Strategic Flood Consequence Assessment of Bridgend County Borough

VOLUME II
Technical Report
Final
October 2010

CAPITA SYMONDS
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Foreword

Bridgend County Borough Council are required to prepare a Strategic Flood Consequence Assessment (SFCA) to support the production of their Local Development Plan (LDP).

The SFCA creates a strategic framework for the consideration of flood risk when making planning decisions. It has been developed in accordance with Technical Advice Note 15 – Development & Flood Risk (TAN15), as well as additional guidance provided by the Environment Agency.

TAN15 advises a precautionary framework to guide planning decisions specifically aiming to direct new development away from areas thought to be at high risk of flooding. TAN15 promotes action through development plans, specifically the consideration of flooding issues during the preparation of Local Development Plans. Flood risk will therefore be a key consideration when sites are being considered for allocation.

The underlying objective of the approach detailed in TAN15 is to steer development away from areas at risk of flooding – so as to decrease and not increase the risk of flooding to people, businesses, property and the natural environment – and to thereby reduce the reliance on long-term maintenance of built flood defences. In order to develop areas at risk from flooding, developments must be in line with the local authority's development strategy. Furthermore, the risks to the development, including residual risks following any mitigation measures, must satisfy certain acceptability criteria as set out in Section 7 of TAN15. It is also expected that development proposals will contribute to a reduction of flood risk.

A SFCA is essential in enabling a strategic and proactive approach to be applied to flood risk management. The assessment allows us to understand current flood risk on a wide-spatial scale and how this is likely to change in the future in response to climate change.

The main objective of the Bridgend County Borough Council SFCA is to provide flood risk information;

- so that an evidence-based and risk-based, precautionary approach can be adopted when making planning decisions, in line with TAN15;
- that will inform the Sustainability Appraisal/Strategic Environmental Assessment and Habitats Regulations Assessment and ensure flood risk is taken into account when considering sites and land use policies at the local development plan:
- to identify the level of detail required for site specific flood consequence assessments and allow BCBC to determine the acceptability of flood risk in relation to emergency planning capability level;
- to enable BCBC to make informed decisions regarding capacity and flexibility of the 'Regeneration led Spatial Strategy' including application of the TAN15 justification test where necessary for the allocation of strategic development sites;
- to facilitate the production of local 'standing advice';
- to identify surface water issues and the suitability of sustainable drainage (SuDS) techniques;

The SFCA is presented in two complementary documents:

- Volume I – User Guide
- Volume II – Technical Report (including flood maps).

1 Introduction

The BCBC SFCA is a 'live' document. The current version has been developed using the best information and concepts available at the time. As new information and concepts become available the document will be updated and so it is the responsibility of the reader to be satisfied that they are using the most up-to-date information and that the SFCA accounts for this information. All revisions to this summary document are listed in the table.

Version	Issue Date	Issued by	Issued to
Internal Draft	07/05/2010		
Stage 1 Draft	21/05/10	CSL	BCBC
Draft Final	10/08/10	CSL	BCBC
Final	30/09/10	CSL	BCBC

1.1 Purpose of this report

1.1.1 This Bridgend County Borough Council (BCBC) SFCA has been developed to inform the Local Development Plan (LDP). The SFCA must be robust and be evidence-based so that it does not leave planning decisions and land allocations open to challenge through the land use planning process. It is crucial therefore that there is transparency in the data and methods used in the assessment.

This volume of the Bridgend County Borough Council Strategic Flood Consequence Assessment is the

Technical Report (or evidence base)

This report represents Volume II of the SFCA, and is the evidence base of Flood Risk in BCBC. This document contains all of the technical information and methods used in the assessment of flood risk across the study area. It includes information on the sources and reliability of data, methods used in the assessment, discussions regarding uncertainty, and key assumptions made.
To ensure that the technical information is easily updated when new assessments are undertaken in the future, the six 'sources of flooding' have been reported in stand alone chapters. Chapter 2 provides a summary of flood risk across Bridgend. The maps generated during the assessment are provided in Annex A to this document.

The user is referred to Volume I for guidance on how to interpret the information in this technical report. The SFCA is based on a range of data from different sources and of various degrees of certainty. It is the responsibility of the user to consider the source and certainty of the data when referring to the flood risk summaries and flood maps.

1.2 Overview of Bridgend County Borough

1.2.1 Bridgend County Borough lies at the geographical heart of south Wales. Its land area of 25.5 km^2 stretches 20km from east to west and includes the Llynfi, Garw and Ogmore valleys, Bristol Channel coastline and a mix of urban and rural communities. According to the 2001 Census, Bridgend County Borough has a population of just over 128,000. The largest town is Bridgend (pop: 39,773), followed by Maesteg (pop: 20,700) and the seaside resort of Porthcawl (pop: 19,238). Some of these settlements are designated conservation areas in order to preserve or enhance their special character or appearance. Map O in Annex A shows the county boundary and main settlements and rivers.

1.2.2 Outside of the main settlements, which are generally found within the river valleys, the land is a mixture of grassland, forest (predominantly coniferous) and scrub. Other habitats are present including: ancient woodlands; unimproved wet grasslands; chalk grassland; rocky gorges; coastal sand dunes; and saltmarsh. Sites receiving statutory designations make up only 4.8% (1215 hectares) of the county borough's land area, but the local plan identifies 18 Landscape Conservation Areas for reasons of scenic and amenity value which together cover some 3,062 hectares or 12% of the County Borough.

1.2.3 To the north of Bridgend the landscape is dominated by very steep topography with the land reaching heights of over 500m. The high ground is sparsely populated and covered with rough grassland and coniferous trees with smaller areas of scrub and non-coniferous trees. Roads and settlements are generally present only in the valleys. The underlying geology is, almost without exception, a mixture of mudstone, sandstone and siltstone.

1.2.4 The industrialisation of the Ogmore valley, especially in the 19th century, severely damaged much of the natural environment in the main river and many of its tributaries. Coal mining in particular severely affected the river and the Rivers Garw and Llynfi. Although mining activity in the area has now ceased many disused mines still exist today and may affect hydraulic pathways below and on the surface. Areas likely to be particularly affected are due to past activity have been identified from the location of disused 'tips' provided by BCB, as shown on Map O.

Topography

1.2.5 The topography varies from the low lying, fairly flat, coastal areas to the west of Bridgend, to the steep valleys to the North of Bridgend where elevations reach over 500mAOD.

1.2.6 In the north, ground rising above 200mAOD is reasonably flat at the highest points but quickly falls away into steep-sided valleys with slopes as high as 1 in 2. The valley bottoms are well defined and generally in the order of 200m wide. Most development in the northern part of BCB is concentrated within these valleys.

1.2.7 From Abergarw southwards, the land is noticeably flatter, with lower ground levels and wider river valleys. In the southern half of the county, there are some areas of isolated high ground, notably at Cefncribwr and Brackla (Bridgend). The land below 40mAOD is generally fairly flat and includes Kenfig Burrows, Kenfig, North Cornelly, South Cornelly, Porthcawl, Newton, Merthyr Mawr, Merthyr Mawr Dunes and parts of Bridgend and Pencoed.

1.2.8 All topographic information (with the exception of some river cross-sections) has been derived from LIDAR (Light Detecting and Ranging) data provided by EAW which has a vertical RMSE (root mean square error) in the order of $\pm$ 0.10m.

Solid and Drift Geology

1.2.9 The solid geology of BCB is dominated by sedimentary rocks. The most common types are 'mudstone, siltstone and sandstone' and 'sandstone', which have varying properties. Mudstone is formed from fine grains of clay and mud and is highly impermeable. Siltstone is formed from larger particles which are predominantly silt. Sandstone is formed from even larger 'sand sized' particles. In contrast to mudstone and siltstone rock types, sandstone is usually porous enough to allow percolation and can store large volumes of water. These rocks underlie almost all of the land north of Bridgend and are rarely found elsewhere. 'Mudstone, siltstone and sandstone' occupies a distinct 2.5km thick band running from east to west to the south of Abergarw and some areas in the north, although 'sandstone' predominates in the north.

1.2.10 The developed area of Bridgend is primarily underlain by 'limestone and mudstone interbedded', with some areas of 'shell-limestone' and 'sandstone'. Limestone is composed largely of mineral calcite: either grains formed from skeletal remains of marine organisms (shell-limestone), or non-granular formations created by chemical precipitation. Although limestone is non-porous it is soluble in weak acid solutions and over geological timescales a wide variety of features develop such as fractures, caves, gorges and sinkholes. This propensity for erosion often provides drainage pathways for water through the limestone. Interbedding occurs when beds (layers or rock) of a particular lithology lie between or alternate with beds of a different lithology. The mixed geology underlying Bridgend is likely lead to varied permeability characteristics.

1.2.11 To the east of Bridgend there is a large area underlain with 'conglomerate' and a smaller area underlain with 'limestone'. Conglomerate is usually a sedimentary rock consisting of small pieces of preformed rocks (often gravel) which have become cemented together within a finer-grained matrix. It typically has a very low porosity and is effectively impermeable when considering drainage.

1.2.12 To the west of Bridgend the geology is dominated by 'limestone and 'conglomerate' with smaller amounts of 'ooidal limestone'. Ooidal Limestone is formed from ooids, which are small, spheroidal, "coated" (layered) sedimentary grains, usually composed of calcium carbonate.

1.2.13 Around Cornelly and the Kenfig Burrows the underlying geology is predominantly ‘conglomerate’ and ‘mudstone’. The area around Porthcawl is dominated by ‘conglomerate’ and ‘limestone’ and between Porthcawl and Bridgend are isolated pockets of ‘Ooidal Limestone’.

1.2.14 The drift geology of BCB is a mixture of clay, silt, gravel, peat and sand. Clay is formed of particles smaller than 3.9μm, although it has a high void ratio its chemical structure is particularly effective at holding water and consequently drainage through clay is effectively non-existent. Silt is formed from particles larger than 3.9μm but smaller than 62.5μm. Sand is composed of fine rock and mineral particles between 62.5μm and 2mm. Sand generally drains very well. Gravel is any loose rock with a particle size of between 2mm-64mm. Due to its large size, accumulations of gravel have significant voids and generally drain particularly well. Peat is an accumulation of partially decayed vegetation matter that forms in acidic anaerobic environments. It is occurs where water levels are at or near the surface for the majority of the year. It is particularly effective at retaining water and drains poorly.

1.2.15 The majority of the main rivers run through ‘clay, silt, sand and gravel’ bands which vary from narrow 20m bands in upland areas to 500m bands close to the coast. In the upland areas these bands generally sit within larger bands of ‘diamicton’, which is defined as unsorted and unstratified sedimentary deposits.

1.2.16 There are small isolated pockets of peat in the northern part of BCB which are generally in forested areas and presumed to coincide with localised depressions. In the low-lying coastal areas and estuarine parts of the River Ogmore the drift geology is almost entirely sand.

1.3 Sources of flooding

1.3.1 BCB contains localised areas that are prone to flooding from a range of sources. The type of flooding is dependent on the interaction of rainfall, catchment characteristics and the sea. This SFCA considers six sources of flooding: flooding from rivers, the sea, groundwater, land (surface water), sewers and artificial sources. Each source is described in the following section and in more detail in the remaining chapters of this report.

Rivers

1.3.2 The River Ogmore, the River Llynfi and the River Ewenny are the main watercourses in BCB.

1.3.3 The River Ogmore (Afon Ogmore) runs roughly north to south from the Ogmore Vale and Pentre, past Bridgend and Ogmore. The River Ogmore is generally considered to start near the cemetery mountain, west of Treorchy, although it is known as the Ogwr Fawr, with the Ogwr Fach, coming from Gilfach Goch to the north merging near Blackmill. The River Llynfi, the River Garw and finally the River Ewenny in its estuary are all tributaries of the Ogmore which flows into the sea between Ogmore-by-Sea and the Merthyr Mawr sand-dunes.

1.3.4 The River Llynfi (Afon Llynfi) runs for around 10 miles from its source north of Maesteg and flows generally southwards through the Llynfi Valley to the confluence with the River Ogmore and the River Garw at Aberkenfig. Its main tributaries are the Nant Cwm-du and Nant Cedfyw which enter on its left bank and the Nant Crynwydd, Nant Sychbant and Nant y Gadlys on its right bank.

1.3.5 The River Ewenny (Afon Ewenni) rises to the north east of Bridgend town, in South Wales, and flows past the village of Pencoed before entering the River Ogmore estuary just below Ogmore Castle. One of its main tributaries is the Afon Alun.

1.3.6 There are numerous smaller watercourses with known flooding issues within BCB, some of these have been formally designated as critical ordinary watercourses (COWs). Those with the most severe flooding issues are presented in Table 1.1

Table 1.1 List of Critical watercourses within BCBC posing a significant flood risk

Area/Town	Watercourse Name	Grid Ref (start)	Grid Ref (end)	Length (m)
Maesteg	**Afon Llynfi**			
Caerau (Tudor Estate North , culvert and open channel)	Un-named watercourse	28543 19419	28512 19461	642
Nantyffyllon (Culvert and open channel)	Nant y Ffyllon	28517 19250	28483 19277	569
Maesteg (Llynfi Road area , culvert and open channel)	Nant y Crynwydd	28511 19145	28436 19158	837
Maesteg (Neath Road , culvert)	Un-named watercourse	28520 19130	28486 19109	536
Maesteg (West Street , culvert)	Un-named watercourse	28535 19160	28500 19082	538
Maesteg (Garn Road , culvert and open channel)	Un-named watercourse	28586 19105	28529 19048	1437
Maesteg (Shoemakers Row , culvert)	Un-named watercourse	28589 19105	28597 19152	559
Maesteg (Crown Rise/Crown Road , culvert/open channel))	Un-named watercourse	28610 19001	28617 19143	500
Maesteg (Cemetery Road , culvert/open channel)	Un-named watercourse	28616 19079	28650 19143	888
Maesteg (Heol Faen culvert / open channel)	Nant y Twlc	28635 19045	28688 19077	1054
Maesteg (Mill Street , open channel)	Nant Cerdin	28634 18996	28581 18991	628
OGMORE VALLEY	**River Ogmore**			
Nantymoel (Pricetown Square culvert and open channel)	Nant Blaenogwr	29351 19211	29403 19296	1293
Nantymoel (OgwyStreet/Hill Street , culvert)	Un-named watercourse	29354 19196	29391 19204	500
GARW VALLEY	**River Garw**			
Blaengarw (Station Street , culvert / open channel/lagoon)	Nant Hir	29011 19273	29070 19315	666
Pontycymmer (Ffaldau Square culvert)	Nant Gelli Wern	29037 19145	29074 19168	500
BRIDGEND TOWN	**River Ogmore / Ewenny**			
Cefn Glas Bridgend	Nant Cefn Glas	29003 17930	28882 18070	2407
Bridgend Town	Morfa Brook	29054 18010	29128 18163	2062
Bridgend Industrial Estate	Nant Pont Sannau	29225 17825	29206 17973	1744
PENCOED AREA	**River Ewenny**			

Area/Town	Watercourse Name	Grid Ref (start)	Grid Ref (end)	Length (m)
Hendre Rd. Pencoed	Nant Heol Y Geifr & Tributaries	29572 18167	29556 18213	503
Pant Hirwaun Heol y cyw	Nant Blaencrymlyn	29439 18376	29406 18403	505

* Nant y Cerdin, Morfa Brook & Nant Crymlyn are designated Main River over part or all of their lengths; Nant Heol-y-Geifr becomes Main River at confluence downstream of Hendre Road

1.3.7 Flooding from these rivers has occurred at a number of locations throughout BCB and is considered to be a major source of flood risk. Flooding from rivers is explored further in Chapter 6.

Sea/ Tidal Flooding

1.3.8 A small area within BCB, properties in the Porthcawl area and land alongside the tidal Ogmore, is at risk of tidal flooding. The River Ogmore freely discharges into the sea and consequently water levels on the lower reaches are influenced by tide levels. The current normal tidal limit on the River Ogmore is a weir just downstream of Portobello Bridge approximately 2km from the coast. Tides may affect flooding much further inland during extreme events especially if sea levels rise as predicted in the future. This type of flooding is explored further in Chapter 7.

Land (surface water)

1.3.9 Flooding from surface water can occur anywhere within BCB although it is less likely in areas where sand overlies a highly permeable rock stratum. Whilst the mechanisms for runoff are well understood, predicting flooding from land is more complicated than other forms of flooding such as flooding from rivers or the sea. Surface water flooding is more likely to occur where soils and geology are less permeable and where there is flat ground (or relatively flat ground receiving run off from steep ground). This type of flooding is explored further in Chapter 8.

Groundwater

1.3.10 For the purpose of the SFCA, groundwater flooding has been defined as flooding from sub-surface water. There are a number of mechanisms that can cause this type of flooding including regional groundwater rise, underground barriers to flow and rebound when pumping from mining activities ceases.

1.3.11 No records of groundwater flooding were made available at the time of writing. However, the large number of springs recorded on OS mapping and the variation of geology throughout the borough suggest that groundwater flooding could present significant risks to localised areas. This type of flooding is explored further in Chapter 9.

Sewers

1.3.12 Flooding from sewers occurs when the man-made sewer system cannot convey the amount of water. This can occur due to extreme rainfall events, due to infrastructure failure or due to increased runoff from new developments. Predicting areas prone to sewer flooding is complex as flooding is localised and sewer systems are constantly being upgraded. This type of flooding is explored further in Chapter 10.

Artificial sources

1.3.13 Artificial sources of flooding identified within BCBC include numerous reservoirs across the borough. However, no records of flooding from artificial sources have been provided. Flooding may occur if these were to overtop, leak or breach. Whilst a breach of embankments has a very low probability, the consequences could be extremely severe. This type of flooding is explored further in Chapter 11.

2 Strategic assessment

The BCBC SFCA is a 'live' document. The current version has been developed using the best information and concepts available at the time. As new information and concepts become available the document will be updated and so it is the responsibility of the reader to be satisfied that they are using the most up-to-date information and that the SFCA accounts for this information. All revisions to this summary document are listed in the table.

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Final	30/09/10	CSL	bcbc

2.1 Context

2.1.1 Information concerning the six types of flooding (river, sea, land, groundwater, sewer and artificial sources) has been collated and analysed for the whole of the study area.

2.1.2 The assessment has aimed to characterise flood risk today and also into the future. A 100 year time horizon has been assessed and is considered appropriate for land use planning.

2.1.3 The Environment Agency and other key stakeholders have been contacted throughout the SFCA process in an attempt to gather as much information as possible.

2.1.4 The methodology proposed for the SFCA (Stage 1) was based on the best use of available information and involved minimal new analyses or hydraulic modelling. Each dataset was reviewed with regard to its accuracy and the most appropriate datasets were used to define flood risk across BCB under varying conditions. Stage 2 includes the development of new hydraulic models to provide the enhanced flood consequence information required for the five strategic areas.

2.1.5 The published development advice map (DAM) zones were used as the starting point for the SFCA. The most up-to-date Environment Agency flood zones were used to build on the existing development advice maps (DAMs) to produce the SFCA Flood Zones during the Stage 1 appraisal of flood risk. Further hydraulic modelling of the strategic sites of Maestag, Valleys Gateway, Pencoed and Waterton and Porthcawl has been used to update the SFCA Flood Zones in these areas. It is important that the source of flood data is considered whenever using it to inform a land use planning decision. The results of the hydraulic modelling in the strategic sites has not been used to update the county wide SFCA Flood Zones. In some areas, for example Porthcawl, there are notable differences between the existing flood zone information provided for the SFCA and that indicated by the broadscale modelling. Differences between the mapped flood zones highlight the need for further investigation in site specific FCAs.

2.1.6 BCBC and the Environment Agency will need to manage the update of the SFCA datasets in the future, as more detailed flood risk information becomes available.

2.2 Strategic Flood Consequence Assessment for BCBC

Summary of flood risk in BCBC

2.2.1 The dominant flooding source affecting the BCBC district is flooding from rivers. The principal watercourses are the River Ogmore, the River Llynfi and the River Ewenny. Flooding from the sea is not currently a significant problem, however it may become more significant in the future as sea level rises. Although incidents of surface water flooding and sewer flooding are potentially significant, there is less certainty in assessing these risks at a strategic level. Flooding from artificial sources is also important due to the potential severity of consequences.

