CAPITA SYMONDS

WOKING (River Wey)
STRATEGIC FLOOD RISK ASSESSMENT

For WOKING BOROUGH COUNCIL

VOLUME 2:
TECHNICAL REPORT
FINAL

March 2009

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Woking Borough Strategic Flood Risk Assessment
Technical Report

Final / March 2009

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PREFACE

It is accepted that the technical content of the Woking SFRA will need to be reviewed and amended as new information becomes available.

Although there is no statutory consultation requirement at this stage the nature of the intended end use for the information makes it appropriate to obtain feedback relating to the report in order to contribute to the overall robustness and credibility of this work. This information will also be an aid when formulating the necessary next steps in engaging those parties who will be involved in the future.

It is the responsibility of the reader to be satisfied that they are using the most up to date information and that this has been included within the Woking SFRA.

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FOREWORD

Woking Borough Council is required to prepare a Strategic Flood Risk Assessment (SFRA) to support their Local Development Framework (LDF).

The SFRA creates a strategic framework for the consideration of flood risk when making planning decisions. It has been developed with reference to Planning Policy Statement 25 (PPS25): development and flood risk and additional guidance provided by the Environment Agency.

The fundamental concepts that underpin the SFRA are outlined in PPS25. The guidance provided in this document requires local authorities and those responsible for development decisions to demonstrate that they have applied a risk based, sequential approach in preparing development plans and consideration of flooding through the application of a Sequential Test. Failure to demonstrate that such a test has been undertaken potentially leaves planning decisions and land allocations open to challenge during the planning process.

The underlying objective of the risk based sequential allocation of land is to reduce the exposure of new development to flooding and reduce the reliance on long-term maintenance of built flood defences. Within areas at risk from flooding, it is expected that development proposals will contribute to a reduction of flood risk.

SFRAs are essential to enable 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.

The main objectives of the Woking SFRA are to provide flood information:

- so that an evidence based and risk based sequential approach can be adopted when making planning decisions, in line with PPS25;
- that is strategic in that it covers a wide spatial area and looks at flood risk today and in the future;
- that supports sustainability appraisals of the local development framework; and
- that identifies what further investigations may be required in flood risk assessments for specific development proposals.

The SFRA is presented in a number of documents:

VOLUME 1 – Decision Support Document;

VOLUME 2 – Technical Report; and,

VOLUME 3 – Mapping.

The SFRA is a live document that is intended to be updated as new information and guidance become available. The outcomes and conclusions of the SFRA may not be valid in the event of future changes to the data or the baseline flooding situation. It is the responsibility of the user to ensure they are using the best available information.

Woking Borough Council
STRATEGIC FLOOD RISK ASSESSMENT - Structure

SFRA VOLUME 1 – DECISION SUPPORT

1. Introduction
2. Flooding in Woking Borough
3. How to Use the SFRA in Land Use Planning
4. How to Use the SFRA in Flood Warning and Emergency Planning
5. How to Use the SFRA in Development Control
6. SFRA Maintenance and Management

SFRA VOLUME 2 – TECHNICAL REPORT

1. Introduction and catchment summary
2. Flood Warning and Emergency Planning
3. Asset and Structure Data
4. Flooding from Rivers
5. Flooding from Land, Surface Water, Sewers and SUDS
6. Groundwater Flooding
7. Flooding from Artificial Sources
8. Flood Risk at Development Sites and Strategic Options

SFRA VOLUME 3 - MAPS

DOCUMENT REGISTER

It is accepted that the technical content of the Woking Borough SFRA will need to be reviewed and amended as new information becomes available.

It is the responsibility of the reader to be satisfied that they are using the most up to date information and that this has been included within the Woking Borough SFRA.

The Woking Borough SFRA (this document) is a live document requiring review in the event of an improvement or change in the fundamental principles or best available data underpinning the strategy. This is likely to include, but should not be limited to:

- An improvement in the best available information or a reduction in uncertainty;
- Revision to relevant policy, plans or guidance at national, regional and local level;
- Outcomes of neighbouring strategies; and
- Changes to the parent guidance contained in the PPS25 or the regional flood Risk Appraisal.

Revisions to this document should be recorded below in Table 1 Document Register to maintain clarity for those making decisions involving flood risk issues.

Table 1 Document Register

Version	Date	Issued by	Issued to
Draft for comment	December 2007	CSL	WBC and EA
Draft V1.1 for comment	March 2008	CSL	WBC and EA
November 2008 Draft	November 2008	CSL	WBC and EA
February 2009	February 2009	CSL	WBC and EA

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CONTENTS

Figures

Tables

Volume 3 – Maps (see separate volume)

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1 Introduction and Catchment Summary

1.1 The Woking SFRA provides a broad scale assessment of flood risk. The need for Local Planning Authorities to consider flood risk when preparing Local Development Documents (LDDs) and to produce SFRAs is outlined in Planning Policy Statement 25 (PPS25, DCLG 2006).

1.2 This document is the Volume 2: Technical Report of the Woking SFRA, and should be read in conjunction with the Woking SFRA Volume 1: Decision Support Document. Volume 1 (Support Document) provides a summary of the SFRA and guidance on how to use the SFRA. The structure of this SFRA is explained in the diagram shown in the foreword to this report.

1.3 This document (Volume 2: Technical Report) outlines and describes the strategy adopted to assess strategic flood risk issues in Woking. The principal requirement for adopting a strategic approach to the assessment and consideration of flood risk is in accordance with advice given in PPS25.

1.4 The approach adopted has primarily been developed in recognition of the need to provide flood risk information to support appropriate land use allocations within the study area, and to support the application of the Sequential Approach.

1.5 The underlying objective is to initiate a strategy that provides a framework for the consistent consideration of flood risk in seeking to accommodate current best practice and best available data for the lifetime of the planning process. This framework will be used to inform the policies and plans described in the emerging Local Development Frameworks (LDF).

1.6 The assessment evaluates risk as the product of the probability and the consequence of particular events. Probability is defined as the frequency and magnitude of floods that are generated by fluvial or tidal flows and intense rainfall activity. The consequence is defined as the impact of floodwater on receptors (people, property, land, etc). This approach is sympathetic to the concept of source, pathway and receptor now adopted for flood risk management.

1.7 The reader requiring specific information is directed to the following chapters:

- Chapter 1 – Catchment Summary
- Chapter 2 – Flood Warning and Emergency Planning
- Chapter 3 – Flooding from Rivers
- Chapter 4 – Flooding from Land, Surface Water and SuDS
- Chapter 5 – Groundwater Flooding
- Chapter 6 – Flooding from Artificial Sources
- Chapter 7 – Flood Risk at Allocation Sites and Strategic Options

1.8 This document does not replace, and should be read in conjunction with, national and regional policy including PPS25 and relevant regional policy. The SFRA does not replace the responsibility at a broader level to consider wider catchment flood risk management approaches and solutions, nor does it remove the requirement for appropriately focused local/site FRA's.

1.9 This Strategic Flood Risk Assessment (SFRA) is a combination of Level 1 and Level 2 assessment as described by the PPS25 Practice Guide (CLG, 2008). This study uses the best available information to assess flood risk. This includes the Flood Zones (EA), and other information, which enables a broad assessment of the Flood Risk for the existing conditions within the study area. The combined Level 1 and Level 2 approach presents a broad scale assessment of flood risk across the whole Borough (Level 1) with additional, more detailed, information provided for areas identified as at risk of fluvial and tidal flooding (Level 2).

1.10 This report is a full technical report documenting the assumptions, processes and assessment undertaken in the development of the SFRA. It is intended to serve as a transparent record of the decisions and methodology that led to the outcomes of the SFRA.

Study Area

1.11 The Woking SFRA covers an area of 63.41km^2 and within this area the River Wey is the principle watercourse. It flows in a predominantly northeast direction from near Petersfield (North Wey) and Liphook (South Wey) to Weybridge. The total length of the main river is 92km, with 37km falling within the SFRA boundary.

1.12 The water levels and flows within the Study Area are dominated by the magnitude of the flows generated in the fluvial catchment of the River Wey. Current flood risk management measures are confined to localised flood bunds and bank protection, no formal flood defences exist within the SFRA study area.

1.13 The Study Area also contains the Basingstoke Canal, which is owned and managed by British Waterways, and used mainly by leisure boats.

1.14 The majority of the transport infrastructure within the study area is located in the main urban centre at Woking. This includes the South West Trains route into London and a network of A roads. The M25 motorway is in the north east part of the study area, between Woking and Guildford.

River Catchments

1.15 The River Wey is a tributary of the River Thames, the source of the north branch is at Alton, Hampshire and the south branch is at Liphook, Hampshire. The two branches join at Tilford. The total catchment area is 900km^2 and is predominantly rural in nature. The total length of the main river from the upper reaches of the South Wey to the Thames is 92km with a drop in level of 190m. The river is navigable for around 32km from Godalming to the Thames at Weybridge to the south-west of London. There are a number of urban areas on the Wey, particularly in the lower catchment, including Woking, Farnham, Godalming, Guildford and Weybridge. Through these urban areas the channel has been modified significantly. The channel contains a large number of mill structures, side channels, and weirs throughout its length, including the rural reaches.

1.16 The Hoe Stream is a small tributary of the River Wey. It rises at Tickners Bridge close to the village of Normandy and continues in a north-easterly direction, joining the River Wey at Newark Lock. Much of the lower Hoe Stream catchment is heavily urbanised and this, with the underlying impermeable geology is likely to produce relatively high runoff rates from the Hoe Stream catchment.

Regional Geology

1.17 In the upper Wey catchment the geology is chalk (upper cretaceous) and is therefore highly permeable. In some areas the chalk is over laid with sand and clays. In the area around Woking these consist mainly of the Bracklesham beds, a mix of clays and marls and to the north again the area becomes highly impermeable, with London Clay becoming the dominant geology. In the Woking area the River Wey valley and the valleys of it's tributaries contain deposits of river alluvium (generally clay, silt and sands) overlaying the solid geology.

1.18 The impermeable geology of the downstream parts of the catchment contributes to the high runoff characteristics of the lower Wey catchment. This is also exacerbated by the high level of urbanisation across the area. This combination contributes to the 'flashy' response to rainfall events in the lower Wey catchment.

1.19 The dominant bedrock in the Hoe Stream catchment is the Bracklesham beds along with the Bagshot Beds, (sands and clays). The upper part of the Hoe Stream catchment sandstones are more significant and the Barton Beds (sands) underlay the very upper parts of the catchment. On the floodplain gravel deposits have been laid down in more recent geological times. The catchment area is generally quite impermeable.

Topography

1.20 The general topography of the study area is dominated by the topography of the River Wey floodplain. From the floodplain hills rise at generally gentle grades onto the valley sides. The meandering floodplain increases in width as it moves downstream / northwards. Around the confluence of the Hoe Stream and the main River Wey, the width of the floodplain widens to 2.0km. Generally the floodplain reduces in width where the river flows through the urban areas.

1.21 The Lower Wey catchment is a modified river system. The River Wey does not entirely follow its original course and has been altered in places with the creation of additional man-made river channels that form the Wey Navigation.

Sources of flooding

1.22 Flooding is heavily dependent on the interaction of rainfall, catchment characteristics and the sea. PPS25 identifies six sources of flooding to be investigated in an SFRA:

- Flooding from rivers
- Flooding from the sea (tidal and coastal)
- Flooding from groundwater
- Flooding from land
- Flooding from sewers
- Flooding from artificial sources (docks, canals, reservoirs, lakes, pumping).

1.23 Woking contains localised areas that are prone to flooding from a range of processes including: fluvial, surface water, sewer, groundwater, and flooding from artificial sources. Flooding from the sea is not an issue in Woking. Each relevant source of flooding is analysed in more detail in Chapters 3 to 7 of this report. Volume 3 of this SFRA contains the corresponding flood maps.

2 Flood Warning and Emergency Planning

Introduction

2.1 PPS25 states, 'the receipt of and response to warnings of floods is an essential element in the management of the residual risk of flooding'. Thus it recognises that flood warning and emergency planning makes a significant contribution to the management of flood risk during extreme events.

2.2 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.

2.3 Flood warning and evacuation procedures can reduce the risk of people being exposed to flood waters and minimise the consequences of flooding. Effective land use planning will reduce the requirement for flood warning and emergency planning as new development is steered away from flood risk areas.

Flood warning

2.4 The Environment Agency have provided the information below in relation to flood warning in the Woking SFRA study area.

In England and Wales the Environment Agency operates a flood warning service in areas at risk of flooding from rivers or the sea. Using the latest available technology, Agency staff monitor rainfall, river levels and sea conditions 24 hours a day and use this information to forecast the probability of flooding. If flooding is forecast, warnings are issued using a set of four easily recognisable codes. Each of the four codes indicates the level of danger associated with the warning. The codes are not always used in sequence; for example in the case of a flash flood a Sever Flood Warning may be issued immediately, with no other warning preceding it. Definitions and symbols for each warning code are described in Table 2.

Table 2 Environment Agency Flood Warning Stages

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

River flood forecasting in the Wey catchment is undertaken by the Environment Agency's regional flood warning office in Reading. Forecasting uses a combination of Meteorological Office weather forecasts and real-time data (rainfall, flow, level and soil moisture).

The Environment Agency maintains a FLOODLINE 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.

The EA provide a flood warning service for the following rivers within the Woking SFRA study area including the Hale Bourne, Addlestone Bourne, Mill Bourne, River Wey and the Hoe Stream. There are three flood watch areas within the SFRA study area and a flood watch would be used when water levels along the river are forecast to overtop the banks. Flood watches are issued for the following three areas:

- *Windle Brook and Hale, Mill and Addlestone Bournes;*
- *Lower River Wey; and*
- *Hoe Stream.*

A Flood Warning is issued when the Environment Agency anticipates flooding to property. Flood warnings are issued for specific flood warning areas within a river catchment. There are six flood warning areas within the SFRA study area:

- *Hale Bourne and Addlestone Bourne at Chobham;*
- *Mill Bourne at Emmetts Mill;*
- *River Wey at Guildford;*
- *River Wey at Old Woking;*
- *River Wey at Byfleet; and*
- *Hoe Stream at Woking.*

The trigger for issue of a Severe Flood Warning is dependent on a number of factors but is essentially used when there is thought to be extreme danger to life. This is a decision that would be made on the basis of river levels, large numbers of properties affected, response required by emergency services and local authorities, likely impact on major infrastructure etc. Severe Flood Warnings are issued for a specific flood warning area within a catchment e.g. River Wey at Guildford.

Nationally, the Agency aims to give a two-hour warning in advance of any flooding taking place. However in certain cases this may not always be possible.

The EA have a telemetry network of river levels gauges. These are used to monitor the river levels and have various alarm levels:

1. ACT ENH D+F – the river is at a high level and could rise further
2. RES WAT – the river has reached the top of its banks
3. ACTCON FW – the river has overtopped its banks and is flowing over its floodplain
4. RES FW – the river has reached the threshold of a nearby property.

These levels and alarms and not necessarily the trigger to issue a warning. As a basic guideline, a flood watch is generally issued if a river is approaching RES WAT and a flood warning is generally issued if a river is approaching RES FW. These trigger levels are not absolutely fixed and are reviewed after every flood event.

All warnings issued are disseminated to professional partners, the media and the public. Once issued, all warnings are available on the internet, teletext and via Floodline. Warnings are disseminated using the Floodline Warnings Direct Service. This service exploits current and emerging technologies to deliver warnings simultaneously via telephone, mobiles, pager, fax, email and SMS text messaging.

Emergency planning

2.5 Local Planning Authorities (LPAs) have a defined role in emergency planning. They are listed as Category 1 Responders along with Emergency and Health Services. The role and responsibilities for emergency planning are 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'.

2.6 The roles and responsibilities of an LPA comprise of preplanning, emergency response and recovery. In the preplanning stage, the LPA's responsibilities include:

- Communication strategy for informing residents;
- Allocation of rest, reception and media centres;
- Location of vulnerable people and sites.

2.7 During an emergency response event, the LPA's responsibilities include:

- Co-operation with all category one and two responders (including the emergency services and the Environment Agency) to coordinate response;
- Assist in warning and informing residents; and
- Liaison with Water Authority to ensure provision of clean drinking water. This is primarily the responsibility of the water authority but it is expected that the LPA will assist where necessary.

2.8 Subsequent to a flood event, the LPA is responsible for the recovery of the local area. This includes:

- Cleaning up of debris on highways and in Council housing / other council properties;
- Provision of accommodation for Council residents made homeless by the event;
- Assisting residents in removal of damaged goods where appropriate; and
- Ensuring continuing education of pupils if schools are affected.

2.9 In order for emergency response to be effective, the key locations during a flood emergency such as Police / Fire / Ambulance stations, control centres, telecommunications installations, and rest, reception and media centres should be located in low risk areas. As PPS 25 states, these are highly vulnerable to flood risk, as they required to be operational during flooding.

References

Woking Borough Council Emergency Plan (2007)

Woking Borough Council Draft Flood Plan (2007)

Civil Contingencies Act 2004

3 Flooding From Rivers

Description

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

- Intense or prolonged rainfall causing runoff rates and flows to increase in rivers, exceeding the capacity of the channel. This can be exacerbated by wet antecedent (the preceding time period) conditions and where there are significant contributions of groundwater;
- 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 gates preventing discharge at the outlet of the river.

