Flood Risk Management (Scotland) Act 2009

Surface Water Management Planning Guidance

First Edition

February 2013

Scottish Water
Always serving Scotland

SEPA
Scottish Environment Protection Agency

The Scottish Government
Riaghaltas na h-Alba

Flood Risk Management (Scotland) Act 2009

Surface Water Management Planning Guidance

First Edition

February 2013

Contents

Introduction

1.1 Purpose

The purpose of this guidance is to assist responsible authorities in preparation of Surface Water Management Plans (SWMPs) to help with the management of surface water flooding as required under the Flood Risk Management (Scotland) Act 2009 (the FRM Act).

The guidance has been developed by the Scottish Advisory and Implementation Forum for Flooding (SAIFF) which has representatives from Scottish Government, local authorities, Scottish Water and SEPA.

1.2 Background

The Flood Risk Management (Scotland) Act 2009 (the FRM Act) establishes a flood risk management planning process for the assessment and sustainable management of flood risks with the aim of reducing the adverse consequences of flooding from all sources, including surface water flooding.

The FRM Act requires two sets of complementary plans, Flood Risk Management (FRM) Strategies produced by SEPA, and Local Flood Risk Management Plans (LFRMPs) produced by lead local authorities[1].

The FRM Act requires SEPA and the responsible authorities to co-operate with each other and to co-ordinate the exercise of their functions[2] with a view to reducing overall flood risk and to achieve the objectives of the FRM Strategies and LFRMPs.

The FRM Strategies and LFRMPs must set objectives for the management of flood risk (including surface water flood risk) in Potentially Vulnerable Areas (PVAs) and identify the most sustainable measures to achieve those objectives. The objectives and measures in the FRM Strategies and LFRMPs must take account of all sources of flooding including surface water management and urban drainage.

The surface water management planning process described in this guidance is currently considered best practice by which to identify the most sustainable measures to manage urban drainage and the risk of surface water flooding. It is expected that the FRM Strategies and LFRMPs will identify the production of Surface Water Management Plans (SWMP) as a measure to manage the risk of surface water flooding.

The Ministerial Guidance[3] on Delivering Sustainable Flood Risk Management (the SFM guidance) states that surface water flooding will be addressed through SWMPs and local authorities will lead on the preparation of SWMPs which will be co-ordinated within the flood risk management planning process set out in the FRM Act.

The surface water management planning process will help to deliver the Scottish Government outcomes for sustainable flood risk management:

[1] Further information on the flood risk management planning process can be found in SEPA's Flood Risk Management Planning in Scotland: Arrangements for 2012-2016.
[2] This refers to the flood risk related functions that are described in section 1(4) of the FRM Act or any functions that are specified in an order from the Scottish Ministers.
[3] The Scottish Ministers issued guidance in 2011, Delivering Sustainable Flood Risk Management, under section 2 (5) and section 29 of the FRM Act

1. A reduction in the number of people, homes and property at risk of flooding as a result of public funds being invested in actions that protect the most vulnerable and those areas at greatest risk of flooding
2. Rural and urban landscapes with space to store water and slow down the progress of floods
3. Integrated drainage that decreases burdens on our sewer systems while also delivering reduced flood risk and an improved water environment
4. A well informed public who understand flood risk and adopt actions to protect themselves, their property or their businesses
5. Flood management actions undertaken that will stand the test of time and be adaptable to future changes in the climate

1.3 Surface water flooding in Scotland

Surface water flooding is a significant problem in Scotland. The National Flood Risk Assessment (NFRA) published by SEPA in December 2011 estimated that around 125,000 properties are at risk of flooding from all sources. This represents 1 in 22 homes and 1 in 13 businesses with the average annual cost of damages estimated to be between £720 million and £850 million. The NFRA estimated that surface water accounts for approximately 38% of these predicted impacts in Scotland.

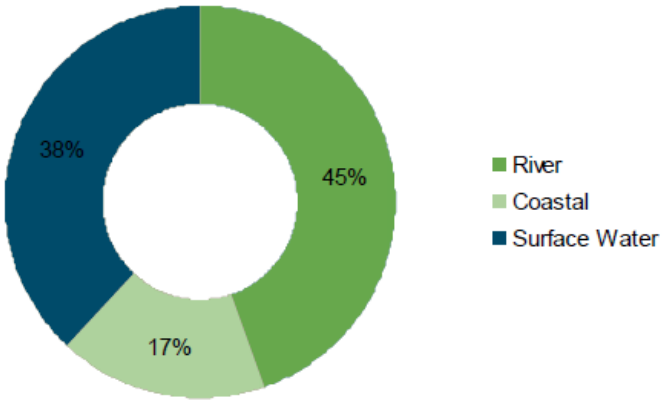


Figure 1. Main sources of flood risk in Scotland

Glasgow 2002 surface water flooding event

Figure 2. Flooding in Cockenzie Street in Glasgow 2002. Photograph courtesy of The Herald and Times.

Figure 3. Flooding in Ardgay Street in Glasgow 2002. Photograph courtesy of Glasgow City Council.

An example of a significant surface water flooding event in occurred in Glasgow on 30 July 2002. 75 mm rain fell in 10 hours, with a maximum intensity of 94.5 mm/hr occurring, this rainfall event was estimated to be a 1 in 100 year return period. The majority of this flooding was from surface water that included flooding from surface water run-off, sewer flooding, flooding from other artificial drainage systems and small urban watercourses.

The East End of Glasgow was the worst affected district of the city with 200 people evacuated from their homes. Train travel was disrupted as a result of flooding and landslides causing closures on the West Coast Main Line, Glasgow to Edinburgh via Carstairs Line and Queen Street station. A number of roads were also badly affected including the A82 and A8. The cost of the damages of this flood was estimated to be in the region of £100 million.

1.4 What is surface water flooding?

In natural (undeveloped) catchments, when rain falls onto a surface, some will evaporate directly back into the atmosphere (evaporation) and the remainder will infiltrate into the ground (groundwater). Some of this will then be taken up by vegetation and evaporates back into the atmosphere (transpiration). Any excess surface water runoff will drain via a network of small and large watercourses and lochs to the sea. During higher rainfall watercourses can reach their bank full capacity and overflow onto floodplains.

Development and urbanisation has fundamentally altered this natural drainage process. Removing vegetation and building over green space reduces infiltration and evapotranspiration (evaporation and transpiration). This has the dual effect of increasing both the volume and rate of surface water runoff in urban areas. This increased runoff combined with the replacement of some watercourses (and other natural drainage features) with drains and culverts (that have a finite capacity) constrains the ability of the drainage network to cope with the surface water, causing flooding when surface water can't reach the drainage network or when the drainage capacity is exceeded. When this increased surface water runoff reaches watercourses it also exacerbates river flooding (Figure 4).

The term surface water flooding is often used to describe flooding from high intensity rainfall events that cause flooding from rainfall runoff flowing and ponding on the ground and also flooding from sewers and other artificial drainage systems such as road drainage when the capacity of drainage systems is exceeded. It is distinct from flooding that occurs from larger rivers and the sea. In reality the general term of surface water flooding is often a complex interaction of many sources of flooding, including flooding from the natural (e.g. smaller watercourses) and artificial (e.g. sewers) drainage systems and direct inundation of areas from surface water runoff. Other sources of flooding can exacerbate surface water flooding for example where high sea levels or river levels prevent drainage systems from discharging freely. The term surface water flooding for the purpose of this guidance includes flooding from the following sources:

- Pluvial flooding – flooding as a result of rainfall runoff flowing or ponding over the ground before it enters a natural (e.g. watercourse) or artificial (e.g. sewer) drainage system or when it cannot enter a drainage system (e.g. because the system is already full to capacity or the drainage inlets have a limited capacity).

- Sewer flooding and other artificial drainage system flooding – flooding as a result of the sewer or other artificial drainage system (e.g. road drainage) capacity being exceeded by rainfall runoff or the drainage system cannot discharge water at the outfall due to high water levels (river and sea levels) in receiving waters.

- Groundwater flooding – flooding as a result of the water table rising to the surface.

- Flooding from small urban watercourses (including culverted watercourses) – flooding which occurs from small watercourses (including culverted watercourses) that receive most of their flow from inside the urban area and perform an urban drainage function. It should be noted for consideration that SEPA will not be assessing flood risk from watercourses with a catchment area less than 3km^2.

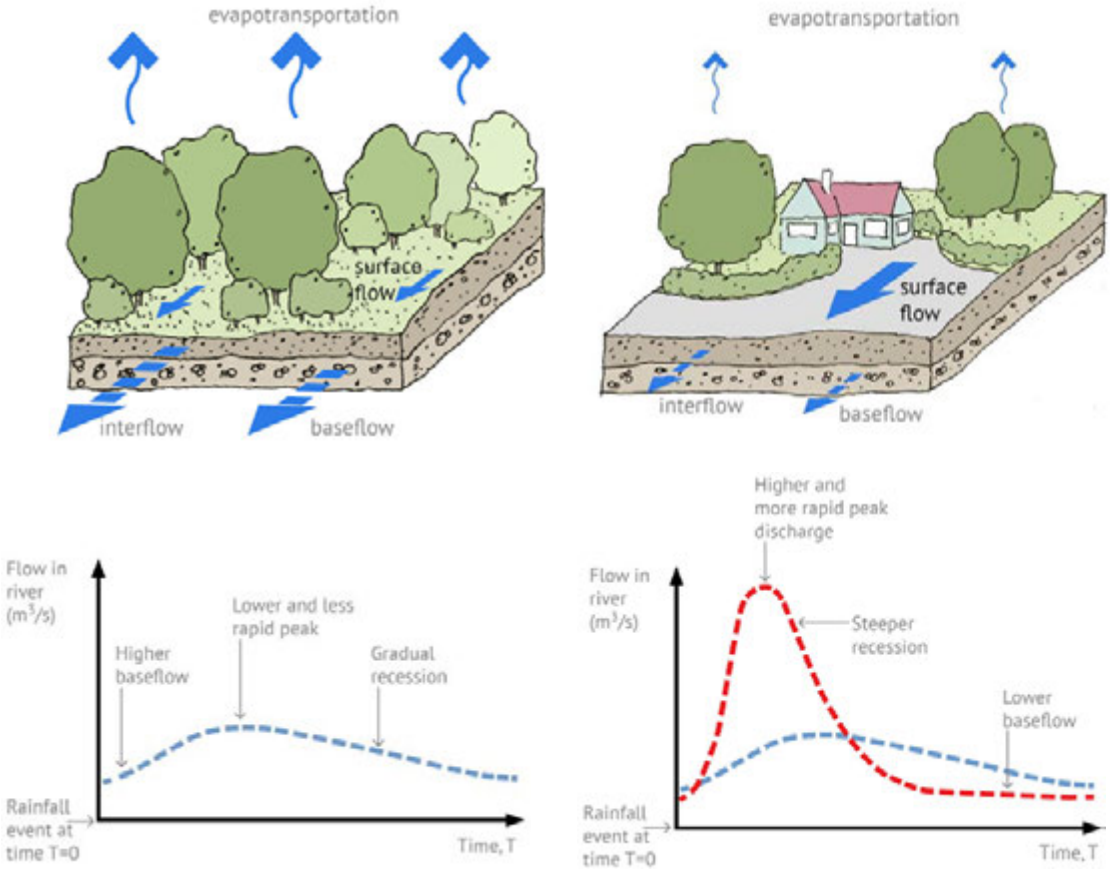


Figure 4. Overview of surface water flows in a natural catchment and in a developed catchment, illustrating the impact of urbanisation showing increased surface water flows and increased river flows. Illustration courtesy of CIRIA and www.susdrain.org.

1.5 Principles to support the sustainable management of surface water flood risk and urban drainage

The risk of surface water flooding has the potential to increase in the future due to climate change, population growth and urban creep (the gradual loss of permeable surfaces from urban areas e.g. paving over gardens to create driveways)[4].

To manage surface water flooding and urban drainage in the long-term, it is not sustainable to rely on continual upgrading of 'traditional' sewerage and surface water infrastructure. Creating ever larger pipes and subsurface storage is impractical, prohibitively expensive and not adaptable to climate change.

Instead, an integrated approach to drainage that takes account of all aspects of the urban drainage systems and produces long-term and sustainable actions must be deployed.

This requires examination of the sources, pathways and receptors of flood waters to ensure that a full range of measures can be applied across the urban area and during any event the flows created can be managed in a way that will cause

[4] Houstoun et al (2011) Pluvial (rain related) flooding in urban areas: the invisible hazard. Joseph Rowntree Foundation.

minimum harm to people, buildings, the environment and businesses and be adaptable to climate change.

A key component of this approach is to manage surface water before it enters the sewer system or receiving watercourse by allowing for the increased capture and reuse of water; increased absorption through the ground; and more above-ground storage and routing of surface water separate from the sewerage system.

This approach will not only help reduce surface water flooding, it will also help to reduce pollutant inputs to watercourses and reduce the reliance on infrastructure, e.g. culverts that can damage the water environment. It can also create other recreational, amenity and economic benefits through the creation of green spaces and opportunities for urban regeneration and become more resilient to climate change.

The SFM guidance states that principles of integrated drainage should be adopted by SEPA and the responsible authorities (Table 1).

Table 1. Principles of integrated drainage
• Increase the percentage of new surfaces that are permeable
• Aim to deal with storm water runoff from impermeable surfaces as close to source as possible
• Replace existing impermeable surfaces with permeable surfaces where practicable
• Minimise the amount of drainage going underground as this is often an inflexible solution that cannot deliver wider benefits or be easily adapted to future conditions
• Maximise opportunities to manage surface water before it enters the sewer system
• Design for exceedance by ensuring that existing and new developments have flood plains and safe flow paths.

