The Flood Risk Management (Scotland) Act 2009

Surface Water Management Planning Guidance

Second Edition
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1 Introduction

1.1 Purpose of the guidance

This guidance sets out the process that responsible authorities should follow when developing and implementing their Surface Water Management Plans (SWMPs). SWMPs should reduce the risk of surface water flooding in the most sustainable way as required by the Flood Risk Management (Scotland) Act 2009 (the “FRM Act”).

The principles advocated can be applied to manage surface water flooding in any area and at any geographical scale. Nevertheless, responsible authorities should prioritise planning in those areas identified through the Flood Risk Management Strategies (FRM Strategies) and Local Flood Risk Management Plans (LFRMPs) as being at greatest risk of surface water flooding.

This guidance has been developed by the Scottish Advisory and Implementation Forum for Flooding (SAIFF), which includes representatives of Scottish Government, local authorities, Scottish Water and the Scottish Environment Protection Agency (SEPA).

1.2 The flood risk management planning process

The FRM Act established a six-year cyclical planning process for assessing and sustainably managing flood risk. Its aim is to reduce the adverse consequences of flooding from all sources, including surface water flooding (Figure 1.1). The FRM Act requires SEPA to produce FRM Strategies and lead local authorities to produce LFRMPs.

The FRM Strategies:

- Identify areas at greatest risk of river, coastal and surface water flooding in Scotland.
- Set objectives to reduce flood risk in those areas.
- Identify actions to achieve the objectives:
  - Require responsible authorities to develop and implement SWMPs to reduce the risk of surface water flooding for areas of greatest risk.
  - Describe any relevant actions that have been identified through the surface water management planning process to reduce surface water flood risk.
  - Actions to reduce the risk of river and coastal flooding are also identified.

The first FRM Strategies published in December 2015[1] identify around 100 towns and cities where SWMPs are required.

The LFRMPs set out the timescales for developing new SWMPs, reviewing existing ones and implementing actions identified. They also set out details for implementing actions to reduce the risk of river and coastal flooding.

Ministerial guidance on Delivering Sustainable Flood Risk Management[2] states that local authorities will lead on surface water management planning, which will in turn be co-ordinated through the flood risk management planning process.

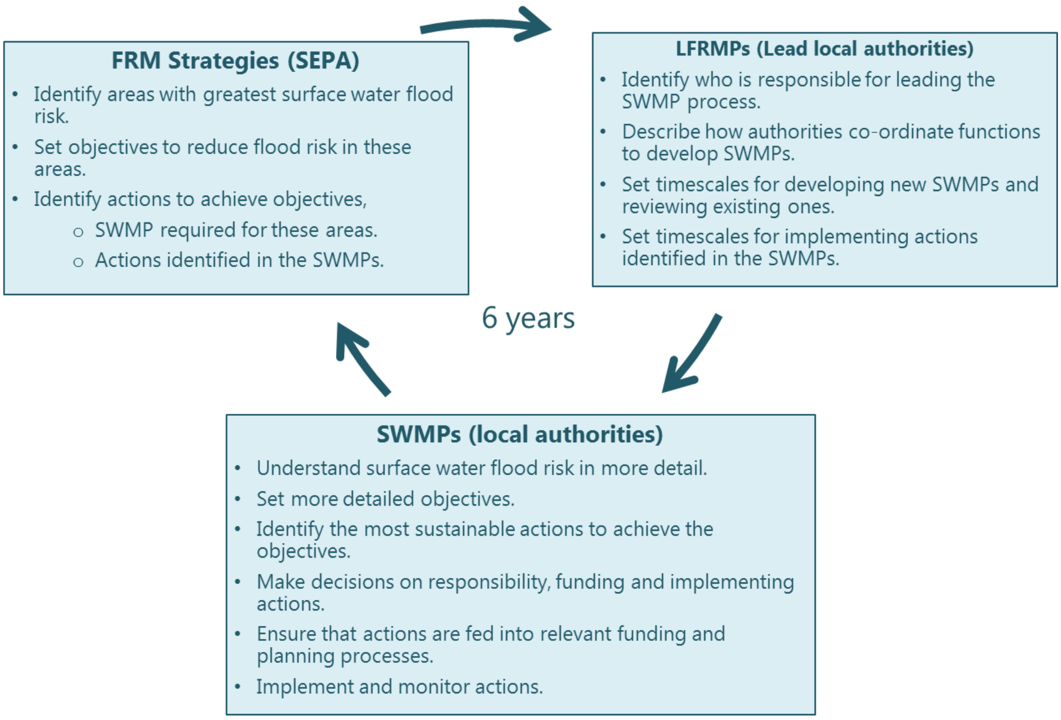


Figure 1.1 Surface water flooding and the flood risk management planning process

[1] Flood Risk Management Strategies: http://apps.sepa.org.uk/FRMStrategies/
[2] Scottish Government (2011) *Delivering sustainable flood risk management*: http://www.gov.scot/Topics/Environment/Water/Flooding/FRMAct/guidance

1.3 Surface water flooding in Scotland

Surface water flooding is a significant problem in Scotland. The FRM Strategies published by SEPA in 2015 estimate that it is responsible for 23% of annual average flood damage (see Box 1.1 and Figure 1.2 for further information). Moreover, the risk of surface water flooding is likely to increase in the future as a result of climate change, the loss of green space in urban areas and, potentially, new development. It is therefore important that land use planning policies take such risks into account when considering new development (Figure 1.3).

Box 1.1 Surface water flooding in Glasgow, 30 July 2002

Flooding in Cockenzie Street, Glasgow 2002. *Photograph courtesy of The Herald and Times.*

Flooding in Ardgay Street, Glasgow 2002. *Photograph courtesy of Glasgow City Council.*

Significant surface water flooding occurred in Glasgow on 30 July 2002, when around 75mm of rain fell in ten hours. The storm had a number of high intensity periods of rainfall interspersed with periods of low or no rainfall. Within the periods of high intensity rainfall, intensities equivalent to 94.5mm per hour were recorded (but for a very short period of time). This rainfall event was estimated to be a 1:100 year return period. Most of the resultant flooding was caused by surface water including surface water run-off, flooding from sewers and other artificial drainage systems and flooding from small urban watercourses.

The East End of Glasgow was the worst affected, with 200 people evacuated from their homes. Flooding and landslides disrupted rail travel, closing routes on the West Coast and Glasgow to Edinburgh via Carstairs lines as well as Queen Street station. A number of roads were also badly affected, including the A82 and A8. The cost of the damage was estimated to be in the region of £100 million.

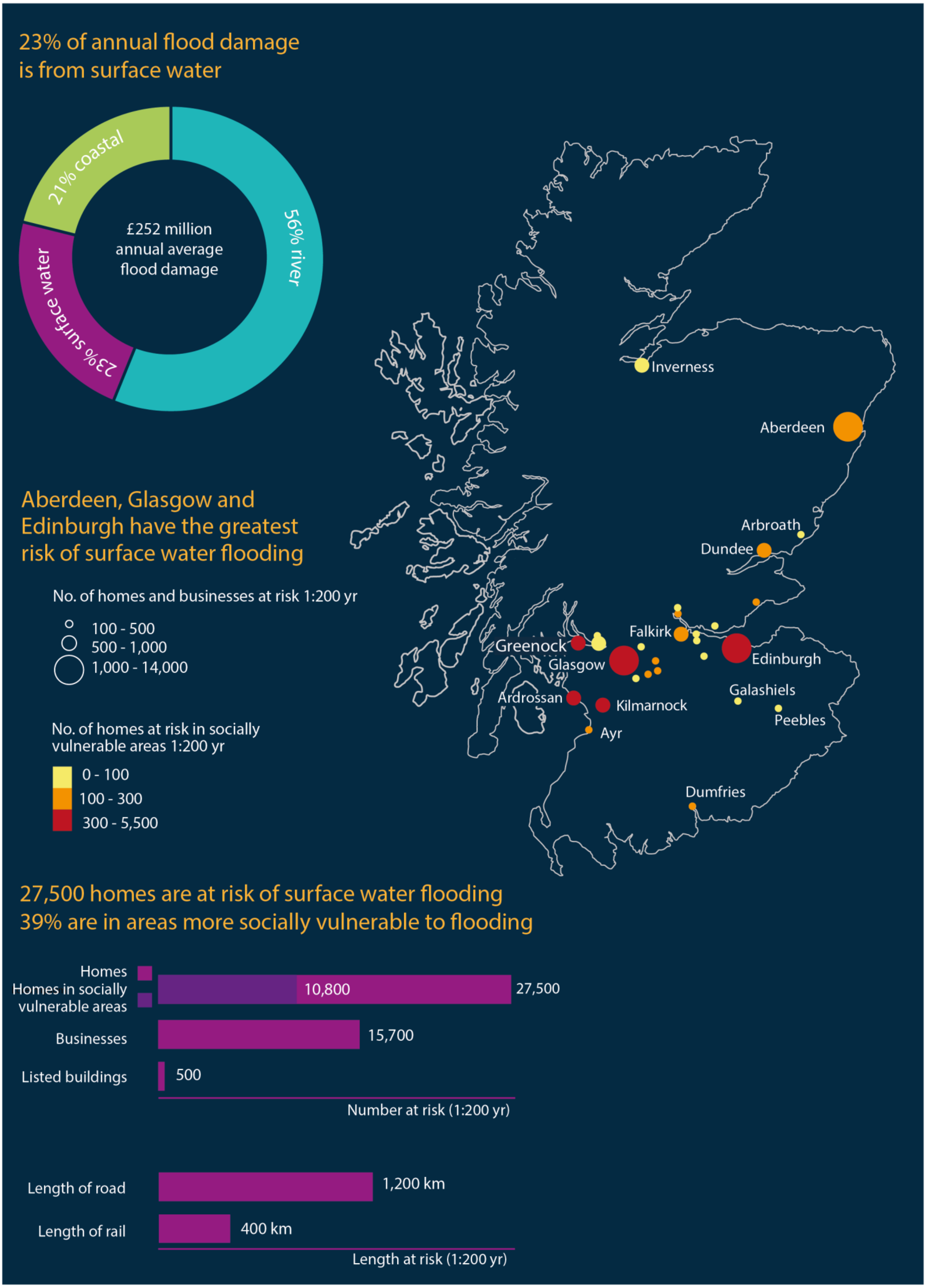


Figure 1.2 Current surface water flood risk in Scotland (based on SEPA 2013 data)

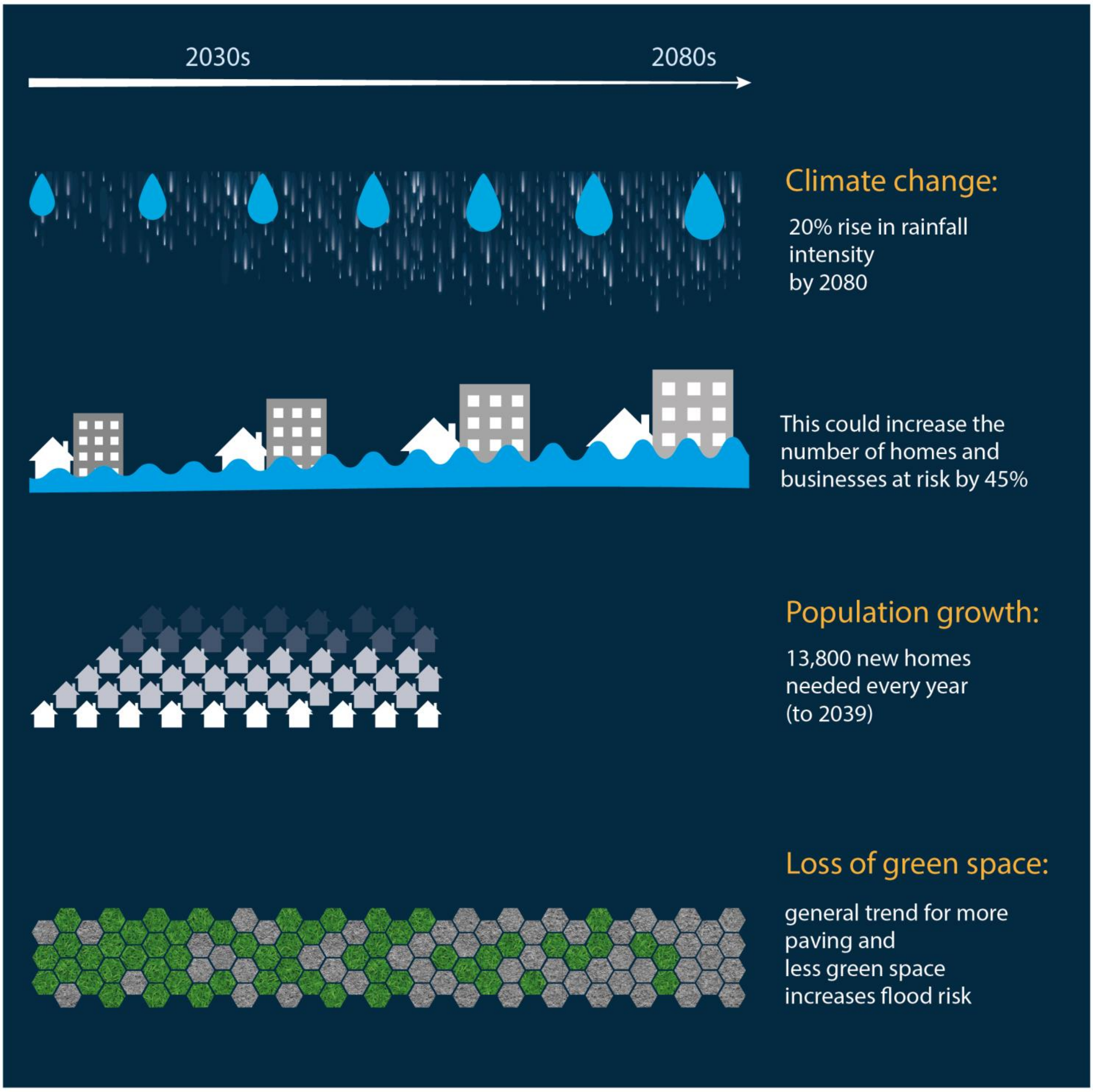


Figure 1.3 Future surface water flood risk (based on SEPA 2013 flood risk data) (projections for new homes based on National Records of Scotland data)

1.4 What is surface water flooding?

In natural (undeveloped) catchments, when rain falls some of the water will evaporate directly back into the atmosphere (evaporation) and some will infiltrate the ground; some of the latter will then be taken up by vegetation and evaporate back into the atmosphere (transpiration). Any excess surface water run-off will then drain, via a network of smaller drainage channels, watercourses and lochs, to the sea. During higher rainfall, watercourses can reach their bankfull capacity and overflow on to floodplains (Figure 1.4).

Development and urbanisation has fundamentally altered this natural drainage process. Removing vegetation and building over green space reduces infiltration and evapotranspiration. This increases both the volume and rate of surface water run-off in urban areas. This increased run-off, combined with the replacement (or removal) of some watercourses and other natural drainage features with drains and culverts (that have a finite capacity), causes flooding, when surface water cannot reach watercourses or the drainage network, or when the drainage network capacity is exceeded. When the surface water run-off reaches watercourses, it can also exacerbate river flooding (Figure 1.4).

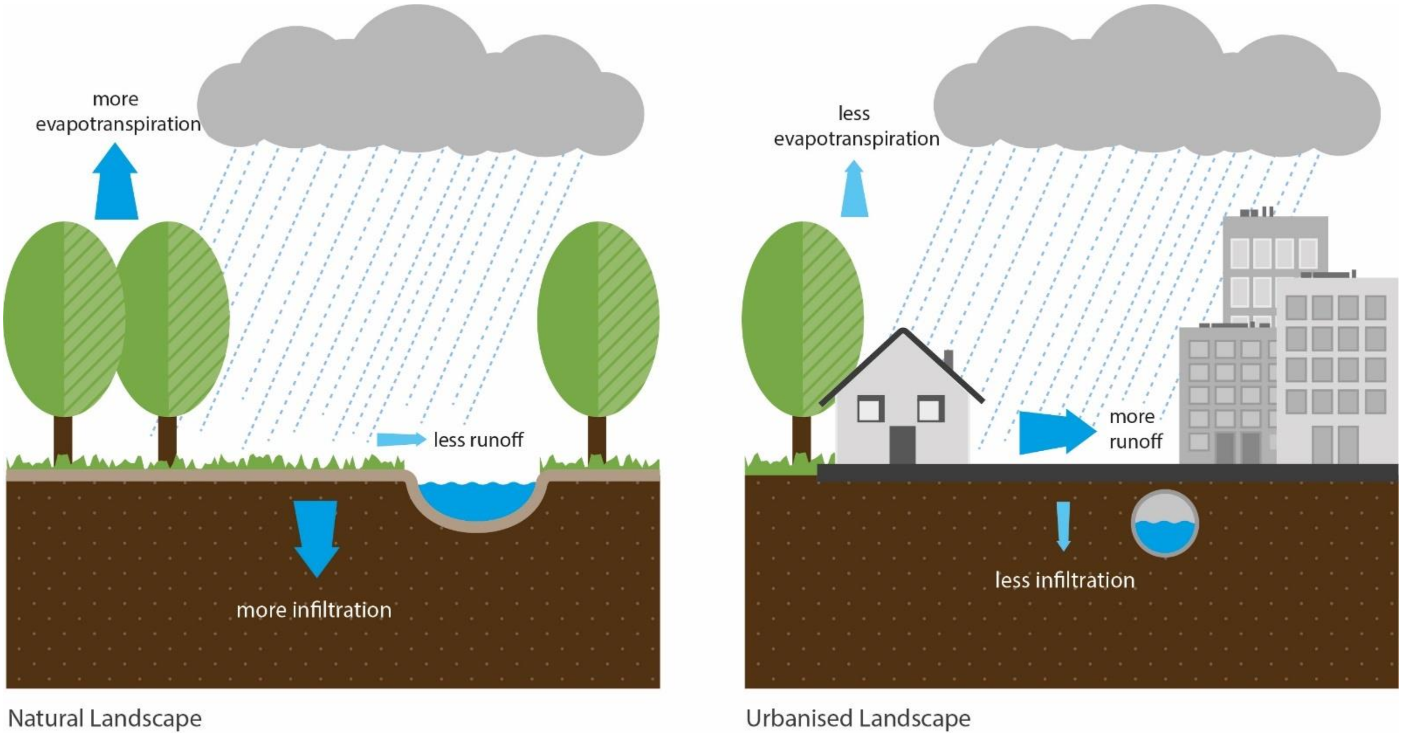


Figure 1.4 Surface water run-off in natural and urbanised landscapes

The term surface water flooding is often used to describe flooding from high intensity rainfall, when surface water run-off flows and ponds on the ground and when sewers and other artificial drainage systems exceed their capacity. It is distinct from flooding that occurs from larger rivers and the sea. In reality the term is often a complex interaction of many sources of flooding, including flooding from natural (e.g. smaller watercourses) and artificial (e.g. sewers) drainage systems and direct inundation from surface water run-off. Other sources of flooding can exacerbate surface water flooding, for example where high sea or river levels prevent drainage systems from discharging freely.