2.2.2 The areas most at risk of flooding are:

- Abergarw - at risk of flooding from rivers, sewers, surface water and groundwater.
- Maesteg - at risk of flooding from rivers, surface water, sewers and groundwater.
- Bridgend – at risk of flooding from rivers, surface water, sewers and groundwater.
- Pencoed – at risk of flooding from rivers, surface water, groundwater and artificial sources.

- Waterton - at risk of flooding from rivers, surface water and groundwater.
- Pyle – at risk of flooding from rivers, surface water, groundwater and sewers.
- Porthcawl / Newton at risk of flooding from tidal, surface water and sewers.

2.2.3 Climate change research predicts an increase in the severity and frequency of rainfall events. Flooding from rivers, sewers and surface water is therefore likely to increase throughout BCBC in the future. BCBC is also expected to become increasingly vulnerable to tidal flooding as sea levels rise.

2.2.4 Of the strategic sites considered for this SFCA, the areas which are likely to have the biggest increases in flood risk in the future are:

- Abergarw - increased flooding from rivers, sewers and surface water.
- Maesteg - increased flooding from rivers, sewers and surface water.
- Waterton - increased flooding from rivers, sewers and surface water.
- Porthcawl/Newton - increased flooding from the sea, sewers and surface water.

Flood risk in BCBC

2.2.5 The Stage 1 SFCA has been undertaken over the whole of BCB administrative boundary so that the Council can make a comparative assessment of flood risk. This allows consideration of flood consequences and the vulnerability of developments in accordance with the principles of TAN15 when allocating land for development and making decisions on the acceptability of planning applications.

2.2.6 The Preferred Strategy for BCBC, in order to achieve the Vision and Objectives of the LDP, is the implementation of a Regeneration-Led Spatial Strategy. Four Key Strategic Regeneration Growth Areas will be brought forward that will deliver a range of mixed-use developments and facilities at: -

- Porthcawl
- Maesteg and the Upper Llynfi Valley
- The Valleys Gateway;
- Bridgend.

In addition, Four Strategic Employment Sites have been identified at:

- Broscastle, Waterton
- Island Farm, Bridgend
- Pencoed Technology Park
- Ty Draw Farm, North Conelly

From these Strategic Development Areas, BCBC have identified five for consideration as part of this SFCA:

- Maesteg
- Porthcawl
- The Valleys Gateway
- Waterton
- Pencoed

2.2.7 These development areas are shown on Map O in Annex A. Table 2.1 provides a summary of the key flood risk statistics across BCBC.

Table 2.1 Key flood risk statistics for BCBC

	Approximate area or number	Percentage of total area or number
BCBC statistics (Map O)		
BCBC district area	255 km^2	100%
Existing urban areas	38 km^2	15%
Flood statistics		
Flooding from rivers and sea (Maps F1 and F2)		
Area of BCBC within SFCA Zone B	3km^2	1%
Area of BCBC within SFCA Zone C1	1km^2	0.4%
Area of BCBC within SFCA Zone C2	19.2 km^2	7.5%
Area within BCBC covered by a flood warning service	6.72 km^2	2.6%

2.3 Sustainable Drainage Systems (SuDS)

2.3.1 Disposal of surface water is a key consideration, whether a development site falls within a flood risk area or not (TAN15 Section 8). Intense development within a catchment could result in increased runoff which if not appropriately managed could result in increased flooding within and downstream of the study area. Consequently, the impact of new developments on flood risk needs to be managed to avoid any negative impacts to the development itself and to other assets within the catchment.

2.3.2 New developments can also increase pressure on sewer systems and urban drainage. It is therefore important to manage the impact of developments in a sustainable manner. TAN15 requires, as a minimum, that the negative impacts of development on surface water runoff should be mitigated. It also details the benefits of SuDS and highlights methods through which the planning system can encourage the implementation of SuDS for new developments such as use of strategies, policies, planning conditions and by developing joint strategies with the EA and sewerage undertakers.

2.3.3 In addition to the concerns over flood risk, there is increasing pressure for efficient and sustainable use of water resources. This can be helped by incorporating Sustainable Drainage Systems (SuDS) and grey water reuse systems into new developments (as per the Building Regulations, Part H).

2.3.4 SuDS aim to control surface water runoff as close to its origin as possible, before it is discharged to a watercourse or sewer. This involves moving away from traditional piped drainage systems towards softer engineering solutions which seek to mimic natural drainage regimes. SuDS have many benefits such as reducing flood risk, improving water quality, encouraging groundwater recharge and providing amenity and wildlife benefits. For an urban drainage system to be termed ‘sustainable’ it must meet three criteria, as depicted in Figure 2.1.

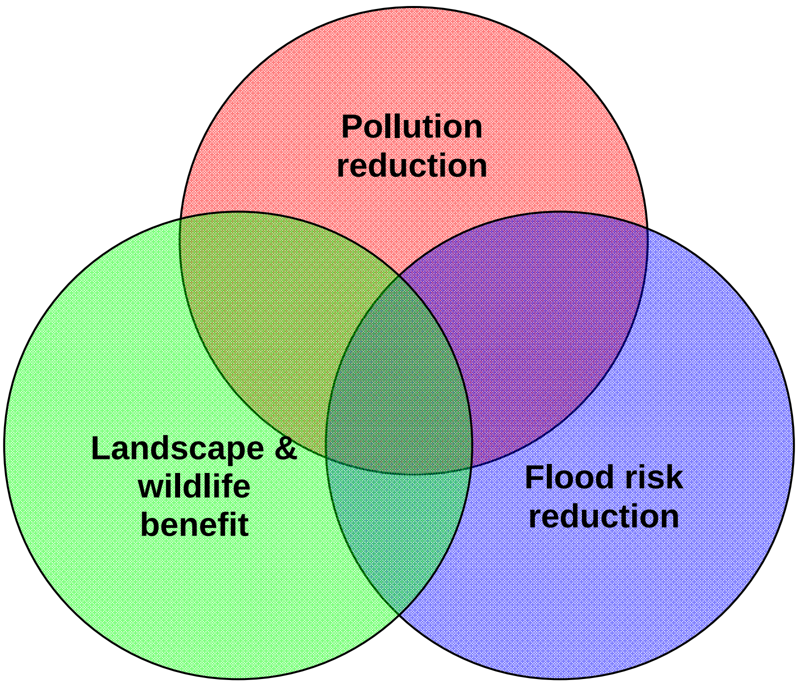

Figure 2.1 Broad criteria of Sustainable Urban Drainage Systems

2.3.5 All three criteria should be considered when designing a drainage scheme. Table 2.2 depicts a hierarchical approach to the selection of SuDS techniques with the most sustainable techniques located at the top of the table. The most sustainable techniques meet all three SuDS criteria.

2.3.6 All probable SuDS options should be explored as part of a site investigation. Before the site layout is decided, it is important that land is first allocated to accommodate these SuDS requirements. A drainage design can consist of a range of SuDS techniques. SuDS systems need to be carefully designed to ensure that they provide habitat for flora and fauna as well as reducing flood risk and improving water quality.

Table 2.2 The SuDS hierarchy

Most Sustainable	SuDS technique	Flood reduction	Pollution reduction	Landscape & wildlife benefit
	Basins and ponds - Constructed wetlands - Balancing ponds - Detention basins - Retention ponds	✔	✔	✔
	Filter strips and swales	✔	✔	✔
	Infiltration devices - soakaways - infiltration trenches and basins	✔	✔	✔
	Permeable surfaces and filter drains - gravelled areas - solid paving blocks - porous paving	✔	✔	
Least Sustainable	**Tanked systems** - over-sized pipes/tanks - storms cells	✔		

2.3.7 Whereas conventional piped networks can be accurately sized using scientific and empirical calculations, SuDS are not so accurate due to the many 'natural' variables that exist, such as soil permeability, the effect of vegetation, irregular channel shapes, etc. There are no definitive design codes or standards for SuDS although design guidance is available. CIRIA offers the following design documents;

- C522 – Sustainable Urban Drainage Systems – design manual for England and Wales;
- C523 – Sustainable Urban Drainage Systems – best practise for England, Scotland, Wales and Northern Ireland
- C609 – Sustainable Drainage Systems – Hydraulic, structural and water quality advise
- C697 – The SuDS manual

Methodology for assessing the suitability of SuDS

2.3.8 Overlaying GIS datasets can produce an indicative overview of appropriate SuDS techniques for the BCBC area. An analysis of physical, hydrological and environmental spatial data sets within a Geographical Information System (GIS) platform was undertaken and allowed areas that would benefit from different types of SuDS techniques to be identified. For the suitability assessment, the various SuDS techniques were broadly divided into storage techniques (wetlands, retention and detention ponds), infiltration techniques (infiltration trenches, soakaways), and source control measures, as shown in Table 2.3.

Table 2.3 SuDS Technique Groups

Group	Technique
Infiltration	Infiltration Trench/Basin and Soakaways
Storage	Retention Ponds, Detention Basins, Wetlands
Source Control	Rainwater harvesting, green roofs

2.3.9 The first stage of the spatial analysis was to identify the main factors affecting the suitability of SuDS techniques. On a strategic scale, the main factors were identified as drift geology and soil type (permeability), topography and available space.

2.3.10 Across BCB each drift geology type and soil type (as defined in the EA aquifer vulnerability dataset) was assigned a value from 0-50 appropriate to its suitability for either infiltration or storage based SuDS. Ground slope was calculated from LiDAR data and divided into three categories <2%, 2-8%, >8%, and again assigned a suitability value from 0-50 for both SuDS types. Each category was then weighted based on its relative importance in defining SuDS suitability. Table 2.4 shows the scores and Table 2.5 shows the weightings applied in the assessment.

Table 2.4 Scores used for the datasets analysed

Drift Geology	Infiltration Score	Storage Score
Sand and/or gravel	50	10
Diamiticon/unclassified	25	25
Layers containing clay and silt	10	40
Clay or Peat	0	50
Soil Type	**Infiltration Score**	**Storage Score**
1	50	10
2 or U	30	30
3	10	50
Area Slope	**Infiltration Score**	**Storage Score**
<2%	30	30
2-8%	50	50
>8%	10	30

Table 2.5 Weighting factors for the datasets used

Variable	Infiltration Weighting	Storage Weighting
Drift Geology	3	2
Soil Type	5	3
Area Slope	4	2

2.3.11 The datasets were then interrogated for a 50m grid cell and the weighting factors applied to calculate a total value indicating the suitability of a particular SuDS technique to each grid cell. The higher the value in each grid cell the higher the suitability of that particular SuDS technique. The results are presented in Maps SS1 and SS2 in Annex A.

2.3.12 It must be understood that this is a broad scale assessment intended to give an indication of general suitability of SuDS techniques. There are many factors affecting the optimum SuDS design for a site which require a site-specific assessment. Furthermore, the constraints that feed into the assessment for storage based solutions do not preclude the use of these techniques, but rather make them more costly to implement.

2.3.13 Broadly speaking, the use of infiltration techniques may be restricted by groundwater pollution concerns. Map SS1in Annex A illustrates the location of intermediately and highly vulnerable aquifers where particular care may be needed to avoid contamination of aquifers through the use of infiltration techniques. Both techniques may be constrained within the fluvial floodplain, as storage techniques could remove floodplain storage and groundwater levels may be too high to allow significant infiltration. Maps SS1 and SS2 both show the extent of the current SFCA Flood Zone C to indicate where this may be a constraint that needs to be considered. The use of both infiltration and storage techniques may be constrained in urban areas, as a result of space restrictions. The use of storage solutions will also be constrained by unstable ground conditions, which are present across parts of the county.

2.3.14 Areas which are not suitable for either infiltration techniques or storage techniques, should consider the use of source control methods such as rainwater harvesting and green roofs.

Capacity for the use of SuDS in BCB

2.3.15 Maps SS1 and SS2 in Annex A were produced identifying the generally suitable areas for each SuDS technique over the BCBC district.

Infiltration

2.3.16 Map SS1 shows the locations where infiltration based SuDS solutions would be suitable for implementation. Infiltration solutions are most dependent on soil and geology type.

2.3.17 In the northern part of BCB the geology is generally unsuitable for infiltration solutions. There are isolated bands of suitable geology within the valley bottoms, but implementation in these areas may be constrained by groundwater levels near the surface. Furthermore, the majority of this area is underlain by vulnerable aquifers which may prevent the implementation of infiltration based options.

2.3.18 In the central part of BCB the suitability of infiltration techniques is relatively varied. On the eastern side of Bridgend and Pencoed are large areas assessed as being highly suitable for infiltration However, these may be constrained by aquifer contamination concerns and by the presence of the floodplain, particularly for Pencoed.

2.3.19 In the western coastal lowlands a significant proportion of the land area may be more suitable for infiltration solutions. This is primarily a result of the dominant sand drift geology. Furthermore, there are limited aquifer vulnerability constraints. However limestone solution cavities may preclude the use of infiltration systems in some areas. Map SS1 shows areas where there is a possible risk of limestone cavities (predominantly in the western coastal lowlands), where infiltration techniques may require a greater detail of assessment.

2.3.20 Storage

2.3.21 Map SS2 shows the locations where storage based SuDS solutions would be suitable for implementation. Storage solutions are most suitable where the existing soils and geology serve to contain site runoff. However they can be implemented elsewhere with the use of a suitable impermeable layer.

2.3.22 The northern part of BCB generally comprises steep-sided valleys and highly developed valley bottoms and is not ideally suited to storage based SuDS. Consequently the implementation will not be widespread. The areas shown on Map SS2 are concentrated within the river valley where there is not only limited available space, but there are also floodplain storage considerations. There will however, be many sites within this area that have the appropriate conditions.

2.3.23 In the central area of BCB storage solutions are most appropriate in the low-lying flatter areas. Again it should be recognised that in these areas interaction with floodplain storage must be considered.

2.3.24 In the western coastal lowlands the ground conditions area generally unsuitable for storage based SuDS solutions.

3 Environment and planning context

The BCBC SFCA is a 'live' document. The current version has been developed using the best information and concepts available at the time. As new information and concepts become available the document will be updated and so it is the responsibility of the reader to be satisfied that they are using the most up-to-date information and that the SFCA accounts for this information. All revisions to this summary document are listed in the table.

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Internal Draft	07/05/2010		
Stage 1 Draft	21/05/10	CSL	BCBC
Final Draft	10/08/10	CSL	BCBC
Final	30/09/10	CSL	BCBC

3.1 Introduction

3.1.1 On the 12th May 2005, BCBC adopted its Unitary Development Plan (UDP). However, a change in Government legislation means that the Council now has to begin work on the preparation of a Local Development Plan (LDP) for the area. Once adopted, the LDP will supersede the UDP.

3.1.2 The Planning and Compulsory Purchase Act 2004 (PCPA) requires Local Planning Authorities (LPAs) to produce LDPs that will replace the system of Local, Structure and Unitary Development Plans. The PCPA 2004 requires all LDPs to undergo a Sustainability Appraisal (SA), which assists LPAs in ensuring that their policies fulfil the principles of sustainability.

3.1.3 Strategic Flood Consequence Assessments (SFCAs) should be used to inform the SA and LDP process and to ensure proposed developments are steered towards the lowest possible flood risk zone. Planning Policy Wales (PPW) administers the production of technical advice notes (TAN), of which TAN15: Development and Flood Risk provides guidance in relation to flooding. LPAs should take into account the guidance provided in TAN15 when preparing their LDPs and when assessing individual planning applications.

3.1.4 As well as TAN15 and the local plans identified above, there are a number of other plans and policies which will influence, and will be influenced by the SFCA.

3.1.5 Catchment flood management plans (CFMPs) and shoreline management plans (SMPs) represent the first 'tier' in the strategic flood risk management process, providing the overall framework within which more detailed assessments, such as the BCBC SFCA are undertaken. The SFCA covers specific land uses and is better able to influence flood risk management policies to address local issues, although CFMPs may be better placed to guide flood risk management policies on a catchment scale.

3.1.6 The SFCA does not eliminate the need for more detailed flood consequence assessments (FCAs) of individual proposed development sites. More detailed FCAs will still be required in accordance with TAN15. Rather the SFCA will provide additional information for these FCAs to draw upon and identify more detailed issues associated with flood hazards and flood consequences. This chapter discusses the national and local plans and policies relevant to developments and flood risk within BCBC.

National Planning Policy

3.1.7 Planning Policy Wales (PPW) sets out the context of the land use planning policies of the Welsh Assembly Government of the Welsh Assembly Government (WAG), within which Local Planning Authorities' statutory development plans are prepared and development control decisions on individual applications are taken. It is supplemented by a series of Technical Advice Notes (TANs).

3.1.8 PPW addresses a wide range of issues including sustainable settlements, the location of new development, the commitment to the re-use of land and promoting sustainability through good design.

3.1.9 Key strategic sustainability policy objectives of PPW relevant to the BCBC SFCA include:

- Minimise the risks posed by, or to, development on, or adjacent to, unstable or contaminated land and land liable to flooding. This includes managing and seeking to mitigate the effects of climate change;

- Contribute to the protection and improvement of the environment, so as to improve the quality of life, and protect local and global ecosystems.

3.1.10 PPW indicates that Local Authorities should recognise in their policies the housing needs of all and must ensure that sufficient land is genuinely available, or will become available, to provide a 5-year supply of land for housing judged against the general objectives and the scale and location of development provided for in the development plan.

3.1.11 Paragraph 13.2.4 of PPW refers to 'flood risk and climate change' and states that '*Local Planning Authorities should take a strategic approach to flood risk and the catchment as a whole. They should ensure that new development is not exposed unnecessarily to flooding therefore, by considering flood risk in terms of the cumulative impact of the proposed development in the locality, on a catchment wide basis (river catchment and coastal cell), and, where necessary, across administrative boundaries.'*

3.1.12 Paragraph 13.3.2 continues that *'when drawing up policies and proposals for their area Local Planning Authorities must acknowledge that government resources for flood and coastal defence projects are directed at protecting existing developments and are not available to provide defences in anticipation of future development.'* PPW then advises that a sustainable approach to flooding will involve avoiding development within areas at flood risk.

3.1.13 Technical Advice Notes and guidance of importance to the preparation of land use planning documents include:

- TAN1 – Joint Housing Land Availability Studies (June 2006) – provides guidance on the preparation of Joint Housing Land Availability Studies in order to provide evidence base for plan preparation.

- Planning Policy Wales – A Companion Guide (June 2006) – provides guidance on the content of Local Development Plans, having regard to national policy and local circumstance.

3.1.14 In addition, TAN15 is of particular importance to the development of the SFCA as it provides guidance on development and flood risk. This is described in more details below.

Technical Advice Note 15 'Development and Flood Risk'

3.1.15 Technical Advice Note 15 'Development and Flood Risk' (TAN15) sets out the criteria against which the consequences of a development in an area at risk of flooding can be assessed.

3.1.16 As part of this process, TAN15 requires that a Flood Consequences Assessment (FCA) be produced for all developments within a flood risk area. Areas considered to be at flood risk are shown on the Development Advice Map (DAM) produced by the Welsh Assembly Government.

The Justification Test

3.1.17 When development is considered to be within Zone C, flooding issues should be considered as a part of the whole planning process. TAN15 advises that any development within this zone should be the subject of a FCA in accordance with Section 7 and Appendix 1 ('Assessing Flooding Consequences') of TAN15. Any development would first have to pass the justification test as detailed in Section 6 of TAN15. The Local Authority will need to ensure that any ideas to be included in the Local Development Plan are justified.

Figure 3.1 – Extract from TAN15- A1.14

6 Justifying the location of development

6.1 Much urban development in Wales has taken place alongside rivers and in the coastal plain. It is therefore inevitable, despite the overall aim to avoid flood risk areas, that some existing development will be vulnerable to flooding and fall within zone C. Some flexibility is necessary to enable the risks of flooding to be addressed whilst recognising the negative economic and social consequences if policy were to preclude investment in existing urban areas, and the benefits of reusing previously developed land. Further development in such areas, whilst possibly benefiting from some protection, will not be free from risk and could in some cases exacerbate the consequences of a flood event for existing development and therefore a balanced judgement is required.