1.6 What is surface water management planning?

Surface water management planning is the process by which the most sustainable measures to manage the risk of surface water flooding are identified in order that they can be described as required in the FRM Strategies and LFRMPs. Further detail on the flood risk management planning process is given in Section 2.

The purpose of a Surface Water Management Plan (SWMP) is to provide sufficient information to support the development of an agreed strategic approach to the management of surface water flood risk within a given geographical area by ensuring the most sustainable measures are identified (i.e. the most economically, socially and environmentally beneficial measures). SWMPs can be implemented at any scale, and should follow a risk based approach, where most effort should be focused in areas of highest risk and where the most complex problems exist. SWMPs can therefore vary in detail to suit local requirements and the amount of detail that a SWMP contains should be proportionate to the surface water flood risk and the complexity of the problem. The principles in this guidance can therefore be followed to address surface water flooding in any area, however the FRM Strategies and LFRMPs will identify where the risk of surface water flooding is greatest and where priorities for surface water management planning should be focused.

SWMPs within the flood risk management planning process should be considered a long-term plan for managing surface water flooding. The SWM planning process should assess the risk[5] of surface water flooding, set objectives and identify measures for the management of surface water flood risk in an area. This should include a description of measures currently in place, measures that can be implemented in the short term and longer term aspirational aims (e.g. where redevelopment provides a cost-effective opportunity to improve surface water management). The SWMP should therefore include a range of structural (e.g. surface water storage structures) and non structural (e.g. emergency response) measures including:

- Policy recommendations to influence land use planning
- Policy recommendations to influence emergency planning
- Ensuring better co-ordination between different authorities
- Identification of where improved maintenance / asset management by all partners will help to reduce surface water flood risk
- Structural measures where informed principally by cost benefit appraisal
- Aspirational options to reduce surface water flooding, which may not be deliverable in the short-term, but nonetheless could become feasible in the longer term

Once an agreed strategy, including a set of agreed measures, has been reached between SWMP partners, detailed appraisal and design of any structural measures identified can then be taken forward under agreed timescales (see section 2 for more information on the flood risk management planning process).

[5] The FRM Act defines flood risk as the combination of the probability of a flood occurring and the potential adverse consequences associated with a flood on human health, the environment, cultural heritage and economic activity.

2 Overview of the FRMP and SWMP process

2.1 Roles and responsibilities

The legal responsibilities for surface water and drainage are complex with different authorities responsible for different parts of the drainage system. Scottish Ministers, SEPA and the responsible authorities have various roles and responsibilities with regard to drainage and surface water flooding, in general terms under various governing Acts, and specifically under the FRM Act. A summary of the key duties and powers in relation to surface water flooding is given below, and further information is given in Appendix 2. It should be noted that the key duties and powers described below are not exhaustive.

Section 1of the FRM Act places general duties on the Scottish Ministers, SEPA and the responsible authorities to:

- Exercise their flood risk related functions[6] to reduce overall flood risk
- Exercise their flood risk related functions to secure compliance with the European Floods Directive[7]
- Act with a view to achieving objectives set in the FRM Strategies and LFRMPs
- Have regard to the social, environmental and economic impact of exercising those functions
- Act in the way best calculated to manage flood risk in a sustainable way
- Promote sustainable flood management
- Act in a way best calculated to contribute to sustainable development
- So far as practicable adopt an integrated approach by cooperating with each other so as to co-ordinate the exercise of their respective functions.

Local authorities have general powers to manage flood risk (from all sources including surface water flooding) within their area, including implementation of measures described in the LFRMPs, carry out flood protection schemes or any other flood protection work. The definition of flooding under the FRM Act does not include flooding solely from a sewerage system (flooding solely from a sewerage system includes flooding from the sewerage system under usual rainfall events that fall under Scottish Water duties). Local authorities also have duties to provide adequate drainage of publicly adopted roads and duties under the land use planning system to consider the risk of flooding.

Scottish Water has duties under the Sewerage (Scotland) Act 1968 to provide and maintain public sewers to effectively drain surface water (under usual rainfall events) from the curtilage of properties.

SEPA has responsibilities under the FRM Act to map and assess flood risk, produce FRM Strategies, provide a flood warning service and to provide flood risk advice to planning authorities and National Park Authorities.

In addition we are all responsible for protecting ourselves and our property from flooding; this means the public and communities working to help minimise flood

[6] This refers to the flood risk related functions that are described in section 1(4) of the FRM Act or any functions that are specified in an order from the Scottish Ministers.

[7] In Scotland the FRM Act implements the European Parliament and Council Directive 2007/60/EC on the assessment and management of flood risks also referred to as the Floods Directive.

damage to their land or property without increasing flood risk elsewhere (if one person's acts causes increased flooding to another person's property there may be resulting common law implications). The public has an important role in sharing local knowledge and engaging in flood protection actions for their areas.

2.2 Risk based approach

The FRM Act sets out a risk based approach to the management of flooding to ensure resources are targeted at the areas of highest risk and where the greatest benefits can be achieved. This risk based approach can be applied to all aspects of flood risk management planning including risk assessment, appraisal of measures and degree of partnership working. Effective assessment of flood risk and appraisal of measures to manage flood risk should underpin decision making at all levels of flood risk management planning including FRM Strategies, LFRMPs and SWMPs.

This is consistent with one of the overarching outcomes of the Ministerial Guidance on SFM, *"a reduction in the number of people, homes and property at risk of flooding as a result of public funds being invested in actions that protect the most vulnerable and those at greatest risk of flooding".*

2.3 FRM and SWM planning process

The principles in this guidance can be followed to address surface water flooding in any area. The FRM Strategies and LFRMPs will identify where the risk of surface water flooding is greatest and where surface water management planning priorities should be focused as a measure to manage the risk of surface water flooding.

The FRM Strategies for each Local Plan District (LPD) will identify PVAs where the risk of surface water flooding is greatest and therefore where surface water management planning effort should be focused. The LFRMPs will summarise this information and describe the governance arrangements put in place to take forward the SWMP(s) in the LPD. The measures identified through the surface water management planning process will be described in the LFRMPs (Figure 5).

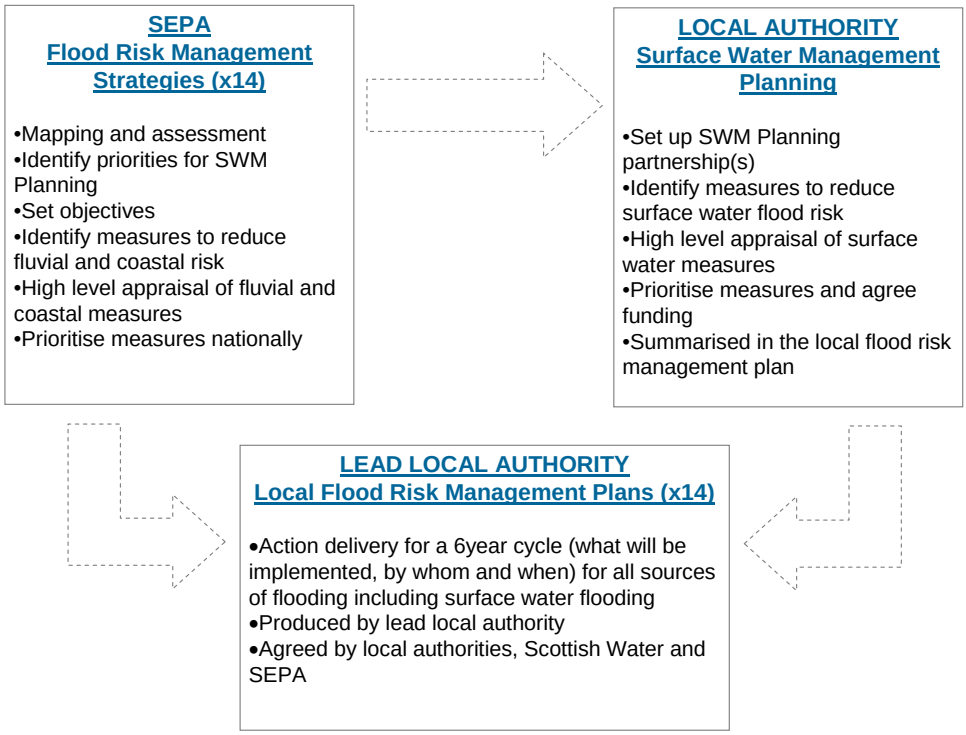


Figure 5. Overview of the flood risk management planning process.

FRM Strategies, LFRMPs and SWMPs will be developed to be complementary through collaborative partnerships between local authorities, SEPA and Scottish Water. It is intended that the FRM Strategies, LFRMPs and SWMPs will be supported by all parties. An overview of the surface water management planning process is given in Figure 6.

The FRM Strategies led by SEPA will:

- Provide a summary of the surface water flood hazards and impacts in the LPD
- In agreement with the LPD partnerships identify the urban areas (and the PVAs within those urban areas) with the highest risk of surface water flooding where surface water management planning effort should be focused
- Set high level objectives for surface water flooding for each PVA
- Describe sustainable measures to manage surface water flood risk that are funded by Scottish Water or the Scottish Government (through any agreed funding mechanism with COSLA). i.e. those measures that will require national prioritisation
- Describe sustainable measures requiring national prioritisation to manage surface water flood risk to be funded by Scottish Water or the Scottish Government subject to appropriate negotiation with COSLA
- The FRM Strategies will also summarise river and coastal flood risk, set objectives and identify sustainable measures to manage the risk of river and coastal flooding

SWMPs led by local authorities should (as a minimum):

- Define geographical area of SWMP(s)
- Set up SWMP partnership(s)
- Collate and review existing information including information on current measures undertaken to manage surface water flood risk.
- Decide on appropriate levels of detail for the SWMP(s)
- Verify existing flood hazard and risk information (does it reflect observed flooding)
- Decide if further assessment is required
- Identify and prioritise drainage areas for further investigation
- Define more detailed objectives for the SWMP area (E.g. identify priority receptors to address in the SWMP area)
- Identify a ‘long list’ of all potential measures
- Screen measures and identify a ‘short list’
- Undertake high level cost benefit analysis of measures
- Prioritise measures and agree with funding bodies
- Provide information to lead local authority for inclusion in the LFRMP
- Implement agreed measures and review progress

The LFRMPs led by the lead local authority will summarise the relevant parts of the FRM Strategy in the supplemental part. The implementation part will then:

- Describe the governance structures set up for surface water management planning in the LPD
- Describe what measures (all measures) are being implemented in the current cycle to address surface water flooding
- State who is responsible for implementing the measures
- Identify the funding arrangements for the measures
- State when the measures will be implemented
- Sate how functions will be co-ordinated to implement the measures that are related to surface water flooding and urban drainage
- The LFRMPs will also summarise this information for river and coastal flooding.

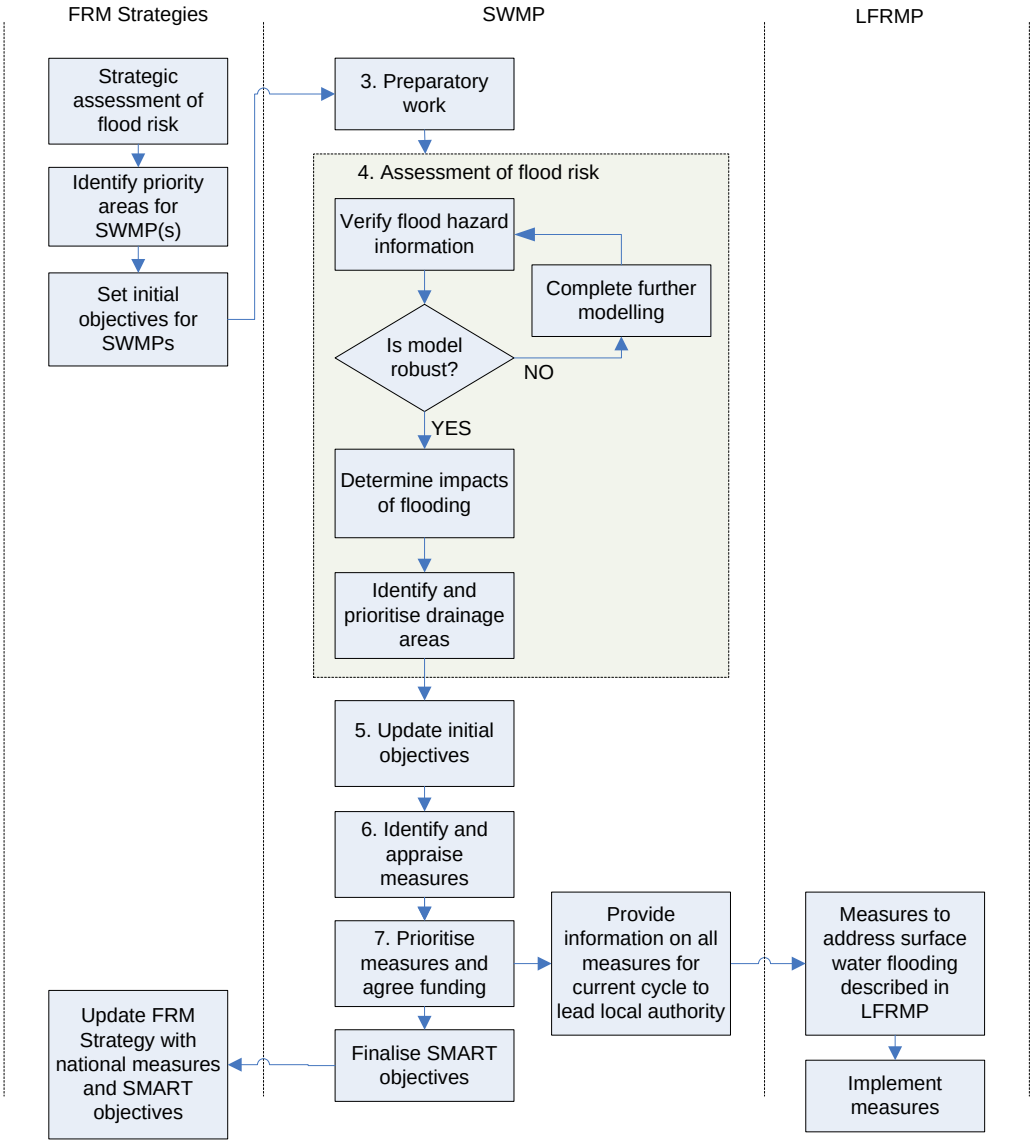


Figure 6. Overview of the surface water management planning process (numbers in flowchart refer to subsequent sections in guidance).

