M/1.3	BCC	No perceived risk
M/1.4	BCC	No perceived risk
M/1.5	BCC	No perceived risk
SG/1.3	BCC	Some surface water risk for extreme event
V/1.4	BCC	No perceived risk
V/1.9	BCC	Nominal surface water risk
CCF2	SCRC	Nominal surface water risk
DF3	SCRC	Nominal surface water risk
DF6	SCRC	Nominal surface water risk
DF8	SCRC	Nominal surface water risk
DF9	SCRC	No perceived risk
NBW2	SCRC	Nominal surface water risk
NBW3	SCRC	Nominal surface water risk
NBW4	SCRC	Some surface water risk for extreme event
NBW6	SCRC	Some surface water risk for extreme event
NBW7	SCRC	No perceived risk
STC1	SCRC	Nominal surface water risk
STC3	SCRC	No perceived risk
STC4	SCRC	Nominal surface water risk
STC5	SCRC	No perceived risk
STC6	SCRC	No perceived risk

Figure 3-1: Proposed site recommendations



3.4.2 Detailed Assessment

Appendix B provides a screening assessment of both fluvial and surface water flood risk to proposed development sites in the BCC AAP and SCRC AAP areas. The SFRA Maps in Appendix A shows the proposed sites together with all flood risk information.

For simplicity in assessing risk in relation to the NPPF and Flood Risk and Coastal Change Planning Practice Guidance (FRCC-PPG) the Bradford Beck outlines will from this point forward be referred to as their equivalent flood zone category i.e. 1 in 20 is Flood Zone 3b and Flood Zone 3ai, 1 in 100 is Flood Zone 3a, 1 in 1000 is Flood Zone 2.

Of the 29 proposed sites in the SCRC AAP area, 22 are located completely within Flood Zone 1. Seven sites have some part of their boundary within the 1 in 1000 AEP event outline (Flood Zone 2), seven sites have some part of their boundary within the 1 in 100 AEP event outline (Flood Zone 3a) four sites are partially within Flood Zone 3ai and a further four sites have some part of their boundary within the functional floodplain. Six sites are at risk of increased flooding due to the impacts of climate change on river flows. SCRC Site CCF4 has extant planning permission thus is not included within the following recommendations.

Of the 40 proposed sites in the BCC AAP area, 22 are completely within Flood Zone 1. 18 sites have some part of their boundary within the 1 in 1000 AEP event outline (Flood Zone 2), nine sites have some part of their boundary within the 1 in 100 AEP event outline (Flood Zone 3a), two sites are partially within Flood Zone 3ai and one site has some part of its boundary within the functional floodplain. Eight sites are at risk of increased flooding due to the impacts of climate change on river flows.

Table 3-7 and Table 3-8 summarise fluvial risk to proposed sites for SCRC and BCC sites respectively. Section 3.5 discusses the impact of climate change and the increased risk to sites.

Table 3-7: Fluvial Flood Risk Summary for SCRC Sites

			Flood Zone 1	Flood Zone 2	Flood Zone 3a	Flood Zone 3ai	Flood Zone 3b
Proposed Use	**No. Sites**	**Area (ha)**	**No. 100%**	**No.**	**No.**	**No.**	**No.**
Residential	18	39.8	16	2	2	2	1
Mixed use	11	64.4	6	5	5	2	3
TOTAL	**29**	**102**	**22**	**7**	**7**	**4**	**4**

Table 3-8: Fluvial Flood Risk Summary for BCC Sites

			Flood Zone 1	Flood Zone 2	Flood Zone 3a	Flood Zone 3ai	Flood Zone 3b
Proposed Use	**No. Sites**	**Area (ha)**	**No. 100%**	**No.**	**No.**	**No.**	**No.**
Residential	20	12.9	11	9	3	1	0
Employment	7	5.4	4	3	2	1	1
Mixed use	12	10.0	6	6	4	0	0
Expansion area	1	0.9	1	0	0	0	0
TOTAL	**40**	**29**	**22**	**18**	**9**	**2**	**1**

Table 3 of the Flood Risk and Coastal Change Planning Practice Guidance (FRCC-PPG) states that only water-compatible uses and essential infrastructure should be permitted in Flood Zone 3b, though any essential infrastructure must pass the Exception Test. Essential infrastructure in Flood Zone 3b must also remain operational and safe during a flood with no net loss in floodplain following construction, whilst also not impeding flood flows and causing increased risk elsewhere.

In Flood Zone 3a, less vulnerable and water compatible uses are permitted whilst highly vulnerable uses are not. Essential infrastructure and more vulnerable uses must pass the Exception Test following completion of the Sequential Test. The FRCC-PPG states that

essential infrastructure in Flood Zone 3a must be designed and constructed to remain safe and operational in times of flood.

Where the Exception Test is required, the application of the Sequential Test should already have taken place, using the site assessment spreadsheets in Appendix B. Part b of the Exception Test is to ensure that development does not increase flood risk to others. One way in which development can increase flood risk to others is by developing within a flood zone. Building within a flood zone can displace floodwater and subsequently increase water levels upstream and downstream of the new development. The Environment Agency state that if development does need to go ahead in the 1 in 100 year fluvial flood zone, then there should be no loss of flood flow or flood storage capacity as a result of the development. See Sections 3.6.1.3 and 3.6.1.4 for compensatory storage options.

One of the policy aims within the FRCC-PPG is to reduce the overall level of flood risk through the layout and form of development sites, using a sequential approach to site layout. This can be achieved by increasing conveyance (flow) through a site or by providing compensatory flood storage either on site or upstream of a development.

The following sections discuss fluvial risk to proposed sites per 'Opportunity Area' within the SCRC AAP area and per 'Neighbourhood' within the BCC AAP area.

These sections should not be read in isolation but alongside the site assessment spreadsheets and SFRA Maps available in the Appendix.

3.4.3 Shipley Opportunity Area - SCRC AAP

Primary development opportunities in Shipley are focused on the town centre, Shipley East and the Dockfield Road area.

3.4.3.1 Site SE1 (Shipley East)

This site has had planning permission granted therefore it is assumed the following advice has already been taken into account. The site is reserved for a residential led mixed use development of up to 150 residential units with the possibility of family housing and apartments and supporting business and retail uses. Bradford Beck runs through the site meaning 9.5% of the site footprint is within the functional floodplain, the extent of which does not deviate from the course of the beck by more than 25 m.

According to Table 2 of the FRCC-PPG, residential buildings fall into the more vulnerable category and retail and businesses are within the less vulnerable category. Table 3 of the FRCC-PPG indicates that neither development type is permitted within the functional floodplain. The site area is 8 ha with 73% of the site footprint in Flood Zone 1, so it is considered practical that development is kept out of the functional floodplain using the sequential approach to site layout.

Much of the area within the functional floodplain is covered by proposed Green Infrastructure (GI), formulated from the Green Infrastructure Study (Section 1.4.3) as illustrated by the SFRA mapping. These GI areas are designated for amenity greenspace and Bradford Beck is included within existing blue infrastructure, which includes any waterbody within areas of GI. The amenity greenspace areas should be extended to the outer boundary of the functional floodplain thus creating a floodplain corridor along Bradford Beck ensuring development is kept out of Flood Zone 3b.

6.6% of the site is within Flood Zone 3a. The residential use of the development must pass the Exception Test in order to be permitted though the less vulnerable retail and business uses are permitted according to the FRCC-PPG. However, as the site is currently predominantly greenspace, it is recommended that no development should take place within Flood Zone 3a to avoid floodplain losses. If this is not feasible then compensatory storage or increased conveyance would need to be found to offset the loss in floodplain. Compensatory storage could take place on-site due to the large area available and the proposed inclusion of GI (see Section 3.6.1.3).

Flood depths in some small pockets, particularly in the northern part of the site, within Flood Zone 3a can reach up to 1 m deep and the hazard rating can reach 'significant' levels, which means 'dangerous for most' (see Table 3-1). This may lead to the site failing the Exception Test.

10.8% of the site is within Flood Zone 2 where more and less vulnerable uses are permitted. Excluding areas within Flood Zone 3a and 3b, 84% of this site is therefore permitted for development, however developers should look to situate as much of the development within Flood Zone 1, focusing on the residential units first. Were any development to take place within Flood Zone 3, a detailed evacuation plan would need to be developed and linked to relevant flood warning alerts.

Surface water risk on-site is minimal, based on the updated Flood Map for Surface Water (uFMfSW). 6.4% is at risk from the 1 in 30 year and 5% is at risk from the 1 in 100 year surface water flood events. Given the large size of the site, consideration should be given to leaving the at risk areas as open space and incorporating appropriate SuDS techniques. Restrictions on surface water runoff from new development should be incorporated into the development planning stage.