6.2 New development should be directed away from zone C and towards suitable land in zone A, otherwise to zone B, where river or coastal flooding will be less of an issue. In zone C the tests outlined in sections 6 and 7 will be applied, recognising, however, that highly vulnerable development and Emergency Services in zone C2 should not be permitted. All other new development should only be permitted within zones C1 and C2 if determined by the planning authority to be justified in that location. Development, including transport infrastructure, will only be justified if it can be demonstrated that:-

i. Its location in zone C is necessary to assist, or be part of, a local authority regeneration initiative or a local authority strategy required to sustain an existing settlement[1]; **or**,

ii Its location in zone C is necessary to contribute to key employment objectives supported by the local authority, and other key partners, to sustain an existing settlement or region;

and,

iii It concurs with the aims of PPW and meets the definition of previously developed land (PPW fig 2.1); and,

iv The potential consequences of a flooding event for the particular type of development have been considered, and in terms of the criteria contained in sections 5 and 7 and appendix 1 found to be acceptable.

Acceptability Criteria

3.1.18 TAN15 advises that most development should be designed to be flood free during the 1% fluvial flood (i.e. that fluvial flood with a 100 to 1 chance of occurring in any year) and the 0.5% tidal/coastal flood (i.e. 200 to 1 chance in any year event). TAN15 advises that development relating to Emergency Services should be designed to be flood free for the 0.1% flood (i.e. with a 1000 to 1 chance of occurring every year). There is, therefore, a frequency threshold of flooding below which inundation of any development should not be allowed. The following table, which should not be regarded as prescriptive, provides indicative guidance as to what that frequency threshold could be for different types of development described in terms of annual probability of occurrence.

Table 3.1 – Indicative Flooding Threshold Guidance (Extract from TAN15 A1.14)

Type of Development	**Threshold Frequency (Years)**	
	Fluvial	Tidal
Residential	1%	0.5%
Commercial/Retail	1%	0.5%
Industrial	1%	0.5%
Emergency Services	0.1%	0.1%
General Infrastructure	1%	0.5%

3.1.19 Paragraph A1.15 within Appendix 1 of TAN15 recognises that ‘beyond the threshold frequency proposed development would be expected to flood under extreme conditions. However even with adequate mitigation measures in place it may still not be sensible to allow particular development to take place. For instance it would not be sensible for developments to be built in areas where the velocity and depth of floodwaters was such that structural damage was possible or that people could be swept away by the flood.’ A table of indicative guidance, referred to as ‘acceptability criteria’ as illustrated within Appendix A1.15, is set out below.

Table 3.2 – Indicative Flooding Threshold Guidance (Extract from TAN15 A1.15)

Type of development	Maximum depth of flooding (mm)	Maximum rate of rise of floodwaters (m/hr)	Maximum speed of inundation of flood risk area (hrs)	Maximum velocity of floodwaters (metres/sec)
	Property Access			Property Access
Residential (habitable rooms)	600 600	0.1	4	0.15 0.3
Commercial & Retail	600 600	0.3	2	0.15 0.3
Industrial	1000 1000	0.3	2	0.3 0.45
Emergency Services	450 600	0.1	4	0.15 0.3
General Infrastructure	600 600	0.3	2	0.3 0.3

NOTE. The above figures are indicative and reflect conditions in which, given the presence of adequate warnings and preparation, appropriately equipped personnel could undertake emergency activities. However they are not definitive. Each site must therefore be considered individually and a judgement taken in the context of the particular circumstances which could prevail at that site.

Local Planning Policy

Bridgend Unitary Development Plan - Adopted May 2005

3.1.20 The Bridgend Unitary Development Plan (UDP) contains policies and proposals for the development and use of land within the County Borough for the period up to 2016.

3.1.21 Strategic Policy 4 states that land will be made available for a net addition of housing of 9,950 dwellings to the total housing stock of the County Borough within the period 1996-2016. Strategic Policy 5 then states that 252 hectares of land will be allocated to satisfy the varying needs of industry etc.

3.1.22 Policy EV15 refers to development within the coastal zone that will only be permitted where it meets, amongst other criteria –

(g) it is not at risk from, nor will it exacerbate, flooding or erosion risk.

3.1.23 Policy ENV16 states that: New Development in areas identified as being liable to flooding will not be permitted, unless it can be demonstrated that:

- They can be properly protected by approved engineering works and/or by other flood protection measures;
- Such remedial measures will not put others at risk of flooding; and

- The development, including any remedial measures, can be sympathetically assimilated into the environment in terms of its siting, scale, design and landscaping, without any detrimental impact on acknowledged sites of archaeological or historic interest, and habitats and species of importance to biodiversity can be safeguarded.

Emerging Bridgend County Borough Council Local Development Plan

3.1.24 BCBC is currently developing a LDP, as required by the Planning and Compulsory Purchase Act 2004. Work commenced formally in December 2005. The LDP will contain land use allocations and policies for future development within the County Borough for the period to 2021. It will include a Spatial Strategy, Strategic Policies and a monitoring procedure to implement the Vision and Objectives. This will provide the core framework to meet the development needs of BCBC. A completed SFCA will help support the vision and strategy.

3.1.25 Other plans and policies

Catchment Flood Management Plan (CFMP)

3.1.26 Catchment Flood Management Plans are an essential component of future flood risk management. The plans are key to delivering the flood risk management outcomes of Welsh Assembly Government (WAG) and Defra. A Catchment Flood Management Plan is a high level strategic planning tool, setting out the policies that will be adopted to manage flood risk for the next 50 to 100 years. The plans include actions that the EA, councils and others need to take now and in the future to ensure adequate response and adaptation to the increasing and changing flood risk.

3.1.27 Catchment Flood Management Plans have been developed for the whole of Wales and England. Each plan covers a single large catchment or a combined number of smaller catchments, with boundaries aligned to catchment boundaries. The plans consider all types of flooding and are based on a standard approach to ensure they provide a consistent assessment of flood risk. They also cover tidally influenced flooding from rivers and estuaries.

3.1.28 The CFMPs look at the current level of flood risk and compare this to the predicted future flood risk. This allows a targeted approach in dealing with flood risk in areas that will need it the most. The CFMP process assesses how flooding might affect people, property and the environment. The CFMP policies should be considered when making land planning decisions.

3.1.29 The Ogmore to Tawe CFMP has the following catchment objectives.

- Reduce the risk of harm to life from flooding (current level of flood risk is not considered appropriately managed).
- Ensure the risk of harm to life caused by flooding does not increase. (where the current level of flood risk is considered appropriately managed)
- Minimise flood related community disruption
- Minimise flood related risks to critical infrastructure
- Reduce economic damages caused by flooding
- Optimise flood risk expenditure in the CFMP such that expenditure is proportional to the risks.

- Mange flood risks to sites of cultural architectural and heritage value. This includes ensuring the natural flood regime of sites that rely on inundation is maintained.

- Protect and improve habitats and species diversity particularly BAP habitat and those relying on freshwater

- Preserve or reintroduce natural fluvial processes, where appropriate, in particular floodplain connectivity

- Protect and improve water quality within watercourses in the CFMP area.

3.1.30 Each CFMP is divided into a number of 'management units' which are defined as areas with similar sources, pathways and receptors of flooding. Each management unit is assigned a preferred flood risk management policy based on an appraisal of the social, economic and environmental damages of flooding.

3.1.31 BCB is divided roughly equally within three separate policy units.

3.1.32 The western part of the county falls within the coastal lowlands policy unit. The selected policy for this area is ‘Reduce existing flood risk management actions’:

> “There is low flood risk to isolated properties in this mostly rural policy unit. The relatively small amount of flood defences help to reduce flood risk locally, and these could continue to be maintained so that the levels of risk do not rise at these locations. The impact of tidal affected flooding will increase; however, there is little that can be done due to the scattered nature of the risk. Doing less maintenance will slightly increase the risk, but not by a significant amount. Flood warning should be continued to help reduce the overall level of risk.”

3.1.33 The northern part of the county falls within the Maesteg and Upland Valleys policy unit. The selected policy for this area is ‘Continue with the existing and alternative actions to manage flood risk at the current level’:

> “The level of flood risk is appropriately managed, fluvial flood risk is contained to localised areas and there is little that can be done to decrease the risk everywhere. The current level of maintenance and other activities should be continued to maintain the current flood risk to people and properties. This will need to include measures to manage surface flooding risks which have been identified as possible issues within Maesteg and Ogmore Vale.”

3.1.34 The central part of the county falls within the Bridgend Urban Policy Unit. The selected policy for this area is ‘Take further action to sustain the current scale of flood risk’:

> “The centre of Bridgend is currently protected against fluvial flooding and the current level of risk taking this into account is considered to be appropriately managed. Action will be required to ensure residents and property occupiers are aware of the possible consequence if flooding does happen. The Communities First regeneration action in Wildmill may provide an option to assist in implementing this policy.”

Shoreline Management Plan (SMP)

3.1.35 Shoreline Management Plans (SMP) provide a large scale assessment of the risks associated with coastal processes and present a long term policy framework to reduce these risks to people and the developed, historic and natural environment in a sustainable manner. SMPs are ‘coastal’ companion documents to the ‘inland’ Catchment Flood Management Plans. SMPs are non-statutory plans and are produced by Coastal Groups made up of maritime Local Authorities and other bodies with coastal defence responsibilities or interests.

3.1.36 The coastal area of BCB falls within the Swansea Bay SMP, specifically within costal process unit 4. 'Port Talbot Docks to Worms Head'. The coast of Bridgend is covered by five management units (MU). Table 3.2 below details the extents of these units and the preferred policies for each. At the time of writing the SMP was in the process of review. When using the SFCA, users should consider the latest SMP policies.

Table 3.2 SMP Management Unit Policies

Management Unit	Location	Approximate Length (km)	Short-term Policy	Anticipated Long-term Policy
MU 4/3	Afon Cynfig to Sker Point	3.8	Do Nothing, Monitor	Retreat
MU 4/4	Sker Point to Hutchwns Point	3.5	Selective Hold Line (do nothing along limestone cliff area to south) – further consultation	Selective Hold Line with retreat
MU 4/5	Hutchwns Point to Porthcawl	1.4	Hold Line	Hold Line
MU 4/6	Porthcawl Point to Newton (slipway	1.4	Hold or possibly advance subject to development proposals	Hold or advance
MU 4/7	Newton to Ogmore River	3.2	Do Nothing, monitor	Retreat

4 Flood defences and assets

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4.1 Introduction

4.1.1 Structures and defences are built to help reduce the occurrence, and therefore consequences of flooding. These assets can be owned, operated and maintained by the Environment Agency, Local Authorities, private business and/or local residents. This chapter summarises the defences identified and reviewed in BCB.

4.1.2 In some instances, river and sea processes have been modified over time by these defences (such as river walls, flood storage areas, flood alleviation channels and embankments) and by undertaking maintenance activities (such as river dredging).

4.1.3 To fully understand flood risk, it is necessary to assess the area at risk of flooding;

- with the flood defences in place
- with the flood defences removed
- with a breach or failure of the flood defence (in some circumstances the consequences of flooding when defences fail can be worse than if the defences were not present).

4.1.4 To do so the existing flood defences must be identified and defined in terms of their type and physical characteristics. In addition, information on ownership, condition and maintenance arrangements are required to assess the likelihood of failure.

4.2 Data collection and manipulation

Sources of data

4.2.1 The Environment Agency's National Flood and Coastal Defence Database (NFCDD) has been the primary source of information for identifying flood defences. Other GIS layers from BCBC have been used to supplement NFCDD as outlined in Table 4.1.

Table 4.1 Flood and asset data sources collected to date

Source	Title	Data type	Date	How used in SFCA
Environment Agency	NFCDD data in the form of defence polyline and point data and structure point data (for strategic sites only)	GIS	2009	To assess existing defences within strategic sites
Environment Agency	River Ewenny reach extracted from Ogmore Catchment Wide Section 105 Flood Risk Mapping	HEC-RAS	2009	For Stage 2 modelling
Environment Agency	River Llynfi reach extracted from Ogmore Catchment Wide Section 105 Flood Risk Mapping	HEC-RAS	2000	For Stage 2 modelling
BCBC	floodmap_defences_wa_010k.TAB	GIS	2009	To define defences across BCB

Additional data to be considered for future assessments

4.2.2 The full NFCDD dataset from the Environment Agency should be analysed as part of any review of this SFCA.

Screening of NFCDD data

4.2.3 The Environment Agency's National Flood and Coastal Defence Database (NFCDD) has been the primary source of information for identifying flood defences. This database contains flood defence and asset data for the whole of England and Wales.

4.2.4 The NFCDD dataset provided by the Environment Agency contained attributed data for flood defences in each of the strategic areas (Porthcawl / Newton, Waterton, Pencoed, Abergarw, Maesteg) but not for the entirety of BCB. Due to the vast amount of information in NFCDD, the dataset was cleaned to remove non-flood defence structures. A number of analyses were undertaken to;

- Determine the type of flood defence
- Determine the source of flooding that it was defending
- Estimate the standard of protection.

4.2.5 NFCDD contains details of a number of structures across the study area and many of these do not have a major impact on flooding during large events. Environment Agency national guidance provides information by which to define flood defences. The defence types identified within NFCDD for the BCB study area were raised defence (man-made), sea defences (man made), maintained channels with a high SoP (Standard of Protection) and flood defence structures. The location of flood defences and other related infrastructure has been included in Map D – Flood Risk Management Infrastructure.

4.2.6 Through identifying defences type it is possible to consider:

- The consequence of failure (such as embankment failure compared to failure of a riverwall).
- Maintenance requirements. For example assets with additional erosion protection may require more inspection but less maintenance. However assets without erosion protection (in a less erosive environment) may eventually require more significant improvement.

4.3 Summary of key flood defences

4.3.1 Flood defences identified within BCB are shown in Map D in Annex A, and summarised in Table 4.2. Defence information provided in the Environment Agency's NFCDD dataset has been supplemented with information provided by BCBC.

4.3.2 At present, the key flood defences in BCB protect against flooding from rivers. These are located in Abregarw/Aberkenfig, Maesteg and Waterton and the Flood Alleviation Scheme in Bridgend town centre. There are also sea defences at Newton/Porthcawl. The most common defence type is "flood defence structure" of which most are some type of revetment, although this dataset does include six weirs. There are two sets of flood relief culverts in Abergarw on either side of the Afon Ogmore. There is also a channel side wall on the upstream side of a flood relief channel. However, the flood relief channel itself doesn't appear to be in the NFCDD data set, it is assumed to be a channel underneath the A48 alongside the Afon Ewenni.

4.3.3 There are only four raised flood defences recorded in the data received, three of these are earth flood banks in Maesteg, Abergarw and Aberkenfig. The other is a blockstone revetment and flood wall in Aberkenfig.

4.3.4 Sea defences in BCB are a sea wall, a blockstone revetment and a flood bank faced with riprap all located in the Newton/Porthcawl area.

Maintained channels and sheet piling

4.3.5 In addition to the flood defences identified some sections of maintained channel, concrete retaining wall and steel sheet piling are identified in NFCDD as having a standard of protection between 20% AEP (5 year return period) and 1% AEP (100 year return period). These maintained reaches include sections of the Afon Ewenni through Waterton and the Afon Llynfi through Maesteg.

4.3.6 Sections of maintained channel and sheet piling are not generally considered defences by the Environment Agency when assessing areas benefiting from defences. However as some sections of maintained channel are assigned a high SoP in NFCDD, they have been considered key infrastructure for the purposes of the SFCA and are shown on Map D.

Maintenance

4.3.7 The Environment Agency and Local Authority carry out annual inspections of flood defence assets and update NFCDD. The data from these inspections is used to inform the owner of their duty to maintain assets to an appropriate level. As a result, information about flood defences is constantly changing.

4.3.8 GIS layers provided within the SFCA must be reviewed to obtain all of the defence information when considering the condition and standard of protection offered by flood defences at specific locations. It is important that users of the SFCA recognise issues with data quality and consistency of the source NFCDD datasets. The most current and correct information should be used. NFCDD is a live database, which is continually updated by the Environment Agency. Future updates of NFCDD should rectify any omissions and errors in the current dataset.

4.3.9 The management of the river defences and assets within BCB is divided between a number of different parties. Many structures acting as defences, by design or not, will be in private ownership and the initial responsibility for maintenance will lie with the owner. The Environment Agency is responsible for the majority of the river defences and has a supervisory duty over all flood defences under the Environment Act 1995.

4.3.10 BCB Council maintains a number of watercourses and assets such as trash screens and culverts throughout the study area.

4.3.11 The Environment Agency has permissive powers to maintain and improve watercourses designated as 'Main River' and associated structures for the efficient passage of river flow and the management of water levels. The Environment Agency also has a general supervisory duty for all flood risk management activities.

4.3.12 As the operating authority, Councils have the regulatory and supervisory role for flood defences on all ordinary watercourses which are not within the area of an internal drainage board (IDB). Culverts under roads are generally the responsibility of the relevant Highways Authority.

Table 4.2. Flood defences considered in the SFCA

ID	Asset Type	Asset Location	Asset Description	Flooding Source	Design SoP	Replacement Cost (£)	Recommended action
1021056410102L02	flood defence structure	U/S SIDE A483 KEEPERS LODGE RD BRIDGE	Channel side wall on the U/S Side of the flood relief channel	fluvial	100	12359	improve condition through maintenance
1021057100101L01	flood defence structure	Upstream of the CONFLUENCE WITH THE EWENNI	'U' shaped concrete units	fluvial	-999	85940	continue active monitoring
1021057100101R01	flood defence structure	D/S OF BONT FAWR ROAD BRIDGE	'U' shaped precast concrete units	fluvial	-999	86512	continue active monitoring
1021055010401L06	flood defence structure	On the u/s side of the A4063 Road Bridge	Blockstone revetment/bank protection works	fluvial	-999	11163	
1021055010501B03	flood defence structure	Just off Heol y Bont Road, Ynysawdre	Blockstone weir	fluvial	-999	3000	
1021055010501B04	flood defence structure	Ynysawdre Gauging Station	Blockstone weir	fluvial	-999	3000	
1021055010501B05	flood defence structure	Ynysawdre Gauging Station	Blockstone weir	fluvial	-999	3000	
1021055010501B08	flood defence structure	Alongside George Thomas Ave, Brynmenyn Ind. Est	Blockstone weir and wing wall	fluvial	-999	3000	
1021055010501B09	flood defence structure	Alongside George Thomas Ave, Brynmenyn Ind. Est.	Blockstone weir and associated wing walls	fluvial	-999	3000	
1021055010501B12	flood defence structure	In the location of George Thomas Ave, Brynmenyn Ind. Est	Blockstone weir	fluvial	-999	3000	
1021055010501L03	flood defence structure	Heol yr Ysgol, Ynysawdre	3 X flood relief pipes	fluvial	20	52769	improve condition through maintenance

ID	Asset Type	Asset Location	Asset Description	Flooding Source	Design SoP	Replacement Cost (£)	Recommended action
1021055010501L09	flood defence structure	In the location of Aneurin Bevan Ave, Brynmanyn Ind. Est	Gabionade revetment/bank protection works	fluvial	20	29267	
1021055010501L12	flood defence structure	Brynmenyn Ind. Est, Brynmenyn	Blockstone Revetment/bank protection works	fluvial	-999	7442	
1021055010501R01	flood defence structure	Heol yr Ysgol Road, Ynysawdre	3 X flood relief pipes approx 900 mm dia	fluvial	20	50029	improve condition through maintenance
1021055010501R02	flood defence structure	Alongside Heol-y-Bont, Ynysawdre	Blockstone revetment/bank protection works	fluvial	-999	9303	
1021055010501R04	flood defence structure	The river gauging station, Ynysawdre	Sheet pilling revetment	fluvial	-999	23248	
1021055600101L02	flood defence structure	Brynmenyn Junction	Blockstone bank protection works	fluvial	-999	4167	improve condition through maintenance
1021056200101R02	flood defence structure	BRYNCETHIN	blockstone revetment	fluvial	-999	3349	continue active monitoring
1021056410102B05	maintained channel	U/S OF WATERTON TENNIS SCHOOL	Blockstone weir	fluvial	100	1000	continue active monitoring
1021056410102L05	maintained channel	NEAR FORDS ENGINE PLANT	Natural bed,Concrete Wall, wide grass bank	fluvial	100	272000	continue active monitoring
1021056410102L05	maintained channel	NEAR FORDS ENGINE PLANT	Natural bed,Concrete Wall, wide grass bank	fluvial	100	272000	continue active monitoring
1021056410102L06	maintained channel	NEAR FORDS ENGINE PLANT	Natural bed,Steel piles with concrete capping, wide grass bank	fluvial	100	482000	continue active monitoring
1021056410102L07	maintained channel	DIAPLASTICS	Blockstone Revetment/bank protection works	fluvial	100	12000	continue active monitoring