2.4 Flood risk management planning and SWMP timescales (1st planning cycle)

The first flood risk management planning cycle will run from 2015 – 2021, the statutory timescales required prior to this date to produce FRM Strategies and LFRMPs for this period are set out in Table 2. The SWMPs will therefore fit within these timescales.

Table 2. Statutory dates for the production of FRM strategies and LFRMPs		
Date	**FRM Strategies**	**LFRMPs**
Dec 2011	National Flood Risk Assessment Identification of Local Plan Districts (LPDs) Identification of Potentially Vulnerable Areas (PVAs)	
Dec 2013	Publish flood hazard and flood risk maps Assess potential for Natural Flood Management (NFM)	
Dec 2014	Public consultation on draft FRM Strategies	Public consultation on draft supplementary part of LFRMP Responsible authority consultation on implementation part of LFRMP (note it is likely that SWMP measures will largely be included in the implementation part of the LFRMP)
Dec 2015	Publish final FRM Strategies	
Jun 2016		Publish final 1st LFRMP
Dec 2018	Update and review National Flood Risk Assessment	
Jun 2019		Publish 1st LFRMP interim report
Dec 2019	Review and update flood hazard and risk maps	
Dec 2020	Public consultation on draft 2nd FRM Strategies	Public consultation on draft supplementary part of 2nd LFRMP Responsible authority consultation on implementation part of 2nd LFRMP (note it is likely that SWMP measures will largely be included in the implementation part of the LFRMP)
Dec 2021	Publish final 2nd FRM Strategies	
Jun 2022		Publish 1st LFRMP final report Publish final 2nd LFRMP

3 Preparatory work

3.1 Defining SWMP geographical areas

This section will focus on the priority areas for SWMPs identified through the FRM Strategies and LFRMPs. However as stated in Section 1 SWMPs can be carried out at any scale and should follow a risk based approach.

Using the SEPA pluvial flood hazard and risk data, LPD partnerships will agree where the surface water flood risk is highest and identify the towns and cities where SWMP effort should be focused.

This will allow the LPD partnerships to set up the governance arrangements for the SWMP(s) that should consider:

- Local authorities within the SWMP area
- Which local authority will lead the SWMP(s) if more than one local authority is involved
- Other partners required in the SWMP(s).

Once the SWMP partnership(s) have been set up they can refine the boundary of the SWMP area if required. This should be done as the current impacts of surface water flooding can be summarised within the defined area and the achievement of objectives can be tracked against this.

SWMP areas should include all the sources and pathways of surface water flooding. The size and extent of the natural (watercourses) and artificial (above ground and below ground) drainage networks should be taken into account, it should be noted that artificial and below ground drainage networks do not always drain the areas defined by natural topography.

Defining the geographical extent of a SWMP may be based on several considerations including;

- Natural drainage catchments
- Sewer catchment boundaries and other artificial drainage networks
- Extent of urban areas
- Local authority boundaries

A SWMP area can extend beyond the boundaries of a PVA (which are based on river catchments) if some of the sources and pathways of surface water flooding or part of the urban drainage area, lies out with a PVA.

Falkirk Integrated Catchment Study

For example a partnership (Integrated Catchment Study) between Falkirk Council, Scottish Water and SEPA has been set up to address surface water flooding in the Falkirk, Grangemouth and Bo'ness areas. This includes modelling to assess the interactions between pluvial flooding, the sewer catchment, rivers and tidal waters. The work done in the Integrated Catchment Study will help inform the SWMP for the area.

The boundary of the study area can be seen in Figure 7 and was based around the sewer catchments draining the urban areas. The integrated catchment study covers 3 PVAs (PVA reference10/11, 10/12, 10/13).

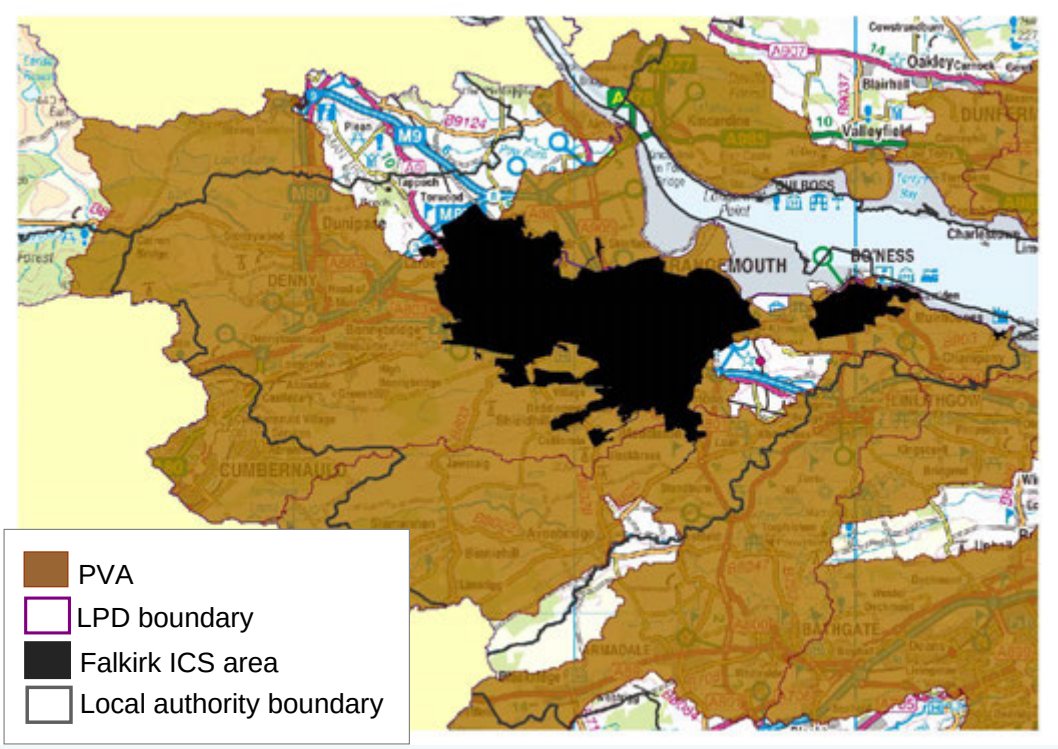


Figure 7. Extent of the Falkirk Integrated Catchment Study covering PVAs 10/11, 10/12 and 10/13.

3.2 SWMP Partnerships

Based on the geographical extent of the SWMP and the risk of surface water flooding the LPD partnerships should agree what governance arrangements are required to take forward the SWMP(s) in the LPD area, which may include specific partnerships to take forward the SWMP(s). This should include identifying what authorities are required in the partnerships and determining what local authority should lead the partnership and the production of the SWMP.

The SWMP partnerships should be underpinned by clear governance arrangements with the SWMP partnerships reporting progress to the LPD partnerships to ensure

the SWMPs are progressing on time to include outputs from the SWMP in the LFRMP.

The lead local authority is expected to lead on setting up the SWMP partnerships and coordinating the work required to develop SWMPs. Other responsible authorities may lead on certain aspects of work required to support the SWMP process e.g. Scottish Water may lead on any sewer modelling required to support the production of a SWMP.

The legal responsibilities for surface water and drainage are complex with different authorities responsible for different parts of the drainage system. The requirement of the FRM Act for responsible authorities to co-operate with each other is therefore particularly important for the management of surface water flooding.

Partnerships should be established to take forward SWMPs that bring together all authorities with responsibilities for the drainage system (this should not be limited to responsible authorities designated under the FRM Act) to ensure co-ordination of actions to manage surface water flooding. The partnerships should work across traditional institutional boundaries to deliver an integrated and sustainable approach to the management of surface water flooding.

It should be seen as an opportunity to identify measures that have multiple benefits that help all the different authorities meet their objectives and legal responsibilities (even when these objectives and legal responsibilities may differ). In order to achieve multiple benefits co-ordination with other planning processes is required, for example:

- River Basin Management Planning
- Biodiversity Action Plans
- Land use planning system (Strategic Development Plans, Local Development Plans, Masterplans, Development Management)
- Climate Change Adaptation
- Scottish Water Ministerial Objectives
- Emergency response planning

The Ministerial Guidance on SFM states "*SEPA and the responsible authorities must work across traditional institutional boundaries to deliver an integrated approach to flood risk management. This will require adoption of partnership working at all levels of flood management from national strategic partnerships through to local / operational partnerships that deliver co-ordinated actions on the ground*."

The authorities required in a SWMP partnership should not be limited to the Scottish Ministers (including Transport Scotland), SEPA and the responsible authorities (local authorities, Scottish Water) designated under the FRM Act. Other authorities may be required depending on local circumstances or on the stage of the SWM planning process e.g.

- Scottish Canals
- Land owners

Different members of the key partner organisations may also be required at different stages of the SWM planning process e.g.

- Land use planning staff
- Emergency planning staff
- Asset maintenance / management staff.

The type or level of partnership working to develop SWMPs can vary and different partnerships will be required to suit individual circumstances – the level of partnership working should be risk based and proportionate to the size and complexity of the problem. For example in lower risk areas where a less detailed SWMP is required the level of partnership working may be less and based on co-ordination (as a minimum between local authorities and Scottish Water).The Ministerial Guidance on SFM identified common types of partnership arrangements (Table 3).

Table 3. Common types of partnership arrangements

Degree of partnership	Characterised by
Co-existence	"*You stay on your turf and I'll stay on mine*" May be a rational solution - where clarity is brought to who does what and with whom.
Co-operation	"*I'll lend you a hand when my work is done*" Often a pre-requisite of further degrees of partnership, where there is early recognition of mutual benefits and opportunities to work together.
Co-ordination	*"We need to adjust what we do to avoid overlap and confusion"* Where the partners accept the need to make some changes to improve services/activities from a user / customer / community perspective and make better use of their own resources.
Collaboration	"*Let's work on this together*" Where the partners agree to work together on strategies or projects, where each contributes to achieve a shared goal.
Co-ownership	"*We feel totally responsible*" Where the parties commit themselves wholly to achieving a common vision, making significant changes in what they do and how they do it.

3.3 Resourcing the surface water management planning process

The LPD partnerships should agree how the production of the SWMP(s) in the LPD will be resourced. This may include consideration of pooling resources or joint funding of posts or consultancy services. The Ministerial Guidance on SFM provides examples of joint funding arrangements (Table 4).

Some of the key tasks involved in the production of a SWMP that should be taken into account when considering resources include:

- Administration of meetings etc
- Storage / management of data and models
- Data licensing and Intellectual Property Rights (IPR)
- Project management
- Carrying out technical tasks (e.g. flood risk assessment / appraisal of measures) including production of associated reports.

Table 4. Examples of funding arrangements	
Type	**Examples**
Aligning resources	- Co-ordination of planning across partner organisations - Targeting funding from different agencies in the same areas - Lead or joint commissioning of related services
Pooling non-financial resources	- Time spent on partnership or inter-agency groups - Information generation and sharing - Different partners providing different elements in combination to provide a service (e.g. awareness raising campaigns) - Secondment of staff with specialist skills to projects or multi-disciplinary teams - Shared use of facilities or equipment
Joint funding	- Joint funded posts - Jointly funded data, tools or models - Contributions to specific activities – with funds managed by one agency
Pooling budgets	- To deliver co-ordinated drainage works or other projects - Creating centres of excellence or expertise in flood management

Joint funding of Integrated Catchment Studies to address the risk of surface water flooding

An example of a collaborative approach to the assessment and management of surface water flooding is the Integrated Catchment Studies (ICS) being undertaken in Falkirk, Tayside, Ayrshire, Aberdeen and Edinburgh. This collaborative approach has involved joint working between Scottish Water, the local authorities and SEPA and joint funding of the studies between Scottish Water and the local authorities. The modelling undertaken in these studies is being led by Scottish Water, with both financial and staffing resources provided by Scottish Water and relevant local authorities, with further staffing resources provided by SEPA. Contracts for all aspects of the studies were issued through Scottish Water's existing contractual agreement, with the local authorities agreeing to provide a scaled financial input to the study. In return all local authorities will receive a copy of the integrated catchment model for their use in any relevant work that will include use in any SWMPs for the areas.

3.4 Collating existing information and scope level of detail required in SWMP

Once the geographical area and partnerships have been established, existing relevant information for the SWMP area should be identified and collated. Data and information will be held by the SWMP partners and maximum use should be made of existing information. A list of information that is required / available for a SWMP is given in Appendix 4.

A project data register should be set up to formally record the information available for the SWMP area. This should include information on:

- What data and information is available
- Who owns the data / information
- The format of the data and information
- The quality of the data
- Potential limitations on the use of the data

As stated above, the SWMP should follow a risk based approach and the level of detail provided in the plan should reflect the resources required from each of the partners and should be proportionate to the risk and complexity of the surface water flooding problem.

Reviewing the available data will provide an initial indication of the level of detail required in the SWMP. In particular the FRM Strategies will give an indication of the level of risk of surface water flooding in an area. Other information and local knowledge will give an indication of the complexity of the flooding mechanisms in the area. The SWMP partnerships should decide on the level of detail likely to be required for the SWMP (Table 5).