3.2 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.

3.3 Flood hazard can vary greatly throughout catchments and even across floodplain areas. The hazard posed by floodwater is proportional to the depth of exposure, the velocity of flow and the speed of onset of flooding. Hazardous river flows can pose a significant risk to exposed people, property and infrastructure.

3.4 Whilst low hazard flows are less of a risk to life (shallow, tranquil water), they can disrupt communities, require significant post-flood cleanup and can cause costly and possibly structural damage to property.

3.5 Much of the Woking SFRA study area lies within the catchments of the River Wey and the tributary, the Hoe Stream. This chapter of the SFRA is concerned with the assessment of the risk of river (fluvial) flooding from the River Wey and the Hoe Stream.

Data Collection

Record of Historic Flood Events

3.6 Data and records of past flooding events in the Woking study area have been collated from the Environment Agency and Woking Borough Council and are reported below. The River Wey hydraulic model which is described below and which was used in this SFRA has been calibrated to observed records of flooding.

Topographic Information

3.7 Topographic survey of the floodplain was received from the Environment Agency. This consisted of Photogrammetry at modelled cross section locations and NEXTmap data where floodplain elevation data was otherwise absent. Section 2.2 of The River Wey Flood Mapping Study, Main Report Volume 1 (Atkins, February 2006) gives details of survey data that was available for that study, which was also made available for this SFRA.

3.8 NEXTmap datasets can in some instances contain considerable inaccuracies that can have significant implications on flood mapping exercises. Atkins carried out a check on the NEXTmap data received by comparing it to surveyed manhole level data. It was found that 71% of spot locations checked fell within ±1.0m of surveyed manhole levels. Atkins concluded that the inaccuracies in the data were within acceptable bounds for this type of survey and therefore could be considered fit for use in the flood mapping. Full details of Atkins assessment of the NEXTmap data can be found in Appendix B of the River Wey Flood Mapping Study, Main Report Volume 1 (Atkins, February 2006)

3.9 To maintain consistency with the Wey Flood Mapping Study the Digital Terrain Model (DTM) created by Atkins (For the Wey Flood Mapping Study outline generation) was adopted unchanged for this SFRA. This DTM had been generated from a combination of photogrammetery cross section data as well as the less accurate NEXTmap data.

3.10 It should be noted that the level of accuracy in the topographic survey is considered suitable for a SFRA, however it is not considered suitable for more detailed studies into flood risk at specific sites and those preparing detailed FRA for specific sites are advised to obtain more accurate topographic data.

Asset and Structure Data

3.11 Traditional defences such as raised banks and walls are built to help reduce the occurrence, and therefore frequency of flooding. Some other structures provide flood defence benefits, however they are also built to manage low flows or are part of the infrastructure network. These assets can be owned, operated and maintained by the Environment Agency, Local Authorities, private business and/or local residents. In addition to defences, infrastructure such as major roads and railway lines can influence river flows and perform a function as being ‘defacto defences’. Although these features are not considered formal flood defences they influence river flows and floodplain extents.

3.12 The Environment Agency’s National Flood and Coastal Defence Database (NFCDD) has been the primary source of information for identifying flood defences. NFCDD contains flood defence and asset data for the whole of England and Wales. NFCDD contains details of a number of structures across the study area. National Guidance provides information by which to define flood defences. Only flood defences such as flood alleviation channels and raised defences have been identified as flood defences for the purposes of the SFRA.

3.13 NFCDD structures not considered flood defences include surface water outfalls, natural banks, raising of ground levels and maintained channels (dredged and weed cut).

3.14 There are no formal flood defences within the Study Area, however there are isolated flood relief facilities including flood relief channels and culverts.

3.15 ***Volume 3, Appendix G*** shows the location of all flood relief facilities within the Study Area (based on data from the NFCDD provided by the EA). The River Wey Improvement Scheme was created in the 1930s, and the Broadmead and Newark channels are constituents of this. The scheme involved increased conveyance in the River Wey channel and the standard of protection provided by this scheme is very low. There is a bypass channel on the Hoe Stream, however the standard of protection along this reach is also low. Provision of new flood defences along the Hoe Stream is currently being investigated by Woking Borough Council.

Existing Hydraulic Models

3.16 Atkins, recently (2006) undertook a Flood Mapping Study of the River Wey on behalf of the Environment Agency, Thames Region, South East Area. The project was undertaken in six stages between 2002 and 2006 with the first three stages undertaken according to the Section 105 Framework Agreement, Section 4 undertaken under the National Engineering and Environmental Consultancy Agreement (NEECA), and Sections 5 and 6 completed under the Strategic Flood Risk Management (SFRM) framework agreement.

3.17 The objectives of the Atkins study were to construct and calibrate a set of hydrodynamic models of the catchment, capable of accurately predicting inundation of the floodplain in extreme fluvial flood events, to use the models to simulate floodplain inundation for a range of different return period events, and to produce flood maps for the Environment Agency.

3.18 To meet these objectives eight one-dimensional (1D) hydraulic models were constructed for the catchment. Due to the size of the catchment it was not feasible to construct one detailed model to cover the entire study area.

Table 3 Hydraulic Model Developed for the River Wey Flood Mapping Study (Atkins 2006)

Model	Watercourses/reaches
Upper Wey	North Wey from Tilford to source, Farnham Bourne, Alton Stream, Lavant Stream, Caker Stream, and the South Wey from Tilford to Liphook
Middle Wey	Lower Wey from Tilford to Peasmarsh, and Elstead tributary
Lower Wey	Lower Wey from Peasmarsh to the River Thames, and the Send tributaries
Hoe Stream	Hoe Stream (this model was later developed by WBC as part of the FAS proposals for the Hoe Stream)
South Wey extension	South Wey from Liphook to Haslemere, Critchmere Stream, and Haslemere Stream
Farnham Park tributary	Farnham Park tributary
Frithend Brook	Frithend Brook
Oakhanger Stream	Oakhanger Stream

3.19 The hydraulic models were constructed using the iSIS software (version 2.3). The Upper Wey model was calibrated to flow and rainfall data collected in the catchment for four historic events. The Middle Wey model used data from three historic events. Four events were used to calibrate the Lower Wey model, and three for the Hoe Stream. The calibration process resulted in significant changes being made to the time-to-peak and standard percentage runoff values for each sub-catchment.

3.20 Hydrological inputs to the models were determined using the FEH Rainfall Runoff Method for 75 sub-catchments within the study reach: 35 on the Upper Wey (18 on the North Wey, 17 on the South Wey), 13 on the Middle Wey, 23 on the Lower Wey and 4 on Hoe Stream. Modelled sub-catchments in the Lower and Middle Wey are mapped in **Volume 3: Appendix B** of this SFRA. The parameter estimates for the Rainfall Runoff model, time-to-peak, standard percentage runoff and baseflow, determined from the catchment descriptors were adjusted using observed flood event data as part of the model calibration process. This data, combined with critical storm durations of 39 and 75 hours was used in the iSIS software package to determine flood flow estimates for the 1 in 5, 20 and 100 year return period events and the 100 + 20% (climate change) event.

Model boundaries

3.21 The extents of the separate models of the River Wey are listed in the Table 4 below. Only the Lower Wey models were adopted for use in this SFRA as the Upper and Middle Wey model extents do not fall within the SFRA Study Area.

Table 4 River Wey Hydraulic Model Extents

Model	Upstream Extent	Downstream Extent
Upper Wey	Alton (on the North Wey) and Liphook (on the South Wey)	Tilford
Middle Wey	Tilford	Peasmarsh
Lower Wey	Peasmarsh	River Thames

3.22 As multiple models were used to construct what is essentially one continuous river network, it is necessary to run the models in sequence in order to complete a simulation for the entire catchment. The downstream outflow from the Upper Wey model provides the top inflow for the Middle Wey model, and the Middle Wey and Hoe Stream downstream outflows provide inflows for the Lower Wey model. The Upper Wey model was not specifically re-run for this SFRA and therefore an inflow had to be generated representing the inflow normally provided by the Upper Wey model.

3.23 With the exception of the Lower Wey model, a conveyance boundary was used as the downstream boundary. These boundary types represent a combined channel and floodplain conveyance relationship and are able to be generated with the iSIS software. The boundary is calculated using channel gradient and roughness data and is based on the Manning's equation. These downstream boundaries are checked against the water levels to confirm the prevalence of normal flow conditions, where backwater effects were found to be present the downstream boundaries were modified.

3.24 The downstream boundary for the Lower Wey uses a peak level for a 1 in 5 year return period for the River Thames. This level was selected to be run with the 1 in 100 year and 1 in 1000 year runs as it was deemed that a large magnitude event in the River Wey would rarely coincide with an event of similar magnitude in the River Thames. This approach is consistent with that taken for the EA River Wey Flood Mapping Study.

Model Calibration and Verification

3.25 It is generally recommended that a hydraulic model is calibrated and verified using at least three flood events. The level of calibration undertaken is limited by the availability of appropriate recorded data.

3.26 The original iSIS models of the Wey and Hoe Stream produced by Atkins for the River Wey Flood Mapping Study were calibrated in two stages, the first stage undertaken for the Strategic Review Study and the second stage after the extension and revision of the models. There were three recorded events utilised for the calibration of the Lower Wey and three recorded events for the Hoe Stream. Each event represents a range of rainfall events and durations.

3.27 The results of the calibration showed that the modelled peak levels were generally within the Flood Mapping Specification target accuracy for level of ±150mm. The peak flow predictions were within -36% to +20% of observed values. These results were deemed satisfactory and to an acceptable level of accuracy for use in strategic flood risk assessments.

3.28 Further details of the calibration work carried out by Atkins are available in Section 5 of the River Wey Flood Mapping Study (Atkins, February 2006).

3.29 It should be noted that when the models were rerun as part of this SFRA the 1 in 1000 year design model could not be calibrated due to an absence of recorded events of this magnitude (unlike other design events modelled and calibrated for the Wey Flood Mapping Study). Therefore there remains a level of uncertainty related to the model outputs for this event.

Model Sensitivity

3.30 Sensitivity testing of the Wey and Hoe Stream models was carried out for the Wey Flood Mapping Study by Atkins. Changes in flow, channel roughness, storm duration, and the downstream boundary condition were tested. Flood levels were shown to be relatively insensitive and thus the model was deemed reliable.

3.31 Further details of the sensitivity testing carried out by Atkins are available in Section 8 of the River Wey Flood Mapping Study (Atkins, February 2006)

Methods for assessing flooding from rivers

3.32 The assessment of risk from fluvial (river) flooding in the Woking SFRA Study Area has been based on the Flood Zones as defined in PPS 25. The Environment Agency Flood Zones dataset has been used as a basis, further detailed information on the extent and distribution of flood risk within the zones and in particular the extent of the Functional Floodplain is presented later in this SFRA under the heading “detailed maps of river flooding”.

Flood Zones

3.33 The Environment Agency Flood Zone maps are available online for England and Wales. The Flood Zone maps show areas at risk of flooding from rivers or sea (without defences) and the extent of the extreme flood. These zones correspond with the three Flood Zones which are referred to in PPS 25 (Table D1) and are the starting point of the Sequential Test.

Table 5 Flood Zones Defined in PPS25, Table D1

Flood Zone	Definition
Flood Zone 1. Low probability	Land assessed as having a less than 1 in 1000 annual probability of river or sea flooding in any year (< 0.1%)
Flood Zone 2. Medium probability	Land assessed as having between a 1 in 100 and 1 in 1000 annual probability of river flooding (1% to 0.1%) or between a 1 in 200 and 1 in 1000 annual probability of sea flooding (0.5% to 0.1%) in any year.
Flood Zone 3a. High probability	Land assessed as having a 1 in 100 or greater annual probability of river flooding (> 1%) or a 1 in 200 or greater annual probability of flooding from the sea (> 0.5%) in any year.
Flood Zone 3b. Functional floodplain	Land where water has to flow or be stored in times of flood. SFRAs should identify this Flood Zone (land which would flood with an annual probability of 1 in 20 (5%) or greater in any year or is designed to flood in an extreme (0.1%) flood, or at another probability to be agreed between the LPA and Environment Agency.

3.34 The Flood Zones show the areas at risk of flooding from rivers and the sea and are a national dataset which is held by the Environment Agency and which was generally developed from JFLOW modelling.

3.35 The latest Flood Zones were obtained from the Environment Agency for use in this SFRA. Plans showing the **Flood Zones** are included ***Volume 3, Appendix B*** of this SFRA**.** The Flood Zone maps held by the EA are updated regularly and users of the SFRA should ensure they are aware of any updates since the SFRA was finalised.

Detailed information on river flooding

3.36 It is a requirement of PPS 25 that SFRAs refine information on the areas that might flood. The SFRA uses more detailed information on river flooding from available 1D hydraulic models to provide more information than is shown in the EA Flood Zones. The River Wey hydraulic model which is described earlier in this chapter is a more detailed hydraulic model than the national JFLOW model which was used to derive the EA Flood Zones. The River Wey model has been developed using surveyed channel and floodplain cross-sections and includes a representation of all the key hydraulic control structures (such as bridges, weirs and culverts) within the study area. These features would not have been included in the JFLOW model. The River Wey model can be used to provide predicted flood levels and velocities for nodes and channels in the model which can be processed to create detailed flood extents.

3.37 Plans showing the more detailed information on river flooding are included in ***Volume 3, Appendix C*** of this SFRA**.**

3.38 Within this SFRA the results from a number of simulations of the 1D iSIS models were used with the aim of producing the maximum flood extents for the 1 in 20, 1 in 100 year and 1 in 1000 year return period flood events to provide more detailed information on river flooding. Within the Study Area there are no significant defence structures present and hence there was no requirement to modify the model from its existing state.

3.39 Simulations carried out by Atkins for the River Wey Flood Mapping Study were aimed at defining the 1 in 100 year flood outline for existing geometry. The outline produced by Atkins for the River Wey Flood Mapping study has been adopted unchanged to provide more detailed information on the risk of flooding in Woking for this SFRA. The flood extents produced by BTP-Hyder have been used to provide more detailed information on the risk of flooding for the Hoe Stream.

3.40 To aid in defining the functional floodplain within the study area, the 1 in 20 year flood event was extracted from the Wey and Hoe Stream models. The resulting flood extent has been mapped with the 1 in 100 year flood extent in ***Volume 3, Appendix C*** of this SFRA .

3.41 Where modelled flood extents were not available, i.e. on small un-modelled tributaries, EA Flood Zone 3 has been used as a substitute for more detailed flooding information. In these areas, no climate change or 1 in 20 year flood extents are available.

3.42 Model simulations of the 1 in 1000 year return period flood event were completed as part of this SFRA to define a comparable flood extent to the modelled 1 in 100 year return period flood extent, and as such indicate areas at risk of flooding in an extreme event. The extent of flooding in this extreme event is also mapped in ***Volume 3, Appendix C*** of this SFRA . Where modelled flood extents were not available, i.e. on small un-modelled tributaries the EA Flood Zone 2 has been used as a substitute for more detailed information.

3.43 As no formal flood defences have been identified within the Study Area there is no residual risk of flooding as a consequence of defence overtopping or failure.

Climate Change

3.44 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. Defra expects this note to be applied to all future appraisals, strategies and management plans that have started after November 2006.

3.45 The guidance is referred to in PPS25 Annex B where it states that '…the most up to date guidance on climate change…should be considered in the preparation of Regional Flood Risk Assessments, Strategic Flood Risk Assessments…'.

3.46 The latest guidance recommends a 20% increase in flows is used to assess the impacts of climate change on rivers for time horizons between 2025 and 2115. Climate change 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.

3.47 The impacts of climate change were also assessed as part of this assessment. Climate change has been accounted for by adding an additional 20% to model inflows and re-running the model simulations. The resulting peak flood envelope is displayed with the 1 in 100 year return period envelope in ***Volume 3, Appendix A***.

3.48 For small tributaries where modelled information was not available there is no further detailed information on the predicted impacts of climate change. The detailed maps show the EA flood zone 2 for these areas and in the absence of any more detailed information this should be used as an indication of the possible impacts of climate change.

Flood Hazard

3.49 The predicted flood levels from the 1d hydraulic model used to inform the Woking SFRA have been processed to show the predicted flood depth across the study area for the 1 in 100 year return period flood event. This process is undertaken in a GIS platform by first creating a grid of the predicted flood level in this event and then subtracting the DTM from this flood level grid to produce a grid showing the predicted flood depth for this event.

3.50 The predicted flood depth for the 1 in 100 year return period flood event is shown in figures in ***Volume 3, Appendix D*** of this SFRA.

3.51 Detailed hazard mapping would usually combine flood depth information with information on the velocity of flow and also the amount of debris carried by the water, however this information (detailed velocity-depth mapping) is not available in Woking and until this detailed information becomes available the SFRA provides information on flood depth only which can be used as a proxy measure for hazard. This depth mapping is useful to Woking Borough Council as it provides a greater level of detail than shown in the EA Flood Zones, ***Volume 3, Appendix B***, or the flood extent mapping in ***Volume 3, Appendix C***, on the hazard to people in this flood event. The flood depth mapping provides information on the distribution of flood risk within the high risk zone (Flood Zone 3) which can be used by WBC and developers in applying a sequential approach to the allocation of sites and to the layout of sites in high risk areas. Furthermore, this mapping provides information which can be used in the application of the Exception Test (where necessary) to assess the safety of particular sites for proposed development.