ID	Asset Type	Asset Location	Asset Description	Flooding Source	Design SoP	Replacement Cost (£)	Recommended action
1021056410102R03	maintained channel	WATERTON, REAR OF COUNCIL OFFICES	Steel piles with concrete capping	fluvial	100	550000	continue active monitoring
1021056410102R04	maintained channel	WATERTON LANE	Natural bed,Concrete Retaining Wall, wide grass bank	fluvial	100	272000	continue active monitoring
1021056410102R05	maintained channel	WATERTON LANE	Natural bed,Steel piling with concrete capping, wide grass bank	fluvial	100	942000	continue active monitoring
1021055800201L11	maintained channel	The cricket ground, Maesteg	channelside Blockstone works, a small berm and a raised footpath running along its length	fluvial	20	25300	improve condition through maintenance
1021055010401R05	raised defence (man-made)	The rear of the Special School, Aberkenfig	Blockstone c/s revetment and flood defence wall	fluvial	50	102200	continue active monitoring
1021055010401R06	raised defence (man-made)	On the u/s side of Heol Persondy	Earth flood bank and associated structures	fluvial	50	5400	improve condition through maintenance
1021055010501L20	raised defence (man-made)	Brynmenyn Ind. Est, Brynmenyn	Natural bed and banks and an earth flood bank set a few metres back	fluvial	100	30000	continue active monitoring
1021055800201L24	raised defence (man-made)	River Street, Maesteg	Earth flood bank	fluvial	20	5000	improve condition through maintenance

ID	Asset Type	Asset Location	Asset Description	Flooding Source	Design SoP	Replacement Cost (£)	Recommended action
102HB90110 102C01	sea defence (man-made)	Newton Porthcawl	Flood bank faced with rip rap	coastal	200	500000	
102HB90110 102C02	sea defence (man-made)	Newton Porthcawl	Newton Sea Wall	coastal	200	500000	continue active monitoring
102HB90110 102C03	sea defence (man-made)	Newton Porthcawl	Newton Blockstone revetment	coastal	200	10000	continue active monitoring
BCBC Assets							
Wilderness Balancing Pond	Balancing Pond	Porthcawl	Balancing Pond	-	-	-	-
Pwll y Waun Balancing Pond	Balancing Pond	Porthcawl	Balancing Pond	-	-	-	-
Eastern Promenade Wall	sea defence (man-made)	Porthcawl	Sea wall	Coastal	-	-	-
Harbour walls	sea defence (man-made)	Porthcawl	Sea wall	Coastal	-	-	-
Eastern Breakwater	Breakwater	Porthcawl	Structure	Coastal	-	-	-
Esplanade sea wall	Sea defence (man made)	Porthcawl	Sea wall	Coastal	-	-	-

ID	Asset Type	Asset Location	Asset Description	Flooding Source	Design SoP	Replacement Cost (£)	Recommended action
Private defences	Defence wall	Trecco Bay, Porthcawl	Defences	Coastal	-	-	-

5 Flood warning and emergency planning

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Version	Issue Date	Issued by	Issued to
Internal Draft	07/05/2010		
Stage 1 Draft	21/05/10	CSL	BCBC
Final Draft	10/08/10	CSL	BCBC
Final	30/09/10	CSL	BCBC

5.1 Introduction

5.1.1 Flood warning and emergency planning is a useful measure for managing flood risk from extreme events.

5.1.2 In exceptional cases where land allocation within flood risk areas is unavoidable, new development should be designed so that flood warning complements other measures and minimises residual risk. It should not be the primary means of protection.

5.1.3 Flood warning and evacuation procedures can reduce the risk of people being exposed to flood waters and minimise the consequences of flooding.

5.1.4 Effective land use planning will reduce the requirement for flood warning and emergency planning as new development is steered away from flood risk areas.

5.2 Flood warning

5.2.1 The Environment Agency is responsible for monitoring flood events and to issue warnings to people in properties and businesses at risk of flooding. Forecasting uses a combination of Meteorological Office weather forecasts and real-time data (rainfall, flow, level and soil moisture).

5.2.2 In order to fulfil their responsibilities, the Environment Agency operates a coded warning system. This is a four stage warning system and each stage will trigger a set of procedures for various organisations. Definitions and symbols for each warning code are described in Table 5.1.

Table 5.1 Environment Agency flood warning stages

Alert state	Symbol	Action
Flood Watch		Flooding of low-lying land and roads is expected in the (XXXX) Area. **Be aware, be prepared, watch out!**
Flood Warning		Flooding of homes and businesses is expected in the (XXXX) Area. **Act Now!**
Severe Flood Warning		Severe Flooding is expected in the (XXXX) Area. There is extreme danger to life and property. **Act now!**
All Clear		Flood Watches or Warnings are no longer in force for this area.

5.2.3 The Environment Agency maintains a FLOODLINE telephone service and website (www.environment-agency.gov.uk/subjects/flood) that carries the latest information on alert states as well as a series of advice publications. Alert categories of 'Flood Warning' and higher may also be broadcast on television and radio.

5.2.4 BCB is covered by the river flood warning areas listed in Table 5.2 and shown in Map D in Annex A. The Flood Warning areas within BCB are also situated within larger geographical areas, where the Environment Agency provides a general Flood Watch early alert to possible flooding.

Table 5.2 Environment Agency flood warning service

Area code	Flood warning area
102FWB108	River Ewenny at Ewenny Village
102FWB402	Tidal area at Ogmore Castle
102FWC404	Tidal area at Newton and Porthcawl
102FWF101	River Llynfi at Maesteg
102FWF102	River Llynfi at Aberkenfig
102FWF103	River Ogmore at Ogmore Vale
102FWF104	River Ogmore at Blackmill
102FWF105	River Ogmore at Bridgend
102FWF106	River Ewenny at Pencoed

Flood Warning Service and flood risk

5.2.5 Where a Flood Warning Area (FWA) covers a watercourse, the extent of the FWA generally includes all locations within the Environment Agency's Flood Zone 3. However the Environment Agency does not provide a Flood Warning Service on some smaller watercourses where there are few people or properties at risk. The areas not within a FWA are predominantly smaller settlements situated in the upper catchments. Environment Agency Flood Warnings only relate to flooding from Main River or the sea in designated areas, flooding from other sources will not be covered by the warning system.

5.3 Emergency planning

5.3.1 The Civil Contingencies Act 2004 classifies Local Authorities as Category 1 responders along with other organisations such as the Police, Fire, Ambulance services. The role and responsibilities for emergency planning is set out by legislation following the implementation of the Civil Contingencies Act 2004. The Act defines the term 'emergency' as:

- *'an event or situation which threatens serious damage to human welfare;*
- *an event or situation which threatens serious damage to the environment, or*
- *war, or terrorism, which threatens serious damage to security'.*

5.3.2 Regional emergency planning is undertaken by Local Resilience Forums (known as LRFs). These are multi-agency partnerships convened in response to the Act. Bridgend County Borough falls within the South Wales Local Resilience Forum. The South Wales Local Resilience Forum (LRF) currently chaired by the Chief Executive Officer of the City and County of Swansea was established in 2004 as a requirement of the Civil Contingencies Act 2004. The group had been operating since 1994 as the South Wales Emergency Services Liaison Committee (SILVER & GOLD Groups). The original groups were established in recognition of the need for integrated emergency management procedures.

5.3.3 The partnership is formed of the emergency services, health agencies, LPAs, the Environment Agency and other organisations such as the Maritime and Coastguard Agency. Together these groups prepare for incidents, including flooding, in the form of contingency plans. They respond to incidents and then assist in the recovery following the incident.

5.3.4 During flood incidents the Environment Agency issues warnings to those likely to be affected, operates flood defences on certain rivers and advises the emergency services on the expected level of flooding. The Environment Agency and Local Authority also liaise closely during a flood incident.

5.3.5 BCBC have a range of contingency plans which detail how local services will work together to respond to any type of incident or disaster. These plans are detailed within the Major Incident Plan document and include the “Environment Agency Flood Plan”.

5.3.6 Bridgend County Borough Council’s Emergency Planning Team is responsible for making sure the local authority is able to react promptly in the event of a disaster or a major emergency to save life, property and the environment. The team is responsible for ensuring that the council is compliant with the Civil Contingencies Act 2004 which details its obligations in relation to emergency planning. These obligations are met through preparing and maintaining plans, training and carrying out emergency planning exercises. The council has a 24-hour Emergency Duty Officer rota in place to ensure an urgent response is given to major incidents.

6 Flooding from rivers

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6.1 Introduction

6.1.1 Flooding from rivers occurs when water levels rise higher than bank levels, causing floodwater to spill across adjacent land (floodplain). The main reasons that water levels can rise in rivers are:

- intense or prolonged rainfall causing runoff rates and flow to increase in rivers, exceeding the capacity of the channel. This can be exacerbated by wet antecedent conditions and elevated ground water tables;
- constrictions in the river channel causing flood water to backup;
- blockage of structures or the river channel causing flood water to backup; and
- high water levels and/or locked flood (tide) gates preventing discharge at the outlet of the river.

6.1.2 The consequence of river flooding depends on how hazardous the flood waters are and what the receptor of flooding is. The hazard of river flood water is related to the depth and velocity, which depends on the:

- magnitude of flood flows;
- size, shape and slope of the river channel;
- width and roughness of the floodplain; and
- types of structures that cross the channel.

6.1.3 Flood hazard can vary greatly throughout catchments and even across floodplain areas. The most hazardous flows generally occur in steep catchments and towards the bottom of large catchments. Hazardous river flows can pose a significant risk to exposed people, property and infrastructure.

6.1.4 Whilst low hazard flows are of less risk to life, they can disrupt communities, require significant post-flood cleanup and can cause superficial and possibly structural damage to property.

6.2 Data collection

Table 6.1 Data provided for the SFCA

Source	Title	Data type	Date	How used/to be used in SFCA
BCBC	DAM Zones	GIS	2009	To define SFCA Flood Zones
Environment Agency	Environment Agency Tidal Flood Zones 2 & 3.	GIS	2009	To check / update SFCA ZoneC
Environment Agency	Environment Agency Areas Benefitting from Defences	GIS	2009	To check / update SFCA Zones (C1 / C2)
Environment Agency	1000yr modelled flood outline	GIS	2009	To update SFCA Zone C
Environment Agency	Historic Flood Outlines	GIS	2009	Presented in Map HF

Historic flooding

6.2.1 Historic incidents of river flooding have been provided by EAW in GIS format. The information comprises four flood outlines, three in Pencoed and one in Waterton, but there is no information associated with the outlines. Information of properties vulnerable from flooding has been provided by WAG, although there is no information on the source of flooding. A preliminary review of the datasets has identified in broad terms the locations and types of previous flooding problems.

6.2.2 Map HF in Annex A shows the locations of previous flood events from all sources.

Existing studies

6.2.3 The Environment Agency holds a number of hydraulic models and hydrological assessments that were developed for previous river flood studies.

6.2.4 The most up-to-date river flooding outputs are the EA flood zones. These are based on a combination of national generalised modelling (JFLOW) and results of more detailed studies where available.

6.2.5 The Environment Agency commissioned a national scale model in 2004 to produce flood extents for the whole country.

6.2.6 The 2004 study involved national generalised broad scale modelling, using a 2D raster flood spreading model (JFLOW), of all rivers in England and Wales. At the time, these models were based on a SAR DTM which had flood defences and major infrastructure removed.

6.2.7 Flow estimates were derived using an automated system of the Flood Estimation Handbook (FEH) Statistical Method. A flow estimate was defined every 200m along all flow paths with catchment greater than $3km^2$. Flood outlines for the 1% AEP and 0.1 % AEP floods were generated. These flood outlines form the basis of the Environment Agency Flood Zone maps published on their website.

6.2.8 The Environment Agency Flood Zones are periodically updated as new information becomes available. The tidal flood zones provided were last updated in 2009, no details on the method of derivation have been provided.

6.2.9 Within BCB, the 1000yr (0.1% AEP) and 100yr (1% AEP) EA Flood outlines incorporate outputs from more detailed modelling studies including the Ogmore and Ewenny model catchment wide model (2009). This model was originally built in 2007.

6.2.10 Two HEC-RAS models were provided by the EA as noted in Table 6.2. These have been used to develop 2D models for the strategic sites at risk from fluvial flooding during Stage 2 of the SFCA.

6.2.11 TAN15 DAM zones were provided by BCBC. These were last updated in 2009. Comparing the outlines with the modelled 1000yr flood outline provided by EA, suggests that these zones are based on the national generalised model or the results of the 2007 Ogmore and Ewenny catchment wide model.

Table 6.2 Previous hydraulic models used in river flood studies

Name	How used in SFCA	Date of model	Return Period used in SFCA	Model Type
Ogmore and Ewenny Catchment Wide Model	Fluvial SFCA Flood Zones	2009	1000	HEC-RAS
Ogmore Feb 2009	Stage 2 Modelling	2009	25, 100, 1000	HEC-RAS
S105 Upper Llynfi model	Stage 2 Modelling	Unknown	None	HEC-RAS

Additional data to be considered

6.2.12 Further details of any historic flooding events should be requested and analysed as part of any review of this SFCA including: EA flooding records, any council records, parish flooding records and highways flooding information. Any detailed model studies, including those carried out as part of FCAs should also be reviewed.

6.3 Methods for assessing flooding from rivers

6.3.1 The level of assessment required for the SFCA is broadscale. For this reason, existing datasets and tools have been used where possible to provide flood risk information.

Flood Zones

6.3.2 As defined in TAN15, Flood Zones B, C1 and C2 indicate the land at risk of fluvial or tidal / coastal flooding. The descriptions of the zones are shown in Table 6.3.

Table 6.3 TAN15 Flood Zones

DAM Zone	Description	Use within the Precautionary Framework
A	Considered to be at little or no risk of fluvial or tidal/coastal flooding.	Used to indicate that justification test is not applicable and no need to consider flood risk further.
B	Areas known to have been flooded in the past evidenced by sedimentary deposits.	Used as part of a precautionary approach to indicate where site levels should be checked against the extreme (0.1%) flood level. If site levels are greater than the flood levels used to define adjacent extreme flood outline there is no need to consider flood risk further.
C	Based on Environment Agency extreme flood outline, equal to or greater than 0.1% (river, tidal or coastal)	Used to indicate that flooding issues should be considered as an integral part of decision making by the application of the justification test including assessment of consequences.
C1	Areas of the floodplain which are developed and served by significant infrastructure, including flood defences.	Used to indicate that development can take place subject to application of justification test, including acceptability of consequences.
C2	Areas of the floodplain without significant flood defence infrastructure.	Used to indicate that only less vulnerable development should be considered subject to application of justification test, including acceptability of consequences. Emergency services and highly vulnerable development should not be considered.

6.3.3 The current DAM zones were updated, where appropriate, with information from the Environment Agency to provide enhanced SFCA Flood Zones. Specifically, the 1000yr outline (0.1% AEP event) was used to update Zone C and the EA Areas Benefitting from Defences (ABD) layer was used to check Zone C1. The ABD is defined explicitly in Environment Agency guidance but in summary in fluvial flood risk areas it is the difference between the flood extents for the undefended and defended 1% AEP flood extent. All areas within Zone C and outside Zone C1 have been designated as Zone C2. Zone B was checked against the BGS (British Geological Society) drift geology information provided and appeared to be in close agreement therefore was left unchanged.

6.3.4 For the SFCA the Flood Zones were defined as follows:

- Zone C – Based on the current 2009 DAM Zone C, replaced with the latest EA 0.1% AEP event flood outline where this is present.
- Zone C1 – Location based on the current 2009 DAM Zone C1, with the boundaries amended where necessary to match the SFCA Zone C as defined above. (The DAM Zone C1 and EA ABD layer were compared and were in close agreement regarding locations served by flood defences).
- Zone C2 – Defined as all Zone C not within Zone C1.
- Zone B – Taken as the current DAM Zone B.

6.3.5 A more detailed assessment of flooding from rivers has been completed for the strategic sites of Maesteg, Valleys Gateway and Pencoed and Waterton, based upon the results of broadscale 2D hydraulic modelling. The details of the hydraulic modelling are given later in this chapter. More detailed flood zone information, as indicated by the results of the broadscale modelling has been provided for the strategic sites. This has not been used to update the county wide SFCA flood zones. Differences between the estimated flood zones suggests that more detailed assessment should be completed for future development in the vicinity.

Impact of climate change

6.3.6 The latest government guidance for climate change and flood risk is contained within FCDPAG3 Economic Appraisal: Supplementary Note to Operating Authorities – Climate Change Impacts October 2006. The note was issued in November 2006 and informs appraisers and decision makers of new climate change allowances and broadly how these should be considered when assessing flood risk. The most important points to consider are;

- Updated figures of regional net sea level risk allowances are contained within Table 1 (of the note)
- New indicative sensitivity ranges covering peak rainfall intensity, peak river flow volume, offshore wind speed and extreme wave heights in Table 2 of the note
- The precautionary approach in assessing sea level rise
- Use of sensitivity analysis to gauge uncertainty of flows, rainfall, wind and wave action on sea levels
- Response to climate change through either managed/adaptive or precautionary approaches. Note: in a SFCA, a precautionary approach is recommended.

UK climate change projections (UKCP09)

6.3.7 This more recent study looks at probabilistic projections on the likely changes to the UK climate under a range of greenhouse gas emission scenarios.

6.3.8 The key findings from UKCP09 are:

- All areas of the UK are likely to get warmer, and the warming in summer is greater than in winter;

- Little change in annual precipitation totals, but with the likelihood that more rain falls in winter, with drier summers; and
- Sea levels rise, and are greater in the south of the UK than the north.

6.3.9 The findings from the UKCP09 project have not superseded the 2006 Defra climate change guidance therefore this has been followed for the SFCA.

6.3.10 A 100 year climate change time horizon has been investigated to provide more detailed information upon which to make land use planning decisions. It will be up to the decision-maker to select the most appropriate time horizon for the specific land use they are investigating.

6.3.11 For this SFCA, the baseline was set as 2010 and future flood zones were derived for 2110. Unlike previous climate change guidance, the latest guidance predicts that sea levels will rise at different rates over the next 100 years.

6.3.12 The Defra guidance also provides guidance on how flows will change over time. River flows in catchments that are not small or particularly urban are expected to increase by 10% in 25 years and 20% in 50 to 100 years. A 100 year design life was considered appropriate for the SFCA.

6.3.13 The SFCA Flood Zones were modified to produce an estimation of their extents in 2110. This was carried out using a basic buffering approach for Zone C. The width of this zone was increased by 30m in both directions for large lowland rivers. For minor watercourses and rivers in the steep upland areas the zone was extended by 10m in both directions. The SoP of the defences, as defined in NFCDD, was used to assess areas that would be served by defence infrastructure in the future. A threshold of 200 year (0.5% AEP) was selected as being approximately equivalent to a future 100 year (1% AEP). No areas were identified therefore no future Zone C1 has been defined for the SFCA. Future Zone B was deleted where it overlapped with the increased extents of Zone C.

6.3.14 These zones will be updated with the results from modelling carried out in Stage 2 of the SFCA for the four strategic sites at risk of flooding from main rivers.

6.4 Hydraulic Modelling of the Strategic Sites at Risk of Flooding from Rivers

Methodology

6.4.1 The strategic sites of Maesteg, Valleys Gateway, and Pencoed and Waterton are at risk of flooding from rivers. Broadscale 2D hydraulic models have been constructed as part of the Stage 2 SFCA in order to provide the additional information required, in relation to fluvial flooding risk, to assess the consequences of flooding for the strategic sites in accordance with TAN 15. These have been run using the latest available version of the TUFLOW software (2009-07-AE-iSP/2009-07-AE-iDP[1]).

6.4.2 The extent of the hydraulic models was defined based upon the boundaries of the strategic areas and the topography of the river catchments. The 2D model domain (grid) was defined using the filtered LiDAR data received for the SFCA. Tuflow models work by solving shallow water equations in an x and y direction. The size of the grid varies for each of the hydraulic models, and has been selected based on the width of the river channel throughout the hydraulic model. For the reaches of the hydraulic models where there is an overlap with existing model data, this data has been used to define the river channel geometry. Where there is no existing model information, the river has been defined using the LiDAR DTM.

[1] Where SP and DP stand for single precision and double precision

6.4.3 In addition to an elevation, each grid cell requires the specification of a roughness value, a value that defines the resistance that the land surface gives against the flow of water. Mastermap has been used to assign the different types of land surface, and to each type of land surface an appropriate value of surface roughness has been assigned based on the Manning's n values of roughness.