A site-specific FRA was carried out for this site in September 2013[15]. The FRA did not consider the functional floodplain as it had not yet been finalised through the Level 1 SFRA. The report did however state that all development would take place within Flood Zone 1 and Flood Zone 2 and therefore outside of Flood Zone 3. The FRA showed that development could proceed assuming finished floor levels, access roads and pedestrian walkways are set to appropriate minimum levels; and compensatory storage is provided in the southern end of the site. The FRA may have to be revisited and updated to show that the functional floodplain defined through this SFRA has been taken account of.

3.4.3.2 Site DF2 (Junction Bridge, Briggate, Dockfield Road)

Currently an industrial site with most of the land clear of buildings according to aerial photography[17]. The proposed use is for business and residential and as the land is Brownfield then runoff rates should not exceed current rates.

Bradford Beck runs along the western boundary of the site and the Leeds Liverpool Canal along the northern edge. Fluvial flood risk occurs immediately along the western boundary from Bradford Beck with 28% of the site at risk. Only 7.7% is within Flood Zone 3a which should be left free from the residential part of the development. If this is not possible following a sequential approach to site layout, then the second part of the Exception Test must be passed to show that flood risk to people and development would be managed satisfactorily and be safe for its lifetime without increasing risk elsewhere and where possible reducing overall risk. Were any development to take place within Flood Zone 3a, a detailed evacuation plan would need to be developed and linked to relevant flood warning alerts.

Flood depths rarely exceed 0.25 m and the associated flood hazard is generally of low to moderate which will aid the passing of the Exception Test.

It is advisable however to leave the whole risk area free from any development if feasible. Surface water risk is minimal according to the uFMfSW though a site-specific FRA would be required to ensure criterion for safe development and flood risk management, including safe access and egress.

3.4.3.3 Site DF4 (Dockfield Road North)

This site is situated on an area of Brownfield land proposed for mixed use development of business and residential uses. The whole of this site is at some level of fluvial risk from the River Aire with 84.6% of the footprint within the Aire's functional floodplain meaning 84.6% of the site should be safeguarded for open space and for flood storage. 12.3 % is within Flood Zone 3a and a nominal amount is within Flood Zone 3ai and Flood Zone 2. The site area is

15 Land off Crag Road, Shipley. Flood Risk Assessment, Final Report v1.0, Weetwood, September 2013

small at 0.6 ha meaning any changes in layout to remove residential development from Flood Zone 3a would not be possible.

An option may be to review and update the 2005 Upper Aire model, through a detailed site-specific FRA, to assess whether the outputs may lower the risk to the site based on more up-to-date hydrological conditions and model components. Potential river modelling could assess the benefit of defences to the site with considerations as to whether the potential associated costs of defending the site would be justifiable when compared to the cost of development.

Site DF5 is located adjacent to this site on the south side of Dockfield Road. This site is also Brownfield land with the same proposed uses. Another option could be to combine sites DF4 and DF5 in such a way that all or most residential development is directed toward site DF5 and businesses are situated within the higher risk DF4 site, though situated outside of the functional floodplain.

The Green Infrastructure Study, 2013, proposes that this area of land could incorporate areas of greenspace. In terms of reducing flood risk, this should be considered as part of the end use of the land.

3.4.3.4 Site DF5 (Dockfield Road South)

As discussed in the previous section for Site DF4, this site is currently Brownfield land proposed for mixed residential and business uses. The site is bordered by the Leeds Liverpool Canal to the south and Bradford Beck to the west. Almost the whole western half of the site is at fluvial risk from Bradford Beck though only 6.6% is within Flood Zone 3a, which should be kept free from residential development to avoid the Exception Test. A nominal amount is within Flood Zone 3ai. FRCC-PPG permits such mixed use development in Flood Zone 2 and as the site is small at under 1 ha (0.7 ha), there would not be a significant loss in floodplain. A site-specific FRA would be required to ensure there would be no significant loss in floodplain that may increase risk upstream or downstream of the site. This may involve interrogation of the current Bradford Beck 2013 model to simulate floodplain loss scenarios.

Another option would be to plan development with a view to combining the proposed uses with site DF4, as discussed in Section 3.4.3.3 previously. Also, as with DF4, the GI Study, 2013, proposes that this site could include open greenspace. This should be the preference for the area within Flood Zone 3a. Were any development to take place within Flood Zone 3, a detailed evacuation plan would need to be developed and linked to relevant flood warning alerts. A site-specific FRA would be required to ensure criterion for safe development and flood risk management, including safe access and egress. Also, as the land is Brownfield, at a minimum, runoff should not exceed current rates.

3.4.4 New Bolton Woods Opportunity Area - SCRC AAP

Development opportunities within this Opportunity Area are centred on the New Bolton Woods Masterplan site and Bolton Woods Quarry. The New Bolton Woods site consists of several individual site options that have also been assessed separately in this section, along with the New Bolton Woods site as a whole.

3.4.4.1 New Bolton Woods 1

This is a large site of 49 ha that currently contains several land uses and is proposed for a mixed use site of residential, employment, a school and playing fields. The south western boundary of the site runs along Bradford Beck which is flowing above surface. There is risk to the site from Flood Zone 2 along the Canal and Valley roads continuing downstream to the site's most northern boundary at Poplar Road, Owlet. A large area of the King George V Memorial Playing Fields is also within Flood Zone 2.

The greatest risk comes north of Gaisby Lane to Owlet where there is risk from Flood Zone 3a and Flood Zone 3b. The major risk from Flood Zones 3b and 3a does not extend more than approximately 90 m from the site boundary at Bradford Beck eastwards from Canal Road and Frizinghall Road, towards the residential area of Owlet. This indicates that previous residential development of Owlet has sought to avoid the floodplain which, for the majority of its length, is currently undeveloped greenspace and playing fields. This area of land should continue to be

used for greenspace and left open. The site as a whole has only 2.6% of its area within Flood Zone 3b, with under 5% within Flood Zone 3a and 8% within Flood Zone 2. 84% of the site is therefore within Flood Zone 1 and is therefore developable subject to a site-specific FRA. Surface water risk is considered minimal.

It is recommended that a Green Infrastructure corridor should be put in place along Bradford Beck, ensuring that such greenspace covers the flood zones up to their eastern extent. Flood Zone 3a is similar in its extent to Flood Zone 2 therefore it should be possible to include all risk areas within a Green Infrastructure corridor and still leave 84% of the site available for development.

Were a Green Infrastructure corridor to be implemented, the site would still be subject to the Exception Test. However, if development can be directed away from the western boundary, out of the floodplain, then passing the second part of the Exception Test is likely. Were any development to take place within Flood Zone 3a, a detailed evacuation plan would need to be developed and linked to relevant flood warning alerts.

3.4.4.2 Site NBW5 (Flats, East Valley Road)

A nominal area of this site is within the functional floodplain (1%) and Flood Zone 3ai (0.1%) whilst only 3.4% is within Flood Zone 3a. Flood Zone 3a flood depths rarely get above 0.5 m with hazard to people low to moderate.

The site is 1.3 ha in size and currently supports several small blocks of flats with large surrounding grassed open areas. Proposed redevelopment of the site for further residential properties means the land use will not change. If the site layout is to change, through demolition of the flats and the addition of new build housing, then the small area of functional floodplain must be left as open space. The recommendation would also be to ensure that Flood Zone 3a is left undeveloped otherwise the Exception Test must be passed for development in this area.

Currently, two blocks are partly situated within Flood Zone 3a. It is unknown as to whether these properties currently benefit from property level protection against a 1 in 100 year flood or whether they have flooded in the past. If these properties are to remain then the prospect of property level protection to a 1 in 100 year standard should be investigated for the ground floor flats. Safe access and egress routes should also be investigated and put in place if not already present. Were any development to take place within Flood Zone 3a, a detailed evacuation plan would need to be developed and linked to relevant flood warning alerts.

A further option would be to demolish the flats and not rebuild within Flood Zone 3a. This would result in a return of part of the site to natural floodplain which may cause a reduction in risk downstream. A site-specific FRA would be required to assess options.

3.4.5 The City Centre Fringe Opportunity Area - SCRC AAP

The emerging development options for the City Centre Fringe include Boars Well Green Corridor (along Bolton Road), the Canal Road Employment Area and the Forster Square and Valley Road Retail Area.

3.4.5.1 Site CCF4 (Land between Singleton Street and Valley Road)

This site is currently a vacant office building, including a car park, with permission granted for a change of use to residential with 60 units planned. This site has previously been granted planning permission in 2013, supported by a site-specific FRA, and therefore has not been assessed through this Level 2 SFRA.