Table 5. Overview of different levels of detail that a SWMP can contain

Management of surface water flooding (low risk areas)

- Areas not identified as a SWM planning priority in the FRM Strategies
- Likely to be in areas with a lower risk of surface water flooding.
- Local authorities still have powers to manage flood risk (including surface water flood risk in their area).
- Any PVA surface water flooding hazards and impacts identified in the FRM Strategies should be summarised.
- Partnerships - Formal / dedicated SWMP partnership not likely to be required however responsible authorities should still co-operate with each other.
- Objectives – the overall objective of avoiding an increase in surface water flooding is likely to apply.
- Measures - local authorities should carry out work to manage surface water flood risk as appropriate and describe what is done at present to manage surface water flood risk.
-

SWMP required medium detail

- PVA / urban area identified a SWMP priority in the FRM Strategies
- Likely to be required in areas with a medium / high risk of surface water flooding and with less complex problems.
- Partnerships – Formal / dedicated SWMP partnership likely to be required e.g. based on cooperation / co-ordination.
- Objectives – objectives of avoid, protect and prepare for surface water flooding should be met where practicable.
- Assessment - Further modelling and assessment is not likely to be required. The causes and consequences of surface water flooding should be understood and described. Priority drainage areas should be identified.
- Measures - should be identified based on existing information as a minimum (e.g. emergency response plans, maintenance regimes, land use planning policies, flood warning).
- Outputs of SWMP should be provided to lead local authority for inclusion in the LFRMP.

SWMP required high detail

- PVA / urban area identified as a SWMP priority in the FRM Strategies
- Likely to be required in areas with a high / very high risk of surface water flooding and with some complex problems.
- Partnerships – Formal / dedicated SWMP partnership likely to be required based on a greater degree of partnership working e.g. collaboration / co-ownership
- Objectives – objectives of avoid, protect and prepare for surface water flooding should be met where practicable.
- Assessment - further modelling and assessment may be required where complex issues exist. The causes and consequences of surface water flooding should be understood and described. Priority drainage areas should be identified.
- Measures should be identified (e.g. emergency response plans, maintenance regimes, land use planning policies, structural measures including SUDS and overland flow pathways).
- Outputs of SWMP to be provided to lead local authority for inclusion in LFRMP.

4 Assessment of flood risk

4.1 Introduction

Flood risk is a combination of the probability of a flood occurring (flood hazard) and the potential adverse consequences of that flooding on receptors.

Flood risk assessment is used to account for the consequences of flooding and is a necessary precursor to the process of options appraisal where appropriate.

This section includes information on:

- How to determine if further modelling and mapping may be necessary to supplement that provided by SEPA or Scottish Water (i.e. if a greater level of detail is required)
- How to undertake a flood risk assessment as part of a SWMP using SEPA and / or Scottish Water provided mapping outputs or new modelling and mapping generated for the purpose.
- The outputs from a risk assessment that will be needed to support cost benefit appraisal of measures (see section 7 for guidance on appraisal).

The approach is 'risk-based' and flexible, meaning that the level of detail can be varied to suit the understood risk and the complexity of the flooding mechanisms as they are appreciated locally. The approach is not prescriptive but provides a framework around which different partnership organisations can collaborate under the leadership of a local authority.

The ultimate purpose is to provide sufficient information to support the development of a locally relevant and agreed strategy for the reduction of surface water flood risk. It is not intended to provide the type of information to support detailed appraisal or engineering design. These more detailed stages can occur once a locally agreed strategy is in place through the SWMP.

Guidance on the principles of modelling surface water flooding is provided in Appendix 3.

4.2 Approach to SWMP flood risk assessment

A process is illustrated below (Figure 8) to support local authorities undertaking a SWMP risk assessment. The process is described in 3 steps and further key references are identified as required.

The process is best followed with the involvement of all key partners in the SWMP so that outcomes have full agreement. The process is indicative only; local authorities are encouraged to be innovative and apply equivalent methodologies to suit local circumstances.

The purpose of the SWMP risk assessment is to provide a clear explanation around the probability and adverse impacts of surface water flooding across a whole SWMP area or focussed around one or more flooding hotspots or drainage areas.

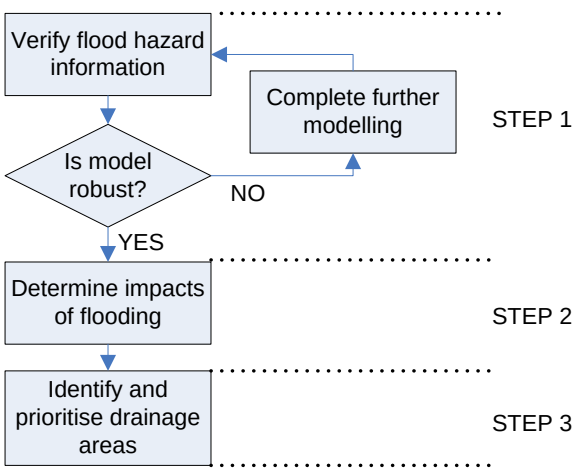


Figure 8. Overview of SWMP risk assessment process

SEPA, Scottish Water and local authorities have duties under the FRM Act to provide information on flood risk (flood hazard and adverse impacts of flooding) and other information that is required for the management of flood risk. This information will be provided to the local authorities leading on the production of SWMPs and is the starting point for the production of SWMPs including the identification of measures to address surface water flooding.

A summary of the information that is being produced as a requirement of the FRM Act can be seen in Appendices 4 and 5.

Two key datasets are being provided under the FRM Act that will contribute to the production of SWMPs:

- Regional pluvial flood hazard mapping
- Regional pluvial impacts of flooding (baseline impacts)

<u>Regional pluvial flood hazard mapping</u>
SEPA have undertaken regional pluvial modelling to produce pluvial flood extents, depths, velocities and hazard ratings. The regional areas modelled were those considered most at risk from pluvial flooding based on the national pluvial modelling that was carried out as part of the NFRA and the availability of LiDAR (light detection and ranging) data. The regional pluvial hazard models have been developed based on a ground model consisting of combined LiDAR and NextMap datasets, applying a 300mm uplift of the ground model to represent buildings and a blanket 1 in 5yr drainage loss allowance for a range of return periods (including climate change scenarios). More information on the regional pluvial hazard modelling can be found in Appendix 5.

<u>Regional pluvial impacts of flooding (baseline impacts)</u>
SEPA will also be determining the adverse impacts of the regional pluvial flood hazards on human health, the environment, cultural heritage and economic activity under the range of return periods. For example this will include information on monetary damages to homes and businesses, the number of people at risk of flooding, community facilities effected etc. With the data provide the local authorities will be able to summarise the adverse impacts within any area they require. More information on how the adverse impacts of flooding are assessed can be found in Appendix 4.

In addition, the Scottish Water assessment of flood risk from sewerage systems (Section 16 of the FRM Act) when used in conjunction with the regional pluvial flood hazard and risk mapping and local knowledge can provide insight into likely flood mechanisms and solutions.

In many cases this information can be used in SWMPs without the need for further modelling. In other cases, further modelling and new hazard and risk mapping may be required or warranted. In these cases, SEPA can provide data to make this further hazard modelling and risk mapping relatively straightforward (and consistent with national flood risk assessments) using a variety of different modelling platforms (software) and methods.

Areas where there is no regional pluvial hazard mapping are covered by the national pluvial hazard mapping. This was undertaken using a coarser type of pluvial modelling and can provide some supporting information for local authorities looking to undertake SWMPs outside of PVAs. However the types of measures that can be identified from this data will be limited as there is more uncertainty associated with this information.

The responsible authorities may have other information that can be used to inform the SWMP, and this should be used where available.

4.3 STEP 1 - Verify flood hazard information and determine if further modelling is required

The purpose of Step 1 is to determine whether the SEPA regional pluvial hazard map and associated impacts of flooding is an appropriate basis for the SWMP, including the strategic identification of measures to address surface water flooding or whether further modelling or assessment is required prior to identification of measures. It is generally expected that the regional pluvial hazard maps and associated pluvial baseline impacts should be appropriate for the following tasks:

- Understanding flood hazard and flood risk
- Understanding flood mechanisms
- Establishing objectives for surface water flooding
- Identification of measures (long list)
- Strategic cost benefit appraisal of measures (structural and non structural)

4.3.1 Comparison of modelled flooding with historical observations

In order to verify the regional pluvial hazard maps, they should be compared to observed flooding events. The regional pluvial hazard maps show a range of modelled scenarios. Initially the 1 in 50 year regional pluvial flood extent should be compared to local records of flooding and other anecdotal information around the location and frequency of previous flooding. The 1 in 50 year pluvial flood extent is used as a starting point as it should represent rainfall events that have been experienced, as opposed to using a more rarely occurring and larger magnitude flood (e.g. 1 in 200 year) that may not have been experienced.

Verification of modelling in Dundee

Figure 9 illustrates an example of a good verification between modelled and observed flooding in Dundee. The flooding that was observed in the Trades Lane area in August 2004 is successfully predicted by the model.

Figure 9. Comparison of modelled flooded areas and areas of recorded flooding in the Trades Lane area of Dundee. Photograph courtesy of DC Thomson & Co.

There is no reliable, scientific way to compare historical and modelled flooding; the judgement of all SWMP partners should be applied. The model should be verified against know flooding locations because alignment (or failure of alignment) between modelled flooding locations and flooding observations is likely to be a combination of:

- locations where flooding is predicted but has never occurred. In this case the model may be accurate but there has been no flood event to verify the model in the given location. Just because a location has not experienced flooding in the past does not mean that it is at risk of flooding in the future.
- locations where flooding has occurred but is not predicted. In this case the model is failing to predict the observed flooding and further information is likely to be required.

Good alignment around known flooding locations is an ideal even if predicted flooding is not matched by observations elsewhere. Where there is good alignment between modelled and observed flooding locations, and the flooding mechanisms are understood, then Step 2 should be carried out.

Complete failure to replicate known flooding locations indicates that undertaking further modelling may be necessary to correctly represent flood mechanisms. If this is the case, then the reasons why this might be the case should be identified in order to help make a decision on what type of further modelling is required.

4.3.2 Reasons why modelled flooding might not be predicting observed flooding

The regional pluvial hazard mapping was carried out using standard inputs for a range of modelling parameters such as drainage capacity, runoff coefficient and topography. These will not be appropriate in all situations and can be adjusted in further modelling to improve verification and model certainty. The development of further modelling can be used to address modelling uncertainties of the following type:

Drainage capacity

Section 16 sewer flooding mapping (where available) is useful to determine local drainage capacity. This knowledge can help inform whether the default 1 in 5 year return period drainage capacity (used in the regional pluvial hazard modelling) is appropriate.

Similarly, Section 16 results can be used to determine the critical duration for drainage exceedance; this will vary with gradient and other factors. This knowledge will guide the selection of mapping scenarios with either a 1 hour or 3 hour storm event duration. If, in consultation with Scottish Water and other partners, it is clear that none of the default drainage capacity or event duration scenarios are suitable then further pluvial modelling should be considered using data supplied by SEPA (Option A in Table 6).

Runoff coefficient

Similarly, if default run-off coefficients for land use types (used in the Regional Pluvial model) are considered inappropriate then the regional pluvial models can be re-run with locally appropriate runoff coefficients. See Appendix 4 for further information on re-running the regional pluvial hazard models (Option A in Table 6).

Inaccuracies in the Digital Terrain Model (DTM)

The regional pluvial mapping may not be representing observed flooding because of inaccuracies or simplifications in the DTM used. The DTM used by SEPA in the regional pluvial hazard maps is based on NextMap and LiDAR that has been processed to remove false blockages and introduce building footprints as indicated on Ordnance Survey data. No ground truthing of the DTM was undertaken. Where it is thought that local topography is not represented in the DTM and it is having an impact on surface water flow routes and flooding locations then topographical surveys can be carried out and this surveyed detail can be added to the DTM e.g. where roads are known to convey significant flows, these can be modelled as 150mm depressions in the DTM, other features can also be added including kerb-lines / heights, low walls, additional buildings and known flow routes (Option A in Table 6).

Further information on this can be found in CIWEM Urban Drainage Group's guide to Integrated Urban Drainage Modelling (2009).

Interactions with other sources of flooding

The regional pluvial modelling may be inaccurate because it's not representing the dynamic interaction of above and below ground flows correctly; this can occur when large sewer pipes transfer flooding from one location to another or where the catchment of the sewer system does not follow above-ground topography. Section 16 sewer flooding data and other sewer asset information can be used to infer the importance of sewer and surface interactions. There can be similar interactions with watercourses (which may be culverted) and coastal waters which can impede discharge from surface water drainage outfalls resulting in a locally reduced drainage

capacity. Such dynamic interactions require a more detailed type of model that can represent above and below ground interactions. This is often called an ‘integrated urban drainage model’ which should be developed in high risk areas or where the appraisal of solutions requires a more detailed understanding of these interactions (Option B or C in table 6).

Whether SEPA regional pluvial mapping is used directly, or amended, or another modelling approach adopted, the end of Step 1 results in a set of surface water flood maps which then form the basis of subsequent analysis and assist in the appraisal of solutions. Mapping outputs on their own can be used to powerfully communicate the location, depth and pathways of surface water flooding. This is useful information for land use planners and emergency planners.

4.4 Options for further modelling

This section describes the modelling options in more detail. As described in section 4.3.2 further modelling will be required if modelled outputs do not reflect observed flooding and the type of further modelling required will depend on the reasons that have been identified.

A risk based approach should be adopted to select the modelling method. The simplest approach that will support robust strategic decision making should be applied at this time. Complexity can be added in small areas (e.g. for priority drainage area(s)) or be recommended as a future investment after a high level assessment has determined high risk areas within the SWMP area.

It is anticipated that most SWMP partnerships should be able to work very effectively with the supplied regional pluvial and Section 16 sewer flooding without having to undertake further modelling at this stage.