For the purpose of this guidance, the term surface water flooding includes flooding from the following sources:

- Pluvial flooding – flooding as a result of rainfall run-off 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 limited capacity).
- Flooding from sewers and other artificial drainage systems (when capacity is exceeded) – flooding as a result of the capacity of sewers or other artificial drainage systems (e.g. road drainage) being exceeded by rainfall run-off or because the drainage system cannot discharge water at the outfall due to high river or sea levels.
- In general Scottish Water is responsible for managing sewer systems that are designed to manage ‘usual’ rainfall (currently interpreted to mean up to the 1:30 year rainfall event). Surface water flooding under the FRM Act is flooding that occurs when the sewer capacity is exceeded (e.g. by higher than usual rainfall or when the sewer system is affected by high river or sea levels).
- Flooding from small urban watercourses (including culverted watercourses) – flooding that 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 that SEPA does not currently assess fluvial flood risk from any watercourses with a catchment area less than $3km^2$).
- Groundwater flooding – flooding as a result of the water table rising to the surface.

1.5 Sustainable surface water management

It is not possible to build underground urban drainage systems that are large enough to accommodate the most extreme rainfall events. Instead extreme rainfall and resultant surface water run-off must be managed safely above ground avoiding harm to people, homes, businesses and other adverse impacts of flooding.

Co-ordination between authorities using multidisciplinary teams (including landscape architects) is important to ensure that surface water management infrastructure integrates with and enhances the urban landscape. This is essential to ensure that management of surface water realises multiple benefits e.g. contributing to providing attractive and inviting places for people, managing rainfall and surface water flooding, reducing surface water in the sewers, improving the quality of the water environment, increasing biodiversity and making the urban environment more adaptable to future change. To help achieve this, the principles of sustainable surface water management set out in Table 1.1 should be followed (see examples in Figures 1.5, 1.6).

Good examples can be seen in Denmark and the Netherlands where landscape architects have led on the design of multifunctional urban landscapes using nature-based solutions that deliver these multiple benefits, including management of rain and surface water flooding (Boxes 1.2, 1.3).

Table 1.1. Principles of sustainable surface water management
Manage rain and surface water in a way that mimics natural systems and protects and enhances both the built and natural environment.
Manage rainfall and surface water safely above ground, avoiding harm to people, homes, businesses and other adverse impacts of flooding. Maximise the use of permeable surfaces and plants and convey water to watercourses using the natural topography. Avoid increasing surface water in the sewers as this can lead to flooding elsewhere. Reduce surface water in the sewers where possible.
Manage all rainfall events: • Everyday rain – manage rain locally at source, maximise infiltration and evapotranspiration by maximising use of permeable surfaces and plants. Water can be collected for use. There should be little or no surface water run-off in these frequent events. • More rain - collect, delay and convey safely above ground to watercourses following the natural topography. Do not increase surface water in the combined sewers as this causes flooding elsewhere. Water can be collected for use. • Extreme rain - delay, store and convey safely above ground to watercourses following the natural topography.
Multifunctional – maximise all benefits: • People – integrate with, protect and enhance the urban landscape, provide attractive and inviting places for people to live, work and visit. • Drainage and flood management – manage all rainfall events, avoid flooding to people and buildings, avoid increasing flows to receiving watercourses and combined sewers. • Water quality – protect and enhance the quality and physical habitat of receiving watercourses. Collecting water for use can reduce the need to abstract water elsewhere. • Biodiversity – protect and enhance biodiversity, maximising permeable surfaces and plants to attract wildlife. • Adaptability to future change – help the urban environment adapt to future challenges of climate change (increasing rainfall, rising temperatures) and mitigate the loss of green space.
Co-ordinate with other authorities and projects to maximise benefits and aid delivery (e.g. using foot paths and cycle paths as routes for infiltrating and conveying water, contributing to ‘green and blue networks’).
Think of different spatial scales required to manage surface water (e.g. what can be done locally at the building and street level, what regional and more strategic management is required and what connections between the different scales are required?).

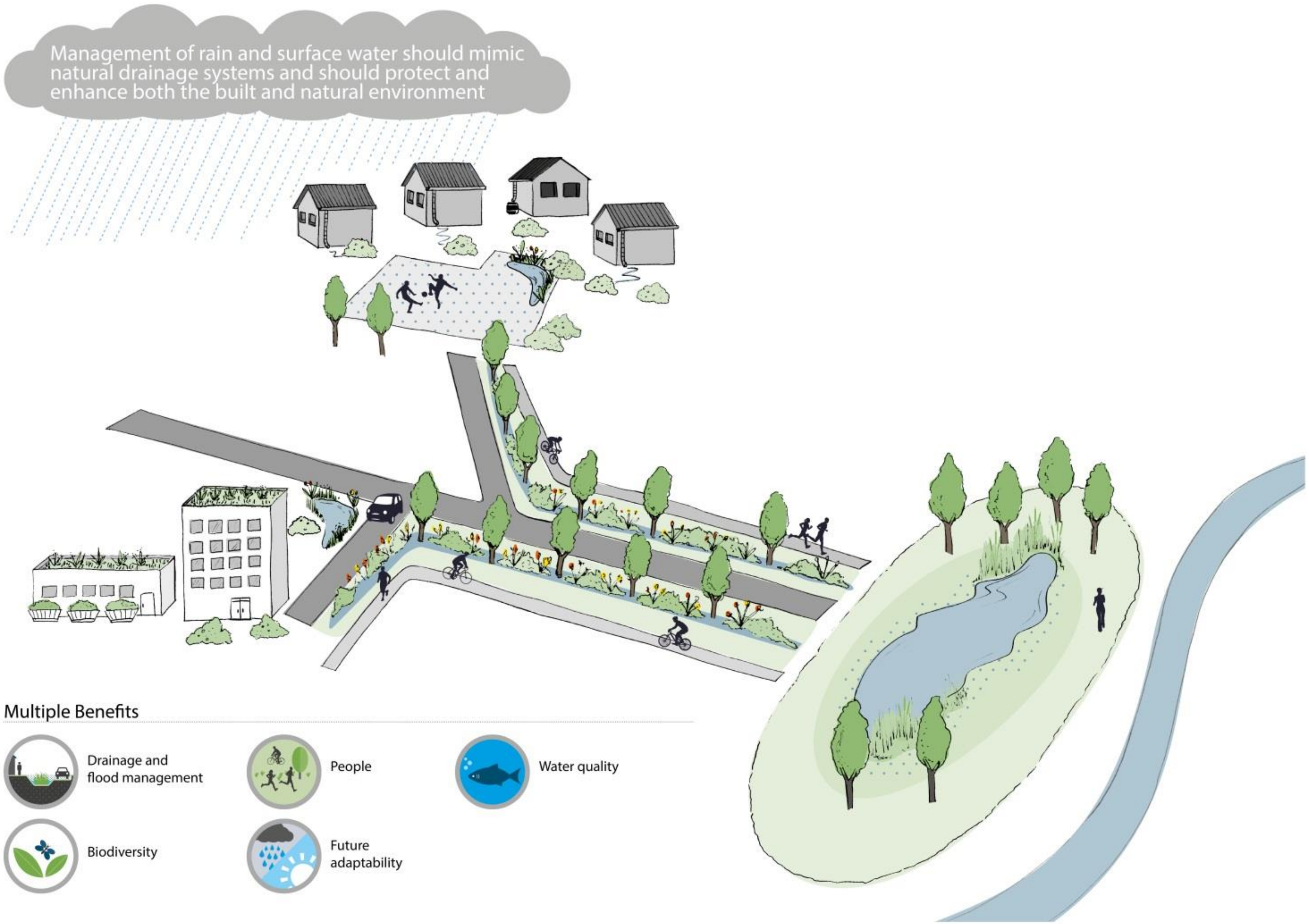


Figure 1.5 Principles of sustainable surface water management

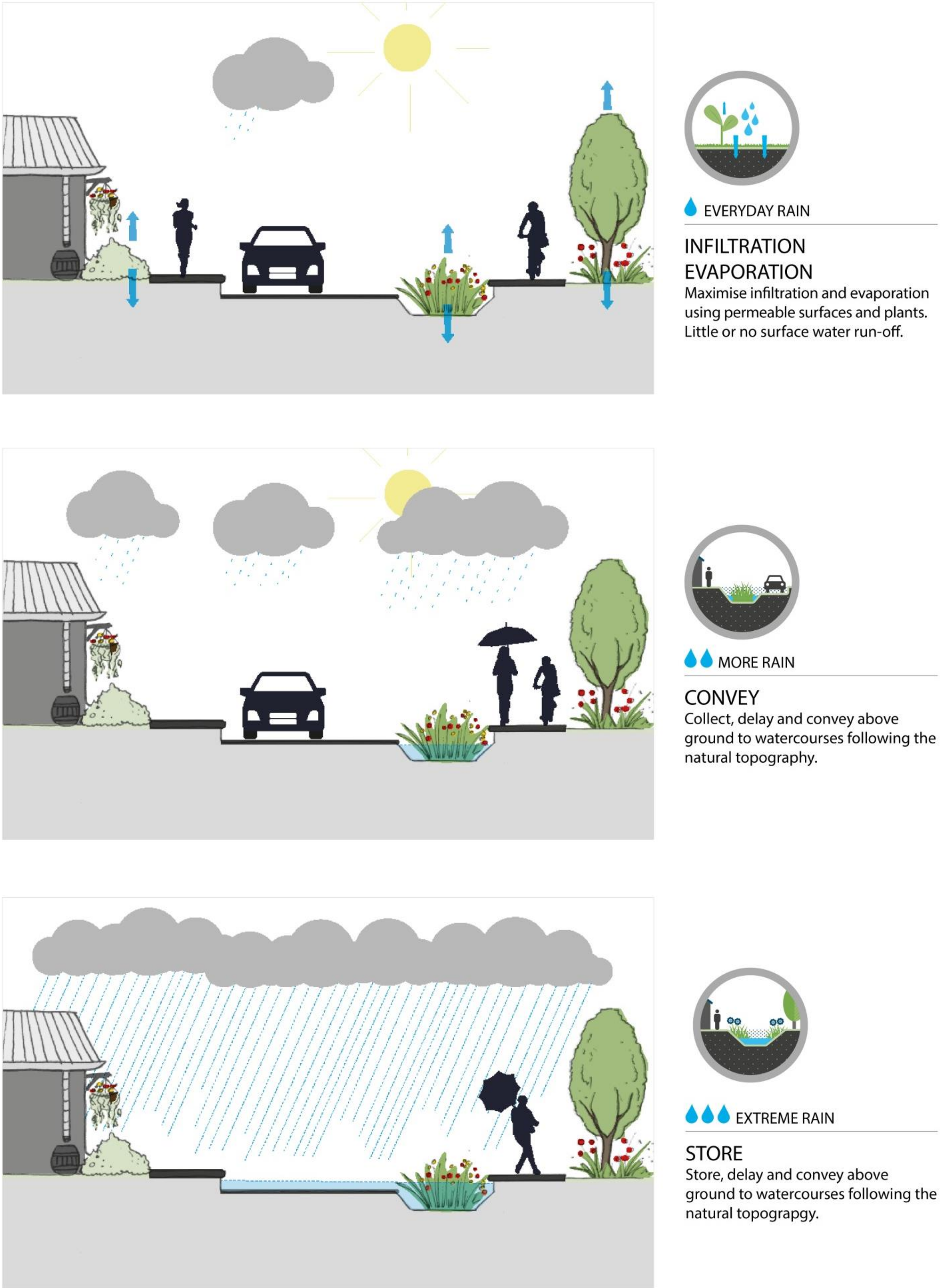


Figure 1.6 Design for all rainfall events

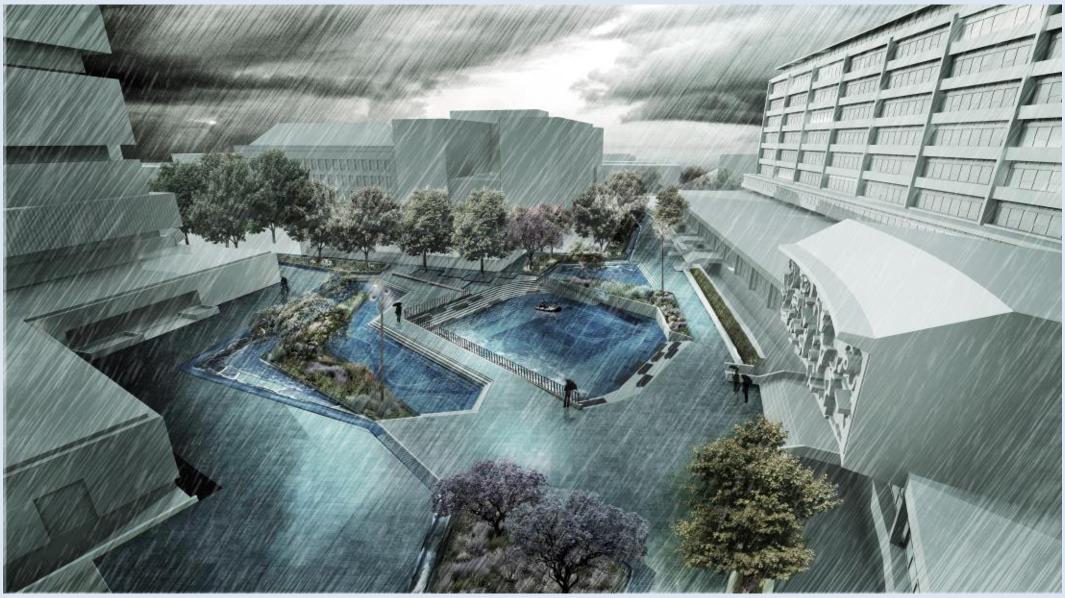
Box 1.2 Copenhagen – providing a multifunctional urban landscape that includes management of rain and surface water flooding

Copenhagen climate change adaptation plan http://en.klimatilpasning.dk/

Proposals for the Nørrebro neighbourhood of Copenhagen by SLA landscape architects http://www.sla.dk/en/projects/hanstavsenspark

Images ©SLA / Beauty and the Bit

Box 1.3 Rotterdam - providing a multifunctional urban landscape that includes management of rain and surface water flooding



Rotterdam climate change adaptation http://www.rotterdamclimateinitiative.nl/documents/2015-en-ouder/Documenten/20121210_RAS_EN_lr_versie_4.pdf

Water square in Benthemplein, Rotterdam by De Urbanisten landscape architects http://www.urbanisten.nl/wp/

Photograph ©Ossip van Duivenbode

Image ©De Urbanisten

2 The surface water management planning process

2.1 Principles of surface water management planning

The aim of a surface water management plan is to reduce the risk of surface water flooding in the most sustainable way, as required under the FRM Act.

Range of sustainable actions

SWMPs are likely to include a range of different actions. These should be the most sustainable combination of actions necessary to manage the risk of surface water flooding (see Appendix 4 for a list of potential actions). The most sustainable actions are those that are the most economically, socially and environmentally advantageous.

SWMPs may also include actions that are the responsibility of different authorities. In such cases, the SWMPS will help to co-ordinate funding and implementation across the relevant authorities. Funding may come from various sources, depending on the cost of implementation and the authority responsible.

Long-term, iterative approach

SWMPs should set out a long-term vision for sustainably managing surface water flooding in an area and the actions needed to achieve that vision. More detailed information is likely to be available for priority actions that will be implemented in the shorter term while less information may be available for longer term actions.

The process should be iterative. SWMPs should be monitored, reviewed and updated with timescales for reviews and updates that take into account the six-year Flood Risk Management Planning cycle. The benefits of adopting a longer term, iterative approach include the ability to:

- Include new data, thereby ensuring that the plan is based on the best available information.
- Monitor how effective actions are that have been implemented and trial innovative solutions.
- Plan for new actions to achieve the long-term vision.
- Adapt to changing circumstances.
- Tackle problems in stages. Surface water flooding is often widespread and fragmented across an urban area so that in many cases it is not feasible to solve all surface water flooding problems at once.
- Co-ordinate with other projects and authorities to realise multiple benefits. It allows different authorities to identify where and when there may be opportunities for co-ordination or joint working. This is more difficult when authorities are focused on their own priorities over the short-term.
- Be more cost-effective. Some surface water management actions may only become cost-effective if implemented alongside other projects. Long-term planning helps to identify where and when this can be done.

Risk-based
Surface water management plans should be risk-based in order that effort and investment can be directed toward areas at greatest risk of flooding and where the most benefits can be achieved.

SWMPs can be carried out at any geographical scale, focusing more detail on areas at greatest risk. For example, an SWMP could be carried out for an entire local authority (LA) area but should contain more detail on locations within it that have been designated by FRM Strategies as being at higher risk (and any other areas of interest to the local authority). Or, a larger urban area could be covered by many SWMPs.

All stages of the surface water management planning process should be informed by risk. The level of detail to go into at each stage (e.g. number of outputs and detail provided for each output) will depend on a number of factors, including: the level of flood risk; the complexity of the flooding problem; the availability of resources; and, the availability of, and confidence in, existing data.

2.2 Stages of the surface water management planning process

Figure 2.1 and Table 2.1 show the stages to be followed when developing and implementing a surface water management plan. All stages are consistent with the development of the FRM Strategy and the principles of the FRM Act.