In order to allocate, the SCRC AAP should include a requirement in the site allocation statement that the measures detailed in the FRA are implemented to ensure the development and occupants are safe from flooding, in accordance with EA recommendations. These measures include the identification and provision of safe route(s) into and out of the site to an appropriate safe haven; and the implementation of flood mitigation measures on the ground floor. The EA recommend that flood proofing and mitigation measures are applied up to 600 mm above ground levels.

3.4.6 The Bowl Neighbourhood - BCC AAP

The Bowl is proposed to become the business core of the city centre with Grade A office development and late night leisure facilities.

3.4.6.1 Site B/1.3 (One Public Estate Site)

This site currently contains a large council office building and open air car parking. The site is proposed for Grade A office space. It is unknown whether the existing development will remain or whether there will be demolition and rebuilding. 87% of the site is within Flood Zone 1. The 13% that is at risk is within Flood Zone 2. Table 3 of the FRCC-PPG indicates that development is appropriate though in order to remove fluvial risk to buildings, the risk area should remain free from development and allowed to flood. The risk area is confined to the south eastern corner of the site meaning any changes in site layout should not be onerous. Risk from surface water flooding is minimal.

A site-specific FRA would be required to assess the risk and due to the site being >1 ha in area. The FRA should investigate the safety of access and egress points as Flood Zone 2 covers much of the access points along the eastern boundary and the south boundary on Croft Street.

3.4.6.2 Site B/1.5 (Former Yorkshire Water Depot)

Current buildings to be demolished for new development containing leisure facilities, retail units and up to 400 residential units. It may be difficult to accommodate the proposed housing numbers as 77% of the site is within Flood Zone 3a for which the Exception Test would be required. Flood Zone 3a depths however remain shallow, not exceeding 0.25 m and the hazard to people is low. 13% of the site is within Flood Zone 2.

A sequential approach to site layout should be followed with the aim of locating the residential units outside of Flood Zone 3a and therefore avoiding the requirement for the Exception Test. Flood Zone 3a covers the central part of the site so it appears unlikely that all residential units could be situated outside of Flood Zone 3a. In order to avoid the Exception Test, there may have to be a reduction in the number of housing units. Compensatory storage would need to be found to make up for the loss in floodplain. Due to limitations on the size of the site (1.07 ha) and the large area at risk from Flood Zone 3a, it is unlikely this would be possible on-site. Off-site storage may therefore have to be considered, as part of a site-specific FRA, though there does not appear to be any suitable land nearby to store floodwater (see Section 3.6.1.4).

A further option would be to construct multi-storey occupancy buildings whereby the ground floor is used for non-habitable space such as car parking or a less vulnerable use such as the proposed leisure or retail units which the NPPF would allow in Flood Zone 3a. This should be feasible with low depths and low hazard to people being apparent in Flood Zone 3a. Emergency planning would be required to ensure the safety of people and consideration should be given to the surrounding streetscape ensuring any large building is in keeping with the local area. Any development within Flood Zone 3a would require a detailed evacuation plan that is linked to relevant flood warning alerts whilst any uses for retail of leisure should implement flood resilience measures for times of flood.

In order to assess whether the site may pass the Exception Test, further modelling may be required, once site layout and mitigation measures are confirmed, to ensure the site will be safe for its lifetime without increasing flood risk elsewhere, and where possible reduce flood risk.

Surface water is also an issue on the site with 24% within the higher frequency 1 in 30 year flood outline. On-site storage would also have to be found to deal with this surface water risk. As part of the FRA, detailed surface water modelling would also be required to calculate additional floodwater volumes that would require storing on-site along with fluvial floodwaters.

3.4.6.3 Site B/1.6 (Former Bradford Odeon Cinema)

The cinema is currently vacant and is proposed for mixed use including a music venue and leisure facilities. All or part of the existing structure may be retained or otherwise demolished. A nominal area of the site is within Flood Zone 3a (2%) though this 2% should be kept free of any development in order to return the area to natural floodplain. Were any development to

take place within Flood Zone 3a, a detailed evacuation plan would need to be developed and linked to relevant flood warning alerts.

Nearly 80% of the site is situated within Flood Zone 2 for which this type of mixed use development is permitted according to the FRCC-PPG. However, as the site is situated in the city centre with limited open space, the effects of building within the extreme event floodplain (Flood Zone 2) should be investigated using the Bradford Beck model as part of a site-specific FRA. Another option, as discussed for Site B/1.5, would be multi-storey occupancy whereby the ground floor is used for non-habitable space such as car parking or a less vulnerable use such as the proposed leisure facilities. Suitable emergency planning would be required to ensure the safety of people. Alternatively, any new development could be situated on the existing development footprint to avoid displacing further areas of floodplain. Any new large development should be considerate of the existing streetscape.

The proposed use of the existing building as a music venue would be permitted according to the NPPF assuming the proposed use would fall under the less vulnerable category of Table 2 of the NPPF. Due to the large amount of people that would be expected during any events, detailed evacuation plans, linked to flood warning alerts, and suitable emergency planning procedures would need to be in place to ensure the safety of people during a flood and to ensure safe evacuation during an extreme event.

There is a significant risk from surface water flooding (34% within 1 in 30 year outline) which would need to be dealt with on-site using appropriate SuDS. As part of the FRA, detailed surface water modelling would also be required to calculate additional floodwater volumes that would require storing on-site along with fluvial floodwaters. The FRA should confirm criterion for safe development and flood risk management.

3.4.7 The Channel Neighbourhood - BCC AAP

Focus on development of Broadway Shopping Centre for expansion of comparison retail and also residential led mixed use development.

3.4.7.1 Site CH/1.1 (Former Carpet Warehouse)

Much of this site is currently cleared open space used for car parking. Several large industrial / retail units also still exist and are mostly located within Flood Zone 3a. It is proposed that these units are demolished and tall, multi-storey residential buildings are built. Almost the whole of the site footprint is at flood risk with 81% within Flood Zone 3a and the majority of the remaining space is within Flood Zone 2.

There may be an opportunity to reduce risk by utilising ground floors for car parking, whereby floodwaters can flow through the building uninhibited, or for flood storage. Flood Zone 3a flood depths however could reach up to 1.5 m in the central southern part of the site with significant hazard to people. This may rule out utilising this part of the site for car parking though scope for flood storage here should be investigated as part of a detailed site-specific FRA. Within the majority of the remaining area of the site, flood depths are mainly between 0.25 - 0.75 m with a low to moderate flood hazard. Emergency planning would be required for any underground / ground level flood storage or conveyance. Were any development to take place within Flood Zone 3, a detailed evacuation plan would need to be developed and linked to relevant flood warning alerts.

In order to avoid increasing risk downstream, the existing building footprints should be used so as to avoid additional removal of floodplain. The proposed development would be required to pass the Exception Test in order to proceed. It would be difficult to pass the Exception Test with the possibility of so much land being removed from the floodplain. The FRA must show that flood risk to people and development could be managed satisfactorily and be safe for the lifetime of the development, without increasing risk elsewhere and where possible reducing risk. Surface water risk is also an issue though could be dealt with in the same way as with fluvial risk.

3.4.7.2 Site CH/1.2 (Former Royal Mail Sorting Office)

The proposal here is for a mixed use site comprising retail, office and residential units. It is unknown whether the plan is to demolish the current Sorting Office or to redevelop the existing structure. 59% of the site is within Flood Zone 3a and 25% is within Flood Zone 2. A sequential approach to site layout should be followed with the aim of locating the residential units outside of Flood Zone 3a and therefore avoiding the requirement for the Exception Test. Flood depths within Flood Zone 3a are relatively low and rarely exceed 0.5 m with the associated hazard to people mainly low to moderate.

Were development to proceed there could be approximately 1.2 ha of land removed from the 1 in 100 AEP event floodplain, unless the existing building footprint is utilised which could maintain current risk. Options should be sought were by flood risk is reduced through construction of multi-storey occupancy developments with car parking on the ground floor, allowing floodwaters to flow through uninhibited. Emergency planning would be required and considerations towards the existing streetscape would be required. A detailed site-specific FRA should look at modelling the effects of floodplain removal on locations upstream and downstream of the development whilst also exploring opportunities for on-site SuDS. Safety of access and egress routes should also be investigated as the site is at risk on all Boundaries and a detailed evacuation plan would need to be developed and linked to relevant flood warning alerts. The FRA should confirm criterion for safe development and flood risk management.

3.4.7.3 Site CH/1.8 (Land West of Wharfe Street)

This currently cleared site has 98% of its footprint within Flood Zone 1. A site-specific FRA would be required to confirm safe development for the 2% area at risk which should be avoided.

3.4.7.4 Site CH/1.12 (Conditioning House)

This site, proposed for residential use, contains several existing industrial buildings and some open land. Conditioning House is a Grade II listed building. Only 0.3% of the site footprint area is within Flood Zone 3a with 4% within Flood Zone 2. Just under 22% of the site area is considered to be within Flood Zone 3ai.