6.4.4 A small number of critical structures have been included in each of the hydraulic models. The structures have been identified as critical based upon their impact on the restriction of flow both within the river channel and on the floodplain. A number of structures were identified as potentially being critical to flow for each of these models based upon existing hydraulic model information, OS mapping, NFCDD (National Flood and Coastal Defence Data) and the DTMs. The impact of these structures on flow was then assessed during a site visit to each of the strategic areas. During the site visit a small number of the initially identified structures were discounted as being critical. The critical structures included in each of the hydraulic models is detailed in the following sections but largely includes road bridges crossing the channels and floodplain (causing a constriction to flow), long culverts and significant flood defence infrastructure such as soft embankments and concrete flood walls.

6.4.5 Hydrological estimates in the form of full flow hydrographs were required for input into each of the hydraulic models, for all of the modelled watercourses. Peak flow estimates exist for the areas of Pencoed and Waterton and were extracted from the Ogmore – Ewenny HEC-RAS hydraulic model. The modelled flows were checked against the flow estimates in the HEC-RAS model and were in close agreement. No further amendments were required. For the watercourses within the Maesteg and Valleys Gateway Strategic areas, there was no existing hydrology. The catchment characteristics of the watercourses for all of the strategic areas were assessed in accordance with the acceptable limits for the use of the Flood Estimation Handbook (FEH) Statistical and ReFH (Revitalised Flood Hydrograph) methods. It was decided that the ReFH method would be appropriate for use for flood hydrograph derivation for all of the watercourses. It was not within the scope of this study to complete flood event analysis to improve upon the catchment descriptor based hydrograph parameters. Appropriate local donor gauging stations were sought in order to improve the catchment descriptor based hydrograph parameters but there were no suitable donor stations for which flood event analysis had already been completed. For the Pencoed and Waterton flow hydrographs, a hybrid approach was adopted, whereby the catchment descriptor based hydrographs were fitted to a specified peak flow, as abstracted from the HEC-RAS model. A single critical duration was selected for each of the strategic areas based upon a critical location. The critical locations and critical durations selected are shown in Table 6.4.

Table 6.4 Critical Locations used for selection of storm duration

Strategic Area	Critical Location	Critical Duration (hours)
Maesteg	In Maesteg (NGR 286344 190424)	4.2
Valleys Gateway	Location adjacent to A4063 at downstream extent of the model. (NGR 290094 182365)	8.1
Pencoed and Waterton	In Waterton at the downstream extent of the model (NGR 290082 177238)	7.5

Maesteg Model

Model Extent

6.4.6 The model extents are shown in Table 6.5.

Table 6.5 Maesteg Model Extents

Watercourse	Upstream Extent (NGR)	Downstream extent (NGR)
Afon Llynfi	286300 194500	287750 188000
Nant y Cerdin	285830 189910	286330 189960

Model Scenarios

6.4.7 A number of current and future scenarios have been modelled in order to assess flooding from rivers. The following scenarios have been modelled:

Current Flood Zones
Zone B – not modelled
Zone C – modelled 0.1% AEP event undefended
Zone C1 / C2 – Difference between modelled 1% AEP event undefended and modelled 1% AEP event defended. Areas shown not to flood for the 1% AEP defended scenario designated as C1, all other areas within Zone C designated as Zone C2.

Future Flood Zones
As above, with model inflows increased by 20% in accordance with Table 2 of the Defra guidance to 2110[2].

Actual risk *
5%, 1%, 0.1% AEP, defended, including climate change allowance

6.4.8 The maps in Annex A of this report show the following information (0.1% AEP event, 2110):

- Maximum Flood Depth (Map AR3)
- Maximum Flood Velocity (Map AR2)
- Maximum Rate of Rise (Map AR4)
- Maximum Speed of Inundation (time from when flooding starts to when flood depths peak) (Map AR5)

Structures, Defences and Breaches

6.4.9 Three structures have been included within the Maesteg Hydraulic model. These are detailed in the table below.

[2] Flood and Coastal Defence Appraisal Guidance FCDPAG3 Economic Appraisal Supplementary Note to Operating Authorities - Climate Change Impacts October 2006

Table 6.6 Maesteg Model Structures

Structure Name	Approximate Location (NGR)	Reason for inclusion
Heol Tywith Bridge	285250 192913	Flow in the floodplain will be restricted to the area upstream of the road bridge due to earth embankments.
Disused Railway Bridge	285202 192497	Flow in the floodplain will be restricted to the area upstream of the bridge due to earth embankments, formally used for the railway line.
A4093_Bridge	285006 191972	Low bridge deck and channel confined by walls.

6.4.10 The flood defence structure included in the Maesteg hydraulic model (NGR 285596 191096) is a small earth embankment. One breach scenario has been modelled for Maesteg, based on a breach width of 40m developing instantaneously to full size when the water level reaches the top of the embankment[3]. The breach location is NGR 285602 191098.

6.4.11 A number of other flood defences that are included within the NFCDD were visited on site. These defences were found to be insignificant at the broad scale of the modelling and therefore were not included in the model.

Valleys Gateway Model

Model Extent

6.4.12 The model extents are shown in Table 6.7.

Table 6.7 Valleys Gateway Model Extents

Watercourse	Upstream Extent (NGR)	Downstream extent (NGR)
River Ogmore	291770 185487	290094 182335
Afon Garw	290625 185850	290669 184784
Nant Bryncethin	291614 184277	290372 183991
Afon Llynfi	289256 185039	289677 183641

Model Scenarios

6.4.13 A number of current and future scenarios have been modelled in order to assess flooding from rivers. The following scenarios have been modelled:

Current Flood Zones
Zone B – not modelled
Zone C – modelled 0.1% AEP event undefended
Zone C1 / C2 – Difference between modelled 1% AEP event undefended and modelled 1% AEP event defended. Areas shown not to flood for the 1% AEP defended scenario designated as C1, all other areas within Zone C designated as Zone C2.

3 Tidal Flood Risk Areas – Simply Credible

Future Flood Zones
As above, with model inflows increased by 20% in accordance with Table 2 of the Defra guidance to 2110.

Actual risk *
5%, 1%, 0.1% AEP, defended, including climate change allowance

6.4.14 The maps in Annex A of this report show the following information (0.1% AEP event, 2110):

- Maximum Flood Depth (Map AR3)
- Maximum Flood Velocity (Map AR2)
- Maximum Rate of Rise (Map AR4)
- Maximum Speed of Inundation (time from when flooding starts to when flood depths peak) (Map AR5)

Structures, Defences and Breaches

6.4.15 Three structures have been included within the Valleys Gateway Hydraulic model. These are detailed in Table 6.8.

Table 6.8 Valleys Gateway Model Structures

Structure Name	Approximate Location (NGR)	Reason for inclusion
Tondu Railway Bridge	289735 184507	Large railway embankment crossing the floodplain at 90° to direction of flow. Bridge and embankment will restrict the amount of flow in the downstream direction.
Hoel Persondy footbridge	28,625 183543	Arched bridge with piers in the channel which will affect flow in channel.
Bridgend Road culvert	289390 183486	Culvert critical for flow from the Nant Cynffig to enter the Afon Ogmore.

6.4.16 Three flood defences have been included within the Valleys Gateway hydraulic model. These are detailed in the table below.

Table 6.9 Valleys Gateway Model Defences

Structure Name	Approximate Location (NGR)	Type of defence
Brynmenyn Industrial Estate Defence 1	290804 184620	Earth Embankment
Brynmenyn Industrial Estate Defence 2	290695 184750	Earth Embankment
Brynmenyn Industrial Estate Defence 3	290448 184491	Earth Embankment

6.4.17 A number of other flood defences that are included within the NFCDD were visited. These defences were found to be insignificant at the broad scale of the modelling and therefore were not included.

6.4.18 One breach has been modelled for the Valleys Gateway model. Based on the observations from the site visit, it was decided that the second defence within the Bryncethin Industrial Estate would be the most likely of the three defences to breach. This is because it had the greatest height difference between the crest of the defence and the ground behind the defence and water would overtop this defence prior to the wall on the opposite bank (which is at a higher level). The modelled breach location is at NGR 290683 184745.

Pencoed and Waterton Model

Model Extent

6.4.19 The model extents are shown in Table 6.10.

Table 6.10 Pencoed and Waterton Model Extents

Watercourse	Upstream Extent (NGR)	Downstream extent (NGR)
Ewenni Fach	297460 182280	295420 179900
Afon Ewenni	296940 182640	290020 177220
Nant Brynglas	293900 179510	293990 179170
Nant Ganna	294480 178420	293940 179150
Brocastle Brook	293660 177640	292790 178510

Model Scenarios

6.4.20 A number of current and future scenarios have been modelled in order to assess flooding from rivers. The following scenarios have been modelled:

<u>Current Flood Zones</u>
Zone B – not modelled
Zone C – modelled 0.1% AEP event undefended
Zone C1 / C2 – Difference between modelled 1% AEP event undefended and modelled 1% AEP event defended. Areas shown not to flood for the 1% AEP defended scenario designated as C1, all other areas within Zone C designated as Zone C2.

<u>Future Flood Zones</u>
As above, with model inflows increased by 20% in accordance with Table 2 of the Defra guidance to 2110.

<u>Actual risk *</u>
5%, 1%, 0.1% AEP, defended, including climate change allowance

6.4.21 The maps in Annex A of this report show the following information (0.1% AEP event, 2110):

- Maximum Flood Depth (Map AR3)
- Maximum Flood Velocity (Map AR2)
- Maximum Rate of Rise (Map AR4)
- Maximum Speed of Inundation (time from when flooding starts to when flood depths peak) (Map AR5)

Structures, Defences and Breaches

6.4.22 Five structures have been included within the Pencoed and Waterton hydraulic model. These are detailed in Table 6.11.

Table 6.11 Pencoed & Waterton Model Structures

Structure Name	Approximate Location (NGR)	Reason for inclusion
Felindre Road Bridge	297087 181247	Road bridge with floodplain flow prevented by concrete pillars.
A4073	295226 180237	HEC-RAS model results indicate structure presents a notable constriction to flood flows
SWTW_Bridge	295424 179876	Bridge with low deck that will restrict high flows.
Pont Fawr	293955 179166	HEC-RAS model results indicate structure presents a notable constriction to flood flows
Moor Bridge	292807 178477	Sluice gate present at bridge exit which will restrict flow.

6.4.23 A breach has not been modelled for this strategic area as there are no identified defences to present a residual flood risk.

6.5 Results

Current SFCA Flood Zones (Map F1)

6.5.1 The current SFCA Flood zones derived for BCBC are shown in Map F1 in Annex A. The Flood Zones have been based on zones provided by BCBC and updated to reflect the most up-to-date information held by the Environment Agency.

6.5.2 Most of BCB lies outside the Flood zones. All of the rivers have an area of floodplain along their length. In the north, floodplains of the rivers are generally well defined by the local topography and therefore the flood outlines for different events do not change significantly. For Abergarw and areas further south the floodplains are significantly wider as is expected of lowland rivers.

6.5.3 The area of floodplain is larger where river flows are large and where the ground adjacent to the river is flat, allowing flood flows to spread out. This is seen along the River Ewenny downstream of Pencoed and the River Ogmore downstream of Abergarw.

6.5.4 7.5% of BCB falls within Flood Zone C2 and within this area there are a significant number of properties. The largest of these are situated in Pencoed, Waterton, Maesteg, Abergarw and Bridgend. The other major settlements Pontycymer, Pyle and Ogmore Vale are all affected by fluvial flooding.

Future SFCA Flood Zones (Map F2)

6.5.5 Map F2 in Annex A depicts the predicted future SFCA flood zones for year 2110. Flood extents are expected to increase throughout BCB. In the northern upland areas flood depths are expected to increase more than flood extents as a consequence of the defined nature of the valleys. In the lowland areas where the floodplain is generally less well defined the flood extents are expected to increase considerably, whereas flood depths are anticipated to only increase gradually. There will be areas around flow constrictions where the change will be more severe.

Results for Strategic Sites

Maesteg

6.5.6 Maesteg is at risk of flooding from and the Nant y Cerdin and the Afon Llynfi. Within Maesteg the majority of properties within Zone C2 (Map FC) are situated on roads adjacent to Afon Llynfi. These properties include some essential services and vulnerable receptors: ambulance station, bus station and a school. In other places, Zone C2 is much wider (~200m), although the density of development is generally less with the presence of playing fields and other open land. The exception is an area adjacent to Oakwood Drive where there is a factory and a works. There is no Zone C1 within Maesteg.

6.5.7 In the future, flood zones (Map FF) are not expected to increase greatly, although flooding may be more severe. For the 0.1% AEP future flood event flood depths (Map AR3) are predicted to be high in places, e.g. Nantyffyllon, where depths may exceed 3m. Flood depths are predicted to exceed 1m in several places. Due to the steep topography, flood velocities (Map AR2) are also high, exceeding 1m/s in several places. Map AR5 shows the estimated speed of inundation (time from when the area first floods to when flood depths reach their peak), which is less than 2 hours for the majority of the study extent. This suggests traditional flood warning systems may be less appropriate. The rate of rise of floodwaters (Map AR4) is also reasonably rapid, with floodwaters rising at a rate of between 0.1 and 0.5 m/h across much of the floodplain.

6.5.8 A breach has been modelled in the defence near Niven Street (Map RR). Minor changes in flood extent are shown in the vicinity although areas of high ground limit the extent. The defence is overtopped for the 1% AEP event, and provides limited protection, therefore the residual risk maps show limited difference from the baseline. Alternative breach locations should be considered for site specific assessments.

6.5.9 The Environment Agency has recently completed 1D / 2D modelling in Maesteg which was not available for inclusion in the SFCA. However preliminary information provided by the Agency suggests that the following locations may have a greater flood risk than indicated by the SFCA broadscale modelling:

- Library Road culvert, Caerau
- Garnwell Terrace Culvert, Natyffyllon – due to overland flood routing
- Talbot Street culvert, central Maesteg – due to overland flow between the school at Castle Street and Talbot Street
- Between Talbot street and Cwmdu Street – due to the capacity of the culvert

Valleys Gateway (Brynmenyn)

6.5.10 Valleys Gateway is at risk of the strategic sites from fluvial flooding, situated in an area where five rivers meet (Afon Ogmore, Afon Llynfi, Afon Garw, Nant Brynthecin and Nant Cynffig). Large areas are located within Zone C2 (Map FC), notably the sports ground between the railway and Heol-Yr-Ysgol; the school and residential properties in the vicinity of Pandy Road and residential properties around Maes Glas. Flood defences are present in this strategic area, although these generally have a standard of protection of between 20 and 50 years, therefore only minor areas of Zone C1 have been identified. Properties within Zone C2 include at least two schools, the police station and large residential areas.

6.5.11 In the future, flood zones (Map FF) are not expected to increase greatly, although flooding may be more severe. For the 0.1% AEP future flood event flood depths (Map AR3) are predicted to be high, notably in the vicinity of Pandy Road, where depths may exceed 1m in places. Flood velocities (Map AR2) are also high, exceeding 0.45 m/s in several areas. Map AR5 shows the estimated speed of inundation (time from when the area first floods to when flood depths reach their peak), which is less than 2 hours in several places, and less than 4 hours for many of the residential areas. The rate of rise of floodwaters (Map AR4) exceeds the thresholds of 0.1 m/hr in several places, in particular around Pandy Road, and exceeds 0.3 m/hr in some generally undeveloped areas.

6.5.12 A breach has been modelled in the defence at Brynmenyn Industrial Estate. Flood extents are increased in the local vicinity although areas of high ground limit the extent. Alternative breach locations should be considered for site specific assessments.

Pencoed

6.5.13 Pencoed is at risk of flooding from the Afon Ewenni and the Ewenni Fach. Within the strategic area of Pencoed a large area of land falls within Flood Zone C2 (Map FC), including a number of residential properties north of the M4. There is no Zone C1 in Pencoed.

6.5.14 In the future, flood zones (Map FF) are not expected to increase greatly, although flooding may be more severe. For the 0.1% AEP future flood event flood depths (Map AR2) are generally predicted to be reasonably low (less than 0.3m), although may exceed 1m in places, especially immediately upstream of the M4 and around Felindre. Flood velocities (Map AR3) are reasonably high exceeding the thresholds of 0.3 and 0.45 m/s in several areas. Map AR5 shows the estimated speed of inundation (time from when the area first floods to when flood depths reach their peak), which is generally between 2 and 4 hours. The rate of rise of floodwaters (Map AR4) is generally below the threshold of 0.1 m/hr although reaches 0.3 m/hr in some places, particularly around Felindre and immediately north of the M4.

6.5.15 A defence breach has not been modelled in Pencoed.

Waterton

6.5.16 Waterton is at risk of flooding from the Afon Ewenni, the Nant Ganna and the Brocastle Brook. A reasonably large area of Waterton falls within Zone C2 (Map FC), predominantly in the industrial estate. There is no Zone C1 within Waterton.

6.5.17 In the future, flood zone C2 (Map FF) is predicted to cover a greater extent of the industrial estate but is otherwise not expected to increase greatly, although flooding may be more severe. For the 0.1% AEP future flood event flood depths (Map AR3) are generally predicted to be reasonably low (less than 0.3m), although may exceed 1m in places, particularly at the northern extent of the strategic area. Flood velocities (Map AR2) are reasonably low, generally below 0.3 m/s, although velocities are expected to be higher along access roads. Map AR5 shows the estimated speed of inundation (time from when the area first floods to when flood depths reach their peak), which is generally less than 2 hours, therefore traditional flood warning systems may not be appropriate. The rate of rise of floodwaters (Map AR4) exceeds the threshold of 0.1 m/hr in several places, within the industrial estate and exceeds 0.3 m/hr is some isolated locations.

6.5.18 A defence breach has not been modelled in Waterton.

Porthcawl

6.5.19 Large areas of Porthcawl are within Flood Zone C2. However, the outlines perfectly match the 0.1% AEP tidal flood zones provided by the Environment Agency. Based on this information it is concluded that Porthcawl is not a risk from fluvial flooding from main rivers. Areas of Porthcawl may be at risk from flooding of ordinary watercourses. This should be considered in more detailed FCAs..

6.6 Uncertainty in flood risk assessment

6.6.1 Due to the extensive coverage of models across BCB, estimation of risk of flooding from rivers for the strategic sites is considered robust for the level of assessment required in the SFCA. The greatest uncertainties in Flood Zones occur as a result of;

- Models not having been fully calibrated or verified (they were only sensibility checked by the Environment Agency).
- The models assume that flood defences do not fail and the conditions of the defences do not change (i.e. the crest levels remain constant).
- Small structures, small flood defences and detailed topographic details in urban areas have not been included in the broader scale models. Thus flood outlines are less certain near these features.
- There is a greater degree of uncertainty with the Future Flood Zones shown on Map F2, due partly to uncertainties surrounded with the predicted impacts of climate change and also the method of assessment for future zones, which is not based on hydraulic modelling in all locations.

6.7 Managing flooding from rivers

6.7.1 Flooding from rivers can be managed in a number of ways, including;

- Avoidance - developing outside of the floodplain
- Prevention - walls and embankments used to exclude water from a site, improved channel conveyance, pumping or flood storage areas used to attenuate/retain peak flows upstream, change in catchment land-use and management processes.
- Management - flood resilient design, flood warning, evacuation and emergency planning, and flood awareness.

6.7.2 CFMPs provide a large-scale assessment of the risks associated with river flooding. They present a policy framework to address the risks to people and the developed, historic and natural environment in a sustainable manner. In doing so, a CFMP is a high-level document that forms an important part of the Department for Environment, Food and Rural Affairs strategy for flood and coastal defence.

6.7.3 CFMPs provide the management plan for the next 100 years and the policies required for it to be implemented. This is intended for general readership and is the main tool for communicating intentions. Whilst the justification for decisions is presented, it does not provide all of the information behind the recommendations, this being contained in the supporting documents. The policies adopted in BCB are discussed in Chapter 3.

6.7.4 The most suitable type of flood management at a site depends on site specific conditions, the receptor of flooding and the type of flooding.

6.8 Planning considerations

6.8.1 Flooding from rivers is one of the most destructive forms of flooding in England and Wales and as a consequence areas liable to flood are usually better defined than other sources. A large amount of information on river flooding can be obtained from local authority or Environment Agency staff, and/or National datasets, such as the Environment Agency Flood Zones. Any potential land use planning decisions should be made after consulting these sources.