Table 6. Options for further modelling	
A) Re-run regional pluvial hazard model	The regional pluvial hazard maps can be re-run with improved information on data inputs for: ▪ drainage capacity ▪ run-off coefficients ▪ DTM SEPA can provide the original input data (to local authorities or consultants acting on behalf of local authorities) to help make this straightforward using a range of software platforms. The parameters in section 4.3.2 (e.g. drainage capacity, DTM accuracy) could be considered for adjustment to better reflect the real conditions with the intention of improving the representation of pluvial flooding. Local knowledge held by local authorities which is considered more representative of individual catchments can be adopted, following appropriate advice by SEPA, and models adjusted accordingly to reflect this information. This can either be via an adjustment to the original model, an alternative modelling package utilising the available data, or via other supporting information pertinent to the area in question. SEPA agrees with the principle of sharing models and model data; however this will be dependent upon licensing conditions. These licensing conditions will apply to both the model themselves, the model outputs developed by the contractor and the datasets supplied for input to the models. This may limit what information SEPA can share until licensing conditions are agreed with the licensors.
B) Sewer and pluvial modelling	Coupled 1D (underground sewer network) and 2D (above ground) model. This model allows water to flow across the modelled urban surface and re-enter the sewer network where there is an inlet and underground capacity.
C) Integrated Catchment modelling	This usually involves combining existing sewerage models with watercourse models and a 2D representation of the urban surface and can also model the influence of other sources of flooding including river and coastal flooding on surface water flooding. This approach is costly, time-consuming and requires a high degree of collaboration between partners. It is already being applied in areas of very high risk (e.g. Glasgow).

4.5 STEP 2 – Calculating / summarising the consequences of flooding

Step 2 can proceed once a locally agreed version of the regional pluvial mapping has been adopted by the SWMP partners, or further modelling has been considered necessary and completed.

SEPA will determine the consequences of flooding based on the initial outputs of the regional pluvial hazard maps in the regional pluvial impact assessment. This information will be provided to local authorities, and it can be summarised at any scale.

The SEPA regional pluvial impact assessment will show the adverse impacts of pluvial flooding on economic activity, human health, the environment and cultural heritage. This will include direct and indirect impacts and monetised and non monetised information.

If further flood hazard modelling is undertaken through the SWMP, the SWMP partnership will need to re-run the impact assessment based on the updated hazard modelling. The SWMP partnerships should re-run the baseline impact methodology

that can be provided by SEPA. SEPA may be able to re-run the base line impact assessment if new hazard outputs are provided but the ability of SEPA to do this will be based on the resources available at the time.

The SWMP should summarise the impact information for each drainage area. This is a necessary first step in understanding the relationship between positive and negative impacts of improvements and to ensure compliance with the Scottish Government's flood appraisal guidance[8].

The scale at which flood consequences are described and summarised within a SWMP is entirely flexible to suit local needs. It may be sensible to first describe / summarise consequences across a whole town but then break this down further by drainage area.

4.6 STEP 3 – Identify and prioritise drainage areas

The purpose of this step is to identify and prioritise drainage areas within the SWMP to give focus to the subsequent options appraisal stage. While some measures will apply across the whole SWMP area (e.g. land use planning measures) some measures will need to be focussed on one or more drainage areas (e.g. structural measures, awareness raising). The number of drainage areas that should be considered will vary depending on the level of surface water flood risk (the number of high risk areas) and available resources to consider solutions at this time. A risk based approach is flexible, allowing the SWMP to focus on a small number of priority areas in line with available resources.

Drainage areas can be prioritised using a number of criteria. There is no single recommended method for prioritisation and this should be a joint decision by the SWMP partners. Factors for prioritisation could include:

- Surface water flood risk (information from impacts of flooding summarised at the drainage area scale)
- Surface water flood risk to priority receptor groups (information from impacts of flooding summarised at the drainage area scale)
- Locations with a history of flooding
- Locations of internal / external sewer flooding (information from Scottish Water)
- River Basin Management Plan – potential to improve water quality (information from SEPA)
- Climate change vulnerability
- Redevelopment / regeneration opportunities (information from local authority)

Areas which are predicted to flood but where there is no history of flooding, should be treated with caution, particularly where more detailed models aren't available. It is sensible to balance predicted and actual flooding information when prioritising drainage areas. It is advisable to follow a process for the prioritisation of drainage areas that is transparent, defensible and sensitive to local requirements.

Finally, it is important to be flexible. It is highly probable that the next significant surface water flood will occur outside one of the selected hotspots. SWMP partners should be looking to keep the process 'live' and ongoing.

[8] Scottish Government Sustainable Principles of appraisal: a policy statement and Flood Protection Schemes – Guidance for Local Authorities Chapter 5 Project Appraisal

5 Setting SMART objectives

SWMPs to address surface water flooding should have a clear statement of the problems to be addressed and the objectives to be achieved.

Objectives are set based on the flooding problem and the impacts of that flooding (this information is provided by the risk assessment outlined in section 4).

5.1 Initial objectives

FRM Strategies will initially set high level objectives for surface water flooding for PVAs, as well as identifying areas for SWM planning priorities and the PVAs that fall within these areas. The high level objectives for surface water flooding will be set around the principles of avoid, protect and prepare (Table 7).

Table 7. Objectives for surface water flooding

Objective	Description
Avoid	Avoid an increase in surface water flood risk to people, economy and environment.
Protect	Reduce overall likelihood of surface water flooding to receptors affected.
Prepare	Reduce impact of surface water flooding on receptors affected by being adequately prepared for flooding should it happen.

5.2 SMART Objectives

The SWMP partnerships should then set more detailed objectives. This should be undertaken in two stages. The initial objectives set out in the FRM Strategies should be updated following the flood risk assessment under Section 4. These should then be finalised after measures have been appraised, selected and prioritised for funding and delivery. This should provide more detail on the receptors and the location of receptors for which objectives will be set and ensure the objectives in the SWMP are SMART (specific, measurable, achievable, relevant, and time-bound) in line with wider government policy and the HM Treasury Green Book (2003).

Targets and timetables will only be used within the SMART objectives as far as the data and information underpinning the appraisal allow. Table 8 provides further definition of what is meant by SMART objectives within the context of the FRM process.

Table 8. Definition of SMART Objectives	
Specific	Objectives will relate to the key flood receptors (e.g. businesses, people) and sources of flooding identified in the baseline appraisal.
Measurable	Where data and information allow, targets will be used to inform objectives, expressed in terms of the key flood risk indicators used in the appraisal method. Flood risk indicators can be expressed in annualised terms, or adapted to communicate management of risk at specific return periods.
Attainable	Tied to capacity within delivery bodies and level of funding at local and national level
Relevant	Aim of reducing overall flood risk. While multiple benefits are a key part of sustainable flood management, these will not form part of the objectives, rather they will be identified and considered through the selection criteria within the appraisal method.
Time-Bound	Where appropriate, deadlines will be set for the achievement of objectives. The deadlines will be set according to the FRM planning cycles, i.e. 2021, 2027, 2033 etc.

The following principles should underpin the setting of objectives in SWMPs:

1. Main impacts and sources of flooding should be referenced
2. Where appropriate, specific return periods should be used, however, this should not prejudge the outcomes of any cost benefit analysis carried out across multiple return periods. An example of where the use of return periods is appropriate is for “avoid” objectives relating to land use planning, which uses a flood risk standard related to the 1 in 200 year event.
3. The baseline levels of flood risk should be included within the objectives to allow progress to be tracked.
4. The objectives should primarily focus on flood risk reduction and should not include other multiple benefits as a primary outcome – these are considered as part of the criteria for selection of the most sustainable measures.
5. The objectives should be aspirational and not set limits on the degree of flood risk avoidance or reduction that is possible/desirable. This is necessary so as to not prejudge the selection of potential measures or level of funding available.

6 Selection & appraisal of measures to manage surface water flood risk

The FRM Act requires that the most sustainable measures to manage flood risk are identified and implemented. This requires effective appraisal of measures to underpin decision making. Measures should be appraised using the following Scottish Government appraisal guidance;

- Delivering Sustainable Flood Risk Management
- Sustainable Flood Risk Management – Principles of appraisal: a policy statement
- Flood Protection Schemes – Guidance for Local Authorities Chapter 5 Project Appraisal

As stated in Section 2.2 appraisals should also follow a risk based approach and can be done at different levels from strategic to detailed. The level of appraisal required will depend on the measure proposed and the data available.

The benefits and costs for all ‘do something’ options should be compared with those of the ’do nothing’ option to provide a common baseline with which to compare options.

As stated in the Scottish Government guidance on appraisal for flood protection schemes, appraisal should start off with as wide a range of measures as possible. Cost benefit analysis can only identify the best of those options considered. A good appraisal will therefore encompass a wide range of management options, as a minimum the measures set out in section 6 should be considered.

This long list of measures should then be screened to create a short list (Figure 10 gives an overview of the appraisal process). Further appraisal on the costs and benefits of measures can then be carried out on the short list of measures.

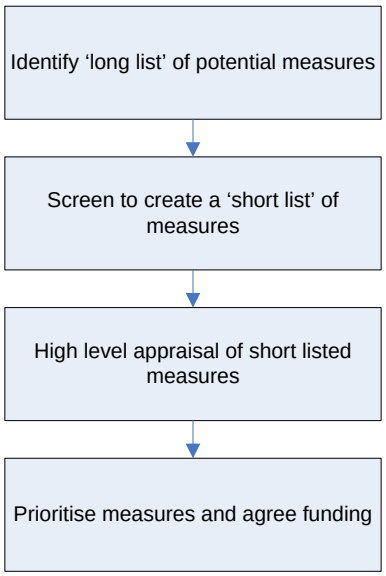


Figure 10. Overview of measures appraisal process

6.1 Identify long-list of measures to address surface water flooding

A range of structural and non structural measures should be identified to achieve the objectives in a way that is most sustainable and follow the principles of integrated drainage set out in section 1.5 and in the Ministerial guidance on SFM.

Structural measures may include, for example, a surface water storage structure or managed overland flow pathway to protect properties from flooding. Measures can also be non structural, for example; development of new land use planning policy, consideration of surface water flooding through settlement strategies in development plans and planning decisions or an identified need for more detailed flood risk assessment. Measures should address the sources, pathways and receptors of surface water flooding.

A SWMP should identify all measures to address surface water flooding i.e. from strategic type measures (e.g. land use planning policy) to detailed structural measures to address specific problems.

A list of potential measures that should be considered to manage the risk of surface water flooding is given in Table 9.

At this stage identification of measures should not be constrained by concerns over funding or delivery mechanisms. The aim is to identify the most sustainable measures (i.e. most economically, socially and environmentally beneficial) to manage surface water flood risk in a given area. Agreements over funding and responsibilities should be made once the most sustainable measures have been identified (see Section 7).

Table 9. Potential measures to address surface water flooding	
Measure	**Description**
Asset maintenance / asset management planning including SUDS (LA and SW)	**Objectives met** – Avoid / Protect **Flood mechanisms addressed** – Source / Pathway **Geographical scale** – Regional / urban area / priority drainage area **Description -** Ensure sewer / road drainage / SUDS and culverts are maintained for optimal performance and clearance and repair works in urban burns are carried out. Ensure LA and SW work is co-ordinated with good lines of communication. Identify where less maintenance could be carried out / where maintenance should remain the same / where more maintenance is required. This may include review of responsibilities in adopting existing (legacy) SUDS and review of new and future policy on SUDS adoption to resolve any issues.
Land use planning policy	**Objectives met** – Avoid **Flood mechanisms addressed** – Receptor **Geographical scale** – Regional / urban area **Description -** Ensure new development is not at risk of surface water flooding – Ensure appropriate policies are included in strategic development plans, local development plans and supplementary planning guidance. Ensure that masterplans and development management decisions require adequate and appropriate drainage (including SUDS) and ensure developments are designed for drainage exceedance events. Additional planning requirements may be needed in areas with a high risk of surface water flooding (e.g. ensuring new development or re-developed areas improve the surface water flooding situation, policies for blue and green corridors, requirements for SUDS when discharging to sewer or coastal waters). Identification of sites constrained by surface water flood risk. **References:** Scottish Government 2011 Green Infrastructure: Design and Placemaking CIRIA 2006 C635 Designing for exceedance in urban drainage: good practice Glasgow and Clyde Valley Green Network web based guidance on Integrating Green Infrastructure and case studies
Emergency response plans	**Objectives met** – Prepare **Flood mechanisms addressed** – Receptor **Geographical scale** – Regional / urban area / priority drainage area **Description -** Use information of surface water flood risk to improve emergency plans e.g. identify emergency routes on roads not at risk of surface water flooding. Ensure people and business are more prepared, can recover more quickly.
Awareness raising	**Objectives met** – Prepare **Flood mechanisms addressed** – Receptor **Geographical scale** – Urban area / priority drainage area **Description –** Ensure people and communities at risk of surface water flooding are aware of the risk and provide information on their responsibilities and how they can protect their property.
Managed overland flow pathways	**Objectives met** – Protect **Flood mechanisms addressed** – Pathway **Geographical scale** – Priority drainage area **Description -** Control of surface water flow through the urban environment to watercourses or storage areas through the creation of flow routes or using the road network as a flow pathway and avoiding property. **References:** CIRIA 2006 C635 Designing for exceedance in urban drainage: good practice CIRIA 2012 C713 Retrofitting to manage surface water