3.52 The Defra/EA report, “Flood Risk Assessment Guidance for New Development” (FD2320) provides further guidance for developers on the use of this detailed information in the assessment of flood risk at specific sites. Table 6 is a reproduction of Table 13.1 from the Defra/EA FD2320 report which can be used as a ‘look up’ table to determine the danger to people based on different combinations of depth and velocity.

Table 6 Danger to People for different combinations of Depth and Velocity (from Table 13.1 FD2320)

Velocity (m/s)	Depth of flooding (m)											
	0.05	0.10	0.20	0.30	0.40	0.50	0.60	0.80	1.00	1.50	2.00	2.50
0.00				Yellow	Yellow	Yellow	Orange	Orange	Orange	Orange	Red	Red
0.10				Yellow	Yellow	Orange	Orange	Orange	Orange	Orange	Red	Red
0.25				Yellow	Orange	Orange	Orange	Orange	Orange	Red	Red	Red
0.50				Orange	Orange	Orange	Orange	Orange	Orange	Red	Red	Red
1.00			Yellow	Orange	Orange	Orange	Orange	Red	Red	Red	Red	Red
1.50			Yellow	Orange	Orange	Orange	Red	Red	Red	Red	Red	Red
2.00		Yellow	Yellow	Orange	Orange	Red	Red	Red	Red	Red	Red	Red
2.50		Yellow	Yellow	Orange	Red	Red	Red	Red	Red	Red	Red	Red
3.00		Yellow	Yellow	Red	Red	Red	Red	Red	Red	Red	Red	Red
3.50		Yellow	Orange	Red	Red	Red	Red	Red	Red	Red	Red	Red
4.00		Yellow	Orange	Red	Red	Red	Red	Red	Red	Red	Red	Red
4.50	Yellow	Yellow	Orange	Red	Red	Red	Red	Red	Red	Red	Red	Red
5.00	Yellow	Yellow	Orange	Red	Red	Red	Red	Red	Red	Red	Red	Red

Key

Danger for some (yellow)
Danger for most (orange)
Danger for all (red)

Results

Historical flooding

3.53 The River Wey Strategic Review (March 2006) commissioned by the Environment Agency states that large widespread flooding occurred in the Wey Catchment on the following dates:

- February 1900
- January 1928
- September 1968
- December 1979
- February 1990
- October – November 2000
- December 2002 – January 2003
- August 2006

3.54 The largest event on record is September 1968, for which widespread and severe flooding was documented, however little reliable information on flood levels or flows are available for this event. The second largest event on record occurred during October and November 2000. For this event accurate information on levels and flows within the catchment is available, and was utilised in the calibration of the Wey and Hoe Stream Models produced for the Wey Flood Mapping Study commissioned by the EA. During this event flooding is known to have occurred within the study area including within the urban areas of Woking and Byfleet.

July 2007 Flooding

3.55 On the 20th July 2007 Woking and the surrounding areas experienced heavy downpours, with several weeks worth of rain falling within a matter of hours. This resulted in some severe flooding in the area.

3.56 The majority of the flooding was caused by surface water runoff, with the drains unable to cope with the excess water on the roads. The amount of surface water runoff flowing into the drains was so much that Surrey's deputy member for transport even stated that "No drainage system in the world would have coped with that."

3.57 The River Bourne was also reported to have burst its banks early on Friday (20/07/07), causing heavy pockets of flooding in the area around Chobham (outside of the Woking Council boundary).

3.58 The Rive Ditch, which flows from Horsell Common to the River Wey and straddles the boundaries of the boroughs of Woking and Runnymede, was reported as being a problem area during this flood event. A blockage in the grill located just before the ditch passes under the canal resulted in the area near the ditch becoming flooded.

Flood Zones

3.59 The Environment Agency Flood Zones shown in ***Volume 3, Appendix B*** show that there are areas within the Woking SFRA study area which are within Flood Zones 2 and 3 and have a medium or high probability of flooding. Most of the main urban centre of Woking is shown in Flood Zone 1 and has a low probability of flooding.

3.60 Land along the south-eastern boundary of the study area which lies within the floodplain of the River Wey is shown on the maps to be in Flood Zone 3 with a high risk of flooding. In this area there is little difference between the extents of Flood Zone 2 and 3. This area which is considered to have a high probability of flooding is mostly non-developed but does include parts of South Woking including Westgate and Old Woking.

3.61 Land within Woking and to the south and west of the town is also indicated as being within Flood Zone 3 and has a high probability of flooding from the Hoe Stream and tributaries. This area which is shown on the map as having a high probability of flooding includes residential areas of the town.

3.62 To the north east of Woking a significant area of Byfleet is shown on the EA Flood Zone maps as having a medium or a high risk of flooding from the River Wey. The area at risk of flooding includes both residential and industrial parts of the town and is shown to cover key infrastructure routes in the area.

Detailed information on river flooding

3.63 The maps in ***Volume 3, Appendix C*** show more detailed information on the predicted extent of flooding in four scenarios:

- 1 in 20 year return period flood event (Functional Floodplain);
- 1 in 100 year return period flood event;
- 1 in 1000 year return period flood event; and
- 1 in 100 year return period flood event including an allowance for climate change.

3.64 The extent of flooding shown in the detailed plans in ***Volume 3, Appendix C*** and ***Volume 3, Appendix D*** is different in places to flood extents shown in the Environment Agency Flood Zones in ***Volume 3, Appendix B***. The plans in ***Volume 3, Appendix C*** and ***Volume 3, Appendix D*** are based on a more detailed hydraulic model and provide a greater level of detail than that shown in the EA Flood Zones. The EA Flood Zones shown in ***Volume 3,***

Appendix B form the starting point of the Sequential Test to be applied by Woking Borough Council and should be used before moving onto the more detailed information shown in ***Volume 3, Appendix C*** and ***Volume 3, Appendix D***.

3.65 Within the study area much of the land at risk of flooding from rivers is limited to rural/farmland areas, many of these areas are Greenbelt and are unlikely to be subject to significant development pressures. Existing, developed areas, which are more likely to be subject to redevelopment or future new development, are considered within the SFRA and the SFRA maps allow the consideration of flood risk to these areas when allocating land for future development.

3.66 The predicted flood extents shown in ***Volume 3, Appendix C*** indicate that the floodplain of the River Wey which forms the south-east boundary of the study area is quite wide in places. The predicted extent of flooding in the 1 in 20 year return period event (functional floodplain) is often similar to the predicted extent of flooding in the 1 in 100 year return period flood event indicating that the flood extent is reasonably well confined. Thus most of the area at high risk of flooding would also be considered to be functional floodplain.

3.67 For much of its length through the study area the functional floodplain is generally undeveloped however small parts of residential areas of the town (Westfield and Old Woking) may be affected by flooding in the 1 in 20 year return period event. Other areas in Westfield (south Woking) are predicted to be affected by flooding in the 1 in 100 year return period event on the Hoe Stream.

3.68 The detailed maps show that parts of south and east of Byfleet are at risk of flooding from the River Wey in the 1 in 100 year return period event. The predicted extent of flooding increases in this area as a consequence of climate change and when the 1 in 1000 year event is considered the extent of flooding is significantly increased. It is important to recognise that in the Byfleet area future changes in climate may lead to a significant increase in the number of properties at risk from flooding. In this area (Byfleet) issues with the EA flood outline for the 1 in 100 and 1 in 100 + climate change event have been recognised. It is suggested that until these issues are resolved and revised flood outlines are available for this area the 1 in 1000 year outline is used to indicate areas which may be impacted in future as a result of climate change.

3.69 There are other residential areas predicted to be at risk of flooding from tributaries of the River Wey. These tributaries are typically unmodelled and no detailed information on fluvial flood risk is available on these small watercourses. In these areas the SFRA relies on the EA Flood Zones to define the level of risk in these locations. Flood Zone 3 should be taken to represent the area that may be Functional Floodplain – unless further detailed modelling of the 1 in 20 year floodplain is provided at a future date. Flood Zone 2 should be used as an indication of the area which may be impacted by the 1 in 100 year flood event in the future.

3.70 Within the Study Area there are areas of existing development considered to be at risk of flooding in an extreme flood scenario (1 in 1000 year return period). The flooding mechanisms and extents in this extreme event are similar to those for the 1 in 100 year return period due to the generally well defined floodplain topography. The most notable exceptions to this, which impact on existing developments, are Byfleet Town centre and surrounding residential areas and many areas of the Hoe Stream floodplain.

Climate change

3.71 The potential impacts of climate change have been assessed and the predicted extents of flooding taking account of the potential impacts of climate change are shown in ***Volume 3,***

Appendix C. This resulted in a significant extension of the floodplain in some areas, however due to the generally well defined river valleys and floodplains which exist on many of the watercourses, the increase in flows resulting from climate change has had a minimal impact on the flood extent in the study area.

3.72 It is important to recognise that in the Byfleet area future changes in climate may lead to a significant increase in the number of properties at risk from flooding. In this area (Byfleet) issues with the EA flood outline for the 1 in 100 and 1 in 100 + climate change event have been recognised. It is suggested that until these issues are resolved and revised flood outlines are available for this area the 1 in 1000 year outline is used to indicate areas which may be impacted in future as a result of climate change.

Flood Depths

3.73 As shown in Table 6, guidance in the Defra/EA R&D Report: Flood Risk Assessment Guidance for New Development (FD2320) suggests that in standing water (velocities of 0m/s) flood depths greater than 0.3m would be considered dangerous for some people (including children and the elderly), depths between 0.6m and 1.5m would be considered dangerous for most people (including the general public) and depths greater than 1.5m would be considered dangerous for all (including the emergency services).

3.74 The plans in ***Volume 3, Appendix D*** indicate that on the basis of the above classification there are significant areas within the Woking SFRA study area where the potential depth of flooding in a 1 in 100 year return period flood event are greater than 0.6m and would be considered dangerous to most people.

3.75 Much of the areas predicted to experience a significant depth of flooding (more than 0.5m) in this event are on undeveloped floodplain, however there are places where areas with a predicted depth of flooding greater than 0.5m coincide with urban areas where there are landuses and populations which are vulnerable to the impacts of flooding. This includes parts of Byfleet and Westfield (south Woking).

3.76 Flood hazard is generally defined as a combination of flood depth, flow velocity and debris. The flood depth information presented in the SFRA does not take into account the predicted velocity of floodwaters in this event. Fast flowing water will present a greater hazard to people than standing water.

Uncertainty in flood risk assessment

3.77 When assessing risk, the impact of uncertainties associated with the predictions of the flood hazard and the consequences should be recognised and appreciated so informed decisions can be made.

3.78 This SFRA addresses the inherent uncertainties and where necessary seeks to institute measures for their reduction.

3.79 The strategy for risk management requires that all phases of the planning and implementation process are fully co-ordinated. The level of detail on flood risk assigned to particular proposals will be limited by the information available at the time of the submission of respective planning applications. It should be noted that the outputs of the SFRA are only as good as the data inputs.

3.80 The Woking SFRA should be kept as a live document, reviewed and updated as necessary as the best available information is improved or the inherent uncertainties identified are reduced. In particular it should be noted that an improvement in topographic data may result in a change in the flood extents presented in this SFRA. The implementation of measures or strategic options may change the magnitude and distribution of flood risk within the study area.

Generic Risks and Uncertainties

3.81 Following a review of the available baseline information it has been possible to identify the following principal elements that contribute to the uncertainty in the quantification of the flood risk in the Study Area:

i. The flows predicted using the hydrological analyses for the River Wey rely on data from a system of gauges that are generally not accurate at high flow magnitudes;

ii. The impact of global warming could result in an increase in the magnitude of predicted peak flow contributions to the watercourses within the Study Area;

iii. Best available topographic data was used in production of the flood extents. However this topographic data is of limited accuracy due to the techniques used for its production. This has a significant bearing on the uncertainty and accuracy of the flood mapping produced; and

iv. Not all watercourses in the Study Area have been specifically hydraulically modelled for this SFRA. Quantification of flood risk on these watercourses is subject to greater uncertainty.

3.82 It was not possible to calibrate the River Wey hydraulic model for the 1 in 1000 year return period design event, although the calibration factors derived for lower return period events have been preserved into the current assessment. Therefore there remains a level of uncertainty attached to the modelled outputs for this event.

3.83 There is a wide envelope of ‘fixed base’ uncertainty attached to the estimation of risk. It should be accepted that adopting a precautionary approach throughout the process could either result in the implementation of excessive flood management proposals that envisage an event that is unlikely to be witnessed or the specification of defences at locations where the standard of protection is compromised as a consequence of provision of revised data. Different standards of risk may also be assigned to adjacent sites simply as a consequence of the timing of the application and the values obtained from the best available information at a particular time. To be consistent with current guidance a precautionary approach is adopted together with recognition of the need to review the results as circumstances change.

3.84 It is probable that development proposals will be a focus for the collection of better data in the future and the catalyst for commissioning studies that lead to a reduction in the uncertainty in the magnitude or frequency of influential parameters, i.e. the improvement of hydrometric data, or completion of new hydraulic models on previously unmodelled reaches. A prudent response is to use the best available data at each stage of the planning process and prepare proposals that are respectively precautionary in accordance with the advice in PPS 25 and flexible with respect to uncertainty. The need to prepare stand alone Flood Risk Assessments in support of the submission of particular planning applications will serve to highlight information that would be the trigger for a review of the Woking SFRA.

3.85 The Woking SFRA is based on information that will inevitably be amended by better data, changes in the baseline condition due to development and changing institutional and policy conditions. To be robust and able to withstand challenge in the planning process there is a need to ensure the Woking SFRA reflects conditions at the time particular evaluations are made. Failure to maintain the SFRA may reduce the effectiveness of flood risk management measures; delay plan making and development processes; and potentially lead to the neglect of flood risk considerations and the failure to capture strategic responses and interventions.

3.86 The Planning Policy Teams at WBC have the prime responsibility for managing and maintaining this SFRA. The SFRA will be reviewed annually as part of the annual monitoring report.

Managing flooding from rivers

3.87 In the Woking area fluvial flood risk is not a widespread issue, however there are areas where the risk of fluvial flooding is high and where this risk may reasonably be expected to increase in the future due to the impacts of climate change. Where these areas coincide with existing development or with areas of planned future development there may be a need to manage flood risk.

3.88 In Woking areas where flood risk management are most likely to be a consideration are along the Hoe Stream, in Byfleet and on the southern edges of Old Woking.

3.89 Flooding from rivers can be managed in a number of ways, including:

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

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

3.91 Regional policy relating specifically to Woking Borough, takes the form of several plans and strategies. Key documents to consider are the Thames Catchment Flood Management Plan and the Wey Strategic Review.

3.92 Catchment Flood Management Plans (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 (Defra) strategy for flood and coastal defence.

3.93 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.

3.94 The Thames Catchment Flood Management Plan outlines the preferred approach to the future management of flood risk in various areas of the Thames catchment. For the Woking catchment, which largely contains undeveloped natural floodplain, the preferred option within the CFMP is to use the natural features of the floodplain to retain water during flood events.

3.95 Although there are plans to establish defences to protect areas currently at risk, (such as areas on the Hoe Stream) the priority will be to prevent development that works against the approach of maintaining and possibly maximising the potential of the floodplain to retain water.

This management plan is likely to be reflected in the Local Development Framework which is currently being developed.

3.96 The Thames CFMP is a high level strategic planning tool for the fluvial part of the Thames and its tributaries. As such it will not provide the same level of detail relating to the Wey and Hoe Stream catchments as this SFRA, however the CFMP does provide a number of key messages for the Thames catchment, which are important to consider in local planning policies. These include:

- It is not sustainable to build defences to protect all of the people and properties at risk of flooding;
- Climate change will be a major cause of increased flood risk in the future;
- Many floodplains in the Thames Region have no flood defences and can serve their natural function of storing water during times of flood; and
- Development and urban regeneration provides a crucial opportunity to manage flood risk.

The Wey Strategic Review and Flood Risk Mapping Project, Environment Agency

3.97 The purpose of the Wey Strategic Review was to build on the recommendations made in an earlier inception report, which recommended the building of hydraulic models to assess the strategic flood management options for the catchment, and to extend the knowledge of catchment flood processes. The Wey Strategy will in the majority echo the aims of the Thames CFMP ‘message’ for developed floodplains with no built defences. This will be locally adapted as and when defences are constructed for the Hoe Stream (see below).

3.98 The analysis for the Wey Strategic Review involved the building of hydraulic models of critical watercourses in the Wey catchment. A subsequent review of results took place to assess the strategic options available for the catchment. The key recommendations were:

- Independent conveyance schemes for Farnham and Woking may be progressed as they do not conflict with a strategic approach to flood risk management for the catchment.
- Upstream storage, could provide significant flood alleviation to Old Woking and Byfleet.
- To consider the adaptation of the current hydraulic models for the development of flood forecasting models.
- To improve the River Wey gauging network and aid in the development of future flood forecasting models.