As Conditioning House is a listed building it cannot be demolished and is likely to be refurbished on the current developed footprint. This building is largely within Flood Zone 1 though the north western corner of the building is at risk from Flood Zone 2 and slightly within Flood Zone 3ai. Any refurbishment could consider this risk and investigate possible resilience or resistance measures, within the restrictions that listed status provides.

For the remaining areas of the site, the areas at risk, particularly the 22% area within Flood Zone 3ai, should be avoided from new development and left as open space. 74% of the site is with Flood Zone 1 and can be developed. Where development to proceed within the Flood Zone 3ai area, then the currently developed footprint should not be exceeded and, where possible, the developed area should be reduce with flood water dealt with on-site

A site-specific FRA would be required to ensure criterion for safe development and flood risk management, including safe access and egress. Surface water risk should be assessed as part of the FRA.

3.4.7.5 Site CH/1.13 (Midland Mills)

This site is situated adjacent to CH/1.12 and also contains a Grade II listed building, Midland Mills. Other existing structures and derelict open land are also present within the site boundary. A large proportion of the site is within Flood Zone 3a accounting for 59% of the site footprint. 23% of the site is within Flood Zone 2. Virtually the whole of the Midland Mills structure is within flood zones 3a and 2 with the building being subject to a change of use to residential. The site as a whole will be subject to the Exception Test as part of detailed site-specific FRA. As Midland Mills is listed and therefore cannot be demolished, any resilience or resistance measures will be limited by listed status restrictions. It would be difficult to create storage areas on-site and there is a lack of surrounding open land that could be used for flood storage. Flood depths on site could reach up to 2.5 m which would cause a significant hazard to people.

It will prove difficult for this site to pass the Exception Test with over half the site footprint being within Flood Zone 3a and the presence of the listed building proposed for residential use. Housing numbers, outside of the Midland Mills structure, may have to be reduced to avoid Flood Zone 3a. The FRA must show that flood risk to people and development could be managed satisfactorily and be safe for the lifetime of the development, without increasing risk elsewhere and where possible reducing risk. Surface water risk is also an issue and should be assessed as part of the FRA.

3.4.8 The Learning Quarter Neighbourhood - BCC AAP

Located in the University area of the city where development will offer increased educational and University facilities including student living.

3.4.8.1 Site LQ/1.3 (University Car Park, Great Horton Road)

Currently a car park, the site is free from development and is proposed for the development of an educational facility. 93% of this site is within Flood Zone 1. A site-specific FRA would be required to confirm safe development for the 7% area at risk which should be avoided.

3.4.9 The Southern Gateway Neighbourhood - BCC AAP

The proposal for this Neighbourhood is for a minimum of 740 residential units with supporting retail, leisure and office space, replacing the former industrial land use.

3.4.9.1 Site SG/1.1 (Clifford Street Car Park)

Currently occupied by a Plumbers Merchants and car park with the proposal for residential development. Over half of the site is within Flood Zone 2, though completely free from Flood Zone 3a, meaning development would be permitted according to the FRCC-PPG, subject to a site-specific FRA. The FRA should focus on protecting properties through property level resilience and / or resistance measures. The site is small (0.5 ha) so the effects of floodplain removal should be minimal. This can be assessed within the FRA.

3.4.9.2 Site SG/1.2 (Britannia Mill Car Park, Portland Street)

This site has been allocated for a sports and leisure complex including a swimming pool. This site was originally allocated for 200 residential units though having applied the Sequential Test, the council decided to change the proposed use. Any development type would require a detailed evacuation plan linked to a relevant flood warning alert.

27% of the site area is within the functional floodplain and therefore, according to the FRCC-PPG, cannot be developed. 18% is within Flood Zone 3a meaning just under half of the site is within the 1 in 100 AEP event floodplain. Land use allocated for leisure purposes falls within the Less Vulnerable category of Table 2 of the FRCC-PPG and therefore would be permitted for development, subject to a site-specific FRA. 29% of the site falls within Flood Zone 3ai. Any re-development of the existing structures in this zone must not exceed the current footprint and, where possible, should attempt to reduce the footprint or deal with the flood water on-site.

The site is also at high risk from surface water flooding with 76% within the 1 in 30 year surface water flood outline. At 1.2 ha in size, it may prove difficult to accommodate surface water on-site. Options would need to be assessed through the FRA using detailed surface water modelling including an appraisal of SuDS options.

Access and egress should also be assessed as part of the FRA to ensure safe pedestrian and vehicular access routes during an extreme flood, for the lifetime of the development.

3.4.10 The Valley Neighbourhood - BCC AAP

The focus of city living with the majority land use proposed for residential or mixed use development including retail, leisure and office space. The aim is to achieve a minimum of 1,650 residential units in this Neighbourhood.

3.4.10.1 Site V/1.1 (Former Provident Financial Headquarters, Sunbridge Road)

This site currently contains multi-story office buildings and open space for car parking. The site is subject to approved planning permission for a change of use to student accommodation. The current structure will be demolished for new development. The site is situated almost wholly in Flood Zone 1 and surface water risk is minimal. A site-specific FRA would still be required to ensure safe development.

3.4.10.2 Site V/1.2 (Former Gas Works, Thornton Road)

Currently cleared Brownfield land used for car parking. The proposed use is for a minimum of 400 residential units with retail and leisure facilities. Runoff should be controlled to existing rates. Also proposed is a linear park along Thornton Road on the north eastern boundary of the site. 70% of the site falls within Flood Zone 2 meaning it would not be possible to locate all development outside of the risk zone.

Development would be permitted, subject to a site-specific FRA, according to the FRCC-PPG. Surface water risk is also a concern with nearly half the site at risk from the extreme 1 in 1000 year rainfall event. The FRA should show that the site can remain safe and there is suitable emergency planning in place in the event of a flood. Resilience and / or resistance mitigation measures should also be examined.

3.4.10.3 Site V/1.5 (Yorkshire Stone Yard and Mill, Thornton Road)

Currently used for employment purposes, this site is proposed for a change of use to residential for the construction of up to 80 units. The proposal is to convert the Mill and to develop on the existing Stone Yard. The site is partially within Flood Zone 2 (43% of the site area) meaning the change of use is not an issue with regards to FRCC-PPG, subject to a site-specific FRA which should confirm criterion for safe development and flood risk management. Most of the Flood Zone 2 outline covers the existing Mill. The FRA should investigate existing resilience / resistance measures to check whether floodwater is permitted to flow through the building or is kept out. If possible, the Mill should serve as a multi-story facility with the ground floors allowed to flood, though suitable emergency planning would be required to ensure the safety of people. If floodwater is currently prohibited from entering the building then this approach could help alleviate some risk downstream. The FRA should ensure criterion for safe development and flood risk management, including safe access and egress. Surface water risk is minimal.

3.4.10.4 Site V/1.6 (Former Bee Hive Mills, Smith Street)

A Brownfield site proposed for up to 220 residential units. Bradford Beck runs through the north eastern quarter of the site which is also within Flood Zone 2 (24% of the site area). The BCC Issues and Options Report, 2013 states that this quarter of the site should be reserved for public open space including trees and soft landscaping. A site-specific FRA would be required. Surface water risk is minimal.

3.4.10.5 Site V/1.7 (Vacant Site South of Sunbridge Road)

The site has been allocated for a residential led mixed use development with up to 80 residential units to be constructed. The site is Brownfield with over half of the land cleared and several existing buildings of which a number are within Flood Zone 2. It is unknown whether these buildings are to be redeveloped or demolished. A site-specific FRA would still be required to ensure safe development.

3.4.10.6 Site V/1.8 (Car Sales / Filling Station, Thornton Road)

According to aerial photography[17], this site is currently developed. There is no further information within the BCC Issues and Options Report, other than that the proposed allocation is for residential led mixed use with up to 230 residential units planned. The change of use should not alter the FRCC-PPG permissions for the site as the boundary is partially within Flood Zone 2 (45%) with only a nominal amount within Flood Zone 3a (0.1%). A site-specific FRA would be required to ensure criterion for safe development and flood risk management, including safe access and egress. Surface water risk is minimal.

3.4.10.7 Site V1.10 (Thornton Road / Water Lane)

The site is currently used for several small businesses with the proposal for a change of use to residential led mixed use, including retail and leisure uses. The change to residential use would not affect the FRCC-PPG permissions as the site is not shown to be at risk from Flood Zone 3a. 40% of the site is within Flood Zone 2 though as the site is small at 0.4 ha, any effects of floodplain removal should be minimal. A site-specific FRA would be required to ensure criterion for safe development and flood risk management, including safe access and egress which should be possible from Water Lane. Surface water risk is minimal.