Table 9. Potential measures to address surface water flooding	
Measure	**Description**
Surface water storage areas (above ground)	**Objectives met** – Protect **Flood mechanisms addressed** – Pathway **Geographical scale** – Priority drainage area **Description** – safe above ground storage of water from surface runoff from the urban area. **References:** CIRIA 2006 C635 Designing for exceedance in urban drainage: good practice CIRIA 2012 C713 Retrofitting to manage surface water
Retrofit SUDS	**Objectives met** – Protect **Flood mechanisms addressed** – Source / Pathway **Geographical scale** – urban area / priority drainage area **Description –** This covers all types of retrofitting SUDS that will reduce the rate and volume of surface water run-off and includes measures and strategies that will reduce and remove surface water from the sewer systems. Should include strategic / focused implementation of retrofitting e.g. in priority drainage areas and should also include policies that will ensure opportunities to retrofit are taken when they arise. **References:** Scottish Government 2011 Green Infrastructure: Design and Placemaking CIRIA 2012 C713 Retrofitting to manage surface water
Strategy for the separation of surface water run-off form the combined sewerage system	**Objectives met** –Avoid / Protect **Flood mechanisms addressed** – Source / Pathway **Geographical scale** – urban area / priority drainage area **Description –** Separation (reduction or elimination) of surface water from the combined sewerage system and managing this water at source and above ground should be considered. This will involve a range of measures identified in this table (e.g. retrofit SUDS, above ground storage areas, flow pathways etc) however the overall impact on surface water flows to the sewerage system should be considered. This should include consideration of strategic / focused plans to separate surface water flows from the sewerage systems and to ensure opportunities to separate flows are taken when they arise.
Land management	**Objectives met** – Avoid / Protect **Flood mechanisms addressed** – Source / Pathway **Geographical scale** - Urban area / priority drainage area **Description** - Runoff from more rural areas can contribute significant flows to drainage systems and watercourses that can impact roads and areas further downstream. Land management measures that reduce the rate and volume of runoff should be considered.
Relocation / removal of receptor	**Objectives met** – Avoid / Protect **Flood mechanisms addressed** – Receptor **Geographical scale** – Priority drainage area **Description** – Removal and relocation of receptors e.g. properties should be considered, where it is more sustainable and feasible to do this in long term as opposed to other measures.
Property / Site level protection	**Objectives met** – Prepare **Flood mechanisms addressed** – Receptor **Geographical scale** – Localised Description – Temporary, demountable defences can be put up at the property or street level to avoid properties getting flooded. Use of flood resilient building materials and methods of construction can reduce impacts if properties do get flooded.
Storage tanks (underground)	**Objectives met** – Protect **Flood mechanisms addressed** – Pathway **Geographical scale** - Priority drainage area **Description** – flooding can be reduced by diverting surface water to storage tanks or by providing storage within the drainage network.

Table 9. Potential measures to address surface water flooding	
Measure	**Description**
Increase size of drainage pipes (roads and sewer)	**Objectives met** – Protect **Flood mechanisms addressed** – Pathway **Geographical scale** - Priority drainage area **Description** – flooding from drainage networks can be reduced by increasing the capacity of the under ground drainage pipes.
Deculverting / river restoration	**Objectives met** – Protect **Flood mechanisms addressed** – Source / Pathway **Geographical scale** - Priority drainage area **Description** – deculverting and restoring urban watercourses can increase capacity available in these systems and reduce flooding.
Watercourse storage (on-line or off-line)	**Objectives met** – Protect **Flood mechanisms addressed** – Source / Pathway **Geographical scale** - Priority drainage area **Description** – may be combined with deculverting and restoration of watercourses. Storage in urban burns may help reduce flood risk down stream, especially in areas where urban burns enter the sewer system.

6.2 Screening

The initial 'long list' of potential measures (or groups of measures) should be screened for technical, financial and legal feasibility. The purpose of this step is to remove any potential measures that are clearly unfeasible or unrealistic at an early stage.

Table 10 describes the criteria that should be used for screening out unfeasible or unrealistic options.

Table 10. Screening criteria		
Feasibility	**Description**	**Metric**
1. Technical	Removal of any measures that are not technically feasible. e.g. Is land available for above ground storage?	Categorical - Y/N Expert judgement
2. Legal	Removal of any measures that represent insurmountable legal issues, including health and safety.	Categorical - Y/N Expert judgement
3. Financial	At this stage, is there evidence that the costs will be disproportionate compared to the benefits? Rapid assessment of cost estimates against key economic and social benefits. Please note this should not be a detailed cost benefit analysis.	Categorical - Y/N Estimated build and maintenance costs of measure vs benefits to economy (direct economic benefits to property) and key social impacts (risk to life/human health).

Expert judgement is involved in making these decisions, which will invoke some element of subjectivity into the process. However the process should still be transparent and an important part of this screening process is therefore to ensure agreement with SWMP partnerships on which measures are discarded at this stage.

Where there is uncertainty about the feasibility of any measure, or where the feasibility of a measure is considered to be borderline, the measure should remain in the appraisal process because these issues will be looked at again in more detail later.

The screening process will produce a short list of potential measures for more detailed appraisal.

The more detailed appraisal of the short listed measures will consider the flood risk benefits of the measures as well as the wider impacts.

6.3 High level appraisal of short listed measures

Please note it is proposed that the Scottish Advisory and Implementation Forum for Flooding (SAIFF) will develop a more detailed methodology on the appraisal of surface water measures to ensure a consistent approach is taken. This will also ensure consistency with the appraisal of river and coastal measures. This will include for example further information on what human health, environmental, cultural heritage and economic impacts should be assessed and how to assess these impacts.

The high level appraisal of measures for surface water flooding should follow the Scottish Government guidance Flood Protection Schemes – Guidance for Local Authorities Chapter 5 Project Appraisal. This should be a high level appraisal to agree a range of cost beneficial measures that could be put in place to address surface water flooding.

Agreement must then be made on what measures can be funded and implemented in the next FRM planning cycle and the funding arrangements for each measure. Detailed appraisal and design of measures will then be carried out at a later stage prior to being implemented.

To ensure the selection of the most sustainable measures the full range of impacts, both positive and negative (i.e. costs and benefits) on human health, the environment, cultural heritage and economic activity should be considered in an equitable manner.

Impacts that cannot be valued in monetary terms should always be described, quantified and brought into the appraisal through appraisal summary tables.

Understanding these impacts is critical to selecting sustainable actions and they should not be ignored simply because they are difficult to quantify or value in monetary terms.

7 Prioritising, funding and implementing measures

The outcome of the appraisal process should be an agreed set of feasible and sustainable measures to manage the risk of surface water flooding in an area.

As previously stated the identification of measures should not be constrained funding concerns or delivery mechanisms. Once the most sustainable measures have been identified the SWMP partnerships should determine who is responsible for implementing the most sustainable measures and how they will be funded.

The SWMP partnerships should prioritise what measures can be implemented in the current FRM planning cycle, who will fund the measures and when they will be implemented.

Funding routes for measures to address surface water flooding include:

- Local authority funding
- Scottish Water funding
- Scottish Government funding
- Private funding (e.g. developer contributions)

The Ministerial Guidance on SFM states:

- "*SEPA and the responsible authorities must work across traditional institutional boundaries to deliver an integrated approach to flood risk management. This will require adoption of partnership working at all levels of flood management from national strategic partnerships through to local / operational partnerships that deliver co-ordinated actions on the ground*."
- "*Fair and practical ways to share costs and responsibilities for the whole drainage system should be identified*."
- "*as a minimum, all resource commitments must be aligned. However, in many instances joint funding commitments or pooling of resources may be necessary. For instance between local authorities working to deliver co-ordinated actions across a catchment or between local authorities and Scottish Water when coordinating their work to deliver integrated urban drainage*"

The Ministerial Guidance on SFM provides examples of joint funding arrangements (see Section 3 Table 4).

Updating SMART Objectives

The final stage in the appraisal process for SWMPs, is to update and finalise the objectives. This will involve using the information generated through the appraisal of the measures short-list, together with the prioritisation of those measures to SMARTen the objectives. Information on how effective the preferred measures are at managing the identified flood risk, together with the high-level timetable for implementation should be included in the final SMART objectives.

The final SMART objectives will be based on a robust appraisal process that has examined what is practical, feasible and affordable for the main surface water flood risks identified within each area. They will provide a joint vision for the SWMP partnerships, as well as informing communities and other stakeholders about the actions being taken to manage flooding in each area.

8 Review

The flood risk management planning process, including SWMPs, is a 6 yearly cyclical process of risk assessment, appraisal of measures and implementation of measures.

Each LFRMP must have progress reviewed through the production of interim and final reports.

The lead local authority must produce an interim report 2-3 years after the LFRMP has been finalised. The interim report should include information on the progress that has been made towards implementing the measures described in the LFRMP.

The lead local authority must produce a final report 5-6 years after the LFRMP has been finalised. The final report should include:

- An assessment of the progress made towards implementing the current measures
- A summary of the current measures which were not implemented, and the reasons for this
- A description of any other measures implemented since the plan was finalised which the lead authority considers have contributed to the achievement of the LFRMP objectives.

Local authorities should regularly review the implementation of the SWMP measures, and should carry out this work in time to inform the required reviews of the LFRMP. The LPD partnerships should help co-ordinate this work. It is recommended that the SWMP partnerships should continue to work together to discuss implementation of the measures identified.

9 SWMP documentation

A SWMP document should be produced that

- Summarises the work done in the SWM planning process
- Summaries the outputs of the key stages
- Summaries the longer term aspirational aims of managing surface water flooding in the area
- Describes the measures that have been agreed to be implemented in the next FRM planning cycle (and will be described in the LFRMP).

In addition to the above it is expected that various supporting documentation is likely to be produced as part of the SWM planning process. This may include:

- Collected data (e.g. maps of culverts)
- Models (if further modelling is carried out)
- Output of models (including outputs from SEPA modelling)
- Technical reports for flood hazard and risk assessments (including summaries of flood risk from SEPA hazard and risk assessments)
- Technical reports on measures appraisal process.

Appendix 1 - References

CIRIA 2006 C635 Designing for exceedance in urban drainage: good practice
www.ciria.org/SERVICE/Home/core/orders/product.aspx?catid=3&prodid=123

CIRIA 2012 C713 Retrofitting to manage surface water
www.ciria.org/SERVICE/Home/core/orders/product.aspx?catid=5&prodid=1909

CIWEM 2009 Urban Drainage Group guide to Integrated Urban Drainage Modelling
www.ciwem.org/media/44495/WaPUG_IUD_Modelling_Guide_Draft_Rev1_v28_(June_09)_v01-001.pdf

Glasgow and Clyde Valley Green Network web based guidance on Integrating Green Infrastructure and case studies
www.gcvgreennetwork.gov.uk/Integrating-Green-Infrastructure.html

Houstoun D, Werritty A, Bassett D, Geddes A, Hoolachan A and McMillan (2011) Pluvial (rain related) flooding in urban areas: the invisible hazard. Joseph Rowntree Foundation.
http://www.jrf.org.uk/publications/pluvial-flooding-invisible-hazard

Scottish Government 2011 Delivering Sustainable Flood Risk Management
www.scotland.gov.uk/Topics/Environment/Water/Flooding/FRMAct/guidance

Scottish Government 2011 Sustainable Flood Risk Management – principles of appraisal: a policy statement
www.scotland.gov.uk/Topics/Environment/Water/Flooding/FRMAct/guidance

Scottish Government 2012 Flood Protection Schemes – Guidance for Local Authorities Chapter 5 Project Appraisal
www.scotland.gov.uk/Topics/Environment/Water/Flooding/FRMAct/guidance

Scottish Government 2011 Green Infrastructure: Design and placemaking
http://www.scotland.gov.uk/Publications/2011/11/04140525/0

SEPA 's Flood Risk Management Planning in Scotland: Arrangements for 2012-2016
www.sepa.org.uk/flooding/flooding_publications.aspx

SEPA 2011 National Flood Risk Assessment
www.sepa.org.uk/flooding/flood_risk_management/national_flood_risk_assessment.aspx

Appendix 2 - Roles and responsibilities in relation to surface water flooding

Further information on the main roles and responsibilities in relation to drainage and surface water flooding are given below. Please note that this list is not exhaustive, and is provided for information purposes.

Local authorities

Flood Risk Management (Scotland) Act 2009

- Section 56 gives local authorities general powers to manage flood risk (from all sources including surface water flooding) in their area, including implementation of measures described in the local flood risk management plans, carry out flood protection schemes or any other flood protection work. It should be noted the definition of flooding under the FRM Act does not include flooding solely from a sewerage system. Flooding solely from a sewerage system includes flooding from the sewerage system under usual rainfall events, under which circumstances Scottish Water have duties to manage. It should be noted that in reality surface water flooding is often a complex interaction of flooding from many different sources and requires close partnership working to address. Many of the measures identified through the SWMP process can help manage surface water flooding and flooding solely from a sewerage system.
- Section 17 and 18 require local authorities to map bodies of water and SUDS, assess bodies of water and prepare a schedule of clearance and repair works.
- Section 59 requires local authorities to carry out the clearance and repair works described in the schedule in specific circumstances.
- Section 1 requires all responsible authorities (including local authorities) when exercising their flood risk related functions to manage flood risk in a sustainable way and to cooperate with all responsible authorities.
- Section 41 requires all public bodies and office-holder to have regard to flood risk management plans and local flood risk management plans, which will include consideration of surface water flooding, when exercising functions that affect a flood risk district.

Roads (Scotland) Act 1984

- The Roads Authority (including local authorities) has a duty in terms of the Roads (Scotland) Act 1984 to provide drainage of public roads (for normal circumstances) and for road safety which may only involve signing and diversion of traffic in the event of flooding.
- Section 31 provides powers to the roads authority to drain a public road or proposed public road or of otherwise prevent surface water from flowing onto it.
- Section 99 allows roads authorities to carry out works to prevent flows of water onto roads, where the owner or occupier of any land has failed to prevent the flow of water or of filth, dirt or other offensive matter from, or any percolation of water through, the land onto the road.
- Section 21 refers to the requirement of consent for new roads built other than by roads authority. Where a developer is seeking to submit a new road to be adopted by the Roads Authority it is necessary for the layout and construction of roads, including road and surface water drainage to satisfy the current design standards.