Hoe Stream Strategy

3.99 In response to the identified risk of flooding on the Hoe Stream, Woking Borough Council has commissioned a detailed feasibility investigation into a flood defence scheme to protect as many properties as possible in the Hoe Valley. As the majority of the houses at risk of flooding ware known to be in the section of river between Bonsey Lane footbridge and St John the Baptist School, this was chosen to be the first phase of the study. This work has been undertaken in close consultation with the Environment Agency, working to the latest development guidelines and standards.

3.100 The proposed flood defence scheme will provide a 1% Standard of Protection to 198 residential properties. In addition other benefits of the Woking Borough Council Hoe Valley Project include the relocation of ten community buildings to improved premises.

3.101 The creation of flood defences is not the end to flood risk management in this reach. Once completed, redevelopment behind the defences must be carefully managed to reduce the consequences of any failures or over topping of the defences. The non-defended floodplain along the rest of this reach, upstream and downstream and mostly rural, will also need additional focus in order to ensure its ability to store floodwater is retained and where possible improved.

River Wey

3.102 No structural flood defence schemes are proposed in this reach. Flood Risk Management is therefore best carried out through the combination of maintenance, spatial planning and flood warning.

3.103 The Thames CFMP explains how floodplain management is a sustainable way of managing flood risk in this reach and can play a major part in reducing the consequences of flooding. In terms of applying this management to the developed floodplain, most of the properties at risk are well established and the scale of re-development is likely to be small over the next few decades. Despite this, Planning Policy Statement 25 and Strategic Flood Risk Assessments provide greater potential for flood risk reductions through spatial planning over the same period. The spatial planning approach should seek to remove vulnerable development from the floodplain and replace with lower vulnerability land uses. Re-development should use flood resilient construction to minimise the consequences of flooding.

3.104 Raising awareness of flooding and the role of flood warning is important in this reach and can play a vital role in reducing the consequences of flooding. In addition, the role of maintaining the current system for conveying water through the catchment to the Thames needs to be maintained by:

- Current maintenance regime and statutory sediment removal to continue.
- Environment Agency weirs to be maintained and replaced as identified.

3.105 The delivery mechanism for flood risk management on the Wey at Woking will be a combination of improving awareness of flooding, and a more focussed approach to spatial planning through the use of strategic flood risk assessments to best comply with the aims of PPS25. This will be achieved by greater consideration being given to the river Wey in the urban area through promoting appropriate land uses and building design.

3.106 Promoting greater awareness of flooding and increasing the number of at-risk people subscribing to the flood warning service is of great importance in this location.

References

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Defra/Environment Agency Flood and Coastal Defence R & D Outputs: Flood risk Assessment Guidance for New Development, FD2320, March 2006.

Communities and Local Government (2008) 'Practice Guide to PPS25' A consultation paper, June 2008

Communities and Local Government (2006) 'Planning Policy Statement 25: Development and Flood Risk' , December 2006

4 Flooding from Land, Surface Water, Sewer and SUDS

4.1 This Chapter considers the risk of flooding from land, surface water and sewers and the management of this source of flooding through the use of Sustainable Urban Drainage Systems (SUDS). The assessment of risk has been divided into two sections:

- Flooding from land and surface water
- Flooding from sewers

4.2 The recommendations for managing flood risk and the planning considerations for these sources of flood risk have been considered together to close this chapter.

Flooding from Land and Surface Water

Description

4.3 Flooding from land 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. Surface water runoff can cause localised flooding in natural valleys and in natural low spots where water may collect or where normally dry areas become inundated.

4.4 Surface runoff in catchments is directly related to the size and shape of the basin. The amount of runoff is also a function of geology, slope, climate, rainfall, saturation, soil type, urbanisation and vegetation. Geological considerations include rock and soil types and characteristics, and the 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.

Causes and classifications

4.5 Distinguishing between flooding from land and flooding from groundwater can be complicated. Rainfall that infiltrates into the soil but resurfaces further down the hill is classified as surface water. The water in lakes, marshes and reservoirs is also classified as surface water. 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.

4.6 Flooding from land can occur in rural and urban areas, but usually causes more damage in the latter. Flood pathways include the land and water features over which floodwater flows. These pathways include drainage channels, rail and road cuttings. Flood management infrastructure can also serve as a flood pathway. Developments that include significant impermeable surfaces, such as roads and car parks may increase the occurrence of surface water runoff. Urban areas usually have extensive drainage or sewer systems.

4.7 Developments which are close to artificial drainage systems, or located at the bottom of hillslopes, in valley bottoms and hollows, may be more prone to surface water flooding. This may especially be the case in areas that are downslope of land that has a high runoff potential including impermeable areas and compacted ground.

Impacts of surface water flooding

4.8 Surface water flooding can affect all forms of the built environment, including:

- Residential, commercial and industrial properties;
- Infrastructure, such as roads and railways, telecommunication systems and sewer systems;
- Agriculture;
- Amenity and recreation facilities.

4.9 Flooding from land 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 the typically short duration, flooding from land tends not to have as serious consequences as other forms of flooding, such as flooding from rivers or the sea.

4.10 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 (Defra 2004).

Data collection

Sources of data

4.11 Data collected to assess flooding from land in this SFRA has included geology, soil, landcover, and digital terrain data.

Records of Historic Flood Events

4.12 Historical flooding records have been supplied by Thames Water and indicate that there have been several incidents of flooding occurring due to the overloading/surcharging of surface water and combined sewers. It appears that flooding as a result of these incidents has previously occurred in the eastern side of the study area, predominantly in the area of Westfield and the southern part of Woking town centre although the data available is not sufficient to pinpoint specific locations where flooding of this type has occurred.

4.13 Historical records of flooding can be useful in determining areas where the sewers are often close to or may be exceeding capacity. It is recommended that the maps showing historical flooding ***Volume 3, Appendix E*** are referred to when assessing sites for allocation or in the development of specific proposals. Where the risk of surface water flooding can not be eliminated as part of the development it may be appropriate to consider an alternative, lower risk location for development.

4.14 The Environment Agency have provided information relating to the July 2007 flood event and reported incidents in and around the borough of surface water flooding occurring. The majority of the flooding at this time was caused by surface water runoff, with the drains unable to cope with the excess water on the roads. Surface water flooding was observed at the following locations during this event:

- Walton Terrace (Maybury)
- Princess Road (Maybury)
- Rectory Lane (Byfleet)
- Station Road (Byfleet)

- Morton Close
- Boundary Road (Maybury)
- Sopwith Drive (Byfleet)
- Blackhorse Road
- Lockfield Drive
- West Byfleet

4.15 The Rive Ditch, which flows from Horsell Common to the River Wey and straddles the boundaries of the boroughs of Woking and Runnymede, was reported as being a problem area during this flood event. A blockage in the grill located just before the ditch passes under the canal resulted in the area near the ditch becoming flooded.

Existing studies

4.16 Currently no single government body is responsible for monitoring or responding to surface water flood events. 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 surface water.

4.17 As a consequence, Defra have instigated a series of investigations into flooding from other sources (Defra 2006). The research project aims were to:

4.18 …'*assess the feasibility of mapping flood risk from different types of flooding (including overland flow), together with the practicalities of implementing flood modelling methods considered for the significant types of flooding*'.

4.19 The research project identified that the greatest barrier to producing accurate flood risk maps for other sources of flooding was:

- The availability of data for ground-truthing in consistent and useable formats.

- The modelling methods required to capture all the observed processes were complex and may not be realistic in the immediate future. Furthermore while there is a general understanding of the causes of flooding from land, the location, timing and extent were difficult to predict because of the poorly understood processes, localised nature of drivers of flooding and lack of available datasets.

4.20 No existing assessments of flooding from overland flow or surface water runoff appropriate to the scale of the SFRA were identified.

Assessment of flood risk

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

4.22 A large percentage of the Study Area is currently undeveloped, therefore surface water runoff and drainage is relatively unchanged from the Greenfield condition in the more rural areas. There are areas within the study area which have experienced heavy urbanisation over the past century; the most intensive existing development being the urbanised centre of Woking and its associated suburbs, and Byfleet.

4.23 Surface water runoff from these developed areas is likely to result in increased water levels within the River Wey compared to the natural catchment river levels. Although this has not been quantified, it is generally accepted that a positive drainage system associated with development increases the peak flow rate from a development area and therefore in the receiving watercourses. Sustainable Drainage systems can reduce this impact.

4.24 The ground conditions (underlying geology) in Woking is predominantly clay and marl (a type of mudstone) with some areas of more sandy rocks and with deposits of river terrace gravels in the valley bottoms. Clay is naturally very impermeable and as a result even in undeveloped areas the amounts of runoff are relatively high.

4.25 The public sewer network is managed by Thames Water and drains surface water within the study area. All surface water within the study area ultimately discharges to the River Thames via the River Wey.

4.26 Only limited records of past incidents of surface water flooding exist. It is recommended that Woking Borough Council seek to improve record keeping in relation to surface water flooding incidents that are reported to them and that WBC and the Environment Agency work together to ensure information on any future surface water flood incidents recorded by the EA are provided to WBC and included in future revisions of the SFRA.

Climate change

4.27 There is no research which specifically considers the impact of climate change on surface water flooding in this study area. Nationally, 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. Table 7 shows the predicted increases in rainfall intensities expected as a result of climate change.

Table 7 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%**

Source: Defra FCDPAG3 Economic Appraisal Supplementary Note to Operating Authorities – Climate change Impacts, October 2006 (reproduced in PPS25).

4.28 In the absence of certainty, Planning Policy Statement 25: Development and Flood Risk, (PPS25) advocates 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 SFRA is reviewed appropriately.

Uncertainty in flood risk assessment

4.29 The causes of flooding from land are generally 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.

4.30 There is a lack of reliable measured datasets and the estimation of AEP for flood events is therefore difficult to verify. Strategic studies tend to present the incidents of flooding from land, rather than undertake frequency analyses.

4.31 The impact of climate change on this type of flooding is uncertain and likely to be very site specific. More intense short duration rainfall and higher more prolonged winter rainfall are likely to exacerbate flooding in the future. In the Woking dense urban areas will likely increase the potential for significant increases in runoff.

Flooding from Sewers

Description

4.32 Flooding from foul and combined sewers occurs when rainfall exceeds the capacity of networks or when there is an infrastructure failure.

Causes of sewer flooding

4.33 The main causes of sewer flooding are:

- Lack of capacity in sewer drainage networks due to original under-design.
- Lack of capacity in sewer drainage networks 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.

Impacts of sewer flooding

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

4.35 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, which are often exacerbated by topography, as water from surcharged manholes will flow into low-lying urban areas.

4.36 The modification of watercourses into culverted or piped structures can result in a reduced capacity. Excess water may be sent along unexpected routes as its original channel is no longer present and the new system cannot absorb it.

4.37 Whilst an area affected by sewer flooding is often localised, the quality of water can be poor. Flooding of combined sewers can lead to contaminated water entering properties and watercourses. This form of flooding has adverse health implications for the local population. If this kind of flooding happens on a regular basis the spread of illness and disease are also a risk.

4.38 Sewer flooding is likely to have a high concentration of solid, soluble and insoluble contaminants. This can lead to a reduction in the environmental quality of receiving watercourses. Flooding of contaminated land (such as landfills, motorways, and petrol station forecourts) will transport contaminants such as organics and metals to vulnerable receptors if the respective drainage systems are not designed to treat the water. The dense urban nature of the Woking area heightens the impact that sewer flooding may have on surrounding properties and population.

Data collection

Records of historic flood incidents

4.39 Information regarding the number of properties flooded by surface water, foul water and combined sewers between 1997 and 2007 was supplied by Thames Water and is shown within ***Volume 3, Appendix E*.** The flooding information is extremely broad scale as the data supplied referred to wide ranging postcodes (e.g. GU21 2_{xx}) which resulted in 22 separate areas within the Borough being identified. The following sections summarise this historical flooding information supplied by Thames Water and is mapped in ***Volume 3, Appendix E* .**

Data Processing

4.40 There are many causes of sewer flooding and therefore information on the cause is required to determine whether the probability of re-occurrence is high. Unfortunately this level of detailed information is not currently available from Thames Water as this information is considered commercially sensitive. The information presented in the maps in ***Volume 3, Appendix E*** of this SFRA is the most specific and detailed available and is not sufficient to highlight specific areas which may be at risk of sewer flooding.

4.41 It is recommended that Woking Borough Council liaise with Thames Water to try and obtain more specific information on sewer flooding in the future and use this data to update future revisions of the SFRA. Until this data is available the maps in Appendix E of this SFRA should be used to identify broad where sewer flooding may be an issue and any proposals for development in these areas should consider local factors which may effect the incidence and hazards associated with sewer flooding.

Methods for assessing flooding from sewers

4.42 Currently Environment Agency Flood 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.

4.43 As the SFRA 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 three most appropriate methods for assessing the risk of flooding from sewers within the SFRA are:

- Review of historical data - qualitative review of areas at risk and/or GIS analysis to create a buffer zone around locations of known risk. This method was used during the SFRA.
- Reference to existing studies carried out by water companies, the Environment Agency and private developers. No studies of this kind were provided during the SFRA.

- Urban drainage modelling – modelling of the urban drainage network to determine locations likely to flood. Historically urban drainage models have been unable to provide a representation of the integrated impact of different flood mechanisms (i.e. river flooding with sewer flooding), however software packages such as TUFLOW are now able to jointly model these sources. This type of analysis is considered too detailed for the requirements of a SFRA.

4.44 The results of the data review and mapping in ***Volume 3, Appendix E*** should be viewed with caution as the sewer network is constantly being maintained, upgraded and improved. Thus flooding issues may be relatively short lived (<10 years).

4.45 The effects of sewer flooding are relatively local and because of the very short lead times typically there is little warning of surface water or sewer floods. If identified by the Environment Agency or the water company as a major risk, sewer flooding will need to be assessed in greater detail in individual flood risk assessments.

Climate Change

4.46 Climate change is expected to impact sewer flooding as a result of increases in rainfall intensity. An increase in rainfall intensity is likely to increase the volume of surface water runoff in a storm event. This will in turn increase runoff reaching the sewer network causing sewers to surcharge more frequently than currently experienced. This may require the upgrading of existing infrastructure to maintain the same level of service and for new infrastructure to be designed with greater capacities. . Table 7 (above) shows climate change predictions for increasing rainfall intensities, taken from PPS 25 which may influence the risk of sewer flooding in the future.

Results

Surface Water Sewers

4.47 The results show that the majority of properties reported to have been flooded over the 10 year period from overloaded surface water sewers are located within Westfield, the southeast corner of Woking town centre and eastern side of Mayford. This area all comes under one postcode area and because of data limitations it is not possible to say whether the nine accounts of flooding from overloaded surface water sewers in this area in the last ten years are related to one or many issues. For example there may have been 1 incident which has occurred repeatedly, or there may be 9 independent and unrelated incidents.

4.48 The areas of Byfleet, West Byfleet and Sheerwater, each have two recorded incidents of flooding from overloaded surface water sewers. Other areas to have been affected by a single reported account of flooding from overloaded surface water sewers are central Woking and Pyrford.

4.49 Woking Borough Council and Environment Agency records of surface water flooding show a small concentration of recorded events in Byfleet (4 incidents) but other than that small cluster recorded surface water flooding incidents are distributed across the Woking Borough Council area **(*Volume 3, Appendix E*, E5)** This is as likely to be a reflection of the fact that very few surface water flood incidents have been recorded than a true reflection of the pattern of surface water flooding in Woking.

Foul Water Sewers

4.50 Flooding from overloaded foul water sewers appears to have occurred more often in the past ten years. The worst affected areas are Sheerwater with ten recorded incidents and Anninglesy Park (the area slightly to the north of Sheerwater) which has nine recorded incidents of flooding from overloaded foul water sewers in the past ten years. Other areas to have been affected are the areas of Horsell and West Byfleet which each have six recorded incidents.

4.51 There are several other areas throughout the study area that have also been affected by the overloading of foul water sewers, these include (in order of magnitude) Pyrford, Woking town centre, Hook Heath, Westfield and Knaphill.

Combined Sewers

4.52 Flooding from overloaded combined sewers is localised to areas that have a sewer network of combined sewers as the majority of the study area has individual surface water and foul water sewers. Areas that have recorded incidents of flooding from overloaded combined sewers include Mayford, Westfield, West Hill and the southeastern corner of Wisley, all of which have four recorded incidents apart from Wisley which only has one.

Uncertainties in flood risk assessment

4.53 Assessing the risk of sewer flooding over a wide area is limited by lack of data and the quality of data that is available. Furthermore, flood events may be a combination of surface water, groundwater and sewer flooding.

4.54 An integrated modelling approach is required to assess and identify the potential for sewer flooding but these models are complex and require detailed information. 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.

4.55 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).

4.56 Use of historic data to estimate the probability of sewer flooding is the most practical approach, however does not take account of possible future changes due to climate or future development.

4.57 It is recommended that Woking Borough Council should seek to collect additional information of surface water and sewer flooding occurring in the WBC area and liaise with Thames Water to try and obtain more specific information on sewer flooding. This data may then be used to update future revisions of the SFRA. Until this data is available the maps in ***Volume 3, Appendix E*** of this SFRA should be used to identify broad areas where sewer and surface water flooding may be an issue and any proposals for development in these areas should consider local factors which may effect the incidence and hazards associated with sewer flooding.