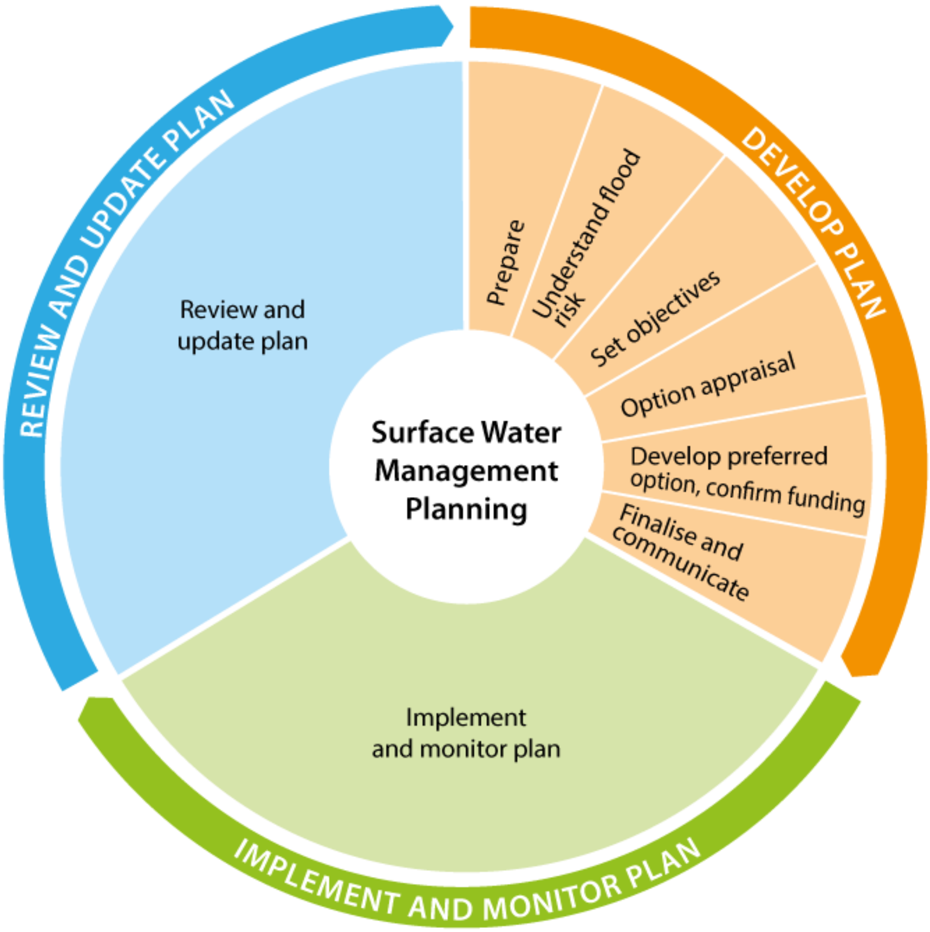


Figure 2.1 Stages of the surface water management planning process

Table 2.1 Summary of surface water management planning stages

SWMP stage	Summary	Example outputs
Prepare	• Resources. • Governance. • Consultation and co-ordination. • Collating existing information on surface water flooding. • Validating existing information. • Scoping level of detail and defining geographical scale of the SWMP(s).	• Initial findings of key stakeholder consultation. • Data on flood hazard and risk. • Data register. • Section of SWMP report clearly communicating findings of this stage. • Other outputs, e.g. GIS (geographic information systems) data and maps showing key information (e.g. SWMP areas).
Understand flood risk	• Analysing and interpreting information to understand surface water flood hazard and risk. • Identifying areas with greatest risk. • Consultation and co-ordination.	• Section of SWMP report clearly communicating the sources, pathways and adverse impacts (risk) of surface water flooding. • Identification of areas with greatest risk. • Other outputs, e.g. GIS data and maps showing key information (e.g. flood hazard and risk, areas with greatest risk), communication material for different audiences.
Set objectives	• Confirming objectives from FRM Strategies • Setting more detailed objectives for areas with greatest risk. • Prioritising objectives if required. • Key consultation and co-ordination stage to identify other projects that could be carried out jointly to aid delivery and realise multiple benefits.	• Consultation findings. • Section of SWMP report clearly communicating objectives, indicators and priority of objectives. • Other outputs, e.g. GIS data and maps showing key information (e.g. areas of greatest risk, objectives for these areas and their priority), communication material for different audiences.
Option appraisal	• Scoping the option appraisal, confirming objectives (e.g. high-level appraisal for all objectives or more detailed appraisal and design for priority objectives). • Developing and comparing options for each objective in order to choose preferred option. • Consultation and co-ordination • Understanding the degree of confidence in the appraisal.	• Section of SWMP report clearly communicating the outcomes of this stage, including reasons for selecting preferred option. • Co-ordination and joint working where required to develop options that will yield multiple benefits. • Other outputs, e.g. supporting information for the option appraisal, clear communication of information to aid decision making, consultation material for different audiences.
Develop preferred option, confirm funding	• Developing preferred option in more detail. • Confirming responsibilities and funding.	• Section of SWMP report clearly communicating the outcomes of this stage, including confirmed action plan and SMART objectives.
Finalise and communicate plan	• Producing an SWMP report that summarises key findings and outputs, and includes proposals for monitoring, implementing, reviewing and updating the plan. • Considering communication material for other stakeholders and the public.	• Detailed SWMP report that provides sufficient information to guide those implementing the plan. • Summary report and maps, including action plan to communicate clearly with other stakeholders, e.g. the public. • Data pack to help share key information, e.g. key GIS outputs, maps, action plan.
Implement and monitor actions	• Implementing actions. • Monitoring success of the actions to determine progress towards achieving objectives. • Gathering information on complete actions.	• Updated summaries of all actions and their status (e.g. a 'live implementation plan') to aid co-ordination and communication, including confirming when an action is complete and objectives achieved. • Key information about complete actions recorded and shared with stakeholders.
Review and update SWMP	• The SWMP is a long-term process that should follow the flood risk management planning cycles. • When reviewing and updating SWMPs the development stages should be repeated and any required changes made, provide information on complete and planned actions.	• Updated or new outputs, e.g. SWMP report; summary SWMP for clear communication to other stakeholders; technical reports; updated 'data pack' to help share key information with others and aid co-ordination, e.g. key GIS outputs, maps, action plan (showing information on complete and planned actions).

2.3 SWMP timescales and flood risk management planning

The flood risk management planning process runs on a six-year cycle, the statutory dates for which are shown in Figure 2.2. Key tasks and dates to consider for surface water management planning are:

- **SEPA update of pluvial hazard and risk data** – the data should be used to inform (or may trigger) a review and update of surface water management plans. At the time of publication SEPA had no timescale for the next update but it will share the information with responsible authorities when it becomes available.
- **More detailed modelling of pluvial flood hazard and risk by LAs** – if a local authority has more detailed modelling of pluvial flood hazard and risk it should contact SEPA to determine whether SEPA's pluvial flood hazard and risk maps should be updated. As the FRM planning process is cyclical, data can be provided to SEPA at any time. That said, key flood risk management planning dates should be considered to allow new data to be included in any National Flood Risk Assessments (NFRAs) or FRM Strategies: for example, SEPA would need data prior to the publication of an NFRA for it to be incorporated – e.g. by 2018 for FRM Strategy 2, or by 2022 for NFRA 3 (as part of FRMP 3 development).
- **Review and update of SWMP areas** 2019, 2025 etc. – SEPA, in consultation with LAs and Scottish Water, will lead on reviewing and updating SWMP areas before each six-yearly FRM Strategy public consultation. LAs should therefore share any knowledge of surface water flooding in their area (e.g. based on observed flood events or more detailed modelling) with SEPA. New SWMP areas may be included if information shows there is a greater risk of surface water flooding than was previously identified; conversely existing SWMP areas may be removed where new information shows the risk to be lower.
- **Actions (planned and completed) identified through the SWMP 2019, 2025 etc.** – in order to inform the FRM Strategy's prioritisation process and funding decisions, LAs should submit information on any planned actions identified through the SWMP process as requiring prioritisation, before each six-yearly public consultation (i.e. 2019, 2025 etc.). Information on completed actions should be provided for progress to be reported. Any actions relevant to the SWMP and confirmed by other authorities (e.g. Scottish Water) can also be included in time for the FRM Strategy public consultation stage, even if they do not require FRM Strategy prioritisation for funding decisions.

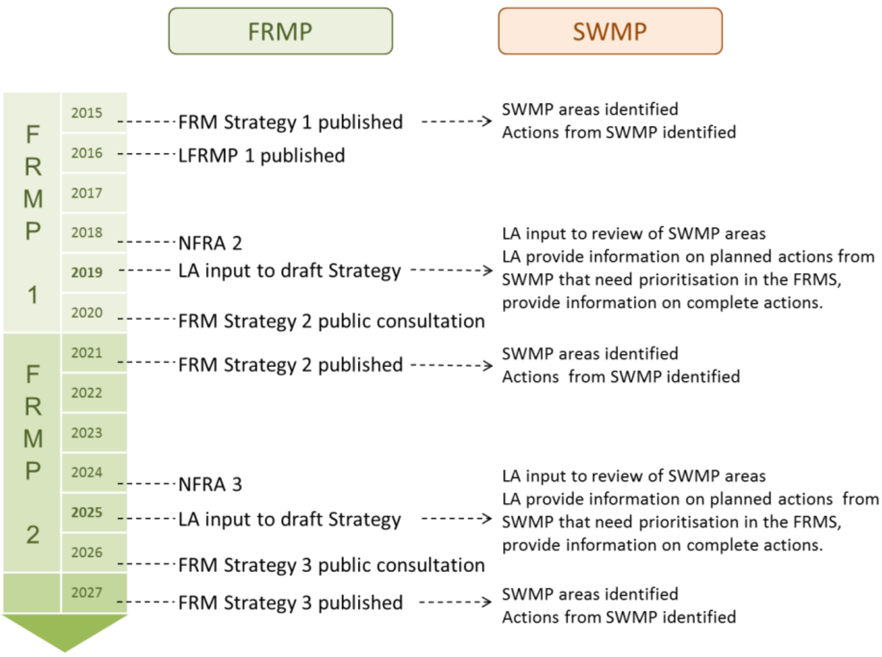


Figure 2.2 Key dates for FRMP and SWMP

3 Consultation and co-ordination

3.1 Roles and responsibilities for surface water (drainage and flooding)

The governance of surface water is complex, with different legislation and different authorities responsible for different parts of the drainage system. The main authorities and processes governing surface water in our urban areas are set out in this section. They represent the key stakeholders to be consulted throughout the surface water management planning process.

The main processes governing surface water management (drainage and flooding) in our urban areas are Scottish Water's management of the sewer network, local authority management of the road network and local authority management of surface water flooding. For new development the local authority-led land use planning system requires drainage and flooding to be taken into account and there are three different surface water infrastructure vesting processes that must be considered (Figure 3.1). Homeowners and landowners also have important responsibilities for managing water on their land.

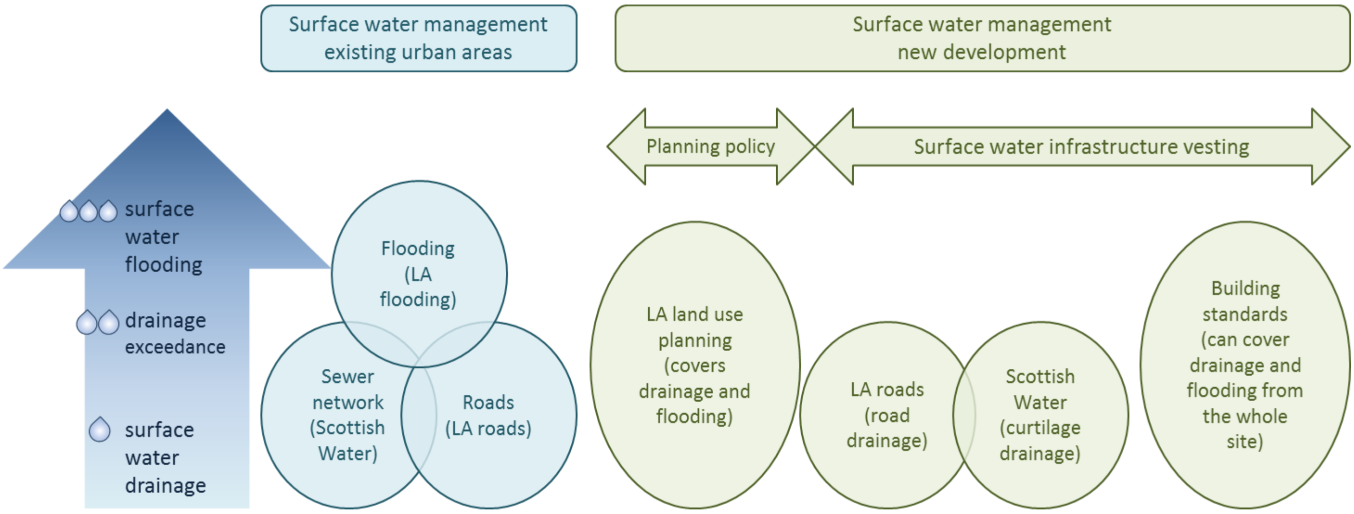


Figure 3.1 Main surface water management authorities

A summary of the main duties and powers involved in surface water management is given below, with further information provided in Appendix 2. It should be noted that the list below is not exhaustive. The FRM Act places a duty on responsible authorities to adopt an integrated approach to flood risk management by co-operating with each other. As surface water flooding can often be a complex interaction of many sources of flooding (see Section 1.4) and responsibilities can lie with different authorities, the duty to co-operate is therefore particularly important.

LA (flooding)
Under the FRM Act, local authorities have general powers to manage flood risk (from all sources, including surface water flooding) in their area. This includes implementing actions described in the LFRMPs, flood protection schemes or any other flood protection work. Section 1.4 has further information on the definition of surface water flooding but in general, surface water flooding under the FRM Act is flooding that occurs when the capacity of the sewer (or other drainage system) is exceeded (e.g. by higher than usual rainfall or when the sewer system is affected by high river or sea levels). The definition of surface water flooding under the FRM Act does not include flooding solely from a sewerage system. Under the Sewerage (Scotland) Act 1968), Scottish Water is responsible for managing flooding solely from a sewerage system (that is, sewerage systems that are designed to manage 'usual' rainfall events, currently interpreted to mean up to the 1:30 year rainfall event).

LA (roads)
Local authorities (as roads authorities) have duties to maintain and manage public roads under the Roads (Scotland) Act 1984. In order to do this, roads authorities have powers to drain roads and, if they construct a drain, a duty to maintain it (including sustainable urban drainage systems). The Roads Act sets out a vesting process for new roads that includes road drainage. It also provides powers to protect roads from flooding.

Scottish Water
Scottish Water has duties under the Sewerage (Scotland) Act 1968 to provide and maintain public sewers that can effectively drain surface water from the curtilage of properties under 'usual' rainfall events (currently interpreted to mean up to the 1:30 year rainfall event). The definition of flooding under the FRM Act does not include flooding solely from a sewerage system (which falls under Scottish Water duties). The Sewerage (Scotland) Act sets out vesting process for new infrastructure draining the curtilage of properties.

LA (land use planning)
Local authorities (as planning authorities) (and National Park Authorities) have powers to grant or refuse planning applications and flood risk is a material consideration when determining planning applications. Strategic Development Plans and Local Development Plans should set out infrastructure required, including drainage infrastructure. Scottish Planning Policy promotes; a precautionary approach to flood risk from all sources, including surface water flooding and; avoidance of increased surface water flooding through requirements for Sustainable Drainage Systems (SuDS) and minimising the area of impermeable surface. Infrastructure and buildings should be designed to be free from surface water flooding in rainfall events where the annual probability of occurrence is greater than 0.5% (1:200 years). Surface water drainage measures should have a neutral or better effect on the risk of flooding both on and off the site, taking account of rain falling on the site and run-off from adjacent areas. Planning should protect, enhance and promote green infrastructure, including open space and green networks, as an integral component of successful placemaking. Development plans should be based on a holistic, integrated and cross-sectoral approach to green infrastructure. They should be informed by relevant plans covering green infrastructure's multiple functions (including flood management). For development management green infrastructure should be treated as an integral element in how the proposal responds to local circumstances, including being well-integrated into the overall design layout and multi-functional.

LA (building standards)

Local authority building standards have duties to ensure that surface water management infrastructure (drainage and flooding) is designed to appropriate standards, where that infrastructure is owned by the land / home owners rather than vested by Scottish Water or a local authority (as roads authority). Section 3.6 of the Building (Scotland) Regulations 2004 sets out the requirements for surface water drainage.

SEPA

SEPA has responsibilities under the FRM Act to map and assess flood risk (including surface water flood risk), produce FRM Strategies (that take into account surface water flooding), provide a flood warning service and issue flood risk advice to planning authorities and National Park authorities.

Individuals

Homeowners and landowners have important responsibilities for managing rainfall and surface water on land they own. This is particularly important where authorities are working with homeowners and landowners to reduce run-off from private land. 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 damage to their land or property without increasing flood risk elsewhere; if one person's acts cause flooding to another person's property it may have common law implications. Members of the public also have an important role in sharing local knowledge and engaging with flood protection activities in their areas.

3.2 Who to consult and why

It is important to consult stakeholders to determine where and when there are opportunities for closer co-ordination or joint working in order to:

- Bring about multiple benefits – actions to manage surface water flooding will be better able to yield multiple benefits, e.g. enhancing the urban landscape, improving the water environment, reducing surface water in the sewer, if work is co-ordinated with relevant authorities.
- Improve cost-effectiveness – carrying out joint projects with multiple benefits may make managing surface water flooding more cost-effective and open up other sources of funding. Some surface water management actions may only become cost-effective when implemented alongside other projects.

As such, consultation should aim to:

- Identify any work being carried out by other stakeholders that could help in managing surface water flooding in a sustainable way (e.g. opportunities for new development to reduce existing surface water flood risk, planned open space or green network development) and;
- Establish whether any stakeholders can co-ordinate their activities with planned surface water flooding actions to bring about multiple benefits (e.g. do any flood management proposals present an opportunity to involve land use planners in order to enhance the urban landscape, or to work with Scottish Water to reduce surface water in the sewers?).

Consultation and co-ordination between main drainage and flooding authorities

As a minimum, the main surface water drainage authorities (LA roads and Scottish Water), flooding authorities (LA flooding) and LA land use planners should be consulted throughout the surface water management planning process. This will make it easier to identify where and when any relevant work (Table 3.1) between the authorities could benefit from closer co-ordination and/or joint working. SEPA can advise on remaining consistent with the FRMP process and any further modelling that might be required.

Consultation and co-ordination between other stakeholders

Other stakeholders may also be implementing work that could potentially help manage surface water flooding, e.g. through the development of 'green and blue' networks, watercourse restoration, biodiversity and habitat creation. Examples of other activities and stakeholders to consider include:

- The development of green networks (LAs, Green Network Partnerships, Greenspace Scotland)
- Open space strategies (LAs)
- Local Biodiversity Action Plans (LAs)
- Active travel plans (LAs)
- Climate Change Adaptation Plans (all authorities)
- River Basin Management Plans (SEPA)
- Communities and the public
- Other infrastructure/land owners (e.g. Scottish Canals, Transport Scotland, Network Rail, Forest Enterprise, Forestry Commission)
- Emergency planning authorities (LA emergency planning).

Table 3.1 Examples of relevant work and key data for co-ordination

Authority	Relevant work that may benefit from co-ordination	Key data to share
Local authority (flooding)	• Identify any work carried out by other stakeholders that could help sustainable surface water flood management. • Identify stakeholders who can co-ordinate with planned surface water flooding actions to help realise multiple benefits. • Implement sustainable infrastructure that manages all surface water (drainage and flooding). * • Work with roads authorities to identify safe, overland flow paths. • Improve information on surface water flooding with input from all authorities. • Work with SEPA to improve understanding/conduct further modelling of surface water flood risk where required. • Ensure that new development (and re-development) manages all surface water sustainably (drainage and flooding up to the 1:200 year rainfall event) and is designed to integrate with and enhance the urban landscape.	• Present understanding of flood risk to key stakeholders. • SWMP area(s). • Locations with greatest flood risk and objectives for these locations. • Initial priorities for the locations with greatest flood risk (initial priority likely to be based on flood risk alone, but priorities may change if opportunities are identified for joint working). • Planned actions to manage surface water flooding (including where and when they will be implemented).
Scottish Water	• Identify any surface water flooding actions that could also help to reduce surface water in sewers. • Identify any surface water flooding actions that could also help to manage sewer flooding and combined sewer overflow (CSO) spills. • Implement sustainable infrastructure that manages all surface water (drainage and flooding). *	• Locations where surface water can be reduced in sewers. • Locations of internal or external sewer flooding or locations where CSOs are being addressed. • Planned work, e.g. where and when work will be carried out to reduce surface water in the sewer; work to resolve sewer flooding and CSO spills.
Local authority (roads)	• Work with LA flood management to identify where significant road flooding can be reduced. • Work with LA flood management to identify safe, overland flow paths. • Identify any surface water flooding actions that could help to reduce surface water on roads. • Implement sustainable infrastructure that manages all surface water (drainage and flooding). *	• Locations of significant road flooding. • Planned road maintenance. • Planned road improvement work (including where and when it will be carried out).
Local authority (land use planning)	• Identify any surface water flooding actions that could help to enhance the urban landscape (or provide new open space opportunities) and ensure that they maximise benefits to people. • Ensure that new development (including new or enhanced green networks) manages all surface water sustainably (drainage and flooding up to the 1:200 year rainfall event), and is designed to integrate with and enhance the urban landscape and contribute to 'green and blue' infrastructure. • Identify where planning policies and new development could reduce existing surface water flood risk.	• Areas identified for development or regeneration. • Information on green space • Proposals to enhance existing or develop new open / green space (e.g. open space strategies, local biodiversity actions plans, 'green and blue' network development, footpath and cycle path development, urban watercourse restoration, park development).
SEPA	• Work with LA where advice and / or further modelling of surface water flood risk is required. • Ascertain whether any actions being implemented under the River Basin Management Plan could also help to manage surface water flooding. • Establish whether any actions proposed in the SWMP could improve the water environment.	• River Basin Management Plans (RBMPs). • Proposals for urban watercourse restoration.