6.8.2 A precautionary approach should be undertaken when making land use planning decisions regarding flood risk. This is partly due to the considerable uncertainty surrounding flooding mechanisms and how flooding may respond to climate change. It is also due to the potentially devastating consequences of flooding to the people and property affected.

6.8.3 The information presented in this SFCA should be used to inform more detailed flood consequence assessments for all new developments as required by TAN15.

7 Flooding from the sea

The BCBC SFCA is a 'live' document. The current version has been developed using the best information and concepts available at the time. As new information and concepts become available the document will be updated and so it is the responsibility of the reader to be satisfied that they are using the most up-to-date information and that the SFCA accounts for this information. All revisions to this summary document are listed in the table.

Version	Issue Date	Issued by	Issued to
Internal Draft	07/05/2010		
Stage 1 Draft	21/05/10	CSL	BCBC
Final Draft	10/08/10	CSL	BCBC
Final	30/09/10	CSL	BCBC

7.1 Introduction

7.1.1 Flooding from the sea occurs when water levels in the sea rise above ground levels of coastal land. This can occur during normal high tides, when there are extreme atmospheric effects, and when wind action causes water levels of the sea to rise.

7.1.2 BCB has a notable area at risk from tidal flooding including Newton/Porthcawl. Tidal flooding can be particularly severe, with rapid inundation, the possibility of multiple overtopping events and the increased damage caused by saltwater. These effects can be even more severe if a breach of sea defences occurs.

7.2 Data collection

Table 7.1 Data provided for the SFCA

Source	Title	Data type	Date	How used/to be used in SFCA
BCBC	DAM Zones	GIS	2009	To define SFCA Flood Zones
Environment Agency	Extreme Tidal Levels for Porthcawl	PDF	Post 2000	To derive future SFCA Zones C1 and C2
Environment Agency	Tidal Flood Zone 2 and 3	GIS	2009	To update SFCA Zone C1/C2
Environment Agency	Wave overtopping locations	PDF	2010	Used to indicate areas where wave overtopping should be assessed for FCAs

Historic flood events

7.2.1 The Environment Agency is the main body which collects records of flooding from the sea. However the little information on tidal flood events was provided. No incidents of flooding were wholly attributed to flooding from the sea (tidal).

Existing studies

7.2.2 Tidal still water levels for Porthcawl were provided by EAW. The levels were based upon the Proudman Oceanographic Laboratory (P.O.L) Internal Document No 65 and Internal Document No 72 (unpublished manuscripts) by M J Dixon and J A Tawn.

7.2.3 No other existing studies on flooding from the sea were provided.

Additional data to be considered

7.2.4 Further details of any historic flooding events should be requested and analysed as part of any review of this SFCA including: EA flood records, any council records, parish flooding records and highways flooding information. Model results from more detailed studies should be considered for future updates. Assessing flood risk from the sea

7.2.5 The level of assessment required for the SFCA is broad scale. For this reason, existing datasets and tools have been used where possible to provide flood risk information.

SFCA Flood Zones

7.2.6 The BCB current DAM zones were updated, where appropriate, with information from the Environment Agency to define the SFCA Flood Zones. Specifically, the EA Areas Benefitting from Defences (ABD) layer was used to amend Zone C1. The ABD is defined explicitly in Environment Agency guidance but in summary in tidal flood risk areas it is the difference between the flood extents for the undefended and defended 0.5% AEP (200 year) flood extent. All areas within Zone C and outside Zone C1 have been designated as Zone C2. Zone B was checked against the BGS drift geology information provided and appeared to be in close agreement therefore was left unchanged.

7.2.7 For the SFCA the Flood Zones were defined as follows:

- Zone C – Based on the current 2009 DAM Zone C, extended to include the EA ABD extent in the Newton / Porthcawl area.
- Zone C1 – Based on a combination of the current 2009 DAM Zone C1 and the EA ABD layer.
- Zone C2 – Defined as all Zone C not within Zone C1.
- Zone B – Taken as the current DAM Zone B.

7.2.8 The current SFCA Flood Zones are shown on Map F1 in Annex A.

7.2.9 A more detailed assessment of flooding from the sea has been completed for Porthcawl, based upon the results of broadscale 2D hydraulic modelling. The details of the hydraulic modelling are given later in this chapter. More detailed flood zone information, as indicated by the results of the broadscale modelling has been provided for the strategic sites. This has not been used to update the county wide SFCA flood zones. Differences between the estimated flood zones suggests that more detailed assessment should be completed for future development in the vicinity.

Impact of climate change

7.2.10 The latest government guidance for climate change and flood risk is contained within FCDPAG3 Economic Appraisal: Supplementary Note to Operating Authorities – Climate Change Impacts October 2006. The note was issued in November 2006 and informs appraisers and decision makers of new climate change allowances and broadly how these should be considered when assessing flood risk.

7.2.11 The most important points to consider are;

- Updated figures of regional net sea level risk allowances are contained within Table 1 (of the note)
- New indicative sensitivity ranges covering peak rainfall intensity, peak river flow volume, offshore wind speed and extreme wave heights in Table 2 of the note
- The precautionary approach in assessing sea level rise
- Use of sensitivity analysis to gauge uncertainty of flows, rainfall, wind and wave action on sea levels
- Response to climate change through either managed/adaptive or precautionary approaches. Note: in a SFCA, a precautionary approach is recommended.

UK climate change projections (UKCP09)

7.2.12 This more recent study looks at probabilistic projections on the likely changes to the UK climate under a range of greenhouse gas emission scenarios.

7.2.13 The key findings from UKCP09 are:

- All areas of the UK are likely to get warmer, and the warming in summer is greater than in winter;
- Little change in annual precipitation totals, but with the likelihood that more rain falls in winter, with drier summers; and
- Sea levels rise, and are greater in the south of the UK than the north.

7.2.14 The findings from the UKCP09 project have not superseded the 2006 Defra climate change guidance therefore this has been followed for the SFCA.

7.2.15 A 100 year climate change time horizon has been investigated to provide more detailed information upon which to make land use planning decisions. It will be up to the decision-maker to select the most appropriate time horizon for the specific land use they are investigating.

7.2.16 For this SFCA, the baseline was set as 2010 and future flood zones were derived for 2110. Unlike previous climate change guidance, the latest guidance predicts that sea levels will rise at different rates over the next 100 years.

7.2.17 The SFCA Flood Zones were modified to produce an estimation of their extents in 2110. Tidal projection was used to provide information on the risk of flooding from the sea. Note that this was only to provide information, on a broad scale, for analysis of the tidal flooding extent in BCBC.

7.2.18 The tidal component of the future flood zones was created using estimated extreme tide levels for Porthcawl, provided by the Environment Agency. Tidal still water levels for the 0.1% AEP event in 2000 were taken and adjusted for predicted sea level rise to derive water levels for 2110. These levels were projected across BCBC and LiDAR data was interrogated to determine flooded extents (Zone C) and depths. These datasets were then manually edited to remove areas shown as flooded for which no hydraulic pathway exists. Zone C1 was based on the EA ABD information and checked by comparing the tidal flood levels for a 0.4% AEP (250 year) event with defence levels as represented in the LiDAR data, to determine whether the defences were likely to continue to provide significant protection in the future.

7.2.19 It must be recognised that the levels used are ‘still water levels’ i.e they do not take into account any wave action. Wave action is dependant on several variables including the fetch reach (distance over which winds can affect tidal levels) and the approach geometry of the coastline.

7.2.20 The future flood zones are contained within Map F2 in Annex A.

7.3 Hydraulic Modelling of the Strategic Sites at Risk of Flooding from the Sea

Methodology for Porthcawl

7.3.1 The strategic site of Porthcawl is at risk of flooding from the sea. A broadscale 2D hydraulic model has been constructed as part of the Stage 2 SFCA in order to provide the additional information required, in relation to tidal flood risk, to assess the consequences of flooding for the strategic site in accordance with TAN 15. This has been run using the latest available version of the TUFLOW software (2009-07-AE-iSP).

7.3.2 The extent of the hydraulic model was defined based upon the boundaries of the strategic areas and the topography of the river catchments. The 2D model domain (grid) was defined using the filtered LiDAR data received for the SFCA. The size of the grid for the Porthcawl model has been selected as 5m in order to define features such as roads properly.

7.3.3 In addition to an elevation, each grid cell requires the specification of a roughness value, a value that defines the resistance that the land surface gives against the flow of water. Mastermap has been used to assign the different types of land surface, and to each type of land surface an appropriate value of surface roughness has been assigned based on the Manning's n values of roughness.

7.3.4 Notable features such as a harbour wall and a flood defence wall/embankment have been included in the hydraulic model. These features have been included due to their potential impact on flooding mechanisms at Porthcawl. The impact of these features on potential tidal inundation was then assessed during a site visit to the strategic areas.

7.3.5 In order to model tidal flooding at Porthcawl, it was necessary to derive a set of design tidal curves for a range of event probabilities. The methodology was based on combining a spring high tide curve and a storm surge curve to provide a design tidal level curve for each return period. The assessment was based on the following information:

- Peak tidal still water levels for Porthcawl for events of various probabilities for 2000 (provided by the Environment Agency).
- The highest spring tide of 2006 (taken from POLTIPS software).

7.3.6 These datasets were updated for future projections following Defra 2006 guidance[4]

7.3.7 The data provided by the EA was used to define the peak of the derived flood events and the difference between these levels and the peak high tide levels was used to define the maximum of the storm surge. The storm surge was defined as having a duration of 6 tides. Based on these criteria a sinusoidal storm surge curve was produced.

7.3.8 The storm surge curve and the tidal curve were added to one another to produce the design tidal curves. It was assumed that the peak tidal levels are caused by a storm surge reaching its maximum level at the same time as the high tide. It should be noted that these tidal inputs have no allowance for wave action.

Model Extent

7.3.9 The model extends from west of Porthcawl (NGR 281500 276500) to Black Rocks (NGR 284500 176000) in the east and extends approximately 1.5km inland.

Model Scenarios

7.3.10 A number of current and future scenarios have been modelled in order to compare the modelled results with the current TAN15 flood zones.

<u>Current Flood Zones</u>
Zone B – not modelled
Zone C – modelled 0.1% AEP event undefended
Zone C1 / C2 – Difference between modelled 0.4% AEP event defended and 0.4% AEP undefended event. Areas shown not to flood for the defended scenario will be designated Zone C1, all other areas with Zone C will be designated Zone C2.

<u>Future Flood Zones</u>
As above, with tide levels increased in accordance with Defra guidance to 2110.

<u>Actual risk *</u>
1%, 0.4%, 0.1% AEP defended, including climate change allowance

7.3.11 The maps in Annex A of this report show the following information (0.1% AEP event, 2110):

- Maximum Flood Depth (Map AR3)
- Maximum Flood Velocity (Map AR2)
- Maximum Rate of Rise (Map AR4)

[4] Flood and Coastal Defence Appraisal Guidance FCDPAG3 Economic Appraisal Supplementary Note to Operating Authorities - Climate Change Impacts October 2006

- Maximum Speed of Inundation (time from when flooding starts to when flood depths peak) (Map AR5)

7.3.12 For the future flood events the tide levels have been increased by 1035mm in accordance with the Defra guidance to 2110[1].

Defences & Breach

7.3.13 The Newton / Porthcawl sea wall defence is included in the model.

7.3.14 A single breach scenario for the Newtown sea wall has been modelled using the 0.4% AEP event, including climate change allowance. The breach location, NGR 283687 176880 has been selected based on a visual assessment of defence condition and the critical locations where a failure may occur from the site visit. The defence is on the boundary of a hard defence wall and sand dunes, and therefore has been breached for a length of approximately 100m for a period of 56 hours (from the peal of the first tidal cycle) and has been simulated as developing instantly to its full size. The assumptions made for the breach are in accordance with Tidal Flood Risks – Simply Credible provided by EA South West Region.

7.4 Results

Current SFCA Flood Zones (Map F1)

7.4.1 The current flood zones derived for BCBC are shown in Map F1 in Annex A.

7.4.2 There are only tidal defences at Porthcawl/Newton, other areas are protected by natural high ground. These are the only developed areas at risk of tidal flooding within BCB although there are some areas of land within Merthyr Mawr Warren and alongside the tidal reach of the Ogmore which are also at risk of tidal flooding.

Future SFCA Flood Zones (Map F2)

7.4.3 The future Zone C2 shows many additional properties within the Newton area at risk. There is also a slight increase in the tidal flood outline at Merthyr Mawr Warren and for land adjacent to the tidal reach of the Afon Ogmore. However, the increase is masked by the increase in the fluvial extents as derived by the method detailed in Section 6. Zone C1 and Zone B have not been changed for the SFCA.

Results for Strategic Sites

7.4.4 Porthcawl is at risk of flooding from the sea. A reasonably small area of Porthcawl falls within Zone C2 (Map FC), near bay View Road, as high ground levels prevent flooding in many areas. As a result, only a small area of Zone C1 has been identified.

7.4.5 In the future, flood zone C2 (Map FF) is predicted to cover a greater extent as sea levels rise. It includes the ambulance station and residential properties to the west of the town and a larger area of land around Bay View Road. For the 0.1% AEP future flood event flood depths (Map AR3) are predicted to be high near to the coast (exceeding 1 to 2m), although are generally lower further inland. Flood velocities (Map AR2) are generally low (< 0.15 m/s) although are estimated to reach 1 m/s in some isolated locations. Map AR5 shows the estimated speed of inundation (time from when the area first floods to when flood depths reach their peak), which is less than 2 hours in many areas close to the coast, therefore traditional flood warning systems may not be appropriate. The rate of rise of floodwaters (Map AR4) is reasonably high, exceeding 0.5 m/hr at the coast, although this is generally lower further inland.

7.4.6 A breach has been modelled in the defence at Bay View Road. Flood extents are increased in the local vicinity although areas of high ground limit the extent of influence. Alternative breach locations should be considered for site specific assessments.

7.4.7 The Environment Agency provided details of areas of the Porthcawl coastline at risk from wave overtopping action (see Figure 7.1). Site specific assessments should consider the impact of wave overtopping in these areas.

Figure 7.1 Wave Overtopping Locations - Porthcawl

7.5 Uncertainty in flood risk assessment

7.5.1 The method used by the EA to define tidal flood risk areas in BCB is unknown therefore the associated uncertainty cannot be fully assessed. If these are based on the results of hydraulic modelling there is likely to be less uncertainty than if they have been defined by tidal projection or similar methods. The EA should be contacted for more information regarding uncertainty. The greatest uncertainties in Flood Zones are likely to occur as a result of;

- Small structures, small flood defences and detailed topographic details in urban areas have not been included in the broader scale models. Thus flood outlines are less certain near these features.
- The methods of assessment not taking account of wave and overtopping actions.
- There is a greater degree of uncertainty with the Future Flood Zones shown on Map F2, due partly to uncertainties surrounded with the predicted impacts of climate change and also the method of assessment for future zones, which is not based on hydraulic modelling.

7.5.2 The EA ABD layer is reasonably extensive in the Newton / Porthcawl area, and extends further than Zone C as shown on the current DAM Zones, or estimated through tide level projection. There is therefore some uncertainty regarding the accuracy of this outline. As a precautionary approach, the ABD layer has been used to define Zone C1 for the SFCA.

7.6 Managing flooding from the sea

7.6.1 Flooding from the sea can be managed in a number of ways, including;

- Avoidance - developing outside of the floodplain
- Prevention - walls and embankments used to exclude water from a site, change in shoreline management processes.
- Management - flood resilient design, flood warning, evacuation and emergency planning, and flood awareness.

7.6.2 SMPs provide a large-scale assessment of the risks associated with sea flooding. SMPs provide the management plan and the policies required for it to be implemented. The policies adopted in BCB are discussed in Chapter 3.

7.6.3 The most suitable type of flood management at a site depends on site specific conditions, the receptor of flooding and the type of flooding.

7.7 Planning considerations

7.7.1 TAN15 requires decision makers to consider flooding from sea when making land use planning decisions. Although the risk from tidal flooding is reasonably low within BCB, it should still be considered especially as Newton / Porthcawl has been designated as a strategic development site.

7.7.2 The impact of climate change on flooding from the sea is particularly important. The latest government guidance indicates exponential growth rates in sea level rise. This will have enormous implications on this type of flood risk in the future. It is important that the land use planning process is used to guide development away from these areas so that there may be less reliance on defences in the future.

7.7.3 For BCB, the main consideration is that increased sea level will increase the influence of tidal events.

8 Flooding from land (surface water)

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8.1 Introduction

Description

8.1.1 Flooding from land, also known as surface water flooding, occurs when intense, often short duration rainfall is unable to soak into the ground or enter drainage systems. It is made worse when soils are saturated so that they cannot accept any more water. The excess water then ponds in low points, overflows or concentrates in minor drainage lines that are usually dry. This type of flooding is usually short lived and associated with heavy downpours of rain. Often there is limited warning before this type of localised flooding occurs.

8.1.2 Drainage basins or catchments vary in size and shape, which has a direct effect on the amount of surface runoff. The amount of runoff is also a function of geology, slope, climate, rainfall, saturation, soil type and vegetation. Geological considerations include rock and soil types and characteristics, as well as degree of weathering. Porous material (sand, gravel, and soluble rock) absorbs water more readily than fine-grained, dense clay or unfractured rock and has a lower runoff potential. Poorly drained material has a higher runoff potential and is more likely to cause flooding.

8.1.3 Distinguishing between flooding from land and flooding from groundwater can be complicated. For the purpose of the SFCA, groundwater is defined as any water that soaks into the ground and re-emerges at a different location. Thus sub-surface flow and springs are considered in Chapter 9 (flooding from groundwater).

8.1.4 Flooding from foul sewers is considered separately in Chapter 10.

Causes and classifications

8.1.5 Water flowing over the ground surface that has not entered a natural channel or artificial drainage system is classified as surface water runoff or overland flow.

8.1.6 Flooding from land can occur in rural and urban areas, but usually causes more damage in the latter. Urban areas can be inundated by flow from adjacent farmlands. Flood pathways include the land and water features over which floodwater flows. These pathways include minor drainage lines, roads and even flood management infrastructure.

8.1.7 Developments that include significant impermeable surfaces, such as roads and car parks may increase the occurrence of surface water runoff.

Impacts of surface water flooding

8.1.8 Surface water flooding can affect all forms of the built environment, including property, infrastructure, agriculture and the natural environment. It is usually short-lived and will tend to last as long as the rainfall event. However flooding may persist in low-lying areas where ponding occurs. Due to this shorter duration, flooding from land tends not to have as serious consequences as other forms of flooding, such as flooding from rivers or the sea.

8.1.9 Flooding may occur as sheet flow or as rills and gullies causing increased erosion of agricultural land. This can result in ‘muddy floods’ where soil and other material are washed onto roads and properties, requiring extensive clean-up. Both rural and urban land use changes are likely to alter the amount of surface water in the future. Future development is also likely to change the position and numbers of people and/or developments exposed to flooding.

8.1.10 Information held by the Environment Agency and local authorities about this type of flooding is limited and due to its nature it is difficult to accurately define all the areas at risk from this source of flooding.

8.2 Data collection

Historic flood incidents

8.2.1 The only source of historical flooding information provided which relates to flooding from surface water is the performance indicators database supplied by BCBC. It includes information on the number of properties vulnerable to repeat flooding based on pre-feasibility studies from the Welsh Assembly Government Database and complaints by residents. This data was divided into two sets, those which fall within the extreme flood outline and those which do not. It has been assumed that the former are caused by fluvial flooding and the latter by drainage networks or overland flow.

8.2.2 No other information on historic flooding has been provided. Further information may be available from BCBC highways maintenance for future updates to the SFCA.

Existing studies

8.2.3 The Environment Agency produced a national assessment of areas susceptible to surface water flooding. This work was finalised in October 2009 with the publishing of the “Areas susceptible to surface water flooding” report and an accompanying GIS based output

8.2.4 The Ogmore to Tawe CFMP includes a desk top assessment of surface water flooding. The analysis was based on available background information, such as annual rainfall (source); ground cover and underlying geology (pathway); land use (receptor).

Additional data to be considered

8.2.5 Details of any historic flooding events should be requested and analysed as part of any review of this SFCA. The results of the ‘potential surface water flooding’ assessment carried out as part of the Ogmore to Tawe CFMP should be obtained and reviewed. Detailed surface water assessment may be completed in the future for local and site specific studies, and may be useful to inform future updates to the SFCA.