3.5 Climate Change

Climate change will increase flood risk over the lifetime of a development. In making an assessment of the impacts of climate change on flooding from the land and rivers as part of a site-specific FRA, the latest sensitivity ranges shown in Table 3-10 (UK Climate Projections 2002 (UKCIP02) scenarios) may provide an appropriate precautionary response to the uncertainty about climate change impacts on rainfall intensities and river flow.

Climate change output estimates have been produced from the Bradford Beck model for the 1 in 100 AEP event (Flood Zone 3a). The effects of climate change were taken account of by increasing the river flows of Bradford Beck and its tributaries by 20%. A more detailed assessment of climate change would be required at the FRA stage, looking at greater increases in river flows from the 20% used in the Bradford Beck 2013 modelling. Table 3-11 shows that upper end estimates of climate change could increase river flows by up to 50% or 75% for extreme climate change.

Table 3-9 lists the sites at increased risk from climate change, based on the 1 in 100 year +cc outline extending further over the site footprints. The SFRA maps in Appendix A present the climate change outline.

Table 3-9: Sites at further risk from the 1 in 100 AEP event plus climate change

Site Reference	AAP	Comments	Climate Change Maximum Depths
DF2	SCRC	Significant Increase in risk	1 - 1.5 m
DF5	SCRC	Significant increase in risk	<1 m
SE1	SCRC	Significant increase in risk	>3 m
NBW1	SCRC	Minimal increase in risk	>3 m
NBW5	SCRC	Minimal increase in risk	1.5 - 2 m
CH/1.1	BCC	Minimal increase in risk	1.5 - 2 m
CH/1.2	BCC	Minimal increase in risk	<1 m
CH/1.8	BCC	Minimal increase in risk	1.5 - 2 m
V/1.8	BCC	Minimal increase in risk	<1 m
B/1.5	BCC	Minimal increase in risk	<1 m
B/1.6	BCC	Significant Increase in risk	<1 m
SG/1.2	BCC	Significant Increase in risk	>3 m
LQ/1.3	BCC	Minimal increase in risk	<1 m

Five sites are subject to a significant increase in risk due to climate change, based on comparison between Flood Zone 3a and the 1 in 100 +cc AEP event outline. In terms of flood depths, those sites where flood depths could be significant due to climate change include sites NBW1, SE1, and SG/1.2 where depths could exceed 3 m.

All sites at risk from Flood Zone 3a should consider climate change in their mitigation strategies for development during the site planning stage. Any development within the 1 in 100 +cc AEP event outline should not reduce the available flood storage, though compensatory storage could be an option.

Considering the impacts of climate change within a FRA will have implications for the type of development that is appropriate according to its vulnerability to flooding and design standards for any SuDS or mitigation scheme proposed. For example through very flat floodplains, using the +20 per cent allowance for peak flows, could see an area currently within lower risk zones (Flood Zone 2), in future be re-classified as lying within a higher risk zone (e.g. Flood Zone 3a). Therefore residential development may not be suitable without appropriate flood mitigation measures or flood resilient or resistant housing. In well-defined floodplains the same climate

change allowance could have significant impacts on flood depths influencing building type and design (e.g. finished floor levels).

Table 3-10: Recommended National Precautionary Sensitivity Ranges

Parameter	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
Peak rainfall intensity	+5%	+10%	+20%	+30%
Peak river flow	+10%	+20%		

The sensitivity ranges shown in Table 3-10 originate from Defra's FCDPAG3 Economic Appraisal Supplementary Note to Operating Authorities – Climate Change Impacts (October 2006) and are based on UK Climate Projections 2002 (UKCIP02) scenarios.

The Environment Agency has updated this advice note, with the Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities[16], which uses the latest science from UKCP09. This advice is based on Government's policy for climate change adaptation, and is specifically intended for projects or strategies seeking Government Flood Defence Grant in Aid (FDGiA). However, Risk Management Authorities (RMA) in England may also find it useful in developing plans and making Flood and Coastal Erosion Risk Management (FCERM) investment decisions even if there is no intention of applying for central government funding. This is important for any future large scale infrastructure used to support the delivery of strategic sites such as flood defence schemes.

This is necessary to ensure that a fair comparison can be made between investment in sites in different locations that compete for central government grants, as well as ensuring that the most appropriate means of reducing risk is investigated in any one place.

The note offers a range of climate change sensitivities called change factors which are different depending on the region of England and are based on UKCP09 information. Upper and lower end estimates of change are also provided to help represent the range of the future risks.

Although, it is anticipated that the eventual change in river flows will lie somewhere within the range of lower to upper end estimates, more extreme change cannot be discounted. To help represent this extreme change "H++ scenarios" have been included in line with the UKCP09 approach. These can be used to represent more severe climate change impacts and help identify the options that would be required. The "H++ scenarios" should be considered in sensitive areas or for contingency planning to understand what might be required if climate change were to happen much more rapidly than expected. The UKCP09 change factors are presented in Table 3-11 for the Humber River Basin District.

Table 3-11: UKCP09 Change Factors

Parameter	Estimates	2020s	2050s	2080s
Peak rainfall intensity	H++	No H++ scenario is provided for changes to extreme rainfall		
	Upper end estimate	+10%	+20%	+40%
	Change factor	+5%	+10%	+20%
	Lower end estimate	0%	+5%	+10%
Peak river flow	H++	+35%	+45%	+75%
	Upper end estimate	+25%	+30%	+50%
	Change factor	+10%	+15%	+20%
	Lower end estimate	-5%	0%	+5%

In order to help local authorities better understand current best estimates of climate change and associated uncertainty ranges across the River Basin (Humber), the Environment Agency has carefully selected UKCP09 outputs and displayed them spatially on a map[17].

16 Environment Agency Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities

17 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/301158/Humber_geho1111bvdj-e-e.pdf

Also the Environment Agency has produced a guidance note called Climate Change Allowances for Planners[18] which gives recommendations on allowances for sea level rise and for peak rainfall intensity and peak river flows. This guidance is designed to help planners, developers and advisors to implement the NPPF's policies and practice guidance on flood risk. It can be used to assist in the preparation of FRAs for Local Plans and for specific planning applications. The Environment Agency would refer to this guidance when commenting on any plans and projects.

3.6 Mitigation Options

This section discusses generic minimum mitigation measures that could be considered, depending on the decisions taken in relation to risk avoidance through site layout for each specific site, as discussed throughout Section 3.4. Planning for each development should investigate measures that could be applicable on a site-specific basis with the aim of reducing or improving on current flood risk. The primary consideration for mitigation should always be for avoidance prior to the investigation of any appropriate resilience and resistance measures.

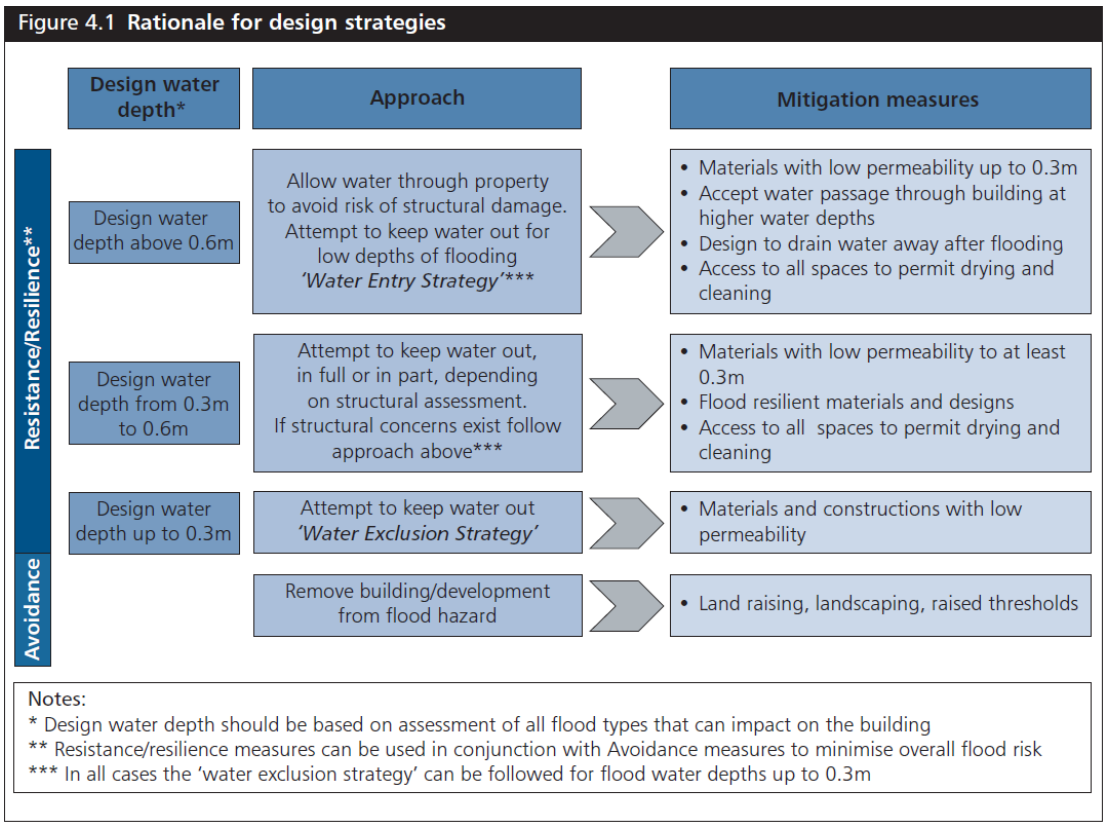
The FRCC-PPG defines flood resilience and flood resistance as flood mitigation approaches for development. Flood resilient buildings are designed to reduce the impact of floodwaters entering a building to avoid permanent damage whilst also maintaining structural integrity. Flood resistance is a more robust approach whereby the entry of water into a building is prevented or minimised. This approach is only applicable where typical floodwater depths do not exceed 0.6 m and must also be combined with resilience measures. Figure 3-2 is an extract from the Defra document 'Improving the Flood Performance of New Buildings'[19] and describes the mitigation measures appropriate to resilience, resistance and avoidance strategies for new buildings.