* e.g. LA roads, LA flooding and Scottish Water working together where required to implement infrastructure that manages surface water drainage from roads and curtilage of properties, and surface water flooding (when drainage is exceeded) for all rainfall events up to a 1:200 year rainfall event.

3.3 How to consult

The risk-based approach should be applied to consultation, with the local authority deciding what consultation or partnership arrangements are required. For example, where less co-ordination is required consultation may be relatively informal and information-sharing meetings with stakeholders considered sufficient. In more complex, higher risk areas requiring a greater degree of consultation and co-ordination, more formal partnerships with agreed governance arrangements may be necessary. Existing communication structures should be considered and used where appropriate, e.g. flood risk management Local Plan District Partnerships.

Where closer co-ordination or joint actions would be beneficial, closer working relationships and more formal partnerships between authorities for these joint actions are likely to be required.

Clear and effective communication is vital when working with stakeholders with different areas of expertise. Sharing relevant information about planned activities is crucial to allow stakeholders to identify opportunities for joint working or co-ordination. Providing key information (Table 3.1) in maps and GIS format will help the process.

3.4 When to consult

Consultation is required throughout the surface water management planning process and should involve a range of stakeholders; different stakeholders may need to be consulted at different stages (Table 3.2). At the SWMP preparation stage the local authority leading on the SWMP development should consider who to consult as well as what information from the SWMP will be required for consultation. A key consultation stage is the objective-setting phase. At this stage the local authority will have a better understanding of its SWMP objectives and priorities, and therefore of what opportunities for closer co-ordination or joint working there may be. Bear in mind that these priorities may change if the consultation identifies opportunities for co-ordination or joint working.

Table 3.2 Key stages for consultation	
SWMP stage	**Consultation: actions and considerations**
Prepare	Identify stakeholders to consult and when to consult them. Carry out initial consultation of key stakeholders (e.g. drainage and flooding authorities): • Introduce key stakeholders to the surface water management planning process, explain the reasons for consulting them and give initial timescales for the consultation process. • Identify and share information relevant to the surface water management planning process, e.g. information that explains surface water flood risk and validation of model outputs, and start to look at opportunities to co-ordinate actions.
Understand flood risk	This stage can be consulted on along with consultation on initial objectives. It may be necessary to consult Scottish Water or roads authorities if there are any complex matters, e.g. where sewer networks or roads drainage may influence surface water flooding.
Set objectives	**KEY consultation stage** to identify where and when there may be opportunities for closer co-ordination or joint working. • As part of the consultation: • Present understanding of flood risk to stakeholders. • Share key information from the SWMP, SWMP areas and locations at greatest risk, objectives for these areas and initial priorities (bear in mind that priorities may change if opportunities are identified for closer or joint working). • Stakeholders should share information on relevant planned work that may present opportunities to co-ordinate with surface water flood management actions.
Option appraisal	Close consultation and joint working will be required if any joint actions have been agreed. If larger scale structural actions are being implemented, land use planning should usually be involved to make sure that actions integrate with and enhance the urban landscape. Relevant communities may need to be consulted.
Develop preferred option; confirm funding	Close consultation and joint working will be required if any joint actions have been agreed. If larger scale structural actions are being implemented, land use planning should usually be involved at the more detailed design stage in particular, to ensure that actions integrate with and enhance the urban landscape. Any relevant communities may need to be consulted, in particular at a more detailed design stage.
Finalise and communicate plan	Communicate to key partners the finalised plan, including the confirmed implementation plan and what actions are to be implemented by whom and when. This should include any joint actions that have been agreed or actions that need closer co-ordination.
Implement and monitor plan	Consultation may be necessary during the implementation process. Larger-scale structural actions may require community consultation. It may also be useful to share monitoring information and/or highlight any significant changes to the implementation plan.
Review and update SWMP	When updating, repeat the plan development stages and carry out the necessary consultation.

3.5 Other legislative requirements

The authority leading on the surface water management planning process is responsible for determining whether any other legislative requirements apply to the planning process. Legislative requirements may have their own statutory consultation requirements and associated timescales. Because an SWMP is a plan produced by a public body, it is likely to fall within the scope of Strategic Environmental Assessment legislation. Further information can be found on the Scottish Government website.[3] Also, any plans that are likely to have significant effects on a 'Natura 2000' site will require an assessment under the Habitats Regulations, further information on which can be found on the Scottish Natural Heritage website.[4]

Other legislative requirements may apply to actions implemented through the SWMP. It is the responsibility of the authority implementing the actions to meet any legislative requirements.

3 http://www.gov.scot/Topics/Environment/environmental-assessment/sea/SEAGuidance
4 http://www.snh.gov.uk/planning-and-development/environmental-assessment/habitat-regulations-appraisal/

4 Preparatory work

Preparatory work: considerations and example outputs	
Considerations	**Example outputs**
• Resources. • Governance. • Consultation and co-ordination. • Collating existing information on surface water flooding. • Validating existing information on surface water flooding. • Scoping the level of detail and defining the geographical scale of the SWMP(s). • General project management and quality control.	• Initial findings of key stakeholder consultation. • Data on flood hazard and risk. • Data register. • Section of SWMP report clearly communicating findings of this stage (e.g. the data on which the SWMP will be based; a summary of confidence in the data used; any other gaps in understanding or data). • Other outputs showing key information e.g. GIS data and maps showing SWMP areas.

4.1 Resources for developing the surface water management plan

The first consideration for a local authority is likely to be what resources it will need to develop the SWMP. Decisions on funding and implementing actions identified through the surface water management planning process will be made at a later stage.

Consideration of the resources needed to develop the SWMP should include:

- The spatial scale of the SWMP – does the LA require an SWMP for the whole LA area, focusing more detail on SWMP areas identified in the FRM Strategies, or will it simply focus on the SWMP areas in the FRM Strategies?
- The level of detail required for each stage of the SWMP (see Section 4.5), for example:
  - Understanding flood risk: how much analysis of existing data and what outputs are required?
  - Setting and prioritising objectives: what outputs are required and how much consultation is needed when prioritising?
  - Identifying actions: what type of appraisal will be carried out, e.g. high-level appraisal of actions for all objectives that could be carried out over the long term, or more detailed appraisal and design for priority objectives?
- Whether there are opportunities for resource-sharing with other local authorities, e.g. if developing SWMPs for more than one LA area.
- Whether the LA has sufficient in-house resources or will need to appoint consultants.
- If consultants are appointed, for what stage(s) of the SWMP development or implementation are they needed.

4.2 Governance, consultation and co-ordination

Governance

The local authority leading on the surface water management planning process should establish internally the governance needed for agreeing the SWMP. This may include governance for:

- Agreeing what actions to implement, funding and implementation of actions.
- Establishing which local authority will lead the SWMP(s), if more than one is involved.
- Links to the Local Plan District partnerships to feed outputs from the SWMP into FRM Strategies and LFRMPs.
- Legal agreements or memoranda of understanding, should the lead authority require more formal partnerships with other authorities. (Time to compile these should also be factored into the process.)

Consultation and co-ordination at the preparatory stage

Further information on consultation and co-ordination is given in Chapter 3, but at this preparatory stage the main considerations include:

- Identifying which stakeholders to consult. As a minimum, they should include drainage, flooding and planning authorities:
    - LA flooding (SWMP lead).
    - LA roads.
    - Scottish Water.
    - LA land use planning.
- Establishing when to consult them and at what stage each stakeholder's input is required.
- Deciding how stakeholders will be consulted, e.g. through informal, information-sharing meetings or more formal partnerships.
- Making sure that initial consultation with stakeholders:
    - Includes an introduction to the SWMP process, and details on how and when their views will be sought.
    - Identifies relevant information held by the key authorities and ways of sharing it. This stage should focus on information that helps to improve understanding of surface water flood risk (see Section 4.3 below), but eliciting information from stakeholders on potential opportunities for co-ordinating actions can also begin here.
- Recognising that consultation requirements may change as the SWMP develops. For example, it may be useful to consult other individuals/partners or to introduce more formal arrangements at the implementation stage.

4.3 Collating existing information on surface water flood hazard and risk

SWMPs should be based on the best available information. Maximum use should be made of the relevant data and information held by various authorities. Much of the data will be subject to licensing requirements so timescales for securing access should be taken into account. Key information is listed below but other information may be available:

SEPA data
Strategic flood hazard and risk (adverse impacts of flooding) data. At the time of publication the SEPA 2013 pluvial hazard and risk data was available and had been shared with local authorities:

- Regional pluvial hazard and risk
- National pluvial hazard and risk
- Pluvial AAD (annual average damages) 1km grid
- Pluvial flood map confidence dataset
- Information on flood events.

(The above information is also available for fluvial and coastal flooding)

LA flooding data
May have more detailed surface water hazard and risk data (e.g. Scottish Water and local authority Integrated Catchment Study (ICS) models)

- Models of watercourses and culverts
- Topographic surveys
- Information on flood events
- Information on existing surface water management structures
- Information on other assets, e.g. culvert locations and surveys
- Maps of SUDS (sustainable urban drainage systems) and watercourses.

LA roads data

- Information on road drainage infrastructure
- Information on flood events.

Scottish Water data

- Flood hazard from the sewer system (Section 16 assessment)
- Other sewer network drainage information (e.g. ICS models, other sewer network models)
- Information on drainage infrastructure (e.g. information on sewer flooding, combined sewer overflows, current and future infrastructure improvements)
- Information on flood events (internal and external sewer flooding registers).

Scottish Government

- Flood disadvantage information and maps (http://www.gov.scot/Topics/Environment/Water/Flooding/resources/research)

Public

- May have local knowledge about flood events.

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

- What data and information is available.
- Who owns the data/information.
- Licensing information, including any potential limitations on using the data (e.g. what data can be made publicly available and how data can be used by consultants).
- The format of the data and information.
- The level of confidence in the data and its suitability for use.

4.4 Validating existing hazard and risk information

Before developing an SWMP it is important to understand how much confidence can be placed in the existing information. This is done by validating the models with observed flood events. The result will determine what the information can be used for, what decisions it can help to inform and how much detail can be assessed at each stage of the SWMP. It will also help to clarify whether more detailed modelling or other information is required. The SWMP should explain clearly what data is being used and what confidence can be put in it.

A summary of how to use key data appropriately during the surface water management planning process is given below:

SEPA regional pluvial flood hazard and risk data

At the time of publication the SEPA 2013 regional pluvial data was available.

There is higher confidence in the regional pluvial data than in the national pluvial data from SEPA. Hence it is generally expected that where there is good validation with observed events, the regional pluvial hazard maps and associated regional pluvial risk should be appropriate for the following tasks:

- Understanding flood hazard and flood risk.
- Understanding some flooding mechanisms (will show flooding from overland flow and possibly from small urban burns, but not flooding from culverts, sewers or interactions between sources, e.g. above- and below-ground interactions or river and sea interactions with drainage infrastructure).
- Identifying neighbourhoods in towns and cities with greater flood risk (flooding hotspots).
- Establishing more detailed objectives for surface water flooding.
- Identifying actions (long list).
- Conducting a strategic cost-benefit appraisal of actions (structural and non-structural).

SEPA national pluvial (hazard and risk data)
At the time of publication the SEPA 2011 national pluvial data was available.

Areas where there is no regional pluvial hazard mapping are covered by the national pluvial hazard mapping. It is undertaken using a coarser type of pluvial modelling and can provide some supporting information for local authorities not covered by regional pluvial modelling. It may be appropriate for identifying towns and cities at greater risk of surface water flooding. It is not likely to provide detail on which neighbourhoods within towns and cities are at greater risk and may not be appropriate for identifying more detailed objectives. Thus the types of actions that can be identified from this data are limited.

Scottish Water flood risk from sewerage systems (Section 16)
Scottish Water's assessment of flood risk from sewerage systems (under Section 16 of the FRM Act) shows flooding locations, volumes and extents from the sewer network. When used in conjunction with the regional pluvial flood hazard and risk mapping and local knowledge, it can provide further insight into likely flood sources and mechanisms.

In many cases this information can be used in SWMPs without the need for further modelling. In others, further modelling and new hazard and risk mapping may be required or warranted, e.g. for locations with lower confidence in the data where existing information does not match observed events, or to carry out detailed appraisal and design of actions. In such cases, SEPA can provide data to make 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. The need for more detailed modelling can be identified as an action in the SWMP; it does not need to be completed for progress on the SWMP to continue.

Responsible authorities may have other relevant information, which should be used where available to inform the SWMP.

Figure 4.1 shows the validation process (see Appendix 3 for further information). The process can also be used with other modelling, e.g. more detailed modelling that an LA has carried out, modelling from integrated catchment studies and Section 16 assessments.

Further information on pluvial flood hazard modelling can be found in SEPA's flood modelling guidance[5] and the regional pluvial hazard mapping methodology.[6]

[5] SEPA Flood modelling guidance for responsible authorities:
http://www.sepa.org.uk/media/219653/flood_model_guidance_v2.pdf
[6] SEPA (2014) Derivation of a regional pluvial flood hazard dataset, Scotland – Methodology Report provided to responsible authorities with regional pluvial hazard data.

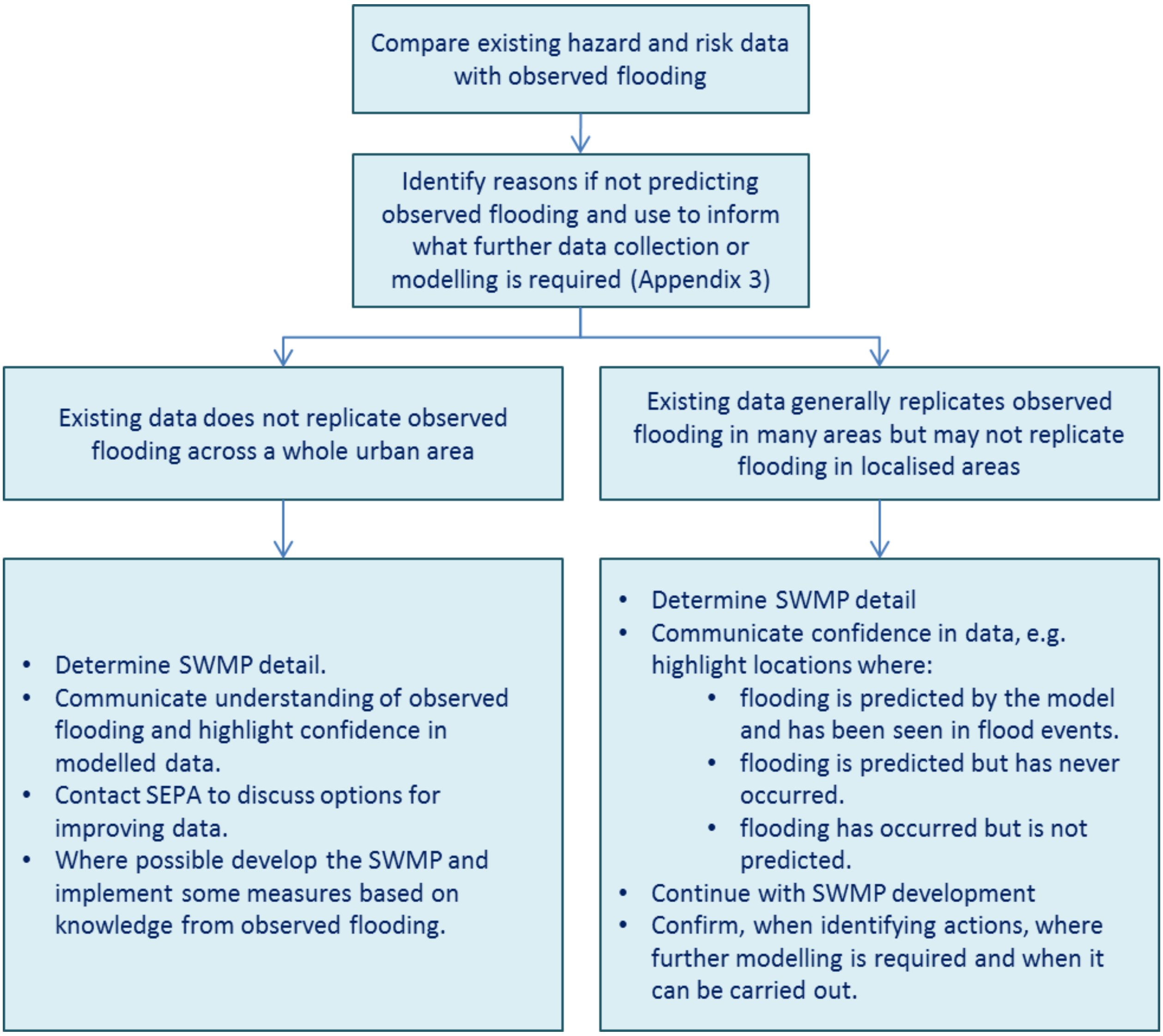


Figure 4.1 Flood hazard and risk data validation process

The **first step** is to compare modelled flooding with observed flooding.

The regional pluvial hazard maps show a range of modelled scenarios. Initially the 1:50 year regional pluvial flood extent should be compared with local records of flooding and other anecdotal information about the location and frequency of previous flooding. The 1:50 year pluvial flood extent is used as a starting point because it should represent rainfall events that have been experienced, as opposed to rarely occurring, larger magnitude floods (e.g. 1:200 year). It should be used where the drainage system is unlikely to have a major impact on flooding. Comparing results using smaller return periods may help to identify areas where better representation of the drainage system is required to reproduce the flooding mechanism correctly.

There is no reliable, scientific way to compare historical and modelled flooding; therefore, all SWMP stakeholders should apply their judgment. The model should be validated against known flooding locations. Alignment (or failure of alignment) between modelled flooding locations and flooding observations is likely to be a combination of:

- Locations where flooding is predicted by the model and has been observed – good alignment between observed and modelled flooding locations is the 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 higher confidence can be placed in the modelled data.
- 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 validate it in the given location. Just because a location has not experienced flooding in the past does not mean that it is not at risk of flooding in the future. It is more difficult to determine confidence in a model if there are no observed events to validate it.
- Locations where flooding has occurred but is not predicted – in this case the model is failing to predict the observed flooding and further information or investigation is likely to be required.

It is likely that for an urban area the SEPA regional pluvial modelling may be more accurate in some locations and less so in others. This should be acknowledged when summarising the impacts of flooding and identifying locations at greatest risk. More detailed modelling for those localised areas where information is less accurate could then be identified as an action in the SWMP.

Failure to replicate known flooding locations across a wider urban area indicates the need for further modelling at a more strategic scale in order to represent flood mechanisms correctly. If this is the case, the matter should be discussed with SEPA in order to determine the most appropriate way forward.

The **second step**, if the modelled flooding is not predicting observed flooding, is to identify possible reasons for this by applying professional judgment. This will then inform what further data collection/modelling is required (see Appendix 3 for further information). To identify possible reasons why a model is not replicating observed flooding it is important to confirm the data and parameters used in the existing model. For SEPA's regional pluvial modelling, the pluvial confidence data can provide this information. For example, the digital terrain model (DTM) used can have a significant impact on the modelling and not all SEPA's regional pluvial modelling is based on the most accurate DTM (LiDAR).

Box 4.1 Validation of modelling in Dundee

Validation of SEPA's pluvial flood hazard map in the Trades Lane area of Dundee shows a good match between modelled and observed flooding. The flooding that was observed in the Trades Lane area in August 2004 is successfully predicted by the model.