Sewerage (Scotland) Act 1968

- Section 7 allows roads authorities (including local authorities) and Scottish Water to enter into agreements as to the provision, management, maintenance or use of their sewers or drains for the conveyance of water from the surface of a road or surface water from premises.

Town and Country Planning (Scotland) Act 1997

- Gives planning authorities (including local authorities) the powers to grant or refuse planning applications.

Planning etc. (Scotland) Act 2006

- Part 2 requires the planning authority to exercise the planning function with the objective of contributing to sustainable development.
- Part 2 states that, a strategic development plan should set out the infrastructure of that area (including communications, transport and drainage system and systems for the supply of water and energy).
- Part 2 states that where land is not within a strategic development plan area, a local development plan should set out the infrastructure of that area (including communications, transport and drainage system and systems for the supply of water and energy).

Town and Country Planning (Development Management Procedure) (Scotland) Regulations 2008

- Regulation 25 and Schedule 5 requires that planning authorities must consult with SEPA where the development is likely to result in a material increase in the number of buildings at risk of being damaged by flooding. Planning authorities must take SEPA's advice into account alongside the development plan and other material considerations in the determination of planning applications involving flood risk.
- Requires key agencies, including SEPA, to co-operate with strategic development plan authorities and planning authorities during the compilation of main issues reports, the preparation of proposed strategic development plans and local development plans, and the preparation of action programmes and proposed action programmes.

The Town and Country Planning (Miscellaneous Amendments) (Scotland) Regulations 2011

- These regulations came into force on 1 April 2011. They amend The Town and Country Planning (Development Planning) (Scotland) Regulations 2008 to include reference to flood risk management plans and local flood risk management plans. Planning authorities, when preparing strategic development plans and local development plans, must have regard to any approved flood risk management plan or finalised local flood risk management plan relating to the strategic development plan and local development plan area.

The Town and Country Planning (Notification of Applications) (Scotland) Direction 2009

- Requires planning authorities to notify Scottish Ministers of any application where SEPA has advised against the granting of planning permission or has recommended conditions relating to flood risk which the planning authority do not propose to attach to the planning permission.

Coastal Protection Act 1949

- Section 4 allows the competent authority to carry out coastal protection works to protect land from coastal erosion and regulate works carried out by others within their authoritative boundary.

Civil Contingencies Act 2004

- Local authorities are a Category 1 responder under this Act.
- Part 3 places duties on Category 1 responders to assess risk of emergency occurring including surface water flooding
- Part 4 requires Category 1 responders to maintain plans, including a duty to maintain arrangements to warn, inform and advise the public in the event of an emergency under Section 14.
- Such assessments and plans are to provide a framework of contingency measures for the co-ordination and flexible response by the council and partner agencies to mitigate the effects of flooding emergencies, including surface water flooding

Water Environment and Water Services (Scotland) Act 2003

- Section 16 requires every public body and office-holder including the local authorities, in exercising any functions to have regard to the River Basin Management Plan.

Building (Scotland) Act 2003

- Section 8 refers to issuing of Building Warrants for construction work and Part 3 cover compliance and enforcement.
- Mandatory Building Standard 3.6, which is subject to review as part of local authorities issuing Building Warrants, requires every building , and hard surface within the curtilage of a building, to be designed and constructed with a surface water drainage system that will:
    - ensure the disposal of surface water without threatening the building and the health and safety of the people in and around the building; and
    - have facilities for the separation and removal of silt, grit and pollutants
- The approach to the disposal of surface water from buildings and hard surfaces clearly needs to be considered at the earliest stage in the design and development process

Lead local authority

In addition to the powers described above for local authorities, lead local authorities have additional responsibilities.

Flood Risk Management (Scotland) Act 2009

- Section 34 requires lead local authorities to prepare a local flood risk management plan
- Sections 37 & 38 require the lead local authority to review the plan and report on progress made towards implementing the measures identified.

Scottish Water

Flood Risk Management (Scotland) Act 2009

- Section 16 requires Scottish Water to assess flood risk from sewerage systems
- Section 1 requires all responsible authorities (including local authorities) when exercising their flood risk related functions to manage flood risk in a sustainable way and to cooperate with all responsible authorities.

- Section 41 requires The Scottish Ministers and every public body and office-holder to have regard to flood risk management plans and local flood risk management plans, which will include consideration of surface water flooding.

Sewerage (Scotland) Act 1968
- S1 – S8 Scottish Water must design and fully maintain public sewers to ensure they remain capable of effectively draining surface water.
- S12 Right for SW to refuse permission or impose conditions for a private owner to connect with and drain into public sewers
- S21 SW must vet building applications and should ensure that no building which could interfere with or obstruct a sewer is constructed over it.
- Other sections (as amended by Water Environment and Water Services Act 2003 and Schedule 3) provide SW with responsibility to maintain for SUDS, which are defined as facilities that attenuate, settle or treat surface water from 2 or more premises (whether or not together with road water), and where designed and completed to a required standard.
- Section 7 allows roads authorities and Scottish Water to enter into agreements as to the provision, management, maintenance or use of their sewers or drains for the conveyance of water from the surface of a road or surface water from premises.

Water Industry (Scotland) Act 2002
- S50 Scottish Water must, in exercising its functions, seek to ensure that its resources are used economically, efficiently and effectively
- S51 SW are compelled to act in a way that will contribute to the achievement of sustainable development
- S53 SW must have regard to protecting cultural heritage, natural beauty/flora/fauna and geological sites of special interest.
- S54 SW must consult SNH and NPAs when it will carry out works that could affect designated sites or NPA land.

Water Environment and Water Services (Scotland) Act 2003
- Section 16 requires every public body and office-holder including Scottish Water, in exercising any functions to have regard to the River Basin Management Plan.

SEPA

Flood Risk Management (Scotland) Act 2009
- Section 9 requires SEPA to produce the National Flood Risk assessment
- Section 13 requires SEPA to identify Potentially Vulnerable Areas
- Section 19 requires SEPA to map artificial structures and natural features
- Section 20 requires SEPA to assess the potential for Natural Flood Management
- Section 21 requires SEPA to prepare flood hazard and risk maps for PVAs
- Section 27 requires SEPA to prepare flood risk management strategies
- Section 72 requires SEPA provide advice on flood risk to the planning authority when requested
- Section 74 requires SEPA to make available flood warnings

Planning etc. (Scotland) Act 2006
- Gives SEPA (as a key agency) the duty to co-operate in the preparation of development plans.

Water Environment and Water Services (Scotland) Act 2003
- Section 10 requires SEPA to prepare River Basin Management Plans

- Section 9 requires SEPA to set objectives for the quality of the water environment and identify measures to achieve those objectives

Civil Contingencies Act 2004
- SEPA is a category 1 responder under this Act

Transport Scotland
Roads (Scotland) Act 1984
- Adequate drainage of all trunk roads

Sewerage (Scotland) Act 1968
- Section 7 allows roads authorities (including Transport Scotland) and Scottish Water to enter into agreements as to the provision, management, maintenance or use of their sewers or drains for the conveyance of water from the surface of a road or surface water from premises.

Police
Civil Contingencies Act 2004
- Are a Category 1 responder under this Act and provide emergency services co-ordination. Emergency services co-ordination in the event of flood.

The Fire and Rescue Service
Civil Contingencies Act 2004
- Are a Category 1 responder under this Act and have a duty to save lives in the event of serious flooding which is likely to cause one or more individuals to die, be seriously injured or become seriously ill.

Public and communities
- It should also be remembered that we are all responsible for protecting ourselves and our property from flooding. This means the public and communities taking action to help minimise flood damage to land or property. The public has an important role in sharing local knowledge and engaging in flood protection actions for their areas.

Appendix 3 - Principles of modelling surface water flooding

We use modelling tools to predict the location, likelihood and impact of surface water flooding. Because surface water flooding is not a regular occurrence which can be understood fully through observation, predictive models help us understand where flooding could occur if there was heavy rain in that location and how this might change with climate change and help test the effectiveness of measures to manage the risk of surface water flooding. Detailed mapping information is used to understand the types of building or infrastructure that will be affected by the flood.

Most surface water flooding models apply design rainfall profiles of a known likelihood (return period) to a digital terrain model (DTM) of the landscape (Figure 1). The rainfall is converted into runoff at a rate depending on the land use type (rural or urban) and then routed along flow pathways (e.g. sloping streets) to low points where it may pond. Through examining the maximum extent and depth of flooding at each point in the modelled area we can determine the homes, businesses and infrastructure which are likely to be exposed to flooding. Over urban areas, a portion of the rainfall input is completely removed to account for the role that urban drainage systems have in removing water from an area. Much of the remaining runoff is routed in the model to natural river channels but a portion cannot reach these 'sinks' in the system and the model indicates where this residual amount may result in flooding. The model is further enhanced by the representation of buildings which are added to the terrain model. Buildings act to control the direction of flows through urban areas.

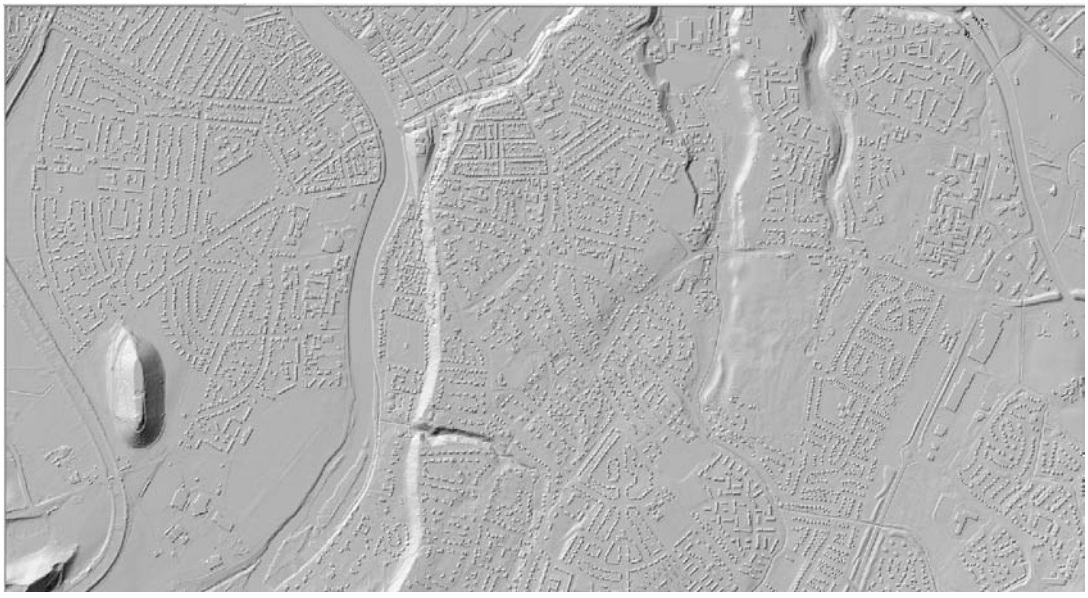


Figure A1 – Representation of the ground is a key component of surface water flood modelling. The example above is a Digital Terrain Model (DTM) produced from LiDAR data with buildings represented.

In some circumstances the complex interaction of sewer systems, watercourses and overland flows mean that the simplified modelling approach described above is inadequate and models inaccurately predict flooding and therefore cannot be used to help design robust solutions. In these circumstances a more detailed modelling approach can be used which includes explicit representation of the sewer system and watercourses which act as important conveyors of surface water underground and through towns and cities. These more detailed models (sometimes referred to as

integrated urban drainage models or integrated catchment models) are time consuming and costly to prepare and require the collaboration of different organisations. Their use is therefore reserved for areas of highest risk and only where complex flooding mechanisms exist.

The types of modelling used to examine surface water flooding and the operation of integrated urban drainage systems is described more fully in section C of the CIWEM Urban Drainage Group's guide to Integrated Urban Drainage Modelling (2009). The guide provides advice on where more detailed modelling approaches are warranted.

Once a robust model that predicts the surface water flood hazard has been developed the consequences of that flooding are then assessed to identify flood risk. Flood risk is calculated in the same way for simple and more complicated models. Multiple simulations of events for different likelihoods are used to estimate the consequences of flooding on human health, the environment, cultural heritage and economic activity. The Ministerial Guidance on SFM states that when assessing the consequences of flooding the following factors should be taken into account:

- Exposure – what will be exposed to the flood
- Vulnerability – can be assessed as a factor of susceptibility (the propensity of a receptor to suffer harm from flooding) and resilience (the ability of a receptor to recover from damage incurred as a result of flooding)
- Value – the value of things exposed to the hazard, which could include costs or how critical the item is.

To support a risk based approach to the assessment and management of surface water flooding and to determine where effort should be focused (this may include focus for certain measures e.g. structural measures, awareness raising or further modelling) drainage areas or flooding 'hot spots' should be identified. 'Hot spots' are concentrations of localised flooding (e.g. street or neighbourhood scale) which most likely have a single or linked cause. The area influencing the hot spot, that covers the main sources and pathways of surface water to the hot spot, is called a 'drainage area'. Drainage areas can be defined through examining the topography and underground drainage connections; it is the zone of influence for the flooding hot spot and the region within which measures to reduce the likelihood of flooding are most likely to be implemented. The flood consequences across different hot spots and drainage areas can be compared.