8.3 Assessment of flood risk

8.3.6 The existing TAN15 DAM and Environment Agency Flood Zones only indicate areas liable to flood from rivers and the sea. Other data must therefore be used to determine the areas susceptible to flooding from other sources, such as flooding from land.

8.3.7 The national ‘Areas susceptible to surface water flooding’ dataset has been used to assess flood risk for surface water for the SFCA. The following sections are based on information contained in the aforementioned report.

Definition

8.3.8 The definition of surface water flooding used for the surface water flood risk assessment is the one that appears in ‘Making Space for Water’ (Defra, 2006).

“A surface water flood event that results from rainfall generated overland flow before the runoff enters any watercourse or sewer. Usually associated with high intensity rainfall (typically >30mm/hr) resulting

in overland flow and ponding in depressions in the topography, but can also occur with lower intensity rainfall or melting snow where the ground is saturated, frozen, developed or otherwise has low permeability. Urban underground sewerage/drainage systems and surface watercourses may be completely overwhelmed, preventing drainage. Surface water flooding does not include sewer surcharge in isolation"

Method

8.3.9 The method involved three stages:

- Generating rainfall data for a 6.5 hour storm with a 0.5% average probability of being exceeded each year (1 in 200 annual probability). A low probability, high magnitude event was chosen as being likely to produce flooding in most significant flow pathways and storage areas, and a storm duration of 6.5 hours was found to be representative of the type of storms that cause most flooding across a range of catchment types;
- Simulating the downhill movement of the runoff using a digital terrain model to identify flow paths and areas where the flow ponds;
- Processing the model outputs. This involved creating three bands based on indicative thresholds, and the removal of isolated 'wet' areas smaller than $200m^2$ and 'dry' areas smaller than $750m^2$

8.3.10 The map was produced using a simplified method that excludes underground sewerage and drainage systems, and smaller over ground drainage systems, excludes buildings, and uses a single rainfall event – therefore it only provides a general indication of areas which may be more likely to suffer from surface water flooding.

8.3.11 There were several key assumptions made:

- intensity, duration and location of rainfall;
- capacity of the drainage network;
- representation, permeability and saturation of land surfaces and overland flow routing;
- The digital terrain model has a grid size of 5m and has been processed to attempt to remove buildings, vegetation and other blockages to natural flow. However, many local surface features will not be suitably represented in the model and this can have a significant impact on flooded areas.

Results

8.3.12 The map provides three bandings, indicating 'less' to 'more' susceptible to surface water flooding. The bands appear in shades of purple and are displayed on Map SW in Annex A.

8.3.13 When compared to the other bands the 'more' band will be useful to help identify areas which have a natural vulnerability to:

- flood first;
- flood deepest;
- and/or flood for relatively frequent, less extreme events

8.3.14 It does not show the susceptibility of individual properties to surface water flooding.

8.3.15 The susceptibility bandings have been applied nationally. Therefore even if a LPA has no 'more' susceptible areas within the national bandings applied, it does not mean that some parts of that LPA area will not be 'more susceptible' than others if a local assessment of relative susceptibility were applied. Representation of surface water flooding is better in steep catchments compared to areas with flat topography.

8.3.16 The general distribution of surface water flooding susceptibility is that the more susceptible areas are concentrated in the valley bottoms roughly following the river and stream channels with intermediate and lower risk areas being further from the main channel. There are also isolated areas scattered across the whole county, particularly within the Bridgend urban area in the centre of the county and the coastal lowlands area to the west.

Maesteg

8.3.17 A significant proportion of Maesteg is shown as being susceptible to surface water flooding. Almost all the areas highlighted within Maesteg correspond with river channels and drainage lines shown on OS mapping or evident in the LiDAR data provided. The more vulnerable areas are generally alongside the main river channels with most of the minor watercourses being assigned an intermediate vulnerability. As would be expected the vulnerability decreases with distance from these channels/drains. The width of the more vulnerable zone increases from upstream to downstream through the strategic area.

8.3.18 There area areas of forestry in the vicinity of Maesteg. Management of the forestry land, including clearance could increase surface runoff and lead to increased risk of flooding from land.

Valleys Gateway (Brynmenyn)

8.3.19 A significant proportion of Brynmenyn is shown as being susceptible to surface water flooding. The pattern of distribution of less to more vulnerable areas is similar to Maesteg, with the more susceptible areas being located close to the major channels, with smaller channels having comparatively less 'more susceptible areas' and susceptibility decreasing with distance from the channels.

Pencoed

8.3.20 Approximately 50% of Pencoed is shown as being susceptible to surface water flooding. In addition to the pattern observed at other sites there is a large area shown as 'intermediate' and 'less' susceptible away from river channels or drains. Within this area it is presumed that free drainage to the Afon Ewenny is restricted by the presence of a raised highway, the A473. Whether this is an accurate reflection of reality is not known, but it is advised that this information is viewed with caution. OS mapping shows a drain running alongside the A473, which may not have been adequately represented in the DTM. Furthermore, this drain presumably discharges to the Afon Ewenny via a culvert underneath the A473 which will not have been represented in the assessment. There are no historical records to support or conflict with the outlines shown.

Waterton

8.3.21 A significant proportion of Waterton is shown as being susceptible to surface water flooding. Besides the more susceptible areas shown along the Afon Ewenni, there are significant areas of industrial land to the south shown as being of more and intermediate susceptibility. It is known from NFCDD that there are numerous flap valves that allow discharge to the Afon Ewenni, which will not have been included in the surface water assessment. Furthermore, the buildings have been removed from the DTM and so the actual spatial distribution of susceptibility to surface water may significantly different.

Porthcawl

8.3.22 A significant proportion of Porthcawl is shown as being susceptible to surface water flooding. Unlike the other strategic sites there are no large channels in Porthcawl and the spatial distribution of susceptibility has different characteristics. The majority of the susceptible areas are the result of the topography of Porthcawl. The land which the caravan park is on is metres higher than the adjacent land to the north. This will cause water to get trapped in this area in the absence of sufficient drainage infrastructure. The other more susceptible areas are centred around the two lakes and the localised depressions in which they sit. Again it should be recognised that buildings have been removed from the DTM and may significantly alter the actual spatial distribution of susceptibility.

Climate change

8.3.23 There is no research covering the study area which specifically considers the impact of climate change on surface water flooding. Future climate change projections indicate that more frequent short-duration, high intensity rainfall and more frequent periods of long duration rainfall are to be expected. These kinds of changes will have significant implications for flooding from land.

8.3.24 Indirect impacts of climate change on land use and land management may also change future flood risk.

8.3.25 In the absence of certainty, it is sensible to adopt a precautionary approach. Sensitivity ranges are suggested for peak rainfall intensities over various time horizons. As our understanding of the impacts of climate change improves, these guidelines are likely to be revised. It is imperative that the site specific flood risk assessments consider the impact of climate change on flooding from land.

Uncertainty in flood risk assessment

8.3.26 The causes of surface water flooding are generally well understood. However it is difficult to predict the actual location, timing and extent of flooding, which are dependent upon the characteristics of the site specific land use, local variations in topography, geology, soils and the hydrological conditions. Furthermore, limited and variable measured datasets make it more difficult to determine an exact annual exceedance probability.

8.3.27 The data presented in this SFCA is accompanied by guidance on how it should be interpreted. It emphasises that the maps are not appropriate to act as the sole evidence for any specific planning decision at any scale without further supporting studies or evidence. Also the maps cannot be used to identify individual properties at risk, and must therefore not be referred to specifically for planning consultations or responses.

8.3.28 It is strongly recommend that the maps are used in conjunction with local knowledge from BCBC planning and engineering teams (for example, data of drainage systems and historic surface water flooding records) to assess the suitability of the map as an indicator for surface water flooding prior to making decisions.

8.4 Managing flooding from land

8.4.1 Until recently there has been no government body with a clear responsibility for flooding from land flooding, having a statutory obligation for measuring and reporting events or providing advice and affording protection to those at risk. However the Flood and Water Management Act 2010 clarifies responsibilities. It places responsibility for ‘local’ flood risk management, which includes surface water flooding, with local authorities (unitary or upper tier), guided by the national flood risk management strategy.

8.4.2 The Environment Agency and Meteorological Office provide a limited warning service for flooding from land in some areas, and includes records of known surface water flooding in its historic flood records. Flood warning is complicated for this source due to the highly varied and localised nature, and generally short lead in times.

8.4.3 Surface water flooding is often highly localised and complex. Management is therefore strongly dependent upon the characteristics of the site. The implications of surface water flooding should be considered and managed through development control and building design.

8.4.4 Possible management and responses to flooding include:

- Sensitive land use management based on policies at a strategic level.
- Major ground works (such as new or improved drainage systems, including drains, dams and embankments).
- Appropriate site selection for developments.
- Development zoning including the use of green space and planting to manage runoff.
- Flood proofing of developments (including land raising and raising floor levels) and flood warning.
- Management of development runoff (such as the inclusion of SuDS).

8.4.5 Long-term operation and maintenance requirements and responsibilities are a key consideration. The appropriateness of sustainable drainage techniques (SuDS) should be assessed. The suitability of different SuDS techniques is discussed in Chapter 2.

8.5 Planning considerations

8.5.1 The TAN15 DAM and Environment Agency Flood Zones Map does not include flooding from land, however consideration should be given to other forms of flooding during the decision making process.

8.5.2 Decision makers should use the SFCA to inform their knowledge of flooding. The SFCA refines the information on tidal and fluvial flooding and determines the variations in flood risk from all sources of flooding across the area. The information then forms the basis for preparing appropriate policies for flood risk management for these areas. TAN15 requires appropriate surface water management and promotes the use of SuDS techniques.

8.5.3 Assessments of flooding from land are therefore needed. The SFCA has provided a map showing areas susceptible to surface water flooding based on a national assessment undertaken by the Environment Agency. However as these processes are highly variable at the local scale, the maps only provide a guide at a strategic level.

8.5.4 Surface water flooding should be managed through the flood consequence assessment process. Further collation of relevant data is required, such as land use, runoff rates, existing drainage systems, past events and consultation with relevant bodies. All new proposed developments should undertake a detailed assessment of the site and upstream catchment characteristics. Bridgend may also wish to consider strategic surface water flooding assessments for allocated development areas. Specific factors that should be considered when undertaking a flood risk assessment include:

- Areas liable to flooding (based on site and catchment characteristics).

- The extent, standard and effectiveness of existing drainage systems.
- The likely runoff rates.
- The likely impacts to other areas (such as increases in surface water runoff rates).
- The likely extent, depth and velocity of flooding.
- The effects of climate change.
- The suitability of different sustainable drainage system options.

9 Flooding from groundwater

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9.1 Introduction

Description

9.1.1 Groundwater flooding is caused by the emergence of water originating from sub-surface permeable strata. Groundwater flooding can happen at point or diffuse locations and it tends to be long in duration, developing over weeks or months and prevailing for days or weeks.

9.1.2 It is important to assess the type of groundwater flooding to fully understand the source and pathway and, if required, potential management solutions. There are many mechanisms associated with groundwater flooding, which can be broadly classified as the phenomena outlined in Table 9.1.

Causes of high groundwater levels

9.1.3 High groundwater levels can result from the combination of geological, hydrogeological, topographic and recharge phenomena and can mostly be associated with the seven mechanisms described in Table 9.1.

9.1.4 For the purposes of the SFCA it is appropriate to consider the geographical scale, social and economic cost and certainty of prediction when considering groundwater flood risk. Of the groundwater flooding mechanisms experienced in the SFCA study area, rising groundwater levels in major aquifers as a result of long duration rainfall present by far the greatest and most extensive level of risk.

Impacts of groundwater flooding

9.1.5 Flooding is generally not hazardous to life, but can cause considerable damage to property and infrastructure due to long durations of flooding. The main impacts of groundwater flooding are:

- Flooding of basements of buildings below ground level – in the mildest case this may involve seepage of small volumes through walls, temporary loss of services etc. In more extreme cases larger volumes may lead to the catastrophic loss of stored items and failure of structural integrity.
- Overflowing of sewers and drains – surcharging of drainage networks can lead to overland flows causing significant but localised damage to property. Sewer surcharging can lead to inundation of property by polluted water. Note: it is complex to separate this flooding from other sources, notably surface water or sewer flooding.
- Flooding of buried services or other assets below ground level – prolonged inundation of buried services can lead to interruption and disruption of supply.
- Inundation of farmland, roads, commercial, residential and amenity areas – inundation of grassed areas can be inconvenient however the inundation of hard-standing areas can lead to structural damage and the disruption of commercial activity. Inundation of agricultural land for long durations can have financial consequences.
- Flooding of ground floors of buildings above ground level – can be disruptive, and may result in structural damage. The long duration of flooding can outweigh the lead time which would otherwise reduce the overall level of damages.

Table 9.1 Groundwater mechanisms and processes

Flooding phenomenon	Sources	Pathways	Receptors	Hazard	Characteristics
Rising groundwater levels in response to prolonged extreme rainfall (often near or beyond the head of ephemeral streams)	Long duration rainfall	Permeable geology, mainly chalk	People, properties, environment	Basement flooding/rural ponding	Responsible for the large majority of groundwater flooding. May occur a few days after the rainfall or up to several weeks after. Usually lasts for a number of weeks. An increase in the baseflow of channels, which drain aquifers, is often associated with elevated groundwater levels and may lead to an exceedance of the carrying capacity of these channels. Floodwaters are most often clear and so this form of groundwater flooding may be referred to as 'clear water flooding'. High groundwater levels may also inundate sewer and storm water drainage networks, exceed capacity and lead to flooding in locations, which would otherwise be unaffected. This flooding can be associated with pollution.
Rising groundwater levels due to leaking sewers, drains and water supply mains	Water in water mains, drainage and sewerage networks	Cracks in pipes/permeable strata	People, properties, environment	Basement flooding/water quality issues	Leakage from sewer, storm water and water supply networks can lead to a highly localised elevation in groundwater levels, particularly where the leak is closely associated with chalk bedrock.
Increased groundwater levels due to artificial obstructions	Groundwater	Permeable near surface geology e.g. gravels	Property, environment	Basement flooding/routing of floodwaters	Structures such as building foundations can present an impermeable barrier to groundwater flow causing localised backing up or diversion of groundwater flow.
Groundwater rebound owing to rising watertable and failed or ceased pumping	Groundwater	Permeable geology and artificial pathways	Property, commercial	Basement flooding/flooding of underground infrastructure	Where historic heavy abstraction of groundwater for industrial purposes has ceased, a return of groundwater levels to their natural state can lead to groundwater flooding. This process can potentially cover large areas or maybe associated with local abstraction points.
Upward leakage of groundwater driven by artesian head	Groundwater emerging from boreholes or through permeable geology	Artesian aquifer and connection to surface	Property	Basement flooding/flooding at surface	Mainly associated with short duration and localised events this process can lead to significant volumes of discharge. It can occur in locations where boreholes have been drilled through a confining layer of clay to reach the underlying aquifer.
Inundation of trenches intercepting high groundwater levels / cutting into hillsides / terraces etc.	Groundwater	Permeable geology	Property	Routing of floodwaters	The excavation and fill of engineering works with permeable material can create groundwater flow paths. High groundwater levels maybe intercepted, resulting in flooding of trenches and land to which they drain.
Other – alluvial aquifers, aquifer, sea level rise	Rivers, rainfall, sea	Floodplain gravels, permeable geology	Property, environment	Basement flooding/flooding at surface/saline intrusion.	Other mechanisms of groundwater flooding include leakage of fluvial flood waters through river gravels to surrounding floodplains e.g. behind flood defences; and a rise in groundwater levels as a result of adjacent sea level rise as a result of the discharge boundary rising.

9.2 Data collection

Historic incidents

9.2.1 Information held by the Environment Agency and local authorities about this type of flooding is very limited and due to its nature it is difficult to accurately define all the areas at risk from this source of flooding. No records of flooding directly attributable to groundwater have been provided.

Existing studies

9.2.2 Historically, no single government body has been responsible for monitoring or responding to groundwater flooding. Defra's Making Space for Water Strategy (MSW) aims to provide greater clarity for the public and professional bodies impacted by and involved in the management of flooding. MSW recognises the need for an integrated understanding of flooding from all sources including groundwater.

9.2.3 As a consequence Defra have instigated a series of investigations into groundwater flooding such as;

- HA5 Groundwater Flooding Records Collation, Monitoring and Risk Assessment, March 2006 - aims to make recommendations for effective collation and monitoring of groundwater flooding information and identify organisational and funding arrangements required to implement this. It has identified that a national database for groundwater flooding is desirable and that scientific research into improving the understanding of groundwater flood processes is required.

- HA4a Flooding from Other Sources, October 2006 - aims to assess the feasibility of mapping flood risk from different types of flooding (including groundwater), together with the practicalities of implementing flood modelling methods considered for the significant types of flooding (including groundwater flooding). It has identified that the greatest barrier to producing accurate flood risk maps of other sources of flooding is the availability of data for ground-truthing in consistent and useable formats. It has further identified that the modelling methods that would be required to capture all the observed processes are complex and may not be realistic in the immediate future.

9.2.4 In 2004, Defra published a series of groundwater emergence maps (GEM) which were developed from analysis of historical datasets and other predictive techniques. The main data used in the analysis were the observations of groundwater flooding in 2000/1. Where insufficient observations existed, representative rises in groundwater levels were mapped and used to determine locations where the water table would have neared the ground surface during this period. The EA were contacted for this information; no groundwater emergence zones were identified within BCB and the EA did not consider groundwater flooding to be a significant issue. However there are known instances within the county where groundwater springs have caused disruption to homeowners.

9.2.5 The Ogmore to Tawe CFMP includes an analysis of soil types and concludes that the only areas with high groundwater tables in BCB are within the Bridgend Urban area. It also states that there is little documented evidence of groundwater flooding in the Ogmore to Tawe catchment and therefore the risk of flooding from this source is considered to be small in comparison with other sources.

Additional data to be considered

9.2.6 Details of any historic flooding events should be requested and analysed as part of any review of this SFCA. Recorded groundwater levels may also provide a better indication of areas at risk of groundwater flooding.

9.3 Assessment of flood risk

Methods

9.3.1 The existing Environment Agency Flood Zones and TAN15 Zones only indicate areas liable to flood from rivers and the sea. Other data must therefore be used to determine the areas susceptible to flooding from other sources, such as flooding from groundwater.

9.3.2 The methodology used in the SFCA to assess flooding from groundwater is built on the premise that this type of flooding is directly related to the physical, hydrological and environmental characteristics of a particular location.

9.3.3 A broadscale assessment was carried out making the best use of available data. The groundwater vulnerability GIS layer provided by the EA and the BGS solid geology GIS layer provided by BCBC were used for the assessment. The groundwater vulnerability ranks aquifers into three vulnerability classifications which are based on the potential for aquifer contamination from activities at the ground surface due to the permeability of the soils and geology providing a pathway for contamination. The highly and intermediately vulnerable aquifers and the areas of sandstone geology were extracted from these original datasets to create areas where a high water table may occur.

9.3.4 Drift geology (BGS) information was then interrogated to remove any areas with low permeability (predominantly clays). The remaining areas were used to derive areas which not only had the potential for high groundwater levels but also had pathways for groundwater flooding to occur. The coincidence of these two layers has been used as a guide to areas where groundwater flooding is more likely than others. A basic ranking was applied based on the drift geology, where a value of 3 was applied to sand and gravel layers, 1 was applied to any layer containing clay and 2 was applied to the remaining, the majority of which were ‘diamicton[5]’.

9.3.5 In addition to these areas, the topography was reviewed to highlight any depressions which may be susceptible to groundwater flooding.

Results

9.3.6 The results of the spatial analysis are shown in Map G in Annex A. The areas generally occur within the river valleys and include a significant area of developed land. The highest risk areas fall in parts of Abergarw, Bridgend, Maesteg, Pencoed and Pyle. It should be noted that many of the areas are heavily urbanised and as such are unlikely to experience significant flooding from groundwater.

9.3.7 Due to the relatively impermeable underlying geology and the absence of any significant areas of chalk within BCBC it is reasonable to expect that there are no areas with a particularly high risk of groundwater flooding. Furthermore, lack of groundwater monitoring in the area and no historic incidents of flooding support this assertion.