The Defra report states that flood depth will dictate whether it is feasible to exclude or delay floodwater from entering a building. Additional freeboard should be used in setting the floor level of a building. The Environment Agency requires that floor levels are set 300 mm above the predicted 1 in 100 AEP event flood level plus climate change where there is risk from fluvial flooding. This approach should be applied to development on all sites at risk from Flood Zone 3a and the 1 in 100+cc AEP event.

18 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/296964/LIT_8496_5306da.pdf

19 Improving the Flood Performance of New Buildings, Flood Resilient Construction, Department for Communities and Local Government, Defra. May 2007

Figure 3-2: Development Mitigation Measures Based on Flood Depth[18]



3.6.1.1 Access and Egress

The FRCC-PPG stipulates that buildings should provide residents and / or users routes to safely access and exit a building during a design flood and to evacuate before an extreme flood i.e. 1 in 1000 AEP event. Climate change should also be taken into account with safe access and egress designed for the lifetime of the development.

For any sites that are required to develop in the floodplain, access and egress routes should be assessed as part of a detailed site-specific FRA. Design event flood depths should be examined and access and egress routes should be located at points on the site where flood depths and hazard to people are lowest.

3.6.1.2 Raised Development

This mitigation scenario may allow safe development in the locality, however the effects of land raising on flood levels upstream and downstream should be examined as part of a site-specific FRA. It is a standard Environment Agency response to object to any loss of floodplain, even if flood levels are not raised elsewhere.

This means that an increase in flood conveyance or some form of compensatory flood storage may be required on-site or off-site to compensate for the loss of floodplain as a result of raising the land out of the floodplain. Agreement between the council and the Environment Agency would therefore be required were land to be raised.

3.6.1.3 On-Site Flood Storage

If development is required within Flood Zone 3a and the development is raised, then the loss of floodplain may need to be compensated (unless the Environment Agency confirms otherwise). Detailed consultation between the council and the Environment Agency would be required to confirm the scope of investigation required and to confirm any site-specific requirements that may need to be addressed.

Two variations of compensatory floodplain storage can be considered. Firstly, storage could be designed on-site, either as underground flood storage (e.g. storage tank, underground car park) or a ground level undeveloped amenity area or greenspace. Alternatively, an undeveloped area upstream could be utilised for flood storage. Upstream storage is described under the next heading.

There are some practical issues associated with on-site storage, as like for like compensation would need to be found. This means that for any development within the floodplain, a similar area and volume would need to be allocated for storage that is free from any development. This may reduce possible housing numbers and not create any overall benefit in this regard. Also, the site area would need to be large enough for any compensatory on-site storage. A wider development strategy may be required to examine the possibilities of upstream mitigation.

The other issue is related to subsurface storage. If the habitable floor level is built above the 1 in 100 AEP +cc event level, the space beneath could be retained for flood storage during the 1 in 100 AEP +cc event flood. This area could be used as a car park, with emergency access and egress procedures for the car park triggered by a suitable flood warning system. However, the type of development that is most likely to be able to handle this type of residential development are multi-storey buildings. In the case of residential uses this would likely entail three storey town houses or flats. For residential developments, allowing the ground floor to flood may be a constrained option and other land uses or mitigation options should be considered.

The situation is not as problematic with less vulnerable land uses such as businesses, retail and other employment land uses in that the Exception Test would not apply. However, any development in the 1 in 100 AEP event area would still need to be compensated for which could have significant implications on development layout and the extent of land available for development. A detailed FRA would need to be carried out to determine the extent of works and should be used to help inform the development layout and planning stages. Ground floor flooding can be achieved more easily with less vulnerable land use e.g. offices on stilts (and car parking under this area) or low grade ground floor use with stock moved to higher levels and flood resilience measures on the ground floor. It is also much easier to evacuate this type of development following suitable flood warning, emergency planning and evacuation routes.

3.6.1.4 Raised Development and Upstream Compensatory Storage

If on-site storage is unfeasible, then upstream flood storage could be considered depending on the suitable availability of upstream land. Upstream storage requires an area of undeveloped land that is not at risk from the 1 in 100 AEP flood event (Flood Zone 3), but close to it, to be retained as flood storage. This is normally an area within the 1 in 1000 AEP flood event outline (Flood Zone 2). This area can be excavated so that it floods during the 1 in 100 AEP flood event. This area would need to be large enough to contain the volume of flood water that would be displaced. Any flood storage area would need to be controlled so that flooding would only occur during low probability events via a flow controlled inlet. The flood water should flow out naturally via a specific designed outlet.

3.6.1.5 Floodplain Widening and Raised Development

This option would involve the design of a widened floodplain corridor either side of Bradford Beck within the Canal Road Corridor, where possible using proposed Green Infrastructure. This would increase flood conveyance and create additional storage to reduce the downstream and upstream increase in flood levels as a result of raising development.

3.6.2 Development Phasing

Development will not all take place at the same time. Development and regeneration of each site will take on a phased approach. The flood risk information provided in this SFRA should be taken account of when deciding the order in which each site is developed. For any site where it is required to develop in the 1 in 100 AEP event floodplain, modelling, using the Bradford Beck InfoWorks model, would be required to ascertain where displaced water would flow to and to calculate subsequent increases in downstream flood volumes. Modelling should

investigate scenarios based on compensatory storage techniques to ensure that downstream or nearby are not adversely affected by development on other sites.

Using a phased approach to development, based on modelling results of floodwater storage options, should ensure that any sites at risk of causing flooding to other sites are developed first in order to ensure flood storage measures are in place before other sites are developed. Also, it may be possible that flood mitigation measures put in place at sites upstream could alleviate flooding at downstream or nearby sites.

3.7 Site-Specific Flood Risk Assessment

According to the Flood Risk and Coastal Change Planning Practice Guidance (Para 030), a site-specific FRA is:

"…carried out by (or on behalf of) a developer to assess the flood risk to and from a development site. Where necessary (see footnote 20 in the National Planning Policy Framework), the assessment should accompany a planning application submitted to the local planning authority. The assessment should demonstrate to the decision-maker how flood risk will be managed now and over the development's lifetime, taking climate change into account, and with regard to the vulnerability of its users (see Table 2 – Flood Risk Vulnerability of FRCC-PPG)."

The objectives of a site-specific FRA are to establish:

- Whether a proposed development is likely to be affected by current or future flooding from any source;
- Whether the development will increase flood risk elsewhere;
- Whether the measures proposed to deal with these effects and risks are appropriate;
- The evidence for the local planning authority to apply (if necessary) the Sequential Test, and;
- Whether the development will be safe and pass the Exception Test, if applicable.

The FRCC-PPG doesn't contain any further detail on the minimum requirements for site-specific FRAs. It is therefore important that the Environment Agency's Flood Risk Standing Advice[20] is referred to as well as the site-specific Flood Risk Assessment Checklist in paragraph 68 of the FRCC-PPG. CIRIA's report C624 Development and Flood Risk also provides useful guidance.

When is a Site-Specific FRA Required?