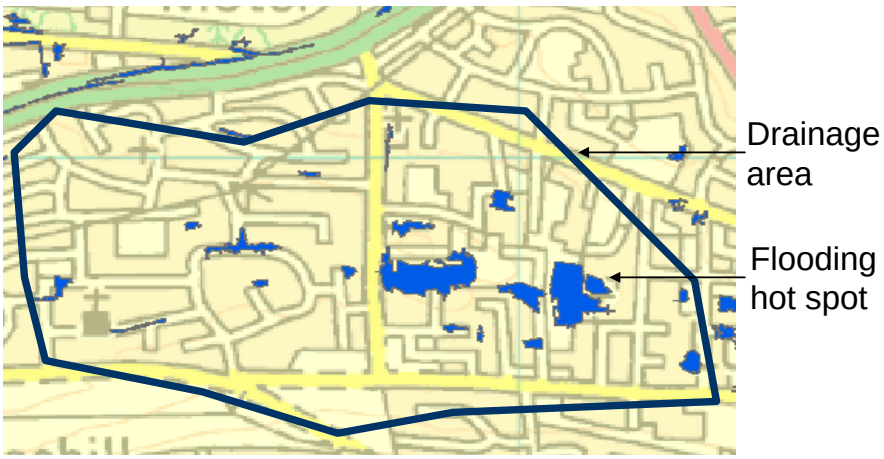


Figure A2 – Indicative example of a surface water flooding 'hot spot' and its associated drainage area.

Appendix 4 - Further information on surface water flooding data

Potentially Vulnerable Areas

Owner – SEPA
Format – GIS shapefile

Potentially Vulnerable Areas (PVAs) were identified as part of the National Flood Risk Assessment (NFRA) required under the Flood Risk Management (Scotland) Act 2009. PVAs indicate where the risk of flooding is significant enough to justify further assessment of flood risk and further identification of measures.

SWMPs will be used to help understand and manage flood risk within PVAs.

It is important to note, not all properties within a PVA are at risk of flooding. PVAs are based on catchment units and will allow Scottish Government, SEPA, local authorities and Scottish Water to develop a planned response to manage flood risk effectively.

National pluvial flood extent (flood hazard)

Owner – SEPA
Format – GIS shapefile
DTM input - NextMap DTM, 5m resolution and a vertical accuracy of 0.7 - 1m.
Model type – ISIS-FAST Rapid Flood Spreading Method
Outputs – flood extents and depths for the 1 in 200 and 1 in 30 rainfall return periods.

These maps provide a national coverage of predicted surface water flooding but with a lower level of confidence than Regional pluvial hazard maps. They can be used by Councils considering flood risk outside of PVAs but provide no information about flow velocity.

Model parameters applied:

	Urban Areas	Rural Areas
Rainfall return period	1in 200 year, 1 in 30 year	1in 200 year, 1 in 30 year
Storm duration	1 Hour	3 Hour
Storm profile	50% summer	50% summer
Percentage runoff	70%	55%
Drainage allowance	12mm/hr	Nil

During post processing of the model results, flood depths of <0.1m were removed and these areas were shown not to flood. The same process was also applied to remove flood depths of <0.3m. These depth thresholds have been provided as two separate layers and have also had small flood 'ponds' of areas <200m^2 removed.

The national pluvial extent map provides a strategic national overview of pluvial flood risk in Scotland. The pluvial extents should not be displayed on a background map that is more detailed that the 1:50,000 scale as this represents the level of modelling detail which can be derived from a national level study. It can be used for:

- A broad understanding of pluvial flood hazards
- Strategic assessment of the negative impacts (costs) of flooding
- An indication of those areas more susceptible to pluvial flooding and used to identify PVAs.
- Indication of where regional pluvial hazard modelling should be carried out
- Set high level objectives in the SFRMPs
- Potential use in land use planning development plans - may be of use in a limited manner at a strategic level by SEPA, working jointly with the LAs, to assist the consideration of catchment drainage issues at preliminary SFRA stage and assist scoping for Strategic Environmental Assessment. This would assist to highlight areas where further more detailed assessment may be required by the LA/ developer.

It does not provide enough detail to:
- Accurately estimate the flood risk associated with individual properties or specific point locations.
- Determine flood risk for insurance purposes or property enquiries.
- Identify or appraise structural measures to manage surface water flooding.

Pluvial flood extent Dundee, Carnoustie, Aberdeen and Inverness (flood hazard)

Owner – SEPA
Format – GIS shapefile
DTM input - LiDAR DTM, 1m resolution and vertical accuracy of approximately 0.15m.
Model type – JFlow 2D flood routing
Outputs – flood extents and depths for the 1 in 200 and 1 in 30 rainfall return periods.

These maps provide greater confidence than the national pluvial extent maps but in a limited number of locations. These will provide information on areas vulnerable to surface water flooding outside of the regions covered by regional pluvial hazard maps.

Model parameters applied:

	Urban Areas	Rural Areas
Rainfall return period	1in 200 year, 1 in 30 year	1in 200 year, 1 in 30 year
Storm duration	1 Hour	3 Hour
Storm profile	50% summer	50% summer
Percentage runoff	70%	55%
Drainage allowance	12mm/hr	Nil

During post processing of the model results, flood depths of <0.1m were removed and these areas were shown not to flood. The same process was also applied to remove flood depths of <0.3m. These depth thresholds have been provided as two separate layers and have also had small flood 'ponds' of areas <200m^2 removed.

This project presents a pluvial flood risk map for Inverness, Dundee and Aberdeen using high resolution LiDAR ground models and a 2D hydraulic model. This approach is an improvement over the earlier mapping which used coarse resolution NextMap ground models and the ISIS-FAST Rapid Flood Spreading Technique.

Buildings were introduced as a +0.3m extrusion and roads were introduced as a -0.1m extrusion.

Modelling assumptions include:

- Filtered DTM to more accurately represent ground surface, streamlines and topographic lows.
- Flow is constrained along road by a notions 0.1m kerb height.
- Mannings *'n'* is applied as a blanket figure of 0.1.
- Overland flow interacting with the edge of the model domain is lost.
- Extended model run time to allow for creation of final flood depths

Regional pluvial hazard maps

Owner – SEPA
Format – GIS shapefile
DTM input – combination of LiDAR and NextMap DTM, 2m resolution and 5m resolution.
Model type – JFlow+ 2D spreading approach
Outputs – flood extents, depth, flow pathways (velocities) and hazard ratings for a range of return periods.

These maps provide greater confidence than the national pluvial extent maps across specific urban locations. These will provide information on areas vulnerable to surface water flooding outside of the regions covered by regional pluvial hazard maps.

14 scenarios being run including rainfall return periods 1in 10, 1 in 30, 1 in 30 plus climate change, 1 in 50, 1 in 100, 1in 200, 1 in 200 plus climate change. Two storm durations are being applied for each scenario. More information on areas with regional pluvial hazard maps and all scenarios can be seen in Appendix 5.

The regional pluvial extent map will be derived via a two-dimensional (2D) modelling to provide pluvial flood extents, depths and velocities for both ponded areas of water and pluvial flow pathways. These model runs are required for selected areas of Scotland identified within Appendix 1.

This work will build upon SEPA's national pluvial project (Derivation of National Pluvial Hazard Database) to provide a more refined representation of pluvial flood hazard and will deliver a range of additional return periods, model loss scenarios and storm durations as detailed in Table 1 of Appendix 5.

The outputs of this contract will feed into the development of flood hazard and risk maps as required by the FRM Act.

The areas to be included in the regional pluvial modelling area shown in Figure 1 of Appendix 5.

Limitations include:

- Degraded LiDAR in areas which include NextMap data.
- Blanket loss parameter
- Limited rural coverage
- Topographic influence in vicinity of watercourses

Flood risk from sewerage systems (Section 16 of the FRM Act)

Owner – Scottish Water
Format – GIS shapefile
DTM input – combination of LiDAR and NextMap DTM, 2m resolution and 5m resolution.
Model type – InfoWorks CS
Outputs – Location, volume, extent and depth of flooding from sewerage systems in areas with a risk of surface water flooding.

This information can be used to assess the local capacity of sewer systems and understand flooding mechanisms in areas with large transfers of flow underground through sewers. Pluvial flood mapping and sewer flood mapping can be used in conjunction to explain flood mechanisms.

1 km^2 grid of impacts on receptors

Owner – SEPA
Format – GIS shapefile

Produced as part of the National Flood Risk Assessment (NFRA) required under the Flood Risk Management (Scotland) Act 2009.

The Risk Grid Cells show the adverse impact on receptors (see table below) from the 1 in 200 year flood event. The impact of pluvial flooding on receptors used the national pluvial flood extents and flood extents for Dundee, Carnoustie, Aberdeen and Inverness.

Receptor Group	Description
Human Health A - People	number of residential properties and the social vulnerability of the area
Human Health B - Community	Important facilities that could cause community disruption if affected e.g. schools, hospitals.
Economic Activity A - Business	number of business properties and the estimated weighted annual average damage related to the property
Economic Activity B – Transport	Roads, railways and airports
Economic Activity C – Agriculture	Agricultural land and forestry
The Environment	Areas designated for natural heritage purposes and their vulnerability to flooding
Cultural Heritage	Cultural heritage sites such as UNESCO World Heritage Sites.

Regional pluvial baseline impacts

Owner – SEPA
Format – GIS shapefile

Produced for the development of SFRMPs / SWMP and LFRMP and for use in the strategic cost – benefit appraisal of measures to address surface water flooding.

Shows the adverse impact of pluvial flooding on receptors for a range of rainfall return periods. The receptors assessed using the regional pluvial flood hazard maps are:

Category	Receptors	Flood Risk Indicators
Economic	Non residential properties (NRPs)	Direct economic impacts expressed in monetary damages (£s)
	Residential properties (RPs)	Direct and indirect economic impacts expressed in monetary damages (£s)
	Transport	Direct damages to transport (road) infrastructure (£s)
	Vehicles	Direct damages to vehicles (£s)
	Emergency Services	Direct damages already considered under RPs and NRPs. Additional assessment of indirect impacts expressed in monetary damages (£s)
Social	Human Health	An assessment of risk to life
		Number of people at risk of flooding adjusted for social vulnerability
	Community Facilities	Count of community facilities
	Utilities	Count of utilities
	Disruption to Transport	Score based disruption to roads, rail and airports
	Cultural Heritage	Score based on importance of site at risk of flooding and vulnerability to flooding.

Historical flood events national database

Owner – SEPA
Format – Excel spreadsheet

SEPA have collated information on historical flood events. This datasets provides a comprehensive list of historic flood records from a number of sources including:

- Local Authority data
- Newspaper chronicles
- Archived data
- SEPA data
- Information from the public
- Academia
- Literature

There are approximately 15000 records within the database which vary in reliability and detail. Screening has been undertaken to isolate the records

that are of most use. Records have been classified into the source of flooding (i.e. fluvial, pluvial, coastal or sewer).

Map of watercourses and SUDS

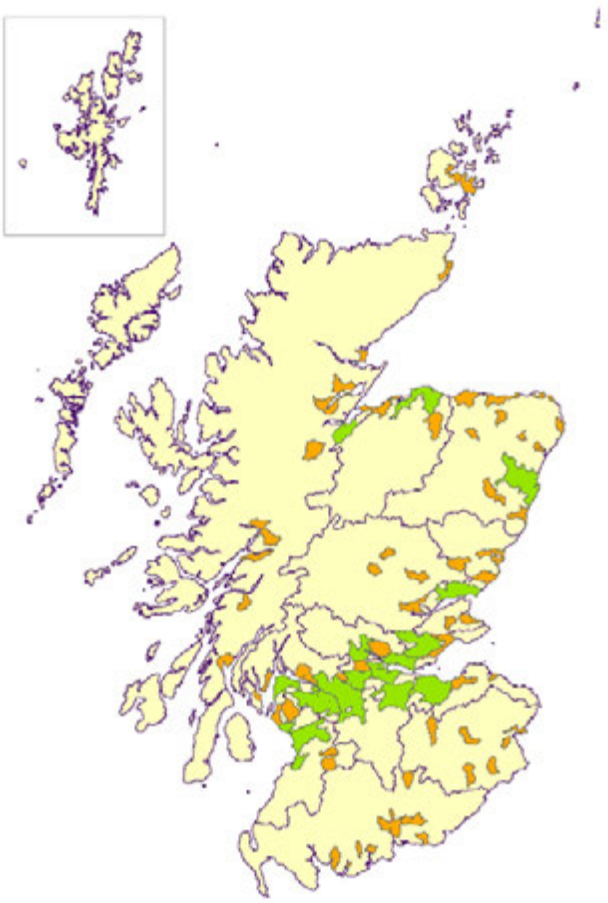
Owner – local authority
Format – to be determined

Section 17 of the FRM Act requires local authorities to map watercourses and SUDS in their area.

Appendix 5 - Regional Pluvial Hazard maps

Table 1 - Model scenarios for the regional pluvial hazard maps			
Scenario	**Return Period**	**Loss**	**Blanket Storm Duration (hours)**
1	10	5 year rainfall return period in urban areas	1
2	10	5 year rainfall return period in urban areas	3
3	30	5 year rainfall return period in urban areas	1
4	30	5 year rainfall return period in urban areas	3
5	30 + climate change increase	5 year rainfall return period in urban areas	1
6	30 + climate change increase	5 year rainfall return period in urban areas	3
7	50	5 year rainfall return period in urban areas	1
8	50	5 year rainfall return period in urban areas	3
9	100	5 year rainfall return period in urban areas	1
10	100	5 year rainfall return period in urban areas	3
11	200	5 year rainfall return period in urban areas	1
12	200	5 year rainfall return period in urban areas	3
13	200 + climate change increase	5 year rainfall return period in urban areas	1
14	200 + climate change increase	5 year rainfall return period in urban areas	3

The areas to be modelled and output resolutions are shown in Figure A3.



Regional pluvial area 2m resolution

Regional pluvial area 5m resolution

Figure A3 – The Regional Pluvial Areas to be modelled

ISBN: 978-1-78256-378-5 (web only)

The Scottish Government
St Andrew's House
Edinburgh
EH1 3DG

Produced for the Scottish Government by APS Group Scotland
DPPAS13910 (02/13)

Published by the Scottish Government, February 2013