Comparison of modelled flood extents and observed flooding in the Trades Lane area of Dundee.
Photograph courtesy of ©DC Thomson & Co.

4.5 Scoping the level of detail

All stages of the SWMP process should be risk-based. The level of detail to go into at each stage (e.g. the number of outputs and detail provided in each) will be influenced by a number of factors, including: the level of flood risk, the complexity of the flooding problem, the resources available and the availability and confidence in existing data.

To give two examples:

- A relatively simple SWMP with lower flood risk may have more informal information-sharing fora with stakeholders, one relatively short report summarising the findings of each stage (including data to share with stakeholders) and a smaller range of objectives and actions.
- Larger urban areas at greater risk of surface water flooding and with complex problems may have more formal consultation arrangements, closer partnership working, numerous outputs (e.g. technical reports supporting different stages, a more detailed SWMP report for implementation and a summary SWMP report for other stakeholders, and other data for sharing with stakeholders), plus a larger range of objectives and actions.

4.6 Defining SWMP geographical areas

SWMPs can be carried out on any geographical scale, adopting a risk-based approach and focusing more detail on areas assessed as being at greatest risk. For example, an SWMP could be carried out for an entire LA area while focusing in greater detail on SWMP areas identified in the FRM Strategies (and any other areas of interest to the local authority). Or, a larger urban area could be covered by many SWMPs.

Defining an area allows flood risk information to be summarised for that area, allowing the level of flood risk to be monitored over time to determine whether the objectives of reducing flood risk and avoiding a rise in flood risk are being met (see example in Figure 4.2).

The following factors should be considered when defining the SWMP area:

- Where the greatest impacts of surface water flooding occur – the SWMP boundary does not limit where actions can be implemented to manage surface water flooding, e.g. there could be storage or land management upstream of an SWMP area. Nor does the area have to include all the sources and pathways of surface water flooding, although they should be considered.
- The extent of urban areas – a good starting point is the National Records of Scotland information on Settlements and Localities. GIS layers showing these spatial boundaries are available on its website: [http://www.nrscotland.gov.uk/statistics-and-data/geography/our-products/settlements-and-localities-dataset.](http://www.nrscotland.gov.uk/statistics-and-data/geography/our-products/settlements-and-localities-dataset)
- The size and extent of natural drainage features – for example, watercourses and their catchments, culverts and topography.
- Sewer catchment boundaries and other artificial drainage networks – it should be noted that artificial and below-ground drainage networks do not always drain the areas defined by natural topography.

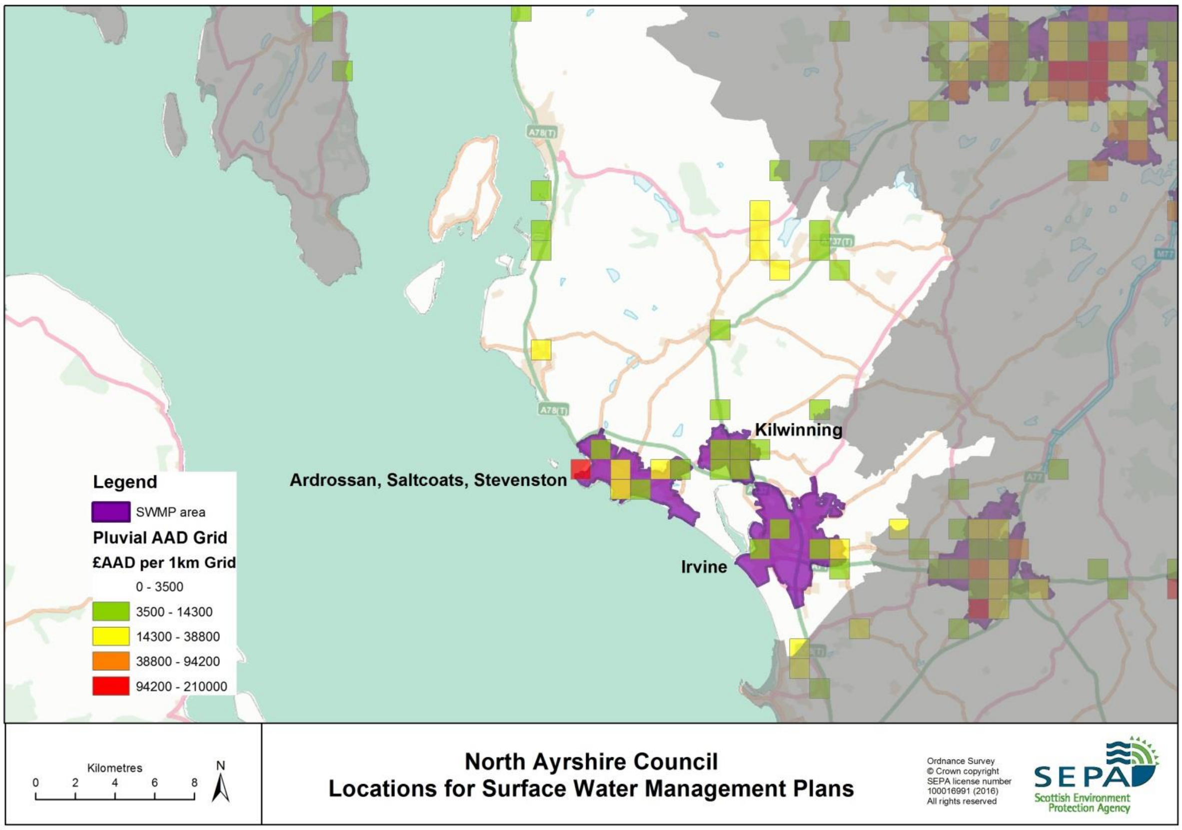


Figure 4.2 North Ayrshire Council locations for surface water management plans based on National Records of Scotland settlements data.

5 Understand surface water flood risk

Understand flood risk: considerations and example outputs	
Considerations	**Example outputs**
• Analysing and interpreting information to understand surface water flood hazard and risk. • Identifying areas with greatest surface water flood risk. • Consulting on this stage along with initial objectives. May need to consult Scottish Water or roads authorities before setting initial objectives if complex problems exist where the sewer network or roads drainage may influence surface water flooding. • Communicating information clearly, considering different communication material for different audiences and stakeholders.	• Section of SWMP report clearly communicating findings of this stage (e.g. clearly describing the sources, pathways and adverse impacts (risk) of surface water flooding in the area and identifying areas at greatest risk). • Other outputs showing key information (e.g. GIS data and maps showing SWMP area, flood hazard, flood risk, areas at greatest risk).

5.1 Introduction

Understanding the causes and consequences of flooding is crucial for making well-informed decisions on how to manage flood risk. Available information should be analysed to gain an understanding of the sources, pathways, receptors and adverse impacts of flooding (flood hazard and flood risk), and the findings communicated clearly.

5.2 Analysing and communicating available information

Having analysed the available information, the findings should form part of the SWMP report. Accompanying maps, figures and key data outputs will help to convey the information more effectively. Different communication materials should be considered for different audiences (e.g. LA flooding, authorities, the public). The level of detail in the report should be proportionate to the level of surface water flood risk, the complexity of the surface water flooding mechanisms and the information available.

For example, information may include:

- Any significant surface water flood events.
- Natural drainage features (e.g. watercourses and their catchments, including small urban burns and culverted watercourses).
- Artificial drainage systems (e.g. Scottish Water sewer catchments, areas with combined sewers, areas with separate surface water and waste water sewers).
- Any interactions between natural and artificial drainage systems and pluvial/other sources of flooding (e.g. any known locations where land drainage, watercourses or the sea has affected surface water drainage or entered the combined sewer).
- Current flood risk:
    - Surface water flood hazard in the SWMP area (e.g. this may include a summary of main sources, flow pathways and depths of flooding).
    - Main adverse impacts (risk) of surface water flooding and more localised areas at greatest risk of flooding (flooding hot spots) at the neighbourhood or street scale.

This should include a summary of receptors at risk at appropriate spatial scales (e.g. for the LA area, the SWMP area, flooding hotspots).

- Future flood risk, which may include information on the impacts of climate change, urban creep and population change.
- Existing actions to manage surface water flood risk.

5.3 Identifying areas with greatest flood risk

Identifying more localised areas at greatest risk of surface water flooding supports a risk-based approach by allowing efforts to be concentrated where they are most needed. So-called flooding 'hot spots' are likely to be found at the street or neighbourhood scale and have a single or linked cause of flooding (Figure 5.1). At this scale objectives and actions can be more focused, allowing flood risk information to be summarised and monitored over time to determine whether objectives are being met at this more localised level.

Level of risk can be based on number of receptors at risk, such as high numbers of homes and businesses or vulnerable single receptors – e.g. a school, a hospital or a road that would cause significant disruption if flooded. Risk in different return periods should also be considered.

The areas at greatest risk should be defined according to where the impacts of surface water flooding occur. This boundary does not limit where actions can be implemented to manage surface water flooding, but the risk should be linked to a single cause (or linked cause) of flooding in order to understand what actions will be appropriate to manage it. When identifying single or linked sources of flooding, account should be taken of the topography and underground drainage connections that influence flood risk in the area. Flood risk across the areas should be summarised (see Table 5.1), and should include a note on confidence in the data for each area. It is important to be flexible; it is possible that the next significant surface water flood may occur outside one of the identified hotspots, thus triggering a review and update of the SWMP plan. Hence, the SWMP process should remain 'live'.

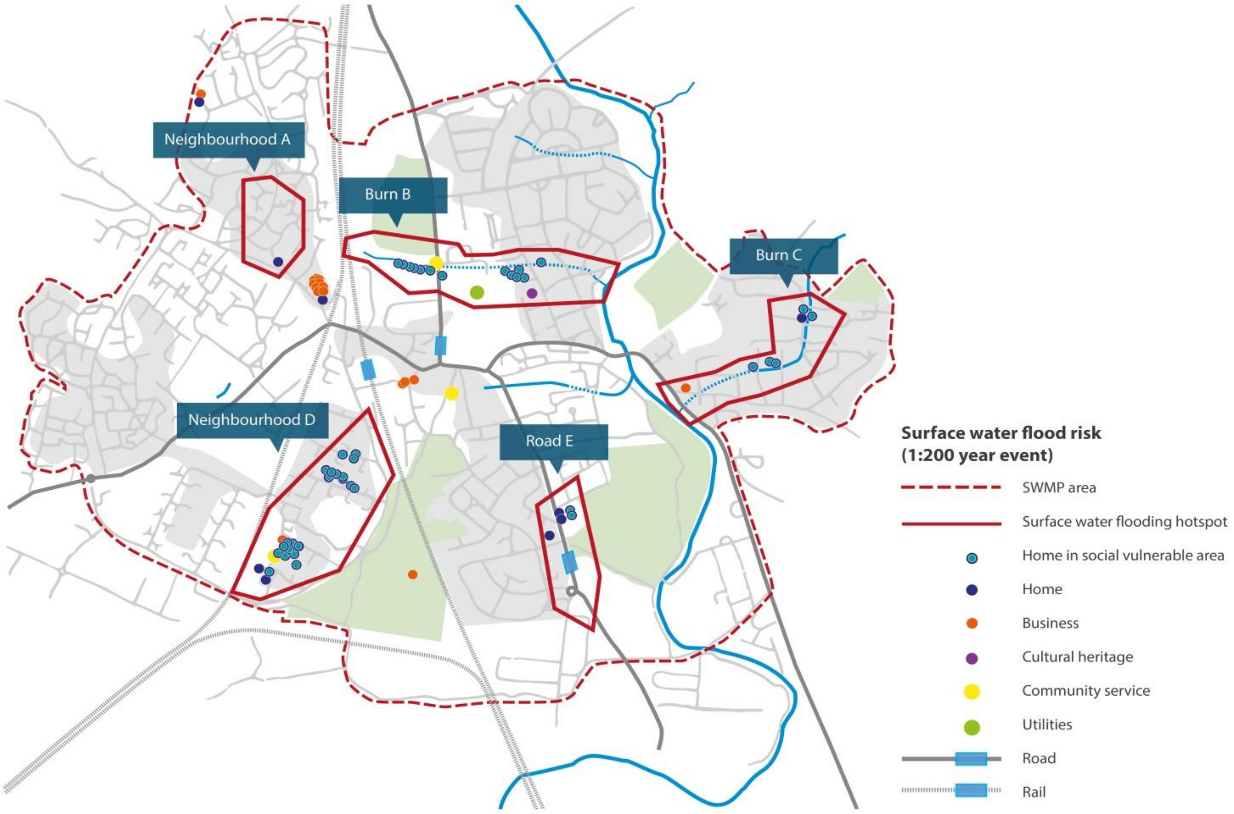


Figure 5.1 Example showing SWMP boundary and areas at greatest risk (surface water flooding hotspots)

Table 5.1 Flood risk in SWMP area

Location	History of flooding Confidence in data	Flood risk						
		Total Annual Average Damage (AAD) (all return periods)	Businesses 1:200 yr	Homes 1:200 yr	Homes in socially vulnerable areas 1:200 yr	Community facilities 1:200 yr	Listed buildings 1:200 yr	Infrastructure 1:200 yr
Whole Town	History of surface water flooding.	£395,000	25	90	65	<10	0	<10 electricity sub- stations, 1.5km road
Neighbourhood A	History of significant surface water flooding but modelling shows low risk. Low confidence in modelled data.	£1,000	0	<10	0	0	0	100m road
Burn B	Observed flooding matches modelled data. Good confidence in modelled data.	£80,000	0	25	15	0	0	10m road
Burn C	Observed flooding in area but existing structure to manage risk not shown in modelled data.	£12,000	2	15	15	0	0	200m road
Neighbourhood D	Observed flooding matches modelled data. Good confidence in modelled data.	£90,000	<10	20	15	1 hospital	0	1 electricity sub-station, 20m road
Road E	No history of surface water flooding but area could be at risk. Medium confidence in modelled data.	£10,000	<10	<10	<10	0	0	500m road

5.4 Future flood risk

Many factors influence flood hazard and flood risk, the main ones being:

- Climate.
- Land use (urban creep can have significant impacts on surface water flooding).
- Demographics.

Knowing more about factors that will influence future flood risk is essential for managing flood risk sustainably now and in the future, because it will allow us to:

- Understand where significant flood risks may arise in the future and what areas may be more sensitive to change.
- Decide what actions can be taken now to mitigate changes in the future (see Chapter 7 Option appraisal and Appendix A7.6 Climate change mitigation).
- Make sure that any actions implemented now are resilient and adaptable to future change (see Chapter 7 Option appraisal and Appendix 6 Adaptation to future flood risk).
- Inform the choice of actions – for example, greater importance should be given to adaptability when considering options in an area that is highly sensitive to climate change.
- Identify how future risks from flooding could change due to different investment scenarios and estimate the level of investment that would maximise benefits under different circumstances (see the Environment Agency's long-term investment scenarios for further information).[7]

At this stage, a strategic-type assessment of how these factors may affect future surface water flood risk in the SWMP area should be carried out using available information, for example identifying where significant flood risks may arise in the future and what areas may be more sensitive to change.

Impact at different spatial scales can be included where information is available (e.g. over the entire LA, SWMP areas or neighbourhoods / flooding hotspots).

Climate change
SEPA's 2013 pluvial mapping generated two climate change scenarios: a 20% uplift in rainfall intensity for the 1:30 and 1:200 year rainfall events by 2080. Where the mapping shows good validation with observed events, it can be used to identify cities, towns and neighbourhoods that may be more sensitive to climate change or where new risks may occur.

Key flood risk indicators (e.g. number of properties at risk) can be estimated as snapshots under the climate change scenarios and compared with the current day flood risk estimate. For example, SEPA's 2013 pluvial data climate change scenario shows that the number of homes and businesses at risk of surface water flooding in Scotland in the 1:200 year rainfall event could rise by 45% by 2080 as a result of climate change (Figure 1.3).

[7] https://www.gov.uk/government/publications/flood-and-coastal-risk-management-in-england-long-term-investment

SEPA's 2013 pluvial model scenarios were based on information issued by Defra in 2006 (and subsequently updated in Environmental Agency, 2016),[8] which represented best understanding at that time. A new UKWIR study[9] suggests that a larger uplift may be appropriate for future strategic studies. UKCP18[10] is also expected to improve our understanding of climate change impacts on rainfall, outputs from which are expected in 2018.

Land use - urban creep

In urban areas the trend is for permeable ground to be replaced with impermeable surfaces, e.g. gardens and other green space paved over or areas re-developed with higher density buildings. Often referred to as urban creep, this can significantly increase surface water run-off and flood risk over time.

Rates of urban creep vary. Although information may not be available for a local area, a strategic-level assessment could explore the extent to which urban creep might occur and its likely impacts on flood risk. Remodelling could be undertaken to estimate the impacts of urban creep on flood risk (further information on urban creep can be found in Appendix A6.3).

Where information on urban creep is available, it could be used to identify areas that may be more sensitive to the impacts of urban creep. Factors such as planning policy, permitted development and local housing stock will influence the rate of urban creep and the subsequent impacts on flood risk, all of which could be taken into account. This information could be used to consider what actions could be taken to mitigate or adapt to the effects of urban creep (see Chapter 7 Option appraisal and Appendix A6.3 for more on adaptation responses).

Demographics

A strategic-level assessment should describe how households and populations are likely to change in the area and show locations that have been identified for development (using information from local authority land use planners and National Records of Scotland).

Between 2014 and 2039, the number of households in Scotland is projected to rise by 14% to 2.76 million – an average annual increase of about 13,800 households. Over the same period, Scotland's population is projected to go up by 7%.[11] The rise in the number of households is projected to affect almost every council area in Scotland, with the largest rises projected for Midlothian and the City of Edinburgh (of 31% and 30% respectively). In contrast, there are just three council areas where the number of households are projected to fall: Inverclyde (by 5%), Argyll and Bute (by 1%) and Na h-Eileanan Siar (by <1%).

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[8] Environment Agency (2016) *Adapting to Climate Change: Advice for Flood and Coastal Erosion Risk Management Authorities*. This is supplementary information to the Defra (2009) policy statement on Appraisal of Flood and Coastal Erosion Risk Management and the Environment Agency's Flood and Coastal Erosion Risk Management appraisal guidance (updating Defra 2006 and EA 2011 supplementary information on climate change): https://www.gov.uk/government/publications/adapting-to-climate-change-for-risk-management-authorities

[9] Bennett J, Blenkinsop S, Dale M, Fowler H, and Gill E (2015) *Rainfall Intensity for Sewer Design - Guidance for water companies*. UKWIR, London.

[10] UK Climate Projections: http://ukclimateprojections.metoffice.gov.uk/

[11] National Records of Scotland Household Projections 2014: https://www.nrscotland.gov.uk/statistics-and-data/statistics/statistics-by-theme/housholds/household-projections

These national changes (and regional variations) may significantly influence future flood risk. The relationship is not straightforward, as factors such as planning policy, development planning and development management will interact with demographic change to influence flood risk.[12] This highlights the importance of adhering to Scottish Planning Policy, which seeks to ensure that new development is not at risk of surface water flooding and does not increase surface water flood risk elsewhere.

Demographic information can be used to:

- Identify areas that are likely to experience greater growth in households, have been earmarked for development or are likely to experience significant change in use.
- Identify areas that are likely to experience a decrease in growth (which may present opportunities to plan for 'shrinkage' and surface water management).
- Help in selecting options (e.g. by identifying where supplementary land use planning actions could be put in place to require new development to reduce existing flood risks).

You can find more information on adaptation responses that may be appropriate in areas experiencing high growth, in Chapter 7 Option appraisal and Appendix 6.