MANAGING FLOODING FROM LAND, SURFACE WATER AND SEWERS

4.58 At present there is no government body with a clear responsibility for managing these three sources of flooding (land, surface water and sewers). As of spring 2006 the Environment Agency assumed a strategic overview role for monitoring flooding from land but the extent and the legislative details remain to be clarified. The Environment Agency and Meteorological Office provide a limited warning service for flooding from land in some areas, and include records of known surface water flooding in the Historic Flood Map. However, flood warning is complicated for this source due to the highly varied, localised and generally short lead in times.

4.59 A review of historical maps may provide evidence that a site has experienced flooding problems in the past, and may therefore experience flooding problems in the future. Historical maps may show the presence of springs, areas of bog or marsh or sewer flooding hotspots.

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

4.61 Possible management and responses to flooding include:

- Major ground works (such as new or improved drainage systems, including drains, dams and embankments).
- Appropriate site selection for developments or re-developments.
- Development zoning including the use of green space and planting to manage runoff (if appropriate).
- Flood proofing of developments (including land raising and raising floor levels) and flood warning.
- Management of development runoff (such as the inclusion of SUDS).

4.62 Long-term operation and maintenance requirements and responsibilities are a key consideration. The appropriateness of sustainable drainage techniques (SUDS) should be assessed.

4.63 Flooding from land, surface water, sewers or urban areas can theoretically be managed with engineering works for any size event. However such works are not always 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.

4.64 Planning Policy Statement 25: Development and Flood Risk (PPS25) recommends that Sustainable Drainage Systems (SUDS) are used to reduce the probability of flooding by limiting the peak demand on urban drainage infrastructure. All new developments (and wherever possible existing development) are advised to separate foul drainage from surface water drainage to reduce the probability that any flooding that does occur is contaminated.

Sustainable Drainage Systems (SUDS)

4.65 With 478,000 new houses proposed for the South East of England between now and 2021, 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 or redevelopments (as per PPS25 and the Building Regulations, Part H).

4.66 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 1 below.

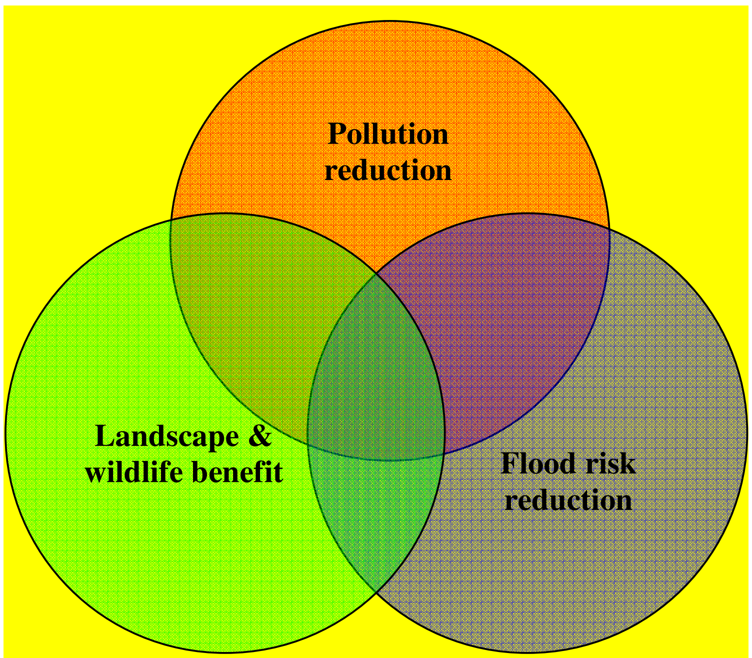

Figure 1 Broad Criteria of Sustainable Drainage Systems

4.67 All three criteria should be considered when designing a drainage scheme. Table 8 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 (flood reduction, pollution reduction and wildlife/landscape benefit).

4.68 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 be made up of a combination 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 8 The SuDS Hierarchy

	SUDS technique	Flood reduction	Pollution reduction	Landscape & wildlife benefit
Most sustainable	Green / living roofs	✔	✔	✔
	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	✔		

4.69 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**

4.70 Based on the geology, soils and topography of the Woking Borough, it is likely that in many areas (those underlain by clay and marl) the most effective SUDS techniques would be **Non-infiltration** based SUDS. Green (living) roofs are at the top of the sustainability hierarchy for SUDS techniques and are suitable in this area. As well as flood reduction benefits, green (living) roofs also provide pollution control and landscape and wildlife benefits. The attenuation provided by green (living) roofs on redeveloped Brownfield sites has been shown to provide a 40% reduction in surface water runoff. The Environment Agency generally prefers to see runoff from development sites restricted to Greenfield runoff rates. The use of green (living) roads can play a significant role in this management of runoff. Permeable surfaces and filter drains are another non infiltration based SUDS technique that should be considered in all new development in Woking Borough.

4.71 Some areas of the borough (those underlain by river gravels and sandstones) may be very well suited to the use of infiltration based techniques and in these areas soakaways, infiltration basins, and permeable surfacing may be especially appropriate. Because the geology of the area is variable where infiltration based techniques are proposed these should be supported by site based ground observations and infiltration testing.

4.72 It is recommended that Woking Borough Council adopt a similar policy in the LDF to the existing EA guidance which requires the use of SUDS on all new developments and the restriction of runoff rates to Greenfield rates.

4.73 Where infiltration based methods of drainage are inappropriately installed on impermeable sites this is likely to **increase** flood risk. Infiltration based methods of surface water disposal should only be permitted in Woking where site specific infiltration testing has been carried out and is sufficient to prove the underlying ground is capable of accepting the amount of runoff proposed.

Determining the most appropriate SUD technique

4.74 To determine the most appropriate type of SUDS technique for a given site Table 9 and Table 10 should be consulted. To use the tables one should consider each type of SUDS technique in turn with reference to a specific site. Knowledge of the physical characteristics of the site (geology, land use, topography and soils) is required in order to undertake this process. An example is presented below on how to use the tables to assess the appropriateness of retention based SUDS techniques in Woking.

4.75 The four main parameters that need to be considered in the choice of SUDS type are geology, land use/cover, soil and DTM/slope, all of which are presented in Table 9 and have been classed according to their significance to the success of the particular SUDS type of interest. The most important factors for each SUDS type have the most stars. Therefore for retention based SUDS techniques the DTM/Slope is the most important factor to the success of the technique, with geology being the second most important parameter.

4.76 After reviewing the relative significance of each factor in the success of a particular SUDS technique, Table 10 should then be used to consider the appropriateness of particular SUDS types on the specific site in mind. Table 10 sub-divides these parameters into most suitable, suitable and least suitable divisions and describes the physical site characteristics which fall within each category of suitability. Using the retention type SUDS example, Table 9 has indicated that the DTM/slope is the most significant factor in determining the success of this particular SUDS type. Table 10 then indicates which type of slope is most suitable for the use of retention based SUDS techniques. The conditions at the particular site under consideration should be compared to the descriptions Table 10 to assess the suitability of a particular SUDS technique for that site. For example, relatively flat sites are most suited to retention based SUDS techniques. These techniques are least suitable in areas of steep gradients and variable land elevations.

4.77 When the most important parameter has been identified (Table 9) and the suitability of the site has been determined (Table 10) then a sequential approach should be applied to the tables to determine if the site is suitable for a particular SUDS technique. If the most important parameter has a suitability of ‘Most Suitable’ move onto the second most important parameter and determine how suitable the site is, if it is ‘Most Suitable’ or ‘Suitable’ then the SUD technique may be appropriate and could be taken forward to more detailed site specific planning.

4.78 If the most significant parameter to the success of a particular SUDS technique has a suitability of ‘Least Suitable’ then the SUD technique should not be used. If the most important parameter is ‘Most suitable’ but the second most important parameter is ‘Least Suitable’ then likewise the SUD technique should not be used.

4.79 The above process should be used to provide an indication of which SUDS techniques would be considered suitable on a specific site. However, the design and final solution should only be determined after more detailed design and a site specific investigation.

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Table 9 Sustainable Drainage Solutions Analysis - Data Set Weighting Criteria

SUDS Solution		Data Set							
Group	**Technique**	**Geology**	**Comment**	**Land Use/Cover**	**Comment**	**DTM/Slope**	**Comment**	**Soils**	**Comment**
Retention	**Retention Ponds and Subsurface Storage**	2	In permeable geology a liner (or other impermeable material such as puddled clay) will be required to prevent the pond drying out.	1	Ponds should be located in, or adjacent to, non-intensively managed landscapes where natural sources of native species are likely to be good.	7	Ponds should not be located on steep slopes, or on unstable ground.	1	The soil below a wet pond should be sufficiently impermeable to maintain the water levels within the permanent pool at the required level, unless a continuous upstream baseflow can be guaranteed.
Wetland	**Shallow Wetland, Extended Detention Wetland, Pond/Wetland, Pocket Wetland, Submerged Gravel and Wetland Channel**	2	In permeable geology a liner (or other impermeable material such as puddled clay) will be required to prevent the wetland drying out.	1	Usually requiring a high land take, the location of a wetland should take account of the natural site features that might be used as additional temporary storage when the wetland capacity is exceeded.	6	Wetland basins require a near-zero (almost horizontal) longitudinal slope, which can be provided using embankments.	2	The soil below a wetland should be sufficiently impermeable to maintain wet conditions, unless the wetland intersects with the water table.
Infiltration	**Infiltration Trench/Basin and Soakaways**	4	Infiltration measures are generally appropriate for catchments with small impermeable areas.	1	Infiltration measures should be integrated into the site planning and should take account of the location and use of other site features.	2	Infiltration measures are usually restricted to sites without significant slopes, unless they can be placed parallel to contours.	6	The seasonally high groundwater table must be more than 1m below the base of the facility. Infiltration measures are designed for intermittent flow and should be allowed to drain and re-areate between rainfall events.
Filtration	**Surface Sand Filter, Sub-surface Filter, Perimeter sand Filter, Bioretention/filter Strips and Filter Trench**	4	Filtration measures should not be used to drain hotspot runoff if soils are permeable and groundwater may be put at risk.	1	Filtration measures should be sited next to and alongside its drainage area. They should be integrated with the overall site design and landscaping. However they are not suitable where pedestrian traffic is expected.	2	Site gradients should not exceed 1 in 20 to prevent erosion and channel flows across the filtration measures.	6	The maximum 'length' of impervious area draining to filtration measures should be controlled to reduce risk of 'sheet flows' changing to concentrated flows, although this is dependant on slope.
Detention	**Detention Basin**	2	There is no maximum catchment area beyond which detention basins cannot be used.	1	Detention basins should be integrated into the site planning process and take into account the location, use of other site features and undisturbed natural areas.	6	The basin floor should be as level as possible to minimise flow velocities, maximise pollution removal efficiencies and minimise risks of erosion.	1	Groundwater level records should be checked to ensure that during periods of high groundwater, the storage capacity of the retention pond is maintained.
Open Channels	**Swales**	4	Swales are generally appropriate for catchments with small impermeable areas.	1	Swales should be integrated into the site planning and should take account of the location and use of other site features.	2	Swales are usually restricted to sites without significant slopes, though careful planning enable their use in steeper areas by considering the contours of the site.	6	The seasonally high groundwater table must be more than 1m below the base of the facility.

Table 10 Sustainable Drainage Solutions Analysis - Data Set Significance Criteria

SUDS Solution		Data Set							
Group	**Technique**	**Geology**	**Comment**	**Land Use/Cover**	**Comment**	**DTM/Slope**	**Comment**	**Soils**	**Comment**
Retention	**Retention Ponds and Subsurface Storage**	3	Impermeable Geology, which would assist retention	1	Urban and Commercial Areas	3	Relatively flat ground levels are advantageous for retention measures	3	Impermeable soils, which would assist retention
		2	Mildly permeable Geology, which may require an impermeable membrane at various locations	2	Green Urban Areas	2	Ground levels that are a mixture of steep and shallow should altered to flat gradient for retention measures	2	Mildly permeable soils, which may require an impermeable membrane at various locations
		1	Permeable Geology, which would require an impermeable membrane	3	Forest and Rural Areas	1	Steep ground levels are not advisable for retention measures	1	Permeable soils, which would require an impermeable membrane
Wetland	**Shallow Wetland, Extended Detention Wetland, Pond/Wetland, Pocket Wetland, Submerged Gravel and Wetland Channel**	3	In permeable geology a liner (or other impermeable material such as puddled clay) will be required to prevent the wetland drying out.	1	Urban and Commercial Areas	3	Relatively flat ground levels are advantageous for wetland areas	3	The soil below a wetland should be sufficiently impermeable to maintain wet conditions, unless the wetland intersects with the water table.
		2		2	Green Urban Areas			2	
		1		3	Forest and Rural Areas	1	Steep ground levels are not advisable for wetland areas	1	
Infiltration	**Infiltration Trench/Basin and Soakaways**	1	Large impermeable areas should be avoided, when using filtration measures	2	Urban and Commercial Areas	3	Relatively flat ground levels are advantageous for retention measures	1	Permanently high ground water is inadvisable in locations with infiltration
		2	A 50/50 split in geological permeability would be acceptable for infiltration measures, if this was the deciding factor	3	Green Urban Areas	2	Slopes should be kept to a minimum, although ground contours can be used in locations with significant gradients	3	Varying ground water is advisable in locations with infiltration
		3	Large areas of permeable geology would be advantageous for infiltration measures	3	Forest and Rural Areas	1	Steep ground levels are not advisable for retention measures	1	Permanently low ground water is inadvisable in locations with infiltration
Filtration	**Surface Sand Filter, Sub-surface Filter, Perimeter sand Filter, Bioretention/filter Strips and Filter Trench**	3	Impermeable Geology, which would assist filtration measures	1	Urban and Commercial Areas	3	Relatively flat ground levels are advantageous for retention measures	3	The maximum 'length' of impervious area draining to filtration measures should be controlled to reduce risk of 'sheet flows' changing to concentrated flows, although this is dependant on slope.
		2	Mildly permeable Geology, which may require an impermeable membrane at various locations	2	Green Urban Areas	2	Slopes should be kept to a minimum, although ground contours can be used in locations with significant gradients		
		1	Permeable Geology, which would require an impermeable membrane	3	Forest and Rural Areas	1	Steep ground levels are not advisable for retention measures		
Detention	**Detention Basin**	1	Geology is not considered a significant issue	1	Urban and Commercial Areas	3	A virtually flat gradient is essential	3	Permanently high ground water is advisable
				3	Green Urban Areas	2	Ground levels that are a mixture of steep and shallow should altered to flat gradient for detention measures	2	Varying ground water levels would be sufficient when using this solution

				3	Forest and Rural Areas	1	Steep ground levels are not advisable for detention measures	1	Permanently low ground water is inadvisable in locations with infiltration
Open Channels	**Swales**	1	Large impermeable areas should be avoided	2	Urban and Commercial Areas	3	Relatively flat ground levels are advantageous for Swales	1	Permanently high ground water is inadvisable
		2	A 50/50 split in geological permeability would be acceptable if this was the deciding factor	3	Green Urban Areas	2	Slopes should be kept to a minimum, although ground contours can be used in locations with significant gradients	2	Varying ground water levels would be sufficient when using this solution
		3	Large areas of permeable geology would be advantageous	3	Forest and Rural Areas	1	Steep ground levels should be avoided for swales	3	Permanently low ground water is advisable

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Planning considerations

4.80 The Environment Agency Flood Map does not include flooding from land, surface water or sewers. The Flood Zones cover only river and sea flooding but PPS25 requires that consideration be given to other forms of flooding during the decision making process.

4.81 PPS25 requires that decision makers use the SFRA to inform their knowledge of flooding. The SFRA refines the information on the Flood Map 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. PPS25 states that local planning authority should further the use of SUDS by, amongst other things, adopting '*policies for incorporating SUDS requirements in local development documents'.*

4.82 Assessments of flooding from land, surface water and sewers are therefore needed. A probabilistic approach to the assessment of surface water flooding requires an understanding of hydrological and hydraulic processes. These processes are highly variable at the local scale and cannot meaningfully be performed at a strategic level. Thus the assessment should be undertaken using site and upstream catchment characteristics and historic incidents of flooding.

4.83 As well as informing land use planning, flooding should be managed through the flood risk 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. 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.
- Capacity of the existing drainage system.
- Increase in surface water runoff rates.
- Effects of climate change.
- Suitable sustainable urban drainage systems.

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5 Groundwater Flooding

Description

5.1 Groundwater flooding is caused by the emergence of water originating from sub-surface permeable strata. A groundwater flood event results from a rise in groundwater level sufficient for the water table to intersect the ground surface and inundate low lying land. Groundwater floods may emerge from either point or diffuse locations. They tend to be long in duration developing over weeks or months and prevailing for days or weeks.

5.2 There are many mechanisms associated with groundwater flooding, which are linked to high groundwater levels, and can be broadly classified as:

- Direct contribution to channel flow.
- Springs emerging at the surface.
- Inundation of drainage infrastructure.
- Inundation of low-lying property (basements).