9.3.8 It should be noted, that that the categories are **relative** susceptibility and that the high relative susceptibility is still likely to equate to a low risk of groundwater flooding compared with other areas of the UK, considering the information included in the CFMP and the

[5] Diamicton is defined as unsorted and unstratified sedimentary deposits

information provided by the EA. However, those areas identified in the SFCA as having a 'high' relative susceptibility to groundwater flooding may warrant further investigation.

Maesteg

The majority of Maesteg is assessed as being at medium relative susceptibility of groundwater flooding. There is a small area at high relative susceptibility and the remaining areas have not been highlighted by the analysis and are considered to have low susceptibility to groundwater flooding.

Valleys Gateway (Brynmenyn)

The risk of groundwater flooding in Abergarw is variable. The northeastern part of the strategic area has generally not been highlighted as part of the analysis, although there are small areas of high, medium and low relative susceptibility. In the majority of the southwestern part of the strategic area the susceptibility is assessed as being high or medium.

Pencoed

The majority of Pencoed has not been highlighted as being susceptible to groundwater flooding. There are small areas of high and low susceptibility at the edges of the strategic site.

Waterton

The north western half of Waterton is assessed as being at low susceptibility to groundwater flooding. The remaining area has not been highlighted as being at risk of groundwater flooding.

Porthcawl

Porthcawl has not been highlighted as being susceptible to groundwater flooding.

Climate change

9.3.9 There is currently no research specifically considering the impact of climate change on groundwater flooding. The mechanisms of flooding from aquifers are unlikely to be greatly affected by climate change. However if winter rainfall becomes more frequent and heavier, groundwater levels may increase. Higher winter recharge may be balanced by lower recharge during the predicted hotter and drier summers. Increases in sea levels are likely to lead to increased groundwater levels in coastal areas by raising the saline wedge onto which the groundwater flows, although the changes in level are likely to be minor.

Uncertainty

9.3.10 The spatial analysis undertaken in the SFCA is highly qualitative. The maps do not indicate specific areas that will flood, but instead indicate areas with a higher propensity for groundwater flooding. Local factors that cannot be assessed without more reliable quantitative data can affect groundwater and the potential for emergence.

9.3.11 The impact of climate change on groundwater levels is highly uncertain. More winter rainfall may increase the frequency of groundwater flooding incidents, but drier summers and lower recharge of aquifers may counteract this.

9.4 Managing groundwater flooding

9.4.1 Until recently there has been no government body with a clear responsibility for groundwater flooding, having a statutory obligation for measuring and reporting events or providing advice and affording protection to those at risk. However, the Flood and Water Management Act (2010) places responsibility for 'local' flood risk management, which includes groundwater flooding, with local authorities, guided by the national flood risk management strategy.

9.4.2 As of spring 2006 the Environment Agency assumed a strategic overview for monitoring groundwater flooding but the extent and the legislative details remain to be clarified.

9.4.3 Groundwater flooding is often highly localised and complex. Management is strongly dependent upon the characteristics of the specific situation. The costs associated with the management of groundwater flooding are highly variable. The implications of groundwater flooding should be considered and managed through development control and building design. Possible responses include;

- Improve conveyance of floodwater through and away from flood prone areas
- Raising property ground or floor levels
- Provide local protection for specific problem areas such as flood proofing properties (such as tanking or sealing of building basements)
- Replacement and renewal of leaking sewers, drains and water supply reservoirs. Water companies have a programme to address leakage from infrastructure, so there is clear ownership of the potential source.

9.5 Planning considerations

9.5.1 The Environment Agency Flood Map and TAN15 DAM zones do not include groundwater flooding. The SFCA is required to investigate other sources of flooding. Decision makers should use the SFCA to inform their knowledge of flooding across the area. These should form the basis for preparing appropriate policies for flood risk management. The propensity for groundwater flooding should be a material consideration when making land use allocation decisions.

9.5.2 Groundwater flooding has always occurred. It generally occurs more slowly than river flooding and in specific locations. The rarity of groundwater flooding combined with the mobility of the population means that people often do not know there is a groundwater flood risk.

9.5.3 New developments are particularly at risk because little consideration is given to groundwater as a source of flooding in the planning process. The sparse frequency of groundwater flood events can contribute to poor decision-making.

9.5.4 Groundwater flood risk should be investigated, identified, quantified and managed where possible by the flood risk assessment process. Assessments of groundwater flooding must therefore always be included at all levels of future flood risk assessment. However a probabilistic approach to mapping groundwater flooding is not currently possible given the current datasets. Thus further collation of all relevant data, such as spring flows, borehole water levels, and recorded flood levels, past history and photographs of events and consultation with local residents should be undertaken in when preparing site specific flood consequence assessments (FCAs).

9.5.5 In particular, the factors that should be taken into account during these FCAs are;

- Areas liable to flood based on the best available information
- Extent, standard and effectiveness of existing flood defences (if present)
- Likely rates of water level rise within the aquifer, and if possible, trigger levels for the onset of overland flow
- Quantities and velocities of overland flow
- Likely depth of flooding
- Likelihood of impacts to other areas
- Possible impacts of climate change.

9.5.6 Indicators that the development may be at risk from groundwater flooding include;

- If the development site is near to the junction between geological strata of differing permeability
- If the development site is located at a similar level to nearby springs, or stream headwaters
- If the development proposals include basements or excavation into the ground or cutting into the ground.
- If the vegetation on the site suggests periodic waterlogging due to high groundwater levels.

10 Flooding from sewers

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10.1 Introduction

Description

10.1.1 Flooding from sewers occurs when rainfall exceeds the capacity of networks or when there is an infrastructure failure.

10.1.2 For the purposes of this SFCA sewer flooding is defined as any flooding which occurs in an urban area with a comprehensive sewer network. This includes combined, and surface water sewers, culverted minor watercourses (lost watercourses), sewer pumping stations and water treatment facilities. It does not include flooding from over land drainage systems in rural areas.

Causes of sewer flooding

10.1.3 The main causes of sewer flooding are;

- Lack of capacity in sewer drainage networks due to original under-design or due to an increase in demand (such as climate change and/or new developments)
- Lack of capacity in sewer drainage networks due to events larger than the system designed event
- Lack of capacity in sewer drainage networks when a watercourse is fully culverted (lost watercourses), thus removing floodplain capacity
- Lack of maintenance of sewer networks which leads to a reduction in capacity and can sometimes lead to total sewer blockage
- Water mains bursting/leaking due to lack of maintenance or as a result of damage
- Groundwater infiltration into poorly maintained or damaged pipe networks
- Restricted outflow from the sewer systems due to high water levels in receiving watercourses or the sea.

Impacts of sewer flooding

10.1.4 The impact of sewer flooding is usually confined to relatively small localised areas. However, flooding associated with blockage or failure of the sewer network can be rapid and unpredictable.

10.1.5 Drainage systems often rely on gravity assisted dendritic systems, which convey water in trunk sewers located at the lower end of the catchment. Failure of these trunk sewers can have serious consequences as water from surcharged manholes will flow into low-lying land that may already be suffering from other types of flooding.

10.1.6 Whilst the area affected by sewer flooding is localised, the consequences for the affected properties and individuals can be particularly severe. Sewer flooding is likely to have a high concentration of solid, soluble and insoluble contaminants. These contaminants can have serious health impacts on residents of flooded properties and are typically significantly more destructive to personal possessions.

10.1.7 Flooding of sewers can also lead to contaminated water entering nearby watercourses, having an adverse effect on the biota in receiving environments.

10.2 Data collection

Historic flood incidents

10.2.1 The only source of information related to sewer flooding was supplied by the wastewater company servicing BCBC, Welsh Water. However, it has been assumed that the BCBC performance indicator database also contains relevant information.

10.2.2 Welsh Water provided information from their 'DCWW Flooding Register' detailing incidents of sewer flooding by postcode. This information is shown in Maps S Annex A.

Table 10.1 Recent incidents of sewer flooding

	Flooding Type		
Postcode	**External**	**External Property**	**Internal**
CF31	6	6	5
CF32	34	8	8
CF33	3	2	2
CF34	8	1	2
CF35	11	10	1
CF36	8	9	8
Total	**70**	**36**	**26**

10.2.3 This dataset is a live document and therefore its contents and the remedial actions conducted by Welsh Water are constantly changing. A property is added to the register when it has experienced either internal or external flooding and can be removed, for example, once an engineering solution has been found to alleviate the problem. It is probable that a number of properties on the register have been misattributed to the wrong source of flooding and hence caution should be applied when using the dataset and more information should be sought during detailed assessments.

Existing studies

10.2.4 No studies were available which investigated existing or future flooding issues within the sewer systems in BCBC.

Additional data to be considered

10.2.5 Details of any historic flooding events should be requested and analysed as part of any review of this SFCA as well as results and outputs from any modelling or capacity studies.

10.3 Assessing flood risk

Method

10.3.6 Currently Environment Agency and TAN15 DAM zones only indicate areas liable to flood from rivers or the sea. Other data must therefore be used to determine the area at risk of flooding from other sources, such as sewers.

10.3.7 As the SFCA investigates flood risk over a large spatial area, it is not practical to undertake a detailed assessment of all sewer networks across the study area. The most appropriate method for assessing the risk of flooding from sewers within the SFCA is a review of historical data.

10.3.8 Sewer flooding information provided by Welsh Water was used as the basis for the assessment. The incidents of flooding were weighted for severity with the following factors: 1

for external flooding; 2 for external property flooding; and 5 for internal property flooding. The postcode areas have been colour coded based on the summed values of the incidence of each type of flooding event.

10.3.9 As an additional measure the WAG Performance Indicator database information, stripped of any locations falling within the 0.1% AEP event have been included as an indication of areas that may suffer from sewer and drain flooding.

10.3.10 Map S in Annex A presents the outputs of this process.

Results

10.3.11 As would be expected the incidence of sewer flooding is concentrated within the large urban areas of BCB.

Maesteg

10.3.12 Flooding from sewers within Maesteg is medium / low to low in the areas which are recorded to have been flooded. The majority of events occurred in the southern part of the strategic site.

Valleys Gateways (Brynmenyn)

10.3.13 Flooding from sewers within Abergarw is low to high in the areas which are recorded to have been flooded. The majority of events occurred in the western part of the strategic site.

Pencoed & Waterton

10.3.14 There are no recorded sewer flooding events in either Pencoed or Waterton although BCBC reported historical flooding from sewers in Coychurch Rd, Heol-Y-Geifr and Pen Gwern

Porthcawl

10.3.15 Flooding from sewers within Porthcawl is low to high in the areas which are recorded to have been flooded. All the events occurred in the western part of the strategic site.

Climate change

10.3.16 Climate change is expected to impact sewer flooding with increases in rainfall intensity. This will require new infrastructure to be designed with greater capacities and existing infrastructure may require upgrading to maintain the same level of service. The relevant climate change predictions in the current Defra Guidance [6] are reproduced in Table 10.2.

Table 10.2 Recommended precautionary sensitivity ranges for peak rainfall intensities

Year	1990 to 2025	2025 to 2055	2055 to 2085	2085 to 2115
Peak rainfall intensity	+5%	+10%	+20%	+30%

[6] Flood and Coastal Defence Appraisal Guidance FCDPAG3 Economic Appraisal. Supplementary Note to Operating Authorities – Climate Change Impacts October 2006

Uncertainty

10.3.17 Assessing the risk of sewer flooding over a wide area is complicated by lack of data and time/budget constraints. An integrated modelling approach is required to assess and identify the potential for sewer flooding but these models are more suited to detailed studies. Obtaining this information can be problematic as datasets held by stakeholders are often confidential, contain different levels of detail and may not be complete. Sewer flood models require a greater number of parameters to be input and this increases the uncertainty of the model predictions.

10.3.18 Existing sewer models are generally not capable of predicting flood routing (flood pathways and receptors) in the 'major system' (i.e. the above ground network of flow routes - streams, dry valleys, highways etc).

10.3.19 Use of historic data to estimate the probability of sewer flooding is the most practical approach. However it does not take account of possible future changes due to climate or future development. Thus flooding issues may be relatively short lived (<10 years).

10.4 Managing flooding from sewers

10.4.20 Flooding from sewers or urban areas can theoretically be managed with engineering works for any size event. However such works are not economically or environmentally sustainable. Improvements to urban drainage can also lead to rapid rainfall runoff into rivers, increasing flood risk downstream and potentially transporting contaminants.

10.4.21 TAN15 promotes the use of SuDS to manage surface water runoff. All new developments, and wherever possible existing networks, are also advised to separate out foul drainage from surface water drainage to ensure that any flooding that does occur is not contaminated. The type, suitability and design of different SuDS are described further in Chapter 2.

10.4.22 It is likely that the sewer systems in BCBC are aging and will require significant upgrade in the medium future. An integrated urban drainage strategy would be a preferred means of managing surface water.

10.5 Planning considerations

10.5.1 The Environment Agency Flood Map and TAN 15 Zones do not include flooding from sewers, however consideration should be given to other forms of flooding during the decision making process.

10.5.2 Assessments of flooding from sewers are therefore needed. A probabilistic approach requires an understanding of hydrological, hydraulic and structural engineering processes. These processes are highly variable at the local scale and cannot meaningfully be performed at a strategic level. Thus a more detailed assessment is required for individual proposed developments. At a minimum, a sewer assessment should be undertaken when proposing additional development in those locations having a medium or high sewer flooding risk from historic incidents, as shown on Map S in Annex A.

10.5.3 As well as informing land use planning, flooding from sewers should be managed by the development control process. Further collation of all relevant data, such as sewer capacity, past events and consultation with water companies and operating authorities should be undertaken when preparing site specific flood risk assessments. Factors that should be taken into account during these flood risk assessments are;

- Capacity of the existing drainage system

- Increase in surface water runoff rates
- Effects of climate change
- Suitable SuDS.

11 Flooding from artificial sources

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11.1 Introduction

11.1.1 For the purpose of the SFCA, flooding from artificial sources has been defined as flooding from non-natural or artificial sources of flooding as reservoirs, canals and lakes where water is retained above natural ground level.

11.1.2 The spatial and temporal extent of flooding from artificial sources can be highly variable. For example, the likelihood of a new reservoir failing is very small compared to that of a canal embankment that is over one hundred years old. However whilst the probability is low, the consequences of a new reservoir failing could be catastrophic.

11.2 Data collection

11.2.1 No data was provided on potential artificial sources of flooding or historic flooding events.

Additional data to be considered

11.2.2 Any information regarding flooding from artificial sources, such as outputs from the national reservoir inundation mapping project (EA), asset information, operating regimes and breach or failure impact studies undertaken by undertaker's and regulators.

11.3 Method and Results

11.3.1 Artificial sources of flooding were identified by reviewing OS mapping. The artificial sources of flood risk identified within BCB are all reservoirs generally of a small size. Map A, in Annex A details the potential artificial sources of flooding. There is a small reservoir outside the BCBC boundary which may affect Pencoed if overtopping or a breach were to occur. None of the other strategic sites are assessed as being at risk of artificial flooding.

11.4 Planning considerations

11.4.1 The Environment Agency Flood Map and TAN 15 DAM Zones do not include flooding from artificial sources, however consideration be given to other forms of flooding during the decision making process. Assessments of artificial sources of flooding are therefore needed.

11.4.2 A probabilistic approach to artificial sources of flooding is not entirely suitable due to the low probability of such flooding occurring, but extreme consequences. Instead, an overall risk assessment should be undertaken which considers both probability and consequences.

11.4.3 Further collation of all relevant data, such as asset information, measured water levels, operating regimes, past history and photographs of events and consultation with operating authorities should be undertaken when preparing more detailed assessments.

11.4.4 More specifically, factors that should be taken into account during these detailed assessments are;

- the probable area liable to flooding
- the extent, standard and effectiveness of existing impoundment structures
- the likely depth of flooding
- the likely velocity of flooding

- any likely cascade effects
- the possible effects of climate change.

11.4.5 A risk-based approach is strongly recommended. Consideration of hydrological and geotechnical factors should be undertaken to determine the probability and consequences of failure when making land use allocation decisions.

11.4.6 This source of flooding should also be considered during development control, with appropriate measures included in building design.

12 Glossary and notation

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ABD	Areas Benefitting from Defences. These areas are shown on the Environment Agency Flood Map and indicate land defended from either a 1% AEP fluvial flooding event or a 0.5% AEP tidal flooding event. The assessment of ABDs assumes that defences are in perfect condition and operate as intended.
Actual risk	The risk that has been estimated based on a qualitative assessment of the performance capability of the existing flood defences
AEP	Annual exceedance probability. The annual chance that a flood of a given magnitude will be exceeded, i.e. there is a 1% probability in any given year that the magnitude of the 1% AEP flood event will be exceeded.
Afon	Welsh for River
BGS	British Geological Society
Breach or failure hazard	Hazards attributed to flooding caused by a breach or failure of flood defences or other infrastructure which is acting as a flood defence.
BCB	Bridgend County Borough
BCBC	Bridgend County Borough Council
CIRIA	**Construction industry research and information association**.
CFMP	Catchment Flood Management Plan
COW	Critical Ordinary Watercourse. The Environment Agency is responsible for the maintenance of COWs.
DAM	Development Advice Map
Defra	Department of Environment, Food and Rural Affairs
DCWW	Dŵr Cymru Welsh Water
DPD	Development Plan Document
DTM	Digital Terrain Model, usually generated from SAR or LiDAR data
d/s	Downstream
EA	Environment Agency
EAW	Environment Agency Wales
FEH	Flood Estimation Handbook
Flood defence	Natural or man-made infrastructure used to prevent flooding
Flood risk	*"Flood risk is a combination of two components: the chance (or probability) of a particular flood event and the impact (or consequence) that the event would cause if it occurred"* as per Environment Agency (2003) Flood Risk Management Strategy
FCA	Flood Consequence Assessment
FCDPAG	Flood and Costal Defence Project Appraisal Guidance

Flood risk management	*"Flood risk management can reduce the probability of occurrence through the management of land, river systems and flood defences, and reduce the impact through influencing development in flood risk areas, flood warning and emergency response"* as per Environment Agency (2003) Flood Risk Management Strategy
Flood Zones	This refers to the Flood Zones in accordance with Table D1 of PPS25. For the purpose of the SFCA, the definition of Flood Zones varies slightly from PPS25 in that it shows the extent of flooding ignoring the presence of flooding defences, 'except where the 'actual risk' extent is greater'
FWA	Flood Warning Area
GIS	Geographical Information System
HEC-RAS	Hydraulic Engineering Centre – River Analysis System, a one-dimensional computational hydraulic modelling package.
IDB	Internal Drainage Board
JFLOW	National generalised modelling software used to produce most of the Environment Agency's Flood Zones
LDD	Local Development Documents
LDF	Local Development Framework
LiDAR	Light Detecting and Ranging. - technique used to capture topographic data from the air.
LPA	Local Planning Authority
LRF	Local Resilience Forum
m	metres (measure of distance)
m/s	metres per second (measure of velocity)
mm	millimetres (measure of distance, one thousandth of a metre)
mAOD	metres above Ordnance Datum. Standard baseline used in all elevation data used in the SFCA
µm	Micrometre – one thousandth of a millimetre
MSW	Making Space for Water
Nant	Welsh for stream
NFCDD	National Flood and Coastal Defence Database. Environment Agency database used to store and analyse flood defence structures and assets. Updated regularly.
OS	Ordnance survey
Precautionary principle	*''Where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost effective measures to prevent environmental degradation*''. The precautionary principle was stated in the Rio Declaration in 1992. Its application in dealing with the hazard of flooding acknowledges the uncertainty inherent in flood estimation.
PPW	Planning Policy Wales
Residual risk	Flood risks resulting from an event more severe than for which particular flood defences have been designed to provide protection.

Revetment	Engineered solution to erosion management
Riprap	A revetment technique used to protect surfaces from erosion by wave action, typically formed from large rocks and found along coastlines and below weirs.
RMSE	Root mean squared error
RSS	Regional Spatial Strategy
SAR	Synthetic Aperture Radar. Technique used to capture topographic data from the air.
SFCA	Strategic Flood Consequence Assessment
SMP	Shoreline Management Plan
SoP	Standard of Protection – the level of protection afforded by a particular defence
SuDS	Sustainable Drainage Systems
TAN15	Technical Advice Note 15 – Development and Flood Risk
u/s	Upstream
WAG	Welsh Assembly Government
1D / 2D	One dimensional / two dimensional