[12] See Chapter six of Houston D, Werritty A, Basset D, Geddes A, Hoolachan A and McMillan M (2011) *Pluvial (rain-related) flooding in urban areas: the invisible hazard*. Joseph Rowntree Foundation, UK. www.jrf.org.uk/publications/pluvial-flooding-invisible-hazard

6 Setting objectives

Setting objectives: considerations and example outputs	
Considerations	**Example outputs**

• High-level objectives for surface water management have been set in the FRM Strategies. In general, they will be:
  ○ To avoid an increase in surface water flood risk (applies everywhere including SWMP areas).
  ○ To reduce surface water flood risk (applies to SWMP areas typically at the town and city scale).
• Setting more detailed initial objectives for localised areas at greatest risk (neighbourhood level), which can be prioritised if required:
  ○ To reduce flood risk, improve flood risk understanding, or accept flood risk and maintain existing actions.
• Using this key consultation stage to identify where and when there may be opportunities for co-ordination or joint working to aid delivery of actions and/or realise multiple benefits.
• Communicating information clearly, considering different communication materials for different audiences and stakeholders.
• Updating objectives to make them SMART once more detail on how actions will be implemented is available.
	• Understanding of flood risk, areas at greatest risk and initial objectives shared amongst key stakeholders.
	• Stakeholders requested to share information on relevant work.
	• Opportunities identified for carrying out projects jointly to aid delivery of actions and realise multiple benefits (opportunities for joint working may influence priority of SWMP objectives).
	• Section of SWMP report summarising findings of this stage (e.g. objectives, objective indicators and priority of objectives).
	• Other outputs showing key information (e.g. GIS data and maps showing flood risk objective areas and their priority, GIS data and maps from key stakeholders showing any relevant work they are planning).

6.1 Initial objectives

The FRM Strategies contain high-level objectives for surface water management. In general, these are:

- To avoid an increase in surface water flood risk (applies everywhere including SWMP areas).
- To reduce surface water flood risk (applies to SWMP areas at the town and city scale).

More detailed and localised objectives for reducing surface water flood risk should be set in line with responsible authorities' assessment and understanding of flood risk (Figure 6.1 and Table 6.1).

Table 6.1 Objectives for SWMPs

Objective	**Example**
Reduce surface water flood risk	Areas where the greatest risk of surface water flooding has been identified (flooding hot spots) through modelling or historical flood events. Areas where there are specific facilities or infrastructure that carry a significant risk, e.g. hospitals or roads.
Accept flood risk and maintain existing actions	Areas where there are existing actions (mainly structural) to reduce surface water flood risk that require maintenance.
Improve understanding of surface water flood risk	Areas where further modelling is required to understand flood risk and decide if action needs to be taken to reduce it. This can apply to the whole urban area or to more localised areas, depending on the outcome of the validation stage (Section 4.4).

Indicators for objectives

The indicators for the flood risk objectives will generally be the at-risk receptors at different spatial scales, summarised under the understanding of flood risk stage (i.e. the flood risk statistics for the SWMP area and more localised areas). By monitoring and reviewing these indicators, the success or otherwise of achieving the objectives can be assessed (Table 6.2).

Other indicators could be used to monitor how sustainable the actions are or how many multiple benefits are being realised through joint projects. Possible examples include the development of green and blue infrastructure and networks, area of impermeable surface changed to permeable, and volume of surface water stored above ground and below ground. Further information on monitoring actions is given in Chapter 10.

Prioritising objectives

Prioritising objectives will help to clarify which factors need to be dealt with first, in the short term, and which can be tackled in the longer term (Figure 6.1). Exact timescales are not required initially, but can be refined once options have been identified and more information on funding and implementation becomes available.

Initially objectives should be prioritised, in consultation with relevant authorities, on the basis of flood risk. These initial priorities may nevertheless change where opportunities for co-ordination or joint working arise.

When prioritising, a number of criteria can be used. There is no single, recommended method but factors to consider include:

- Surface water flood risk (using information on impacts of flooding).
- Surface water flood risk to priority receptor groups, e.g. homes at risk in more socially vulnerable areas.
- Locations with a history of flooding.
- Areas where there is no history of flooding but which are predicted to flood and should therefore be treated with caution, particularly where more detailed models are not available. It is sensible to balance predicted and actual flooding information when prioritising.
- Locations where there are opportunities for joint working (e.g. making management more cost-effective and delivering multiple benefits).

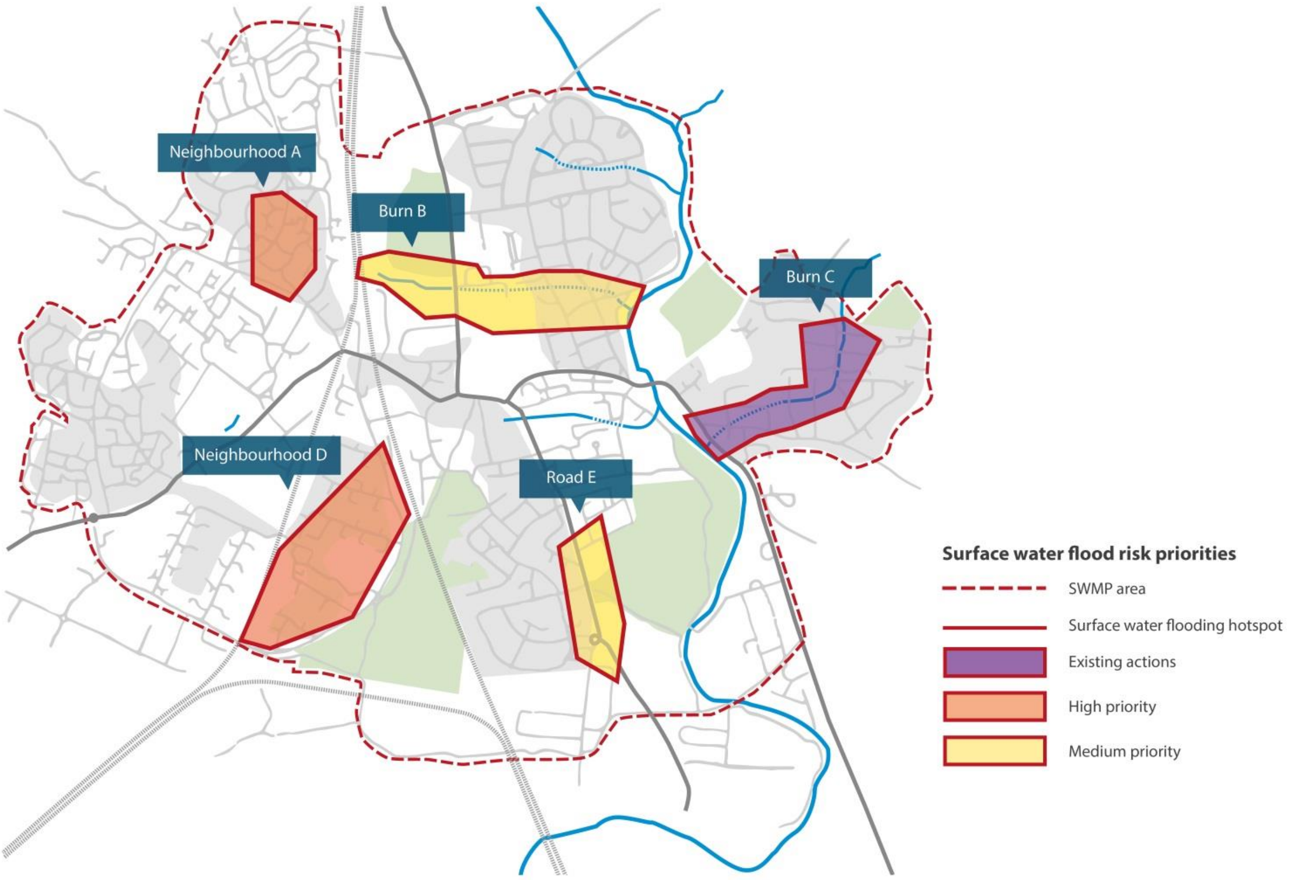

Figure 6.1 Example of prioritising objectives in the SWMP

Table 6.2 Example of initial objectives and indicators for an SWMP

Location / hotspot	History of flooding Confidence in data	Initial objective	Initial priority	Objective indicators						
				Annual Average Damage (AAD) (all return periods)	Businesses 1:200 yr	Homes 1:200 yr	Homes in socially vulnerable areas 1:200 yr	Community facilities 1:200 yr	Listed buildings 1:200 yr	Infrastructure 1:200 yr
Whole Town	History of surface water flooding.	Avoid an increase in surface water flood risk in Whole Town. Reduce surface water flood risk in Whole Town.	High	£395,000	25	90	65	<10	0	<10 electricity sub- stations, 1.5km road
Neighbourhood A	History of significant surface water flooding but modelling shows low risk. Poor confidence in modelled data.	Improve understanding of surface water flooding in Neighbourhood A.	High	£1,000	0	<10	0	0	0	100m road
Burn B	Observed flooding matches modelled data. Good confidence in modelled data.	Reduce surface water flood risk from Burn B.	Medium	£80,000	0	25	15	0	0	10m road
Burn C	Observed flooding in area but existing structure to manage risk not shown in modelled data.	Maintain existing structure at Burn C.	On-going	Existing structural action reduces flood risk – provides 1:100 yr standard of protection, £20,000 AAD damages avoided, 20 homes protected 2 businesses protected						
Neighbourhood D	Observed flooding matches modelled data. Good confidence in modelled data.	Reduce surface water flood risk in Neighbourhood D.	High	£90,000	<10	20	15	1 Hospital	0	1 electricity sub-station, 20m road
Road E	No history of surface water flooding but area could be at risk. Medium confidence in modelled data.	Reduce surface water flood risk at Road E.	Medium	£10,000	<10	<10	<10	0	0	500m road

6.2 Consultation and co-ordination

Consultation at this stage is important for identifying other projects that could be co-ordinated or implemented jointly with surface water flood management to aid delivery and realise multiple benefits (e.g. urban regeneration, green networks and Scottish Water work). At this point the local authority will understand where surface water flood risk is greatest and have prioritised objectives in place (priorities which may change after consultation).

Information from all stakeholders should be shared and communicated clearly. Providing this information in maps and GIS formats will also help stakeholders to identify opportunities for joint working or co-ordination. Information on what data to share can be found in Table 3.1.

6.3 SMART objectives

Objectives should be updated with more detail on timescales (i.e. made SMART) after actions have been identified and funding and implementation have been confirmed. This information should form part of the final action plan (see example in Table 8.1).

If, after undertaking the action appraisal, it is not feasible to reduce flood risk in any locations then the priority for dealing with the risk can be lowered (e.g. it may become feasible in the future through other projects or opportunities). Alternatively, the ‘reduce’ objective could be removed from the SWMP, leaving in place the ‘avoid’ objective where non-structural actions, e.g. land use planning, will still apply.

Table 6.3 Definition of SMART objectives

Specific	Objectives relating to high-risk areas or specific receptors.
Measurable	Key flood risk indicators that show what is at risk in each SWMP area/flooding hotspot, or the specific receptor at risk.
Achievable	Tied to responsible bodies’ capacity and the level of funding at local and national level.
Relevant	Having the aim of reducing overall flood risk. While multiple benefits are a key part of sustainable flood management, they will not form part of the objectives. Rather, they will be considered as part of the selection criteria of the appraisal method. Other objectives can be used to determine the sustainability of actions or their ability to link in with other processes, e.g. green and blue network development, volumes of water stored above ground, area of green space created, or volumes of water reduced in the combined sewer.
Time-Bound	Where appropriate, deadlines will be set for achieving objectives. Deadlines can be set in line with FRM planning cycles, i.e. 2021, 2027, 2033 etc.

7. Option appraisal

Option appraisal: considerations and example outputs	
Considerations	**Example outputs**

• Scoping the option appraisal, confirming objectives (e.g. high-level appraisal for all SWMP objectives or more detailed appraisal for fewer, high-priority objectives).
• Making sure that the methods and level of detail of the appraisal are proportionate to the scale and complexity of the problem and the decisions to be made.
• Developing and comparing options for each objective in order to choose preferred option.
• Consultation and co-ordination:
  ○ Where there are links with other projects (or joint projects) then co-ordination and close working will be required to ensure that multiple benefits are realised.
  ○ Consulting land use planning is likely to be essential to ensure that any preferred structural options integrate with the urban landscape.
  ○ The local community may need to be consulted.
• Understanding the degree of confidence in the outputs of the appraisal.
• Communicating information clearly, considering different communication material for different audiences.
	• Section of SWMP report clearly communicating the outcomes of this stage (e.g. options considered, confidence in the appraisal, reasons for selecting preferred option).
	• Co-ordination and close joint working where required to develop options that will yield multiple benefits.
	• Other outputs, e.g. supporting information for the option appraisal, clear communication of information to aid decision making, consultation material for different audiences.

7.1 Introduction

This chapter provides guidance on how to appraise and select the most sustainable options to meet the objectives. The outcome of this stage should be an agreed set of feasible and sustainable options that meet the objectives for managing the risk of surface water flooding in an area (see Box 7.1 for a definition of options and actions). The appraisal process is iterative, which means that it can be progressively refined. Preferred options will go on to the next stage where they will be developed, have their funding confirmed and then be implemented (see Chapter 8).

This guidance is consistent with, and should be read alongside, Scottish Government guidance and policy on option appraisal for flood risk management and the HM Treasury Green Book (see Box 7.2).

The main stages of options appraisal are shown in Figure 7.1.

Box 7.1 Options and actions

An **option** is one or more flood risk management action(s) developed to meet an objective of the SWMP. For example:
Option 1. Above-ground storage and conveyance.
Option 2. Above-ground storage and conveyance; below-ground storage and conveyance.

Actions can be structural or non-structural, and can be combined to make up options. A list of possible actions can be found in Appendix 4.

Box 7.2 Reference material for options appraisal

Public sector appraisal guidance

- HM Treasury (2011) *The Green Book: Appraisal and Evaluation in Central Government*: www.gov.uk/government/publications/the-green-book-appraisal-and-evaluation-in-central-governent
- Scottish Government (2012) *Scottish Public Finance Manual*: www.scotland.gov.uk/Topics/Government/Finance/spfm/Intro

Scottish Government flood risk management guidance and policy

- Scottish Government (2011) *Sustainable Flood Risk Management – Principles of appraisal: a policy statement*: www.scotland.gov.uk/Publications/2011/07/20125533/0
- Scottish Government (2016) *Options appraisal for flood risk management to support SEPA and the responsible authorities*. http://www.gov.scot/Publications/2016/06/4633

SEPA strategic appraisal methodology for flood risk management

- SEPA (In prep.) *Flood risk management appraisal methodology*. Due for online publication at: http://www.sepa.org.uk/environment/water/flooding/FRM-strategies/frminfo/

CIRIA Susdrain website http://www.susdrain.org/

- Provides useful resources on sustainable drainage, including links to case studies and technical documents on the detailed design of actions.

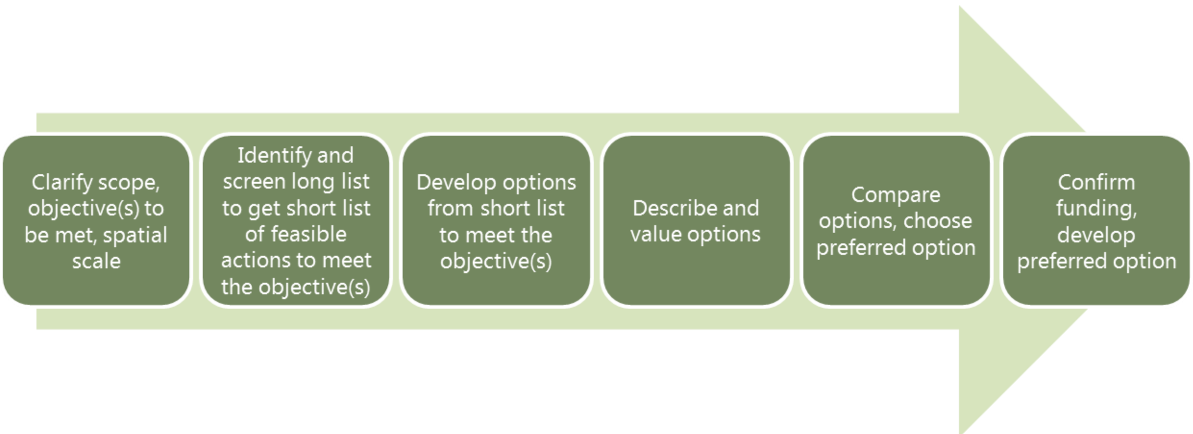

Figure 7.1 Steps in option appraisal

These steps can be reviewed and refined as the process progresses to provide more detail if required.

7.2 Scoping the appraisal

Clarify the objectives

An SWMP may have many objectives for reducing flood risk in the areas at greatest risk, and these objectives may have been prioritised. A decision should be made on whether to conduct a high-level appraisal for all the objectives, or whether to carry out a more detailed appraisal for the priority objectives only. If an option appraisal is not carried out for all objectives, an action to the effect that one will be carried out for lower priority, longer term objectives at a later date, can be noted in the SWMP. See the example in Table 7.1 below.

Table 7.1 Example SWMP and what objectives to take forward for option appraisal

Location/hotspot	History of flooding Confidence in data	Initial objective	Initial priority	Include in option appraisal
Whole Town	History of surface water flooding	Avoid an increase in surface water flood risk in Whole Town.	High	Yes
		Reduce surface water flood risk in Whole Town.		Yes
Neighbourhood A	History of significant surface water flooding but modelling shows low risk. Low confidence in modelled data.	Improve understanding of surface water flooding in Neighbourhood A.	High	Yes - although action for this will be further modelling to improve understanding followed by option appraisal, so detailed appraisal of structural options not required at this stage.
Burn B	Observed flooding matches modelled data. Good confidence in modelled data.	Reduce surface water flood risk from Burn B.	Medium	Not at this time – action can be for future option appraisal.
Burn C	Observed flooding in area but existing structure to manage risk not shown in modelled data.	Maintain existing structure at Burn C.	On-going	No – existing action in place.
Neighbourhood D	Observed flooding matches modelled data. Good confidence in modelled data.	Reduce surface water flood risk in Neighbourhood D.	High	Yes – appraisal of structural options likely to be required.
Road E	No history of surface water flooding but area could be at risk. Medium confidence in modelled data.	Reduce surface water flood risk at Road E.	Medium	Not at this time – although a general action will be collecting data on observed flooding. Future option appraisal may be required.

Appraisal method

Scoping the approach for option appraisal will help to establish what information and resources are required. The type of appraisal and level of detail should be informed by risk and be proportionate to the scale and complexity of the problem, the planning stage (be it strategic or more detailed) and the level of detail needed to make a decision. A detailed benefit-cost analysis is not always required, nor is it always feasible. A simplified appraisal should not, however, be interpreted as one that lacks rigour.

Factors that will influence the type and detail of the appraisal include:

- The level and complexity of flood risk.
- The availability of, and confidence in, hazard and risk modelling and mapping.
- The availability of, and confidence in, other data such as whole life costs and wider impacts.
- The type and scale of the action and the information required to differentiate between options in order to make a decision in choosing a preferred option.

Less detail may be needed where the choice between options is clear, for non-structural actions or for a long-term strategic plan. Conversely, more detail is likely to be required where the situation is complex, differentiation is more difficult, a lot of resources are being invested or project planning is at the design stage.