5.3 Groundwater levels rise and fall in response to rainfall patterns and distribution, with a time scale of months rather than days. The significance of this rise and fall for flooding, depends largely on the type of ground it occurs in, i.e. how permeable to water the ground is, and whether the water level comes close to or meets the ground surface.

5.4 Groundwater flood events have been recorded in various aquifer units (including Cretaceous Chalk, Limestones, river terrace gravels). Compared to other aquifer units, Chalk is more vulnerable to groundwater flooding because of its geological formation. It contains many pores and fissures which can result in rapid rises in groundwater levels, which take a long time to recede.

5.5 The primary controls on the distribution and timing of groundwater flooding include:

- Spatial and temporal distribution of rainfall.
- Spatial distribution of aquifer properties.
- Recharge mechanisms.
- Spatial distribution of geological structures (drift deposits, stratigraphy).
- Efficiency of the surface drainage network.

5.6 The likelihood of an area experiencing groundwater flooding can largely be determined on a broad scale through an analysis of the previous meteorological conditions and geological knowledge. This can be helped by the analysis of groundwater boreholes and historic information.

Causes of high groundwater levels

5.7 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 11. Each has been described using the source-pathway-receptor model.

Table 11 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 exceedence 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 e.g. adits	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	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.

Impacts of groundwater flooding

5.8 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.

5.9 Additionally groundwater flooding can cause a change in the structural properties of clay overlying aquifers. This may cause costly damage to structures in the ground and the buildings that they support.

5.10 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.

5.11 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. The economic and social costs of groundwater flooding are compounded by the relative long duration of events.

5.12 The nature and occurrence of groundwater flooding in England is highly variable. 1.7 million properties are vulnerable to groundwater flooding in England (Jacobs 2006). The occurrence of groundwater flooding is very local and often results from the interaction of very site specific factors, e.g. aquifer properties, topography, man made structures etc.

5.13 In general terms groundwater flooding rarely poses a risk to life. However groundwater flooding can be associated with significant damage to property.

Data collection

Sources of data

5.14 Data collected to assess groundwater flooding in this SFRA included geology, soil, aquifer and digital terrain data.

Record of Historic Flood Events

5.15 Environment Agency records of flooding in this area include six reported incidents of groundwater flooding in Woking, in the spring seasons of 2001, 2003 and 2004. The EA have indicated that the underlying geology of the sandy Bagshot Formation could hold a relevant water table which may have been associated with these flooding events.

5.16 The records of historic flooding available from Woking Borough Council and Thames Water do not contain any flooding incidents related to groundwater.

5.17 The lack of historic records however does not prove that there have not been more incidents of groundwater flooding in Woking Borough Council, only that such events have not been recorded or have not been attributed to groundwater.

Results

5.18 The Lower Wey catchment around Woking is largely underlain by clay and marl (a type of mudstone) which make up the Bracklesham Beds and partly by clay and sandstone of the Bagshot beds. The geology is generally clay and therefore very impermeable and as a result the likelihood of groundwater flooding within areas underlain by this geology is very limited. In the valley bottoms where there are deposits of river alluvium on top of the clays there may be potential for locally perched water tables to exist. Groundwater flooding from these areas is likely to be localised and of a very minor scale. These areas of river alluvium are located in the valley bottoms and generally coincide with the areas defined as Flood Zone 3 and 2 (as a result of fluvial flood risk). Flood risk assessments (which will be necessary for most sites within Flood Zone 2 and 3) should examine the potential for groundwater flooding on a local site scale.

5.19 Areas at relatively higher risk of groundwater flooding may include the areas around Mayford and Kingsfield to the south of Woking town centre, Pyrford Common, Pyrford Green, Ridgeway, West Byfleet and Byfleet as these areas are all located on areas of river gravels. Other areas of Woking Borough are probably at medium to low risk of groundwater flooding.

Climate change

5.20 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 affected by climate change, however if winter rainfall becomes more frequent and heavier, groundwater levels may increase. Higher winter recharge may however be balanced by lower recharge during the predicted hotter and drier summers.

Uncertainties in flood risk assessment

5.21 The causes of groundwater flooding are generally understood. However groundwater flooding is dependent on local variations in topography, geology and soils. It is difficult to predict the actual location, timing and extent of groundwater flooding without comprehensive datasets.

5.22 There is a lack of reliable measured datasets to undertake flood frequency analysis and even with datasets this analysis is complicated due to the non-independence of groundwater level data. Studies therefore tend to analyse historic flooding which means that it is difficult to assign a level of certainty.

5.23 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

Management of groundwater flooding

5.24 At present there is 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. 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. The Environment Agency currently provides some data of known groundwater flooding incidents in the form of the Historic Flood Map.

5.25 Groundwater flooding is often highly localised and complex. Management is highly 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:

- Raising property ground or floor levels or avoiding the building of basements in areas considered to be at risk of groundwater flooding.
- 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.
- Major ground works (such as construction of new or enlarged watercourses) and improvements to the existing surface water drainage network to improve conveyance of floodwater from surface water of fluvial events through and away from areas prone to groundwater flooding.

5.26 Most options involve the management of groundwater levels. It is important to assess the impact of managing groundwater with regard to water resources, and environmental designations. Likewise, placing a barrier to groundwater movement can shift groundwater flooding from one location to another. The appropriateness of infiltration based drainage techniques should also be questioned in areas where groundwater levels are high or where source protection zones are close by.

Planning considerations

5.27 The Environment Agency Flood Map does not include groundwater flooding. The SFRA is required to build on the Flood Map by investigating other sources of flooding. PPS25 requires that decision makers use the SFRA 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.

5.28 Groundwater flood risk should be investigated, identified, quantified and managed where possible by the flood risk assessment process. This SFRA has concluded that groundwater flooding in Woking is most likely to occur in areas underlain by river terrace gravels although areas underlain by the Brackleshan and Bagshot beds may also be at risk where the geology is dominated by sands rather than clays. The risk from groundwater flooding is likely to be strongly influenced by local ground conditions and given this and the absence of any records of past groundwater flooding it is not possible within the SFRA to indicate specific areas where groundwater flooding may occur in the future.

5.29 It is suggested that an assessment of the level of risk from groundwater is included at all levels of future flood risk assessment in the borough. 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 when preparing site specific flood risk assessments (FRA).

5.30 In particular, the factors that should be taken into account during the preparation of site specific FRA 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.

5.31 When undertaking a site specific FRA, more detailed indicators that the site may be at risk from groundwater flooding which should be investigated 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 includes construction of any sub-surface structures (including basements or foundations) the FRA should investigate local groundwater levels and the potential for the construction to exacerbate groundwater flooding for neighbouring properties with basements.
- If the vegetation on the site suggests periodic waterlogging due to high groundwater levels.
- If nearby recorded borehole levels reach those of the site.

5.32 If the FRA concludes that the risk of groundwater flooding on a site is particularly significant, a more detailed assessment of groundwater flooding may then be required. Such an assessment should be undertaken by specialist hydrogeologists and may involve further hydrogeological monitoring and statistical analyses of recorded borehole water levels. The results of this more detailed analysis should be incorporated into the next revision of the SFRA by updating this Chapter as appropriate. This will ensure that the SFRA is continually updated to present the best available data on groundwater flooding across the whole borough. Additionally, the outcomes of these detailed assessments may be used by the Environment Agency to inform their strategies for the management of groundwater throughout Thames Region.

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6 Flooding from Artificial Sources

Description

6.1 PPS25 requires an assessment of non-natural or artificial sources of flooding such as reservoirs, canals and lakes where water is retained above natural ground level. PPS25 also includes operational and redundant industrial processes including mining, quarrying, and sand and gravel extraction as they may increase water depths and velocities in adjacent areas. In addition to this the impacts of flood management infrastructure and other structures need to be considered. Flooding may result from a facility being overwhelmed or from failure of a structure. Failure of structures can result in rapid, deep flowing water, which poses a serious hazard, threatening life and potentially causing major property damage. Failure of pumps may also result in flooding.

6.2 For the purpose of the SFRA, flooding from artificial sources has been defined as that arising from failure of man-made infrastructure or human intervention that causes flooding. This includes failure of canals or reservoir embankments, as well as activities such as ground water pumping. To understand flooding from artificial sources the whole hydrological and drainage system must be considered, along with the potential for interaction with other sources of flooding.

6.3 The spatial and temporal extent of flooding from artificial sources is highly variable. For example the likelihood of a new reservoir failing is very low compared to that of a canal embankment that is more than one hundred years old. However the consequences of a reservoir failing is potentially catastrophic in comparison to a local canal embankment breaching.

6.4 Increased urbanisation, aging infrastructure and the impacts of climate change all result in the requirement for consideration of flooding from artificial sources within the development process.

6.5 The main artificial source of flooding in the SFRA area is the Basingstoke Canal. ***Volume 3, Appendix F*** of this SFRA shows the Basingstoke Canal which flows through the study area on its route between Greywell, Hampshire and Woodham, Surrey.

Overview of flooding from artificial sources

Canals

6.6 Canals are man-made waterways, usually connected to (and sometimes connecting) existing lakes, rivers, or seas. There are two main types of canals: irrigation canals for the delivery of water, and transportation canals for passage of goods and people. Canals are sometimes part of a waterway, which is not entirely artificial (usually where a river has been canalised to make it navigable).

6.7 As well as the Basingstoke Canal which flows across the study area, the other significant artificial watercourse in the area is the Wey Navigation.

Interaction with other watercourses

6.8 Within the study area the Basingstoke Canal interacts with both watercourses classified as 'Main River' and drainage ditches. These include the Rive Ditch (enmained April 2006) and the Brookwood Lye (defined by the EA as ordinary watercourses). The Wey Navigation uses navigable parts of the River Wey and also man made sections. The natural parts of the river would continue to flood with the river; however, the man-made sections should be protected from flooding by the locks.

6.9 Tributaries of the River Hart pass underneath the embanked canal in culverts. The first of these is about 1km south of Crookham Village, between Poulters Bridge and Chequers Bridge, two further culverts at about 1 km spacing west of Chequers Bridge carry other tributaries of the river. There are no weirs or discharges from the canal into any of these tributaries. It should be noted that the River Hart and its tributaries are outside the SFRA Study Area.

Flooding Mechanisms

6.10 ***Volume 3, Appendix F*** highlights the areas that could be liable to flooding in an embankment breach or culvert failure, the areas of the canal potentially subject to a breach or failure were identified by the Basingstoke Canal Authority, topographic data was used to define the area of land which may be at risk in the event of a failure. Detailed breach modelling was not undertaken and the identified areas are based on a visual assessment of the topography. The mechanisms behind these flooding problems are outlined below:

6.11 **Breach of embankment -** Throughout the Study Area, the Basingstoke Canal passes through low-lying land, (which at some sites was originally marshland and has been historically drained for development). Consequently the land particularly to the south of the canal has extensive drainage ditch networks in place. In the event of the canal breaching its banks, these drainage ditches could back-up or may have a surcharge effect and waterlog the surrounding areas causing flooding. This will affect drainage and possibly result in flooding remote from the canal (Refer ***Volume 3, Appendix F***). A breach at sites 2 to 10 (refer ***Volume 3, Appendix F***) would possibly result in a discharge of very large volumes of water into the Rive Ditch.

6.12 **Culvert Failure -** There are many culverts under the Basingstoke Canal within the Study Area. These culverts enable the canal to pass over many minor watercourses. A blockage or collapse (resulting in blockage) of any of these culverts could result in extensive flooding and could also surcharge the land drainage system. The sites at risk of culvert failure include sites 8, 10 and 13 shown in ***Volume 3, Appendix F***.

Assessment of Flood Risk

6.13 Flooding is a risk that must be considered in association with the Basingstoke Canal. The contour style construction of the Basingstoke Canal requires that a ledge be excavated around the hill, for which the spoil is then placed on the downhill side of the excavation to form a bank to retain water. This form of construction is considered a low risk if construction is to currently accepted standards - spoil forming water retaining embankments 'keyed' into the hillside, is properly compacted in layers, has a well drained core to prevent saturation and potential slippage, and has a slope constructed to match angle of repose of the material used. It has been advised the Basingstoke Canal embankment is not 'keyed' into hill side, compaction is only a result of gravity over the past 200 years, there is no core drainage, and has slopes which exceed currently accepted standards. These factors make the Basingstoke Canal embankment inherently prone to failure.

6.14 Historic records for the canal detail that due to a lack of routine maintenance and a period of exceptionally heavy rainfall, the Basingstoke Canal breached its banks in two places on September 15th 1968. The first breach was at Farnborough and the second at Aldershot. The Aldershot breach caused limited damage, but did leave a substantial opening in the Ash embankment. Should the breach occur today it has potential to cause substantial damage, however the Aldershot section of the canal is outside of the study area for this SFRA so will not be considered in any more detail.

6.15 In addition to increased water levels within the canals as a direct effect of excessive rainfall, flood risk has been increased by large amounts of surface water runoff that have been diverted from road drains, camp parade grounds and railway line drainage into the canal during its working life.

6.16 The flood risk posed by the Basingstoke Canal has been considered within the Weir Protocols (instructions on the operation of the canal weirs held by the Basingstoke Canal Authority) and draining down procedures produced by The Basingstoke Canal Authority[1]. There are three protocols in place for the Basingstoke Canal; Summer, Winter and Emergency (or severe weather) Protocols.

6.17 Summer Weir Protocol ensures that the adjustable sections of weirs in the Surrey section of the canal will be restored to their normal working heights to maintain full water levels in the canal. Winter Weir Protocol requires the adjustable sections of weirs on the Surrey section of the canal to be reduced in height by 100mm to establish a flow on the canal towards the weirs. In the event of extreme rainfall or a canal emergency, the protocol states that the canal should be isolated into discrete sections, which can then be controlled via the use of sluices. In the case of a dire emergency it is advised in the protocol that the sluices are fully drawn to allow canal water to drain quickly. Although this would result in an immediate relief of flood risk to the area, it is likely that this action could cause flooding problems elsewhere in the vicinity. In such an event the Environment Agency would be informed of this magnitude of weir movement.

6.18 It should be noted that flood risk from the Basingstoke Canal is considered a residual risk and in accordance with PPS25 new developments will be required to manage this risk. Therefore, on those sites which fall within the areas identified on ***Volume 3, Appendix F*** as being at risk of flooding from a breach of the Basingstoke Canal or culvert failure the risk and hazards from a Canal Breach should be considered further.

The Wey Navigation

6.19 The Wey Navigation is managed by the National Trust. The navigation is a combination of engineered channels separate from the river, and sections of navigable river. The sections of navigable river will flood with the river naturally, and therefore the extent of flooding is indicated by the modelled fluvial flood extents. The engineered sections should not flood, and are controlled by various weirs and gates. However some of the engineered sections are on perched embankments and therefore there is a small risk of breach or failure. Should there be a failure the gates controlling water flow through the engineered section of the navigation could be operated to isolate the breached section. Although a specific breach analysis has not been done as part of this SFRA it is likely that as the Wey Navigation is located in the valley bottom, parallel to the river, the flooding resulting from a breach would be within the extents of flooding indicated on the fluvial flood maps.

Climate change

6.20 Artificial sources of water should be controlled under a management regime. Therefore, climate change should not significantly increase flood risk. There may be some requirement to adapt the management regime to accommodate the potential

[1] In recognition that the canal must be managed coherently across local authority boundaries, Hampshire County Council and Surrey County Council have handed control of the management and maintenance of the Basingstoke Canal to the Basingstoke Canal Authority.

increase in rainfall and storm intensity particularly for water bodies which receive surface water drainage, either formally or informally.

Management of flooding from artificial sources

6.21 Flooding from artificial sources can be managed through regular inspections of structural integrity, development of emergency procedures, development design and emergency escape routes.

6.22 The canals described above are managed and maintained by the National Trust (Wey Navigation) and the Basingstoke Canal Authority (Basingstoke Canal). They are regularly inspected and maintained.

Planning considerations

6.23 The Environment Agency Flood Map typically does not include flooding from artificial sources. The Flood Zones cover only river and sea flooding but PPS25 requires that consideration be given to other forms of flooding during the decision making process.

6.24 PPS25 requires that decision makers use the SFRA to inform their knowledge of flooding. The SFRA refines the information on the Flood Map and determines the variations in flood risk from all sources of flooding across their area. The information then should form the basis for preparing appropriate policies for flood risk management for these areas. The propensity for flooding from artificial sources should be a material consideration when making land use allocation decisions.

6.25 Flooding from canals should be treated differently from river floodplain flooding and in particular any development near canals should be considered on the basis that:

- Small changes to bank or ground levels close to canals can potentially change the pattern and extent of flooding quite significantly;
- The land that is at risk from flooding from canals will potentially be a flow route for water returning to the flood plain (particularly on the Wey Navigation) – hence there is a need to consider development form carefully and the vulnerability of particular forms of development to such flooding;
- The concepts used to maintain flood volume storage might not be applicable to circumstances where there is “overland flow” from canals to the flood plain; and
- The flooding could seriously overload sewer and drainage systems and cause significant secondary flooding at locations that are remote from the canal.