According to the NPPF Footnote 20, a site-specific FRA should be prepared when the application site is:

- Situated in Flood Zone 2 and 3; for all proposals for new development (including minor development and change of use)
- Greater than 1 ha in size and located in Flood Zone 1
- Located in Flood Zone 1 where there are critical drainage problems or within a designated Critical Drainage Area (CDA) as notified to the LPA by the Environment Agency
- At risk of flooding from other sources of flooding, such as those identified in this SFRA
- Subject to a change of use to a higher vulnerability classification which may be subject to other sources of flooding

The LPA may also like to consider further options for stipulating FRA requirements during production of the Local Plan, such as:

- Situated in an area currently benefitting from defences;
- Situated within 20 m of the bank top of a Main River;

20 http://www.environment-agency.gov.uk/research/planning/82584.aspx

- Situated over a culverted watercourse, such as Bradford Beck in the city centre, or where development will require controlling the flow or any river or stream or the development could potentially change structures known to influence flood flow.

4 Critical Drainage Areas

4.1 Introduction

As defined in the Town and Country Planning (General Development Procedure) (Amendment) (No. 2) (England) Order 2006 a Critical Drainage Area is…

"…an area within Flood Zone 1 which has critical drainage problems and which has been notified… [to]…the local planning authority by the Environment Agency"[21].

Critical Drainage Areas can be a useful planning tool, giving the LPA the means to reject a planning application or request further work from a developer.

A Critical Drainage Area (CDA) is considered to be an area contributing surface water runoff, either as direct overland flow or from the existing sewer network, which causes flooding at locations within that area, or at an area where development pressure could increase the strain on a system already at capacity. Flooding can also be encouraged by development which makes connection to a highway which in times of heavy rain acts as a pathway for excess runoff. The risk of flooding is thereby confirmed, either by historical evidence, through an assessment of the updated Flood Map for Surface Water, through 'on the ground' local evidence provided by the council or through local detailed surface water modelling.

4.2 CDA Identification in AAP Areas

Historical flood incident data has been provided by a number of stakeholders for this SFRA. This included City of Bradford MDC, the Environment Agency, Yorkshire Water and West Yorkshire Fire and Rescue Authority. Unfortunately the data provided by Yorkshire Water and West Yorkshire Fire and Rescue Authority was not suitable for use in the SFRA. The flood incident data provided by the council was divided into surface water flood incidents and other incidents. This dataset was overlain on top of the Environment Agency's updated Flood Map for Surface Water (uFMfSW) (see SFRA mapping) and used to scope the possibility for the designation of CDAs.

There is no obvious correlation between available recorded surface water flood incidents and the uFMfSW meaning the surface water flood outlines are not backed up by historic events, based on available data. There are certain isolated areas of the city centre that do appear to be at high risk, based on the uFMfSW alone, though with no recorded incidents to back this up. As discussed throughout Section 3.4, there are proposed sites at varying levels of risk from surface water flooding where it has been recommended that detailed surface water modelling should be carried out as part of a site-specific FRA. However, judging from the site screening spreadsheets in Appendix B and from Table 3-6 of this report, there are not any proposed sites within Flood Zone 1 whereby surface water is a major issue and therefore no compelling evidence for the designation of CDAs within the AAP areas.

In order to fully assess surface water risk within the AAP areas as a whole, a Surface Water Management Plan (SWMP) should be carried out as recommended in the Humber River Basin Management Plan, 2009. Consultation between the council and Yorkshire Water would be required concerning the capacity of existing sewer systems in order to identify critical parts of the system (pinch points). Model outputs could be obtained to confirm the critical parts of the drainage network. Recommendations could then be made for future development i.e. strategic SuDS sites, parts of the drainage system where any new connections should be avoided, parts of the system that may have any additional capacity and recommended runoff rates.

4.3 Surface Water Management Plan

In June 2007, widespread extreme flooding was experienced in the UK. The Government review of the 2007 flooding, chaired by Sir Michael Pitt recommended *that*

"Local Surface Water Management Plans (SWMPs) … coordinated by local authorities, should provide the basis for managing all local flood risk."

21 Surface Water Management Plan Technical Guidance, Defra, 2010

The Government's guidance document[22] for SWMPs defines a SWMP as:

- *A framework through which key local partners with responsibility for surface water and drainage in their area, work together to understand the causes of surface water flooding and agree the most cost-effective way of managing surface water flood risk.*
- *A tool to facilitate sustainable surface water management decisions that are evidence based, risk based, future proofed and inclusive of stakeholder views and preferences.*
- *A plan for the management of urban water quality through the removal of surface water from combined systems and the promotion of SuDS.*

As a demonstration of its commitment to SWMPs as a structured way forward in managing local flood risk, Defra announced an initiative to provide funding for the highest flood risk authorities to produce SWMPs.

4.4 Surface Water Drainage and Development

The Ministerial statement of December 2014[23] announced the government's expectation that Sustainable Drainage Systems (SuDS) will be provided in new developments wherever possible. The statement continues to explain that the LPA should consult the LLFA on the management of surface water to help ensure that minimum operation standards are appropriate and that clear arrangements are in put in place for ongoing maintenance over the lifetime of the development. This applies to major developments of which are considered to be 10 dwellings or more, or equivalent non-residential or mixed use.

When proposed major developments come forward, opportunities for developing an Integrated Water or Drainage Management Strategy across development site boundaries should be explored, and a catchment led approach should be adopted. This approach has been recognised in the consultation paper by Defra, Making Space for Water[24]. An integrated approach to controlling surface water drainage can lead to a more efficient and reliable surface water management system as it enables a wider variety of potential flood mitigation options to be used. In addition to controlling flood risk, integrated management of surface water has potential benefits, including improved water quality and a reduction of water demand through grey water recycling.

Integrated drainage systems may be considered suitable for catchments where other development is being planned or constructed, and where on-site measures are set in isolation of the systems and processes downstream.

Surface water drainage assessments are required where proposed development may be susceptible to flooding from surface water drainage systems. The potential impact upon areas downstream of the development, including the impact on a receiving watercourse, also needs careful consideration.

The specific requirements for surface water drainage systems will need to be discussed with the Council's Land Drainage Engineers, the Environment Agency and Yorkshire Water. Consideration should be given to whether a "greenfield runoff approach" in the assessment of source control is appropriate. This method is generally satisfactory in the cases where the development is relatively small, isolated from other planned sites and the runoff processes are fully understood.

A FRA should then conclude with an assessment of the scale of the impact, and the recommended approach to controlling surface water discharge from a proposed development.

4.4.1 Sustainable Drainage Systems (SuDS)

Development has the potential to cause an increase in impermeable area, an associated increase in surface water runoff rates and volumes, and consequently a potential increase in

22 Surface Water Management Plan Technical Guidance - https://www.gov.uk/government/publications/surface-water-management-plan-technical-guidance

23 https://www.gov.uk/government/speeches/sustainable-drainage-systems

24 http://www.look-up.org.uk/2013/wp-content/uploads/2014/02/Making-space-for-water.pdf

downstream flood risk due to overloading of sewers, watercourses, culverts and other drainage infrastructure.

Managing surface water discharges from new development is therefore crucial in managing and reducing flood risk to new and existing development downstream. Carefully planned development can also play a role in reducing the amount of properties that are directly at risk from surface water flooding.

The FWMA, 2010, transferred the adoption and maintenance of SuDS to Sustainable Drainage Systems Approval Bodies (SABs) established by local authorities, or LLFA's, under Schedule 3 of the Act. This designation of a SAB however has since been removed following lengthy consultation, with the announcement from the Department for Communities and Local Government (DCLG) in December 2014 that local planners will be responsible for delivering on SuDS. Changes to planning legislation give provisions for major applications of ten or more residential units or equivalent commercial development to require sustainable drainage within the development proposals in accordance with the interim national standards published in April 2015[25].

The system proposed by government builds on the existing planning system, which developers and local authorities are already using. Policy changes to the planning system can also be introduced relatively quickly ensuring that flood risk benefits from sustainable drainage systems can be brought forward as part of planning application proposals.

The NPPF continues to reinforce how planning applications that fail to deliver SuDS above conventional drainage techniques could be rejected and sustainable drainage should form part of integrated design secured by detailed planning conditions so that the SuDS to be constructed must be maintained to a minimum level of effectiveness. Maintenance options must clearly identify who will be responsible for SuDS maintenance and funding for maintenance should be fair for householders and premises occupiers; and, set out a minimum standard to which the sustainable drainage systems must be maintained.

The runoff destination should always be the first consideration when considering design criteria for SuDS including the following possible destinations in order of preference:

1. To ground;
2. To surface water body;
3. To road drain or surface water sewer;
4. To combined sewer

Effects on water quality should also be investigated when considering runoff destination in terms of the potential hazards arising from development and the sensitivity of the runoff destination.