The type and complexity of the options will also determine what expertise is required to carry out the appraisal. For example, a simple, localised problem and solution (e.g. raising a kerb to divert flood waters to a safe pathway) is unlikely to require a detailed assessment of costs and benefits. Professional judgment should be sufficient to design and implement this type of smaller-scale action with confidence.

Appraisal for a more complex flooding mechanism and/or larger-scale solution (e.g. using multiple actions above and below ground) will require greater detail and expertise. It may for example necessitate flood damages data to be manipulated or flood hazard maps remodelled, which may require the services of a multidisciplinary team including landscape architects, engineers, modellers and other specialists.

Further guidance on how to take a proportionate approach can be found in Scottish Government's 2016 Appraisal guidance (see Box 7.2).

7.3 Identifying and screening long list of actions to get short list

7.3.1 Identifying the long list

For each objective, a long list of actions that could help to meet it should be identified. More strategic actions that may help to achieve more than one objective should also be considered. A list of possible non-structural and structural actions to use as a starting point can be found in Appendix 4.

A long list of actions should be identified with the following points in mind:

Meeting the objectives

- Consider all actions (structural and non-structural) that could partially or completely achieve the objectives.
- Consider actions that are effective at the property, neighbourhood or more strategic scale, as appropriate.
- Bear in mind that actions being considered for objectives at a strategic scale may not need to be considered for more localised objectives (e.g. if land use planning, emergency response planning or review of maintenance regime actions are being considered for objectives for the whole SWMP area, they may not need to be considered for more localised ones).
- Consider actions that can be implemented in the short term, as well as longer term, aspirational ones.
- Consider whether there are opportunities to help meet objectives for managing river and coastal flood risk.
- Consider opportunities to improve existing actions, e.g. change maintenance regimes or enhance or replace existing actions.

Promoting sustainable actions

- Seek to apply the principles of sustainable surface water management (Table 1.1).
- Consider the impact of actions on surface water flood risk now and in the future – actions to manage flood risk should be flexible enough to meet the needs of future generations and be adaptable to a changing climate and other drivers of changing flood risk.
- Consider actions that could realise wider benefits, such as creating better places for people, preventing deterioration of (and where possible improving) the water environment, improving biodiversity, or reducing the costs associated with water and waste water treatment.

Working with stakeholders

- Consider actions that would be carried out by the full range of stakeholder organisations – identify the most sustainable actions and do not be constrained by responsibilities, funding concerns or delivery mechanisms.
- Be aware that actions may be added to or refined by Local Flood Risk Management Partnerships or Local Advisory Groups, or through engagement with all stakeholders.

7.3.2 Screening the long list

Screening may be necessary to reduce a long list to a short list of actions. This will help to remove any actions that are unfeasible, leaving a smaller number for further appraisal. Sustainability must be a key consideration, and actions that are clearly unsustainable should be rejected early. Complex and integrated solutions should not, however, be shied away from.

Three main criteria are recommended for screening out unfeasible actions – technical, legal and economic (Table 7.2). If necessary broad beneficial and adverse impacts can be identified for each of the actions, but detailed assessments should not be done at this stage and impacts do not need to be valued. Instead, experience and judgment should be applied. Where there is doubt, an action should be retained for further evaluation as part of the short list. Screening of actions should not be constrained by concerns about funding or methods. Agreements on funding and responsibilities should be made once the most sustainable actions have been identified (see Chapter 8).

All decisions and reasoning should be clearly set out and recorded.

Table 7.2. Screening criteria

Criteria	Considerations
1. Technical Remove any actions that are not technically feasible, e.g. permeability of ground insufficient for infiltration, storage volume required and available space (above- or below-ground space).	Ground conditions – e.g. permeability, contamination (if considering ground infiltration). Topography – areas set aside for temporarily storing surface water must be positioned down slope from the areas generating run-off, to allow water to flow by gravity. Existing land use – this may affect the feasibility of some solutions, for example: • Using carriageways or entire roads for conveying or storing surface water may be incompatible with their use as strategic routes and for road safety. • Exceedance flow management may increase flood risk downstream. • Above-ground storage may not be feasible because of a shortage of space (or lack of safe access for maintenance). Innovative ideas for creating space or for combining public space with storage areas should not, though, be overlooked. Flood forecasting – forecasts for surface water flooding are likely to remain probabilistic or have short lead times. Consequently, demountable (temporary) property-level protection may not be appropriate where no (or only a short) warning of a flood event is possible. (Permanent property-level protection or resilient property design/retrofit might be more appropriate in these conditions.)
2. Legal Remove any actions that represent insurmountable legal challenges, including health and safety.	There are various legal constraints on what actions can be taken, or more specifically, the manner in which they are taken. They mainly deal with the impact on people and the natural or built environment. Specific legal obligations should be clarified early in the appraisal process and how such obligations can be met considered. Further guidance can be found in Scottish Government (2016) appraisal guidance (see Box 7.1).
3. Economic Examine whether at this stage there is any evidence that the costs will be disproportionate to the benefits?	This may be done using professional judgment or by making a relatively rapid assessment of costs (at the lower end of the whole life cost estimate) and benefits (flood damages avoided to properties). Whole life cost estimates can include any obvious significant additional costs, for example: • Some retrofit storm water actions (e.g. roadside rain gardens) may require costly disturbance or relocation of buried urban infrastructure (e.g. power and telecoms services). • Directing surface water to combined or foul sewer systems may increase flooding and pollution risks downstream unless infrastructure is upgraded. Great care should be taken not to screen out actions that can significantly reduce flood risk for other (non-monetised) receptors, or actions that may bring about wider social, environmental and / or economic benefits.

7.4 Developing options from short list

Having removed any unfeasible actions through the screening exercise, the resulting short list should be used to develop viable options for each objective (some strategic options may apply to multiple objectives). This may involve providing further detail on particular actions (e.g. location, size, construction).

7.4.1 Baseline: the 'do nothing'/'do minimum' option

The starting point will be to develop a baseline against which the impacts and costs of other options can be compared. This is either the 'do nothing' or 'do minimum' option – see Scottish Government (2016) appraisal guidance for further information (Box 7.2).

For the purpose of surface water management, a 'do minimum' option is likely to be the most appropriate baseline. This is because there is a statutory requirement to continue some activities (for example, there will never be a total abandonment of all existing surface water drainage infrastructure). The 'do minimum' option is therefore the minimum existing actions required to adhere to statutory duties and responsibilities, for example:

- Adherence to Scottish Planning Policy.
- Duties for emergency response planning.
- Agreements between responsible authorities as a matter of policy.
- Continuation of asset management.

The 'do minimum' option assumes that the baseline model drainage capacity (e.g. 1:5 year drainage capacity if using SEPA pluvial modelling) is maintained (through an effective schedule of clearance and repair or an inspection and maintenance regime of drainage infrastructure by the relevant authorities). Once existing structures reach the end of their design life, it should be assumed that they will be replaced.

Under the 'do minimum' option, flood risk is likely to increase over time as a result of climate change, urban creep and potentially new development.

7.4.2 'Do something' options

The 'do something' options should be developed using one or more of the shortlisted actions. This may include developing further detail for particular actions (e.g. location, size, construction). Table 7.3 gives some examples of developing options for different objectives.

Opportunities for sustainable and best-practice actions that meet the principles of sustainable surface water management should be sought initially (Table 1.1). Less sustainable options, e.g. below-ground actions, can then be considered only if the more sustainable options cannot meet the objectives. The process is likely to be iterative, with options being progressively refined.

Where discussions with other stakeholders are either required or desired, they should be planned at the outset and may take the form of:

- Consultation with land use planning colleagues, to ensure that any preferred structural options integrate with and enhance the urban landscape.
- Consultation with other departments or authorities likely to be responsible for any options (e.g. land use planners for any changes to land use planning policy; emergency response planners for any action relating to emergency response or roads departments if any changes to roads maintenance regimes are being considered).
- Close co-ordination and joint working with relevant colleagues and authorities, which will be required if joint projects and opportunities for co-ordination to realise multiple benefits have been identified.
- Discussions with SEPA and Scottish Water on actions to improve understanding of flood hazard and risk, in order to identify the scale and type of remodelling required, assign responsibilities and co-ordinate with any existing plans.
- Consultation with communities at relevant points in the appraisal and detailed design stages.

Table 7.3. Example of option development	
Objective: Avoid an increase in surface water flood risk in Whole Town	
Option	**Description of actions**
Do minimum (baseline)	• Current situation for comparison, includes maintaining existing actions.
Option 1	• Land use planning policy (adhere to existing). • Clarify responsibilities for new surface water management infrastructure.
Option 2	• Land use planning policy (adhere to existing). • Clarify responsibilities for new surface water management infrastructure. • Clarify responsibilities for existing surface water management infrastructure (including SUDS).
Objective: Reduce surface water flood risk in Whole Town	
Option	**Description of actions**
Do minimum (baseline)	• Current situation for comparison, includes maintaining existing actions.
Option 1	• Review emergency response plans.
Option 2	• Review emergency response plans. • Land use planning policy (implement more stringent policies where required). • Review drainage maintenance regimes.
Objective: Reduce surface water flood risk in neighbourhood D	
Option	**Description of actions**
Do minimum (baseline)	• Current situation for comparison, includes maintaining existing actions.
Option 1	• Property-level protection.
Option 2	• Above-ground infiltration, conveyance and storage.
Option 3	• Above-ground infiltration, conveyance and storage. • Below-ground storage.

7.5 Describing and valuing options

All the baseline and 'do something' options should be subjected to a robust and transparent appraisal of costs, benefits and impacts (both beneficial and adverse). The appraisal does not need to be complex or detailed, but it should provide sound evidence on which to base decisions. This process is likely to be iterative, with options being progressively refined over time.

Non-structural actions in particular are unlikely to need a detailed appraisal of costs and benefits. What they do require is an understanding of both their benefits and disbenefits, compared with those of baseline actions, and the resources needed to implement them. Structural actions, on the other hand, are likely to require a detailed cost-benefit appraisal.

For each option the following attributes should be described and valued:

- Impact on flood risk (Section 7.5.1)
- Adaptability to climate change and other drivers of future flood risk (Section 7.5.2)
- Wider beneficial and adverse impacts (Section 7.5.3)
- Whole life costs (Section 7.5.4)
- Economic benefits and costs (Section 7.5.5).

Where appropriate and possible, flood risk impact and wider impacts should be assessed in quantitative or monetary terms. That is because in this form they can easily be compared with whole life costs to estimate the likely return on investment (by calculating net Present Values and benefit-costs) (Section 7.5.5).

Some impacts may be difficult and / or may entail disproportionate effort to value in monetary terms. Nonetheless it is crucial that they too are included in the appraisal, so that all sustainable options are considered. This can be achieved by describing them in qualitative terms in the appraisal summary tables (see Section 7.5.3)

The decision on whether to try to quantify or monetise an impact will depend on:

- Proportionality (relative to the complexity of the problem and the information required to identify a preferred option).
- Availability and robustness of data.
- Availability and robustness of the methodology.

Determining what a proportionate approach is can in turn depend greatly on the expertise of the appraisers. It is therefore essential that this information is also recorded.

The appraisal is thus likely to generate both qualitative and quantitative (including monetary) data. Appraisers must determine early on in the process how to deal with this mix of data. They may, for example, draw up a list of criteria against which to assess each option. Techniques such as benefit-cost analysis (Section 7.5.5) and multi-criteria approaches may help. Scottish Government (2016) guidance and references therein contain further guidance.

The summing of costs and impacts for a particular option will also require a degree of judgment, as the amount of detail available for the individual actions that make up an option may vary. Thus a range of outputs, both detailed and summarised, may be helpful in informing decisions.

Enough information should be gathered at this stage to decide on the most sustainable and preferred option. If an option is obviously the most sustainable and there is sufficient confidence in the data, further appraisal and comparison of options should be unnecessary and the next stage (developing the preferred option in more detail) can begin.

Spatial scale and time period
The spatial extent of the appraisal should take into account the objective's target areas as well as any other area that the options may affect. It may not be possible to assess all impacts, in which case a reasoned decision should be made on how far to purse the process.

When appraising options, a 100 year appraisal period should be used. If the anticipated lifespan of an option is less than 100 years, the appraisal should assume that capital maintenance occurs to make the lifespan up to 100 years and include this recurring cost in the appraisal (e.g. the cost of replacing electrical and mechanical equipment after 25 years). Consideration should be given to how the benefits, costs and wider impacts of actions might change over this period. This includes considering possible changes in future flood risk as a result of climate change and other drivers.

7.5.1 Impact on flood risk

This section provides guidance on how to estimate the impact on flood risk of the different options. In accordance with the FRM Act, the assessment should include the impact of flooding on the economy, society, cultural heritage and environment.

The assessment should show the flood risk management benefits of each option, along with any adverse impacts if flood risk is increased elsewhere. The assessed flood risk for each option can be compared against a baseline (e.g. to show the reduction in flood damages and number of properties at risk). Alternatively, as is often the case, the benefits for each option can be shown (e.g. showing the flood damages avoided and number of properties protected).

Approaches to assessing flood risk
Four approaches to assessing the impacts on flood risk are proposed below. The more sophisticated the approach the greater the certainty in the assessment but also the more detail required. The choice of approach will be influenced by a number of factors:

- The level and complexity of flood risk
- The availability of, and confidence in, hazard and risk modelling and mapping
- Spatial scale
- The type of actions being appraised.

Table 7.4 Approaches for assessing flood risk impacts

Approach	Description
1. **Simple**	Simple and pragmatic assessment of the number of properties or other receptors removed from flood risk. Economic benefits can be assigned using the Scottish Pluvial Annual Average Damage Estimates (SPAADEs; see Box 7.3) per property. May be appropriate for relatively low risk and localised / simple flooding, e.g. raising road kerb heights to divert water away from homes to a safe route, or trash screen replacement. Based on professional judgment. Relatively quick and low cost.
2. **Map-based**	Makes use of existing SEPA flood risk data to show receptors removed from flood risk and economic benefits of different options. Does not require additional modelling or mapping. High level assessment of the impacts of an option on flood risk.
3. **Simplified modelling**	Involves re-running SEPA regional pluvial models for each option to show receptors removed from flood risk and economic benefits. The impacts of options on flood risk can be modelled and mapped by adjusting model parameters (e.g. varying assumptions about drainage capacity, run-off coefficients or digital terrain model (DTM)).
4. **Detailed modelling**	More detailed modelling for each option, e.g. more detailed pluvial modelling or integrated urban drainage modelling and the explicit modelling of actions and their effects. Useful for high-risk areas with complex flooding problems that may need larger-scale, more strategic solutions.

Approach 1: Simple
This approach will be suitable for many simple situations, where professional judgment can be used to link a straightforward option with a certain reduction in flood risk: for example, replacing a screen that is less susceptible to blockage to ensure the proper functioning of a culvert, thereby removing the risk of flooding from four properties. The flood risk impacts can be quickly and simply expressed by the number of properties (or other receptors) removed from flood risk. Assessment of economic impacts may be limited to the Scottish Pluvial Annual Average Damage Estimates per property (see Box 7.3).

Approach 2: Map-based
This approach makes use of existing SEPA flood risk data to show receptors removed from flood risk and economic benefits. It does not require additional modelling or mapping. A worked example is given in Appendix 5. It uses professional judgment to estimate the effectiveness of an option and links it to a standard of protection. For example, professional judgment may estimate that changes to maintenance regimes will improve drainage to achieve no flooding in the 1:30 year event.

It is suitable for many situations where SEPA's regional pluvial mapping shows good validation with observed flood events. It may also be suitable for more detailed local authority flood hazard and risk data where this is available (Appendix 3 has information on further modelling).

Approach 3: Simplified modelling (using SEPA regional pluvial models)
This approach requires re-running SEPA's regional pluvial models for each option to determine the impact on flood risk. It is suitable where SEPA's regional pluvial mapping shows good validation with observed flood events and has been used to provide the baseline. It may also be suitable for more detailed local authority flood hazard and risk data where this is available (Appendix 3 has information on further modelling).

The effectiveness of certain options can be re-modelled by adjusting parameters in the pluvial models. For example, drainage capacity can be increased locally to simulate the effect of an improved drainage system providing a 1:10 year or 1:30 year standard of protection; run-off coefficients can be varied locally to account for the use of permeable surfaces or green space in urban neighbourhoods; and local topographical changes (such as high kerbs or bunds) can be represented by altering the DTM.

Based on the new flood hazard for each option, the adverse impacts of flooding (flood risk) will need to be re-assessed. Flood risk under the FRM Act includes impacts on the economy, society, cultural heritage and the environment. If using the SEPA regional pluvial as the baseline option, flood risk will need to re-assessed using SEPA's method.[13] This will show the impact of each option on flood risk and allow it to be compared with the baseline.

Approach 4: Detailed modelling
This allows for the most comprehensive representation of options and calls for an experienced modeller and engineer working together. It can be applied where more detailed models (e.g. more detailed pluvial models or integrated urban drainage model) are required to replicate known flood hazard and has been used to assess the adverse impacts of flooding (flood risk), achieving good agreement between observed and modelled floods. These models may be developed earlier in the process to provide a more detailed picture of flood hazard and flood risk, and can be used as the baseline in the appraisal.

[13] SEPA (In prep.) Appraisal Method for Flood Risk Management Strategies www.sepa.org.uk

The effectiveness of each option can be re-modelled showing new flood hazard (e.g. extents and depths) with the option in place. Based on the new flood hazard for each option, the adverse impacts of flooding (flood risk) which include impacts on the economy, society, cultural heritage and the environment), should be assessed. The method used to assess the adverse impacts of flooding should be the same as that used to assess the baseline impacts. This will allow the impact on flood risk of each option to be compared with the baseline.

A detailed model can be used to optimise the effectiveness of options, such as the capacity of individual sewers and storage areas, the management of flow moving across the surface or the effect of source control at property level.

Assessing flood risk

To be able to compare the flood risk management benefits of each option, adverse impacts of flooding (flood risk) on the economy, society, cultural heritage and environment should be determined for the baseline and the ‘do something’ options, using the same assessment method. A range of flood risk indicators should be used to do this, including economic impacts described in monetary terms and other impacts described in monetary and non-monetary terms.

Scottish Government’s 2016 guidance on appraisal gives further information on assessing flood risk. The Flood Hazard Research Centre Flood and Coastal Erosion Risk Management: Handbook and Data for Economic Appraisal also provides detailed guidance on monetising the impacts of flooding (see Box 7.3).

Where SEPA pluvial flooding data is used (approaches 2 and 3), it is anticipated that the range of indicators applied will reflect those used in SEPA’s pluvial risk data (Table 7.5). If the SEPA data is being used as the baseline, then any reassessment of flood risk for each option should be done using SEPA’s method. If a local authority has more detailed pluvial modelling and is assessing flood risk to establish a baseline, then the same method should be applied to assessing the flood risk for each ‘do something’ option to allow baseline comparisons.

Economic impacts (Box 7.3) will be represented as an estimate of the economic cost of the damages caused by flooding. This is then used to compare against the whole life costs of the option in order to assess the balance of benefits and costs and compare value for money (Section 7.5.5).

Box 7.3. Assessing economic flood damages

The Flood Hazard Research Centre, Flood and Coastal Erosion Risk Management: Handbook and Data for Economic Appraisal (Multi-Coloured Handbook and Data) http://www.mcm-online.co.uk/ provides guidance and data for assessing the economic damages of flooding. In general it presents three approaches, each with different levels of detail for assessing economic damages (NB: the approach used may differ for the different receptors being assessed):

- Overview appraisals – less complex (for example, the use of weighted annual average damages (WAAD)) and used where less detail is required and / or there is little or no information on the depths of flooding. WAAD can be applied to residential and non-residential properties.
- Initial appraisals – require more information, e.g. the depth of flooding for each property for different return periods. Can be used to assess damages in each return period for each property. Annual Average Damages (AAD) can then be assessed for each property based on all return periods over long periods of time. They are based on the relationship between flood damage and the probability of incurring that damage in any one year. Economic damages for properties can then be summed at different spatial scales.
- Full-scale appraisals – require more detailed information on the receptors being flooded, e.g. type of house and social demographics of the occupants. Damages for each property in each return period are assessed and AAD for each property then calculated.