6.26 Assessments of artificial sources of flooding on a site specific basis are therefore needed as part of the FRA process. A probabilistic approach to artificial sources of flooding requires an understanding of hydrological, hydraulic, and structural and geotechnical engineering processes. These processes are highly variable at the local scale and so do not warrant a strategic assessment. The SFRA has identified areas within the study area that are potentially at risk of flooding from a breach or culvert failure along the Basingstoke Canal. A more detailed assessment of the risk of flooding from artificial sources is required for individual proposed developments within these areas.

6.27 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. More specifically, factors that should be taken into account during these detailed assessments are the:

- area liable to flooding;
- extent, standard and effectiveness of existing impoundment structures;
- likely depth of flooding;
- likelihood of impacts to other areas;
- effects of climate change.

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7 Flood Risk at Development Areas and Strategic Options

7.1 Chapters 4 to 8 of this Volume have assessed the flood risk in the Woking Area from five sources of flooding:

- Fluvial flooding in the catchment;
- Tidal flooding;
- Flooding from land, surface water and sewers;
- Groundwater flooding; and
- Flooding from artificial sources.

7.2 This assessment has shown that there are parts the Woking study area which are at risk of flooding from one (or more) of these sources. The guidance presented in Volume 1 of this SFRA explains how this flood risk information should be used in land use planning, development control and emergency planning. This chapter presents a general summary of the flood risk in the SFRA area.

Summary of Flood Risk at Proposed Development Areas

7.3 Through the use of a strategic level 1D hydraulic modelling program (iSIS), and the understanding of flood mechanisms and processes developed for the Woking SFRA, flood risk in the Study Area has been examined. The SFRA provides a framework for the consideration of flood risk in the River Wey catchment within Woking Borough Councils area and supports the application of the Sequential Test to site allocations . The SFRA does not however remove the need for detailed, site specific flood risk assessments to support planning applications.

7.4 Within the study area much of the land at risk of flooding from rivers is limited to rural/farmland areas, many of these areas are Greenbelt and are unlikely to be subject to significant development pressures. Existing, developed areas, which are more likely to be subject to redevelopment or future new development, are considered within the SFRA and the SFRA maps allow the consideration of flood risk to these areas when allocating land for future development.

7.5 Within the Study Area there are areas of existing development at Actual Risk of flooding (1 in 100 year return period). The most notable areas are summarised as follows:

- North eastern and southern areas of Byfleet adjacent to the River Wey;
- Southern extent of Old Woking; and
- Woking residential developments within the floodplain of the lower reaches of the Hoe Stream.

7.6 The potential impacts of climate change have been assessed. This resulted in a significant extension of the floodplain in some areas, however due to the generally well defined river valleys and floodplains which exist on many of the watercourses, the increase in flows resulting from climate change has had a minimal impact on the flood extent in the study area. The climate change scenarios most notably impacted on existing developed areas in Byfleet.

7.7 The 1 in 20 year flood extent has been mapped within the SFRA to aid in defining the Functional Floodplain.

7.8 Within the Study Area there are areas of existing development considered to be at risk of flooding in a Residual Risk flood scenario (1 in 1000 year return period). The Residual Risk scenario flooding mechanisms and extents are similar to those for Actual Risk due to the generally well defined floodplain topography. The most notable exceptions to this, which impact on existing developments, are summarised below:

- Byfleet Town centre and surrounding residential areas; and
- The developed Hoe Stream floodplain.

7.9 During a flood event major transport infrastructure may be non operational. An Emergency Plan should be formulated to facilitate an appropriate response should areas become cut off. The maps contained within the SFRA should be used to advise the emergency response plan for flooding.

7.10 There are areas within the Study Area that are potentially at risk of flooding resulting from a breach or culvert failure along the Basingstoke Canal alignment (***Volume 3, Appendix F***).

7.11 Other sources of flooding, including surface water, sewer and groundwater flooding are considered within the SFRA and are generally considered to be more localised and less of a hazard than fluvial flooding. Evidence of past sewer and surface water flooding has been presented within the SFRA however the information currently available may not give a full picture of the spatial extent of surface water of sewer flooding within the study area. It is recommended that in future updates of the SFRA these sources of flooding are given further consideration as and when additional information becomes available.

8 Glossary and Notation

Actual Risk	The risk from flooding based on best available information and representing the influence of flood defences and the distribution of risk within the Flood Zones.
Atkins	Atkins Consulting Engineers sometimes referred to as Atkins Global. The consultants commissioned to carry out the River Wey Flood Mapping Study.
BHS	British Hydrological Society
cu.m (cumecs)	Cubic metres of water per second
DCLG	Department for Communities and Local Government (previously ODPM)
DEFRA	Department for Environment, Food and Rural Affairs
DTM	Digital Terrain Model created using LiDAR, IfSAR or Photogrammetry data.
EA	Environment Agency
FEH	The Flood Estimation Handbook (1999) gives guidance on rainfall and river flood frequency estimation in the UK and is the main method used for the calculation of peak flood flows. The Handbook is accompanied by the FEH CD-ROM containing catchment descriptors and gauging station details for catchments throughout the UK.
Flood Zones	This refers to the Flood Zones in accordance with Table D1 of PPS 25 derived for this Woking SFRA and do not refer to the Environment Agency's Flood Zones.
Flood Zones (EA)	This refers to the Environment Agency's Flood Zones.
Formal Raised Defences	Formal defences are typically raised embankments or structures which are specifically designed and maintained for the purpose of flood defence. Informal defences are all other structures which were not designed specifically for the purpose of flood defence, but may afford some protection against flooding e.g. walls or railway embankments located next to watercourses.
FSR	Flood Studies Report (1975) the predecessor method of flood peak estimation in the UK largely superseded by the Flood Estimation Handbook.
GIS	Geographical Information System
IFSAR (NEXTmap)	Interferometric Synthetic Aperture - An aircraft-mounted sensor designed to measure surface elevation, which is used to produce topographic imagery. Sold under the name NEXTmap.
iSIS	iSIS Flow is a one-dimensional fully hydrodynamic simulator for modelling flows and levels in open channels and estuaries; it incorporates both unsteady and steady flow solvers.
JFLOW	JFLOW is a 2-D flood routing program developed by JBA, which is able to calculate time travel across flood cells and simulate inundation extent based on an underlying

	Digital Elevation Model
Km2	Square kilometres
LiDAR	Light Detection and Ranging survey method used to collect data for construction of a ground model.
M	Metres
m/sec	Metres per second
mAOD	Metres Above Ordnance Datum
Main River	As Defined by the Environment Agency main rivers are usually larger streams and rivers, but also include smaller watercourses of strategic drainage importance. A main river is defined as a watercourse shown as such on a main river map, and can include any structure or appliance for controlling or regulating the flow of water in, into or out of the main river. The Agency's powers to carry out flood defence works apply to main rivers only. Main rivers are designated by the Department for Environment, Food & Rural Affairs in England.
mm	Millimetres
NEXTMAP	Digital terrain elevation and radar image data
ODPM	Office of the Deputy Prime Minister (now DCLG)
Ordinary Watercourse	As Defined by the Environment Agency an ordinary watercourse is every river, stream, ditch, drain, cut, dyke, sluice, sewer (other than public sewer) and passage through which water flows which does not form part of a main river. On ordinary watercourses, the local authority and, where relevant, Internal Drainage Boards have similar permissive powers as the Agency has on main rivers.
PPG 25	Policy Planning Guidance Note 25: Development and Flood Risk - Guidance explaining how flood risk should be considered at all stages of the planning and development process in order to reduce future damage to property and loss of life. Superseded in December 2006 by PPS25.
PPS 11	PPS11 Regional Spatial Strategies. This Statement replaces Planning Policy Guidance note 11 - Regional Planning and sets out the procedural policy on the nature of Regional Spatial Strategies (RSS) and focuses on procedural policy, on what 'should' happen in preparing revisions to them and explains how this relates to the Act and associated regulations.
PPS 12	PPS12 Local Development Frameworks. This statement replaces Planning Policy Guidance note 12 - Development Plans and sets out the Government's policy on the preparation of local development documents which will comprise the local development framework.
PPS 25	Planning Policy Statement 25. Development and Flood Risk Guidance replaced PPG 25 in December 2006 and outlines how flood risk should be considered at all stages of the development process.

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.
QMED	The median flood flow calculated in the FEH method and used to estimate flood peaks by the statistical method in the WINFAP package. This is the flood that can be said to occur with a return period of two years (50% annual probability).
Residual Risk	The risk remaining after applying the sequential approach and taking mitigation actions (e.g. the risk of defences being overtopped)
Return Period	The average time until the next occurrence of a defined event.
Section 105	Environment Agency Floodplain Modelling produced in accordance with Section 105 of the Water Resources Act 1991.
Sequential risk-based assessment	Priority in allocating or permitting sites for development, in descending order to the flood zones set out in Table D1 of PPS 25, including the sub divisions in Zone 3. Those responsible for land development plans or deciding applications for development would be expected to demonstrate that there are no reasonable options available in a lower-risk category.
SFRA	Strategic Flood Risk Assessment
Study Area	Refers to the area of Woking Borough within the River Wey catchment.
WBC	Woking Borough Council
WINFAP-FEH	WINFAP is the software package associated with the Flood Estimation Handbook and FEH flood peak dataset used to calculate flood flow peaks by the FEH statistical method.
1D	1 Dimensional
2D	2 Dimensional
1 in 20 year return period flood event	The flood event that is predicted to occur with an annual probability of 5.0% (there is a 1 in 20 (5%) chance each year this event will be witnessed).
1 in 100 year return period flood event	The flood event that is predicted to occur with an annual probability of 1.0% (there is a 1 in 100 (1%) chance each year this event will be witnessed)
1 in 1000 year return period flood event	The flood event that is predicted to occur with an annual probability of 0.1% (there is a 1 in 1000 (0.1%) chance each year this event will be witnessed)

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APPENDIX A – Details of Hydrological and Hydraulic Analysis

HYDROLOGY

INTRODUCTION

A1. This appendix outlines the adjustment of existing hydrology (from the Wey Strategy Study) to provide information for this SFRA. The flows derived have been used to run hydraulic models of significant parts of the catchment, as described in Chapter 8. Where watercourses within the SFRA study area have not been modelled the EA Flood Zone Data set has been used to inform the SFRA.

RIVER WEY CATCHMENT

A2. The characteristics of the Wey catchment and the hydrological analysis undertaken as part of the Woking SFRA are discussed below.

Catchment Characteristics

A3. The River Wey has a catchment area of 905 km^2 to its confluence with the River Thames at Weybridge. It is a slightly urbanised (URBEXT = 0.033), moderately sloping catchment (DPSBAR = 55.30) with borderline permeable/impermeable soils (SPRHOST = 23.0). The Flood Estimation Handbook (FEH) catchment descriptor data indicates that the catchment is affected by the flood attenuation effects of lakes or reservoirs (FARL = 0.945) and receives a standard average annual rainfall (SAAR) of 791mm. The River Wey originates as two separate watercourses, the North Wey and the South Wey, these join at Tilford and become the River Wey.

A4. The River Wey has 3 tributaries of note, the Cranleigh Waters which join the river on the right bank at Peasmarsh (499750 146480), the Tilling Bourne which joins the river on the right bank at Shalford (NGR 499700 148050) and the Hoe Stream which joins the river on the left bank near Woking (NGR 504450 157650).

A5. The Hoe Stream, which is within the study area, has a catchment area of 84 km^2 to its confluence with the River Wey. It is a slightly urbanised (URBEXT = 0.041), gently sloping (DPSBAR = 32.70) catchment with impermeable soils (SPRHOST = 33.0). The catchment is slightly affected by the flood attenuation effects of lakes and reservoirs (FARL = 0.990) and receives a standard average annual rainfall (SAAR) of 686mm.

Environment Agency Information

A6. There are three Environment Agency flow gauging stations within the River Wey catchment, although none of which are within the study area. They are; on the River Wey at Tilford (FEH gauging station no. 39011), on the Tilling Bourne at Shalford (FEH gauging station no. 39029) and on the Law Brook, a tributary of the Tilling Bourne, at Albury (FEH gauging station no. 39036).

A7. The gauge on the Wey at Tilford (NGR 487400 143200) is a Crump profile weir which has recorded 48 years of data. The station has only been gauged to 55% of the median annual flow

(QMED). QMED is below bankfull and the weir is standard, however as there are insufficient gaugings to verify the rating both above and below bankfull the gauge is not considered fully reliable.

A8. The Environment Agency also has Flood Warning and operational gauges in the catchment.

Model inflow nodes

A9. Inflow node locations are as selected for the previous Wey Flood Mapping Study Middle and Lower Wey models, which have remained unchanged in this SFRA

HOE STREAM CATCHMENT

A10. The Hoe Stream, a major tributary of the River Wey, Surrey, flows predominantly northeast from Deepcut near Farnborough to Pyrford near Woking. The characteristics of the catchment and the hydrological analysis undertaken as part of the Woking SFRA are discussed below.

Catchment Characteristics

A11. The Hoe Stream has three tributaries of note, the Stanford Brook which joins the Hoe Stream on the right bank at Stanford Common (NGR 495550 154050), an un-named tributary which joins the main watercourse on the left bank close to Kemishford Bridge (NGR 498150 155400) and another un-named tributary which joins the main watercourse on the right bank at Mayford Bridge (NGR 499550 155850).

A12. Stanford Brook has a catchment area of 24.7km^2 to its confluence with the Hoe Stream. It is an essentially rural (URBEXT = 0.018), gently sloping catchment (DPSBAR = 37.70) with impermeable soils (SPRHOST = 33.1). The catchment is not significantly affected by flood attenuation (FARL = 0.999) and receives a standard average annual rainfall (SAAR) of 713mm.

A13. The un-named tributary of the Hoe Stream which joins the main watercourse at Kemishford Bridge has a catchment area of 14.5km^2. It is a moderately urbanised (URBEXT = 0.059), gently sloping catchment (DPSBAR = 28.80) with impermeable soils (SPRHOST = 33.5). The catchment is unaffected by flood attenuation (FARL = 1.000) and receives a standard average annual rainfall (SAAR) of 672mm.

A14. The un-named tributary of the Hoe Stream which joins the main watercourse at Mayford Bridge has a catchment area of 10.6km^2. It is a moderately urbanised (URBEXT = 0.068), gently sloping catchment (DPSBAR = 29.40) with impermeable soils (SPRHOST = 39.2). The catchment is unaffected by flood attenuation (FARL = 1.000) and receives a standard average annual rainfall (SAAR) of 683mm.

Environment Agency Information

A15. There are no Environment Agency flow gauging stations within the Hoe Stream catchment.

Model inflow nodes

A16. ISIS model inflow node locations selected for the Hoe Stream model within the Wey Flood Mapping Study have remained unchanged in this SFRA.

PREVIOUS STUDIES

A17. Atkins, recently (2006) undertook a Flood Mapping Study of the River Wey on behalf of the Environment Agency, Thames Region, South East Area. The project was undertaken in six stages between 2002 and 2006 with the first three stages undertaken according to the Section 105 Framework Agreement, section 4 undertaken under the National Engineering and Environmental Consultancy Agreement (NEECA), and sections 5 and 6 completed under the Strategic Flood Risk Management (SFRM) framework agreement.

A18. The objectives of the Atkins study were to construct and calibrate a set of hydrodynamic models of the catchment, capable of accurately predicting inundation of the floodplain in extreme fluvial flood events, to use the models to simulate floodplain inundation for a range of different return period events, and to produce flood maps for the Environment Agency.

A19. To meet these objectives eight one-dimensional (1D) hydraulic models were constructed for the catchment. Due to the size of the catchment it was not feasible to construct one detailed model to cover the entire study area.

Model	Watercourses/reaches
Upper Wey	North Wey from Tilford to source, Farnham Bourne, Alton Stream, Lavant Stream, Caker Stream, and the South Wey from Tilford to Liphook
Middle Wey	Lower Wey from Tilford to Peasmarsh, and Elstead tributary
Lower Wey	Lower Wey from Peasmarsh to the River Thames, and the Send tributaries
Hoe Stream	Hoe Stream
South Wey extension	South Wey from Liphook to Haslemere, Critchmere Stream, and Haslemere Stream
Farnham Park tributary	Farnham Park tributary
Frithend Brook	Frithend Brook
Oakhanger Stream	Oakhanger Stream

Table 12 Hydraulic models developed for the River Wey Flood Mapping Study

(Atkins, 2006

A20. The models were constructed using iSIS version 2.3. The Upper Wey model was calibrated to flow and rainfall data collected in the catchment for four historic events, the Middle Wey model used data from three historic events, four events were used to calibrate the Lower Wey model, and three for the Hoe Stream. The calibration process resulted in significant changes being made to the time-to-peak and standard percentage runoff values for each sub-catchment.

A21. Hydrological inputs to the models were determined using the FEH Rainfall Runoff Method for 75 sub-catchments within the study reach: 35 on the Upper Wey (18 on the North Wey, 17 on the South Wey), 13 on the Middle Wey, 23 on the Lower Wey and 4 on Hoe Stream. Modelled sub-catchments in the Lower and Middle Wey are shown in ***Volume 3, Appendix G***. The parameter estimates for the Rainfall Runoff model, time-to-peak, standard percentage runoff and baseflow, determined from the catchment descriptors were adjusted using observed flood event data as part of the model calibration process. This data, combined with critical storm durations of 39 and 75 hours was used in the iSIS software package to determine flood flow estimates for the 1 in 5, 20 100 year return period events and the 100 + 20% (climate change) event.