The non-statutory technical standards for sustainable drainage systems[26] (March 2015) set out appropriate design criteria based on the following:

1. Flood risk outside the development
2. Peak flow control
3. Volume control
4. Flood risk within the development
5. Structural integrity
6. Designing for maintenance considerations
7. Construction

In addition, the Local Planning Authority may set local requirements for planning permission that have the effect of more stringent requirements than these National Standards. More stringent requirements should be considered where current Greenfield sites lie upstream of high risk areas. This could include improvements on Greenfield runoff rates. CIRIA has also

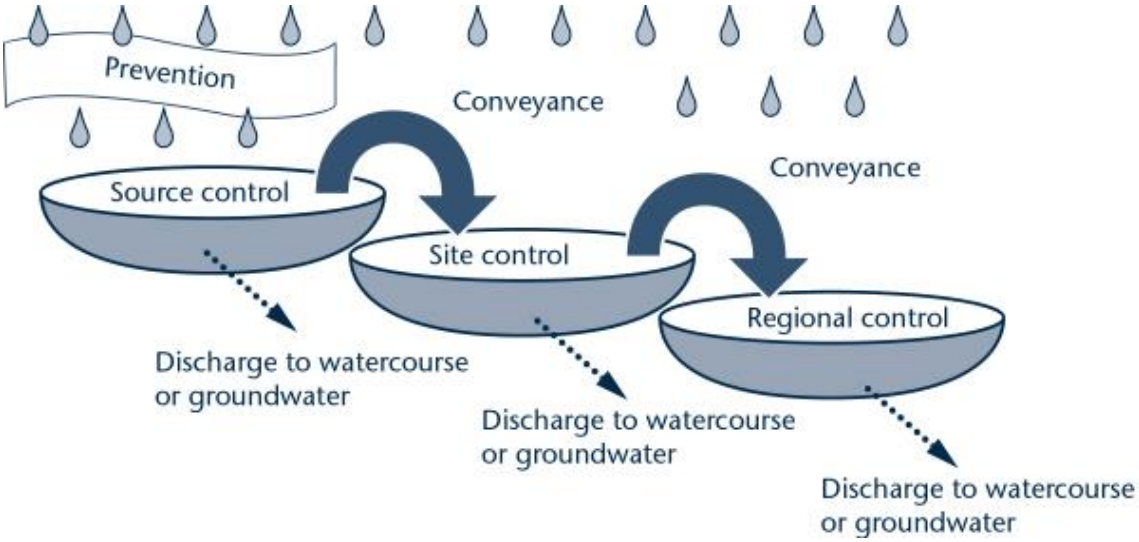
25 https://www.gov.uk/government/speeches/sustainable-drainage-systems

26 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/415773/sustainable-drainage-technical-standards.pdf

produced a number of guidance documents relating to SuDS that should be consulted by the LPA and developers.

Many different SuDS techniques can be implemented. As a result, there is no one standard correct drainage solution for a site. In most cases, a combination of techniques, using the Management Train principle (see Figure 4-1), will be required, where source control is the primary aim.

Figure 4-1: SuDS Management Train Principle[27]



The effectiveness of a flow management scheme within a single site is heavily limited by land use and site characteristics including (but not limited to) topography; geology and soil (permeability); and available area. Potential ground contamination associated with urban and former industrial sites should be investigated with concern being placed on the depth of the local water table and potential contamination risks. The design, construction and ongoing maintenance regime of any SuDS scheme must be carefully defined as part of a site-specific FRA. A clear and comprehensive understanding of the catchment hydrological processes (i.e. nature and capacity of the existing drainage system) is essential for successful SuDS implementation.

27 CIRIA (2008) Sustainable Drainage Systems: promoting good practice – a CIRIA initiative

5 Conclusions and Future Work

5.1.1 Conclusions

This Level 2 SFRA has assessed flood risk to the LPAs proposed development sites within the council's Area Action Plan (AAP) areas. The AAPs encompass the key regeneration areas of the Shipley and Canal Road Corridor (SCRC) and Bradford City Centre (BCC). Fluvial modelling outputs from the Bradford Beck 2013 model including flood extents, flood depths and flood hazards have been assessed along with surface water flood risk as indicated by the updated Flood Map for Surface Water.

The aim of this assessment has been to demonstrate whether proposed sites could remain safe if developed and whether development may increase flood risk elsewhere. A number of different flood mitigation measures have been discussed and recommendations have been made where appropriate. Section 3.4 discusses the options and recommendations for each proposed site at risk.

As stated within the CBMDC Core Strategy Publication Draft, the proposed sites within the AAP areas are required for continued growth and regeneration in targeted areas to provide economic and social benefits the city. The Core Strategy Publication Draft also states that the benefits of development in these areas outweigh the risk of flooding thus satisfying the first part of the Exception Test.

A number of sites are within Flood Zone 1 and are perceived either to be flood free, subject to residual risk, or subject to nominal risk from surface water flooding. Based on this it is recommended that these sites should be permitted (see Table 3-6). Those sites within Flood Zone 1 though whose site area is greater than 1 ha must complete a site-specific Flood Risk Assessment (FRA).

Only five sites, in both AAP areas, are at risk from Flood Zone 3b. Of these five sites, only two are considered unlikely for development to proceed safely. These sites are Site DF4 in Shipley which is at significant risk from the River Aire and Site SG/1.2 at Britannia Mill in the City Centre.

There are a number of sites within / partially within Flood Zone 3a. In order to mitigate the flood risk, considerations of layout design have been discussed along with a number of direct mitigation strategies. The mitigation measures would need to reduce flood risk to the new development, ensure flood risk does not increase to third parties downstream and if possible allow for some amenity benefit through Green Infrastructure.

5.1.2 Future Work

There are several steps the council should take in the future, based on the evidence provided in the Level 1 SFRA and this Level 2 SFRA:

- Finalisation of the Draft Local Flood Risk Management Strategy (LFRMS) - this is a key LLFA responsibility under the Flood and Water Management Act 2010 (FWMA). A LLFA is required to develop, maintain, apply and monitor a local strategy for flood risk management in its area. The local strategies will build on information such as national risk assessments and will use consistent risk based approaches across different Local Authority areas and catchments. The local strategy will not be secondary to the national strategy; rather it will have distinct objectives to manage local flood risks important to local communities.
- Asset Register - also a key responsibility for LLFAs under the FWMA. A LLFA has a duty to maintain a register of structures or features, which are considered to have an effect on flood risk, including details on ownership and condition as a minimum. The register must be available for inspection and the Secretary of State will be able to make regulations about the content of the register and records.
- Investigation and recording of flood incidents as required under the FWMA - a LLFA has powers to investigate and record details of significant flood events within their area. These powers include identifying risk management authorities and their functions and how they intend to exercise those functions in response to a flood. The responding

risk management authority must publish the results of its investigation and notify any other relevant risk management authorities.

- SuDS - CBMBC should identify internal capacity required to deal with SuDS applications, set local specification and set policy for adoption and maintenance of SuDS.
- Surface Water Management Plan - to ascertain whether there are any areas within the local authority area that may suffer critical drainage issues and therefore could be designated Critical Drainage Areas.
- River Aire modelling updates - investigate options to update the modelling of the River Aire with a view to reducing risk to Dockfield Road. May include flood mitigation scenario modelling of proposed defences or upstream storage options.
- Finalise CBMDC Core Strategy and Local Plan.
- Removal of the Valley Road culvert and the extension of the linear park for potential flood storage.
- Re-naturalisation of Bradford Beck once the culvert has been removed.

Appendices

A SFRA Maps

The SFRA Maps consist of all flood risk information used within the SFRA, by way of interactive GeoPDFs. Open the Index Map in Adobe Acrobat. The Index Map contains a set of index tiles covering specific parts of the AAP areas. Clicking on an index tile will open up a more detailed map of the area covered by that index tile, by way of a hyperlink. Within Adobe Acrobat, use the zoom tools and the hand tool to zoom in and pan around the maps. Using the dropdown arrow in the legend on the right hand side of the detailed maps, layers can be switched on and off when required. For the proposed sites layer, use the tick box to switch the proposed sites labels on and off if required.

The GeoPDFs consist of:

- 2014s1688_CBMDC_SFRA_Index.pdf
    - 2014s1688_CBMDC_SFRA_Map 1.pdf
    - 2014s1688_CBMDC_SFRA_Map 2.pdf
    - 2014s1688_CBMDC_SFRA_Map 3.pdf
    - 2014s1688_CBMDC_SFRA_Map 4.pdf
    - 2014s1688_CBMDC_SFRA_Map 5.pdf
    - 2014s1688_CBMDC_SFRA_Map 6.pdf

B Development Site Assessment Spreadsheets

Includes:

- 2014s1688 - BCC Development Site Assessment Rev2.xls
- 2014s1688 - SCRC Development Site Assessment Rev2.xls

C Functional Floodplain & Flood Zone 3ai Methodology

- 2014s1688-W-N001-2 - Functional Floodplain & FZ3ai.doc

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