Scottish Pluvial Annual Average Damage Estimate (SPAADEs)
Where there is no reliable estimate of the depth of flooding, SEPA's Scottish Pluvial Annual Average Damage Estimates (SPAADEs) should be used in place of the WAAD. SPAADEs provide an estimate of the average pluvial flood damages to an individual property per year, based on SEPA's 2013 regional pluvial data. Economic damages for properties can then be summed at different spatial scales.

For a residential property, the SPAADE is £1,100; for a non-residential property, the SPAADE is £1,700. (These estimates are for 2010 and so an uplift will be required to convert them to present values.) SPAADE estimates are lower than the corresponding values of WAAD in the Multi-Coloured Handbook, as the latter tend to be used to estimate fluvial flood damages. This reflects the differing characteristics of pluvial flooding, which is often shallower and more localised than fluvial flooding.

SPAADEs are not based on observed pluvial flood damages; instead they are derived from strategic national modelling. See SEPA (in preparation) Flood Risk Management Appraisal Methodology for more information.

Table 7.5. Flood risk indicators assessed in SEPA's 2013 pluvial risk data

Category	Receptors	Flood risk indicators	Applied to:
Economic	Non-residential properties	Count of non-residential properties flooded	National and regional models
	Non-residential properties	Direct economic damages (£s) (including SPAADE for national and AAD for regional models)	National and regional models
	Residential properties	Direct and indirect economic damages (£s) (including SPAADE for national and AAD for regional models)	
	Roads	Direct damages to road infrastructure (£s) and AAD	Regional models only
	Vehicles	Direct damages to vehicles (£s) and AAD	
	Emergency services	Additional assessment of indirect damages (£s) and AAD	
Social	Residential properties	Count of residential properties flooded	National and regional models
	Residential properties	Social flood vulnerability score for each residential property	National and regional models
	Community facilities	Count and type of community facilities	National and regional models
Cultural heritage	Cultural heritage	Area and type of cultural heritage sites affected	National and regional models
	Cultural heritage	Count and type of listed buildings flooded	National and regional models
Infrastructure	Utilities	Count and type of utilities	National and regional models
	Transport	Length of roads flooded	National and regional models
	Transport	Length of rail flooded	National and regional models
	Transport	Count of airports flooded	National and regional models
Environment	SEPA's pluvial risk data does not include an assessment of the adverse impact of pluvial flooding on environmental designated sites, because the risk from pluvial flooding was deemed low. A more detailed assessment of impacts on the environment was not feasible at a national strategic scale.		

7.5.2 Adaptability to future flood risk

Taking future change in flood risk into account when considering surface water management options is essential if sustainable actions are to be selected that will stand the test of time. Drivers of future change include climate change, urban creep and demographic change. Every option should always be assessed on its adaptability to climate change, and to the other factors where required. Appendix 6 contains further information on adapting to future flood risk.

Climate change

Climate change in particular poses serious challenges and risks for managing flooding in Scotland. Its impacts include the potential rise in intensity and frequency of rainfall events increasing the risk of surface water flooding.

This section provides guidance on assessing the impact of options on climate change adaptability. Two adaptation approaches are described in the Defra 2009 policy statement.[14] Both approaches could also be applied to urban creep and population growth. For each option, an indication of which approach is likely to be implemented should be given:

- Managed adaptive – this approach allows for adaptation in the future by planning multiple 'phased' interventions over time. The first phases can initially use lower allowances for climate change over the shorter term, with further interventions implemented if and when required. Change in risk is monitored over the lifetime of the actions and any change managed through multiple 'phased' interventions (often interventions are implemented after a trigger point, indicating that the risk will become unacceptable, is reached). This approach is flexible enough to manage future uncertainties associated with climate change during the whole life of a flood risk management system. Other benefits of managed adaptive approaches are:
    - They can be less costly – as future adaptation phases have been planned from the start and can be implemented if and when required, the need to introduce new or significantly change existing actions to manage future changes may be avoided.
    - They use a risk-based decision framework – enabling risk to be monitored and managed at periodic intervals during the design life of a development.
    - They are usually more sustainable over the long term – presenting opportunities for enhancing the environmental, societal benefits and cost savings that cannot be achieved through precautionary approaches.
    - They can take advantage of innovative advances over time and are sufficiently flexible to cope with changing climate change projections that may differ from those available to us today.
- Precautionary – in some circumstances, future adaptation may be technically unfeasible or too complex to administer over the long term. Hence this approach, resulting primarily in one-off interventions with a higher allowance in the design for climate change over the longer term, may be the only feasible option (such as in the design capacity of a major culvert or underground storage).

[14] Defra (2009) *Appraisal of flood and coastal erosion risk management: A Defra policy statement*. https://www.gov.uk/government/publications/appraisal-of-flood-and-coastal-erosion-risk-management-a-defra-policy-statement-june-2009

For each option a short description of the level of intervention, the costs and feasibility associated with ensuring that the action can respond to changing conditions should be provided. The assessment may include:

- A description of likely impacts of climate change and other drivers.
- A description of adaptability to climate change – e.g. whether a managed adaptive or precautionary approach is being taken and how it will be implemented.
- A description of adaptability to other future flood risks – urban creep and demographic change (managed adaptive or precautionary approaches may also be used for these factors).
- Information on the level of intervention, costs and feasibility associated with ensuring that the option can respond to changing flood conditions.

It may be helpful to present this information as a class or score in an appraisal summary table.

Land use - urban creep

Urban creep can significantly compound surface water flooding; therefore options (and costs) should be developed that allow for its occurrence (see Appendix 6). The allowance to include may vary (e.g. on the type or location of option, or whether a managed adaptive or precautionary approach is being taken). Note that both managed adaptive and precautionary approaches can be applied to urban creep.

Some actions may mitigate the impact of urban creep, e.g. de-paving strategies that make urban areas more permeable and green over time. Other factors, such as planning policy, permitted development and local housing stock, will influence the rate of urban creep and its subsequent impacts on flood risk, all of which can be taken into account.

Demographics

It is important that land use planning policies are adhered to, to ensure that new development is not at risk of surface water flooding and does not increase the risk elsewhere. If deemed necessary, projections for news homes required could be taken into account to help inform appropriate options to mitigate or adapt to any impact (further information can be found in Section 5.4). Information, including projections for new homes, is available from local authority land use planners and National Records of Scotland.

7.5.3 Assessing wider beneficial and adverse impacts

The wider impacts of the options on the economy, society and environment – such as improvements to water quality or the urban landscape – that are not related to changes in flood risk, should be assessed. Understanding these wider impacts is an important component of managing flood risk in the most sustainable way. It is therefore essential that they are identified and assessed alongside flood risk reduction benefits (see Appendix 7 for further information).

The assessment should focus on impacts that are likely to be significant and have the potential to affect decisions. The following questions may help to determine which to assess and how to establish their significance:

- What is the economic, social and environmental baseline against which wider impacts will be assessed? Information being developed for the Flood Risk Management Strategies and Local Flood Risk Management Plans will help with this, as will other sources of information such as River Basin Management Plans and Scotland's Environment Web (www.environment.scotland.gov.uk).
- What is the magnitude and direction (large or small, beneficial or adverse impact) of change?
- Will the option help to mitigate potential future economic, social and environmental pressures (e.g. climate, land use (urban creep) or demographic change)?
- How important is the receptor that is affected: is it locally, regionally, nationally or internationally important?
- Do impacts occur along the flow pathway?
- What is the predicted duration of the impact?
- What steps can be taken to mitigate any adverse impacts?
- How important are the impacts likely to be to local stakeholders and communities?
- Are the impacts important enough to affect the final decision?

Deciding which impacts to assess should be proportionate and based on risk. For example, simple, small-scale options are unlikely to require extensive assessment, whereas large and complex ones may necessitate more detailed consideration. Table 7.6 gives examples of the types of impact most likely to arise; further guidance can be found in Appendix 7. The guidance does not provide an exhaustive list and any other significant impacts must be identified and described.

The wider impacts will usually be described in non-monetised terms, such as short descriptive statements, rather than being quantified in detail. That is because they may be unsuited to or difficult to define in monetary terms. Classifying impacts on a five-point scale (e.g. from 'Significant Negative' to 'Significant Positive') may be a useful way of summarising the information. That said appraisers may choose to monetise some impacts if it is considered important and approaches for doing so are available.

Some adverse impacts may be avoided or minimised through appropriate mitigation measures. Any such mitigation should be specified, costed and included as an integral component of the option.

Table 7.6 Likely significant wider beneficial and adverse impacts of surface water management actions

Receptor	Assessment may include:
Human health and wellbeing	• Description of significant impacts on making better places for people to live (e.g. enhancing the urban landscape, active travel, recreation, outdoor access, wildlife watching opportunities). • Description of significant impacts on opportunities to promote healthy lifestyles. This should consider both the physical and mental health benefits of access to green space and promoting active travel.

Local economy	• Description of the potential for providing wider economic benefits, for example:
	  ○ Boosting local economic opportunities (e.g. attracting businesses and investment) by enhancing the urban landscape and providing better places to live and work.
	  ○ Enabling redevelopment by freeing up capacity in waste water systems.
	  ○ Reducing water purifying and treatment costs.

Water quality	• Description of significant impacts on the water environment (in particular, water quality and physical habitat). • Identification of opportunities to help meet River Basin Management Planning objectives: e.g. restoring habitat / straightened channels; opening up culverts; preventing deterioration of the water environment (including bathing waters) by avoiding a rise in the frequency of CSO spills.
Biodiversity, habitats and species	• Description of any significant impacts on habitats and species, such as degradation of habitats or improvements to habitat connectivity. • Identification of opportunities to help achieve objectives of Local Biodiversity Action Plans. • Description of significant impacts on ecosystem health.
Climate change mitigation	• Description of whether the option gives rise to greenhouse gas emissions during construction and maintenance / repair stages (e.g. through the use of building materials, construction traffic or change in land use). • Description of any beneficial, longer term reduction in greenhouse gas emissions (e.g. through reducing water treatment or pumping).
Any other relevant impacts	• Assessment of any other significant relevant impacts, e.g. on air quality or on the historic environment.

7.5.4 Estimating the whole life cost

Whole life costs are the total costs of an option over its whole life. They take account of design costs, initial capital costs (including mitigation), operation, maintenance and repair, and, where significant, disposal costs. They do not include costs already incurred, such as investment in preceding studies or defences; these are defined as 'sunk' costs and cannot be recovered whatever decision is subsequently taken.

Present Value

The whole life cost will be expressed in Present Value (PV) terms. It will be assessed over a 100-year time period (with reinvestment in actions taken into account if their anticipated lifespan is less than 100 years- see Section 7.5). The discount rate used to determine Present Values will be assigned according to the 'social time preference' discount rate recommended in HM Treasury Green Book (see Box 7.2). Under this system a discount rate of 3.5% is applied to years 1 to 30, of 3% to years 31 to 75 and of 2.5% to years 76 to 100.

Optimism bias

When estimating costs, contingencies should be built in to account for the likelihood of costs being under or over estimated. An optimism bias of 60% is typically used for projects (including strategies) at an early stage of consideration. At the more detailed project stage, a figure of 30% is commonly used. The adopted optimism bias should ultimately reflect the uncertainty of construction costs for a particular element, and may therefore vary depending on the proposed approach.

The HM Treasury Green Book recommends that final whole life costs be subject to sensitivity testing for key variables such as levels of capital costs, duration of works and levels of operating costs.

Estimating costs

The approach to estimating whole life costs should be proportionate and informed by risk: in some cases professional judgment may be sufficient, whereas in others a more detailed estimate may be required (Table 7.7). Appraisers should select the most appropriate source of information, including those listed below, and consider costs from previous studies and works (e.g. estimates from local authority departments). The source of cost estimates should be recorded.

Costs for run-off reduction strategies should be calculated on the basis of the unit cost for impermeable surfaces or disconnections.

Table 7.7 Potential sources of information on whole life costs

Type of estimate	Sources
Professional judgment	• Local authority or Scottish Water officers • Consultants
Strategic estimates	• JBA (2013) Costs of flood risk management actions. Report commissioned by SEPA (contact: flooding@sepa.org.uk) • JBA (2014) Assessing the flood risk management benefits of property level protection. Technical and economic appraisal report. JBA, Skipton: http://www.gov.scot/Resource/0046/00466212.pdf • SEPA (2015) Natural Flood Management Handbook: http://www.sepa.org.uk/environment/water/flooding/developing-our-knowledge
Previous studies and works	• Studies and works commissioned by local authority or Scottish Water officers • Studies and works completed by consultants
Detailed estimates	• AECOM (Eds.) (2015) SPON's Civil Engineering and Highway Works Price Book 2016. CRC Press • CIRIA (2015/2016) Benefits of SuDS Tool. Links to tools and supporting resources: http://www.susdrain.org/resources/best.html

7.5.5 Valuing the economic benefits and costs

Where the impacts of an option have been assessed in monetary form, the costs of implementing the option can be assessed against the costs of the economic flood damages avoided for each. Net Present Value and Benefit-Cost Ratios can be used to assess the balance of benefits and costs over a longer period and compare value for money of different options.

Net Present Value (NPV) works out the net benefits of an option in order to demonstrate the magnitude of the economic benefits and whether they outweigh the costs. It is the Present Value of the benefits minus the Present Value of the costs (Section 7.5.4).

A Benefit-Cost Ratio (BCR) examines the relative return on investment for every pound spent. It is the Present Value of the benefits divided by the Present Value costs (Section 7.5.4). Assuming all (significant) benefits and costs have been valued in monetary terms, an option with a benefit-cost ratio greater than one represents value for money. Appraisers should always consider significant non-monetised impacts too, as these are important for identifying sustainable solutions. The benefit-cost ratio should therefore not be the sole criterion for decisions.

For further guidance see Scottish Government (2016) appraisal guidance and HM Treasury (2003) The Green Book (Box 7.2).

7.6 Comparing options and choosing the preferred one

Flood risk management decisions should be underpinned by a thorough appraisal of economic, social and environmental impacts, whole life costs, risk and uncertainty. It is by balancing all these factors that the most sustainable solution can be found. Decisions should therefore be based on robust information and presented clearly and transparently so that they can be easily understood by those affected.

A range of outputs, both detailed and summarised, is likely to help in making and communicating decisions. A well-designed appraisal summary table with supporting information will assist with this. The Environment Agency appraisal summary note provides an example of a summary table, at: [https://www.gov.uk/guidance/flood-and-coastal-defence-appraisal-of-projects.](https://www.gov.uk/guidance/flood-and-coastal-defence-appraisal-of-projects)

When deciding on which option(s) to implement, several questions should be borne in mind:

- Will the option meet the objectives?
- Does the option represent best value for money?
- Will the option yield multiple benefits and what are the adverse impacts?
- What are the uncertainties and robustness in the appraisal and what are the risks in implementation?

It is important that all impacts (both beneficial and adverse) of the options are taken into account when making decisions. It is therefore necessary to weigh up those impacts that have not been valued in monetary terms and assess whether they are significant enough to change the option that would be preferred on the basis of economic criteria alone.

There are many ways of making these decisions. See Scottish Government's 2016 appraisal guidance for further information.

7.7 Degree of confidence in the appraisal

The degree of confidence in the appraisal should be recorded as it may influence the outcome of the next stage, i.e. confirming funding and developing the preferred option in more detail.

Innovative solutions should not be compromised in favour of more traditional solutions, just because there might be less confidence in the results of the appraisal. If more innovative options have potentially greater benefits, further trials and evidence-gathering on their costs and benefits should be considered. Most actions (with the exception of the simplest ones) will require detailed design and assessment prior to the implementation stage.

Any uncertainties raised during the appraisal can be examined using sensitivity analysis to test the implications of alternative assumptions. For example, by exploring a range of costs and benefits a sensitivity analysis can help to determine whether the preferred solution still measures up if the costs and benefits are different from those originally estimated. This technique avoids the need to collect additional data, thereby helping to keep the effort and cost of carrying out the appraisal proportionate.

8 Develop preferred option, confirm funding

Develop preferred option, confirm funding: considerations and example outputs	
Considerations	**Example outputs**
• Once the preferred option is chosen it will probably need to be developed and assessed in more detail. • Timings for assigning responsibilities for implementation, confirming funding and further developing and designing the preferred option, are likely to vary. • Good design and appropriate expertise (e.g. landscape architects) will be needed to ensure that multiple benefits are realised. • The level of detail required will depend on the flood risk and scale of the action (e.g. enough detail should be provided to have high confidence in the effectiveness of the action, and to inform and have high confidence in funding decisions).	• Section of SWMP report clearly communicating outcomes of this stage, including confirmed action plan and SMART objectives. • Other outputs showing key information (e.g. details of actions being implemented).

Develop preferred option
Once the preferred option is chosen it will probably need to be developed and assessed in more detail. The level of detail required will depend on the flood risk and scale of the action (e.g. enough detail should be provided to have high confidence in the effectiveness of the action, and to inform and have high confidence in funding decisions).

Timings for confirming funding and assigning responsibilities for implementation, and for further development and design of the preferred option, are likely to vary (e.g. depending on the scale of option, source of funding and so on).

Good design is essential to ensure that surface water management infrastructure is able to realise multiple benefits, including integrating with and enhancing the urban landscape. It is therefore important that multidisciplinary teams include landscape architects, as well as flood management and drainage engineers.

The outcome of this stage should be an agreed set of feasible and sustainable actions to manage the risk of surface water flooding in an area.

Confirm funding and implementation
SWMPs are likely to identify a range of different actions. Where they include actions for different authorities they should be used to co-ordinate funding and implementation. An agreed action plan that clearly sets out the actions, those responsible for them, the funding mechanism, the implementation dates and key information on actions (particularly structural actions) should be confirmed. This will provide information on the finalised objectives with confirmed dates for achievement making them SMART, as well as aid communication with the various stakeholders, e.g. the public, responsible authorities, information for the LFRMP and the FRM Strategy (see Figure 8.1 and Table 8.1). The Environment Agency programme of flood and coastal erosion risk management schemes provides an example of information that could be recorded [https://www.gov.uk/government/publications/programme-of-flood-and-coastal-erosion-risk-management-schemes.](https://www.gov.uk/government/publications/programme-of-flood-and-coastal-erosion-risk-management-schemes)

If existing funding and delivery mechanisms are not capable of supporting the most sustainable actions, then Local Plan District Partnership Groups should be informed.

SWMPs may include priority actions that are implemented over the short term, for which more detail is likely to be available. They may also include longer term, aspirational actions for which there is less certainty or information available. Nevertheless, all information that is available should be shared.

Sources of funding will vary depending on who is responsible for implementation, the scale of action required, and so on. They may include:

- Local authority revenue
- Local authority capital via FRM Strategy prioritisation
- Scottish Water maintenance
- Scottish Water capital via quality and standards process
- Private funding (e.g. developer contributions)
- Other sources e.g. EU funding, or if joint projects are being taken forward other funding sources may be available.

Where different authorities are jointly implementing actions, funding may need to be aligned. This should be taken into account when planning implementation.