REVIEW AND APPLICATION OF THE RIVER WEY FLOOD MAPPING STUDY TO DETERMINE RIVER WEY AND HOE STREAM SFRA INFLOWS

A22. As the River Wey Flood Mapping Study was undertaken relatively recently and involved a detailed study of the hydrology of the Wey catchment, it is appropriate to re-use some of the existing hydrological estimates in the current SFRA study.

A23. Following a review of the hydraulic models, it was decided to use two of the eight models summarised in Table 7.1 (The Hoe Stream and Lower Wey), in the SFRA.

A24. A review was undertaken of the hydrological inputs to the River Wey Flood Mapping Study to identify whether any of the data was suitable for use in the SFRA. It was found that in general the methods used adhered to current best practice in flood estimation and could be re-used in the Woking SFRA, however it would be necessary to make some minor adjustments in order to allow the 1 in 1000 year return period event to be modelled. The 1 in 1000 year return period event was not modelled in the River Wey Flood Mapping Study but is required in this SFRA commission.

A25. Although it was decided to re-use the data for the 1 in 100 year return period event in this study and also adapt it to obtain the 1 in 1000 year hydrograph, the following observations made in the review process should be noted:

- Some of the sub-catchment areas appear truncated in comparison to those detailed in Flood Estimation Handbook CD-ROM (FEH) and the reason for this difference is not explained in the River Wey Flood Mapping Study report;
- Model calibration, and hence calibration of the FEH Rainfall Runoff model parameters, (time-to-peak, baseflow and standard percentage runoff) is based on less than four events for each model. The FEH recommends a minimum of four events be used, and therefore the use of less than this increases the uncertainty in the flood flow hydrographs;
- A storm duration of 75 hours was selected based on historic rainfall data. This seems very long as FEH methods indicate the time-to-peak for the catchment to be 14 hours based on standard equations;
- A winter storm profile was used for all flow nodes whereas FEH recommends that a summer storm profile should be used for urban sub-catchments to better characterise the runoff response to rainfall in urban catchments. The reason for the use of a winter profile throughout the study area is not explained in the report; and
- Some of the incremental reaches of the catchment, particularly in the Middle Wey do not appear to be accounted for.

A26. Despite the above issues the hydrological estimates are considered suitable for use in the current SFRA. The 1 in 100 year hydrographs were used unchanged whilst the 1 in 1000 year hydrographs were determined by simply altering the flood return period in iSIS to be 1000 rather than 100 years.

HYDRAULICS

INTRODUCTION

A27. The SFRA requires that levels of flood risk in the study area are quantified both for the current situation and including the effects of future climate change. The complex nature of the watercourses that interact within the study area necessitate the use of computational hydraulic modelling as a flood estimation tool for use in this SFRA.

A28. Where modelled data is not available for watercourses within the SFRA study area the EA Flood Zone Data set has been used to inform the SFRA.

APPROACH

A29. 1D computational models constructed using the HR Wallingford software package iSIS have been previously developed for the River Wey Flood Mapping Study (FRM) by the engineering consultancy, Atkins. The River Wey Flood Mapping Study models have been adopted for use in the SFRA. Details of the hydraulic modelling that has been adopted from the Wey Flood Mapping Study are given in *Section 4* of the *River Wey Flood Mapping Study, Main Report Volume 1 (Atkins, February 2006).*

A30. The hydraulic modelling carried out for the Wey Flood Mapping Study was based upon 'best available' information. No major new data collection has been carried out on the River Wey in this SFRA and the original information from the EA Wey study remains the best available information and has been assumed fit for use in this SFRA. The exception to this is Hoe Stream, which was included in the Wey FRM Study, but has been re-modelled in more detail as part of the Hoe Valley Project. The Hoe Valley Project is an ongoing piece of work being progressed by BTP-Hyder on behalf of WBC.

A31. The Hoe Valley Project has provided Hoe Stream modelled flood level and flood extent data for the 1 in 100 and the 1 in 20 year return periods events, under current climatic conditions and the 1 in 100 year event plus 20% to represent the potential effect of climate change. This modelling has been the focus of a four-year study to investigate the provision of flood defences along the stream, as part of the Hoe Valley Project. The proposed defences will alter the shape of the floodplain, defending existing properties from flooding, some of which currently are at risk in the 20 year return period or less, to the 100 year standard. The flood defence scheme has been designed in co-operation with the Environment Agency with sufficient mitigation to ensure that there are no adverse flood impacts to any third party land owners. By virtue of the proposed defences, properties in the defended reaches of the Hoe Stream will effectively be removed from the 100 year floodplain leaving the residual risk of flooding at less than 1% in any year. (BTP-Hyder, November 2006).

A32. The flood extents provided by BTP-Hyder have been used to modify the flood outlines on the Hoe Stream produced by the Wey Flood Risk Mapping study for the 1 in 100+20%, the 1 in 100 and the 1 in 20 year return periods. The 1 in 1000 flood extent was not available.

A33. The objectives of the Wey Flood Mapping Study were to produce flood extent maps for various scenarios in order to aid the Environment Agency and Local Planning Authorities in assessing the flood risk of existing and proposed developments. These objectives are very similar to those of this SFRA and therefore it has been deemed that detailed review and reconstruction of these models is not required. It has however been necessary to re-run the models to provide additional information for the 1 in 1000 year flood outline.

MODEL SELECTION

A34. In the case of the River Wey previously completed iSIS 1D models were provided by the EA (developed for the Wey Strategy and Flood Risk Mapping projects). Initial assessment of these models deemed them fit for purpose. Full details of the model selection and modelling approach adopted for these water courses is given in *Section 4.2* of the *River Wey Flood Mapping Study, Main Report Volume 1 (Atkins, February 2006).* With respect to the Hoe Stream, flood extents for the 1 in 20, 1 in 100, and 1 in 100 +20% (for Climate change) events, have been provided for use in this SFRA by WBC. These flood extents are from a model of the Hoe Stream developed as part of the Hoe Valley Project. The Hoe Valley Project includes additional survey information, not included in the Wey Strategy and Flood Risk Mapping models. Therefore these flood extents have been used in preference to those provided by the EA, which are based on older survey data.

MODEL DEVELOPMENT

A35. No specific new model development was required for the River Wey and Hoe Stream as part of the SFRA. The River Wey Flood Mapping Study report states that it was not possible to construct just one model of the River Wey due to the size of the catchment. A total of eight hydraulic models were constructed, three of them representing the River Wey and the remaining five representing tributaries. For the purpose of this study, it was only necessary to work with the models of the River Wey and the Hoe Stream as all other tributaries modelled did not fall within the SFRA Study Area.

A36. The extents of the separate models of the River Wey are listed in the Table 8.1 below. Only the Lower Wey models were adopted for use in this SFRA as the Upper and Middle Wey model extents do not fall within the SFRA Study Area.

***Table 13*– River Wey Hydraulic Model Extents**

Model	Upstream Extent	Downstream Extent
Upper Wey	Alton (on the North Wey) and Liphook (on the South Wey)	Tilford
Middle Wey	Tilford	Peasmarsh
Lower Wey	Peasmarsh	River Thames

A37. As multiple models were used to construct what is essentially one continuous river network, it is necessary to run the models in sequence in order to complete a simulation for the entire catchment. The downstream outflow from the Upper Wey model provides the top inflow for the Middle Wey model, and the Middle Wey and Hoe Stream downstream outflows provide inflows for the Lower Wey model. The Upper Wey model was not specifically re-run for this SFRA and therefore an inflow had to be generated representing the inflow normally provided by the Upper Wey model.

A38. The Hoe Stream model adopted from the River Wey Flood Mapping study extends from Kemishford Bridge to the Hoe Stream confluence with the River Wey downstream.

A39. The Lower Wey model provided had only been previously run with inflows up to a 1 in 100 year + 20% (climate change allowance) for the River Wey Flood Mapping Study. When these models were run for the 1 in 1000 year event, it was found that the maximum flood levels for a number of cross-sections exceeded that of the extents of the modelled cross-section. When this occurs, the iSIS software package assumes a vertical wall at the extremities of the cross section. This results in a reduction in conveyance for the cross-section and therefore water levels higher than what would result if the model cross-section extents were sufficient.

A40. In order to prevent this occurring, it is necessary to extend the cross-section to a level known to exceed that of the modelled flood level. This was performed with the best available topographic data, which, for the purposes of this SFRA is the NEXTmap data used in the River Wey Flood Mapping Study. The NEXTmap data provided has a quoted average accuracy of ±500mm, which has been checked and deemed acceptable as part of River Wey Flood Mapping Study, and in turn assumed fit for use in this SFRA. Details of this assessment may be found in *Appendix B of the River Wey Flood Mapping Study, Main Report Volume 1 (Atkins, February 2006).*

A41. ***Volume 3, Appendix G*, G1,** shows the extent of hydraulic modelling.

MODEL INFLOWS

A42. Hydrological inputs for the River Wey and Hoe Stream models utilised in this SFRA were provided by the EA with the models from the River Wey Flood Mapping Study. These inflows were provided for the 1 in 100 year flood event. The Wey catchment was split into smaller sub-catchments based on topography, drainage paths and geology. There are a total of 75 hydrological sub-catchments for the River Wey. Atkins adopted the FEH rainfall-runoff method to calculate the inflows, discussed in detail in *Section 3* of the *River Wey Flood Mapping Study, Main Report Volume 1 (Atkins, February 2006).*

A43. The model inflows generated for the extreme 1 in 1000 year flood event for use in this SFRA study were scaled from the inflows provided. Further information on how these model inflows were generated is included in Section 7 of this report.

A44. Since it is necessary to run all the models sequentially it is essential to ensure consistency in the hydrology for all the watercourses. Inflows had to be generated for the critical duration of the watercourse being modelled as well as the critical duration of the Lower Wey model. The watercourses critical duration inflow would be used in a model simulation to generate the worst case flood extent for that watercourse, where as the longer duration (critical for the Lower Wey) inflow would be included in a model simulation to generate an inflow for the Lower Wey model.

A45. Table 14 ***Peak Flood Inflows***, details the peak inflows into the models for the 1 in 100 year and 1 in 1000 year return period. The values shown are the peak values for the critical duration of each watercourse and not the hydrology used to determine the inflows for the top of the Lower Wey model.

Table 14 **Peak Flood Inflows**

Model Name	iSIS Inflow Node	Return Period	
		1 in 100 year	1 in 1000 year
	Guildford1	1.916	3.258
	Guildford2	1.826	2.961
	Guildford3	0.258	0.375
	Guildford4	1.031	1.783
	Guildford5	0.625	0.912
	Guildford6	0.736	1.077
	Wisley	3.316	5.654
	S1_4.038_fp	1.594	2.712
	SendA2	1.651	2.731
	S2_5.019_fp	3.918	6.703

Lower Wey	SendB2	1.421	2.407
	CranleighW	61.281	97.23
	Tbourne	7.690	14.938
	WD01.042	83.042	105.967
	Ockham1	8.105	13.768
	Ockham2	3.045	5.185
	Pyrford	1.824	3.169
	Wbdg1	0.922	1.528
	Wbdg2	6.966	25.685
	Wbdg3	0.686	1.106
	Wbdg4	1.520	2.662
	Wbdg5	0.296	0.508
	Wbdg6	0.393	0.576
	Wbdg7	0.059	0.110
	Hoe	29.810	47.805
Hoe Stream	Standford	40.129	67.365
	Worplesdon	10.333	17.121
	Hoe	2.689	4.463
	Woking_1	1.830	3.107
	Woking_2	1.830	3.107
	Woking_3	1.830	3.107
	Woking_4	1.830	3.107

MODEL BOUNDARY

A46. With the exception of the Lower Wey model, a conveyance boundary was used as the downstream boundary. These boundary types represent a combined channel and floodplain conveyance relationship and are able to be generated with the iSIS software. The boundary is calculated using channel gradient and roughness data and is based on the Manning's equation. These downstream boundaries are checked against the water levels to confirm the prevalence of normal flow conditions, where backwater effects were found to be present the downstream boundaries were modified.

A47. The downstream boundary for the Lower Wey uses a peak level for a 1 in 5 year return period for the River Thames. This level was selected to be run with the 1 in 100 year and 1 in 1000 year runs as it was deemed that a large magnitude event in the River Wey would rarely coincide with an event of similar magnitude in the River Thames.

MODEL CALIBRATION AND SENSITIVITY

A48. The original iSIS models of the Wey and Hoe Stream produced by Atkins for the River Wey Flood Mapping Study were calibrated in two stages, the first stage undertaken for the Strategic Review Study and the second stage after the extension and revision of the models. There were three recorded events utilised for the calibration of the Lower Wey and three recorded events for the Hoe Stream. Each event represents a range of rainfall events and durations.

A49. The results of the calibration showed that the modelled peak levels were generally within the Flood Mapping Specification target accuracy for level of ±150mm. The peak flow predictions were within -36% to +20% of observed values. These results were deemed satisfactory and to an acceptable level of accuracy for use in strategic flood risk assessments.

A50. Further details of the calibration work carried out by Atkins are available in *Section 5 of the River Wey Flood Mapping Study (Atkins, February 2006)*

A51. Sensitivity testing of the Wey and Hoe Stream models was carried out for the Wey Flood Mapping Study by Atkins. Changes in flow, channel roughness, storm duration, and the downstream boundary condition were tested. Flood levels were shown to be relatively insensitive and thus the model was deemed reliable.

A52. Further details of the sensitivity testing carried out by Atkins are available in *Section 8 of the River Wey Flood Mapping Study (Atkins, February 2006).*

MODELING TO DEFINE FLOOD ZONES

A53. Within this SFRA a number of simulations of the 1D iSIS models were carried out with the aim of producing the maximum flood extents for the 1 in 20, 1 in 100 year and 1 in 1000 year return period flood event. Flood Zones are a representation of flood risk without defences. Within the Study Area there are no significant defence structures present and hence there was no requirement to modify the model from its existing state.

A54. The method for generation of the Flood Zones and criteria agreed with the EA are detailed below and used in the analysis:

- **Zone 1** (Little or No Risk) including land on higher ground than the areas defined by Zones 2 and 3. Hence, no flood modelling was required to define this zone.

- **Zone 2** (Low to Medium Risk) was defined by the peak flood envelope of the 1 in 1000 year return period fluvial flows and a model geometry representing the current River Wey system (undefended). The 1 in 1000 year flood levels were not included in previous studies and therefore were completed by Capita Symonds as part of this SFRA. The results from these runs were extracted from iSIS and used for generation of the Flood Zone outlines as detailed in Section 10 of this SFRA report.

- **Zone 3** (High Risk) was defined by the peak flood envelope of the 1 in 100 year return period fluvial flows and a model geometry representing the undefended case. This model run was completed by Atkins for the Wey Flood Mapping Study and by BTP-Hyder for the Hoe Stream. The 1 in 100 year outlines produced by BTP-Hyder and Atkins have been used for definition of Flood Zone 3.

A55. Plans showing the modelled Flood Zones are included in ***Volume 3, Appendix C***. Where modelled flood extents were not available, i.e. on small un-modelled tributaries , the EA Flood Zones have been used.

MODELLING TO DEFINE DETAILED RISK

A56. Simulations carried out by Atkins for the River Wey Flood Mapping Study were aimed at defining the 1 in 100 year flood outline for existing geometry. The Actual Risk characteristics of the Study Area are defined by a peak flood envelope produced using the 1 in 100 year return period fluvial flows. The outline produced by Atkins for the River Wey Flood Mapping study has been adopted unchanged for definition of actual risk in this SFRA. The flood extents produced by BTP-Hyder have been used to define Actual Risk for the Hoe Stream.

A57. The impacts of climate change were also assessed as part of the assessment of Actual Risk. Climate change has been accounted for by adding an additional 20% to model inflows. The resulting peak flood envelope is displayed with the 1 in 100 year return period *Actual Risk* envelope in ***Volume 3, Appendix C***.

A58. To aid in defining the functional floodplain within the study area, the 1 in 20 year flood event was extracted from the Wey and Hoe Stream models. The resulting flood extent has been mapped in ***Volume 3, Appendix C***. The flood extents are displayed with the 1 in 100 year Actual Risk envelopes.

A59. Where modelled flood extents were not available, i.e. on small un-modelled tributaries EA Flood Zone 3 has been used. However in these areas, no climate change or 1 in 20 year flood extents are available.

EXTREME FLOOD RISK

A60. A number of simulations of the 1D iSIS models were carried out for this SFRA with the aim of defining the extreme risk of flooding within the Study Area. Model simulations of the 1 in 1000 year return period flood event were completed to define a comparable flood extent to the modelled 1 in 100 year return period flood extent, and as such indicate extreme risk.

A61. The assessment was based on the maximum modelled flood extent using the 1 in 1000 year flood event inflows.

A62. The peak flood envelope associated with this extreme risk is shown on plans in ***Volume 3, Appendix C***. Where modelled flood extents were not available, i.e. on small un-modelled tributaries the EA Flood Zone 2 has been used.

A63. The residual risk of defence breach has not been assessed, as no formal flood defences have been identified within the Study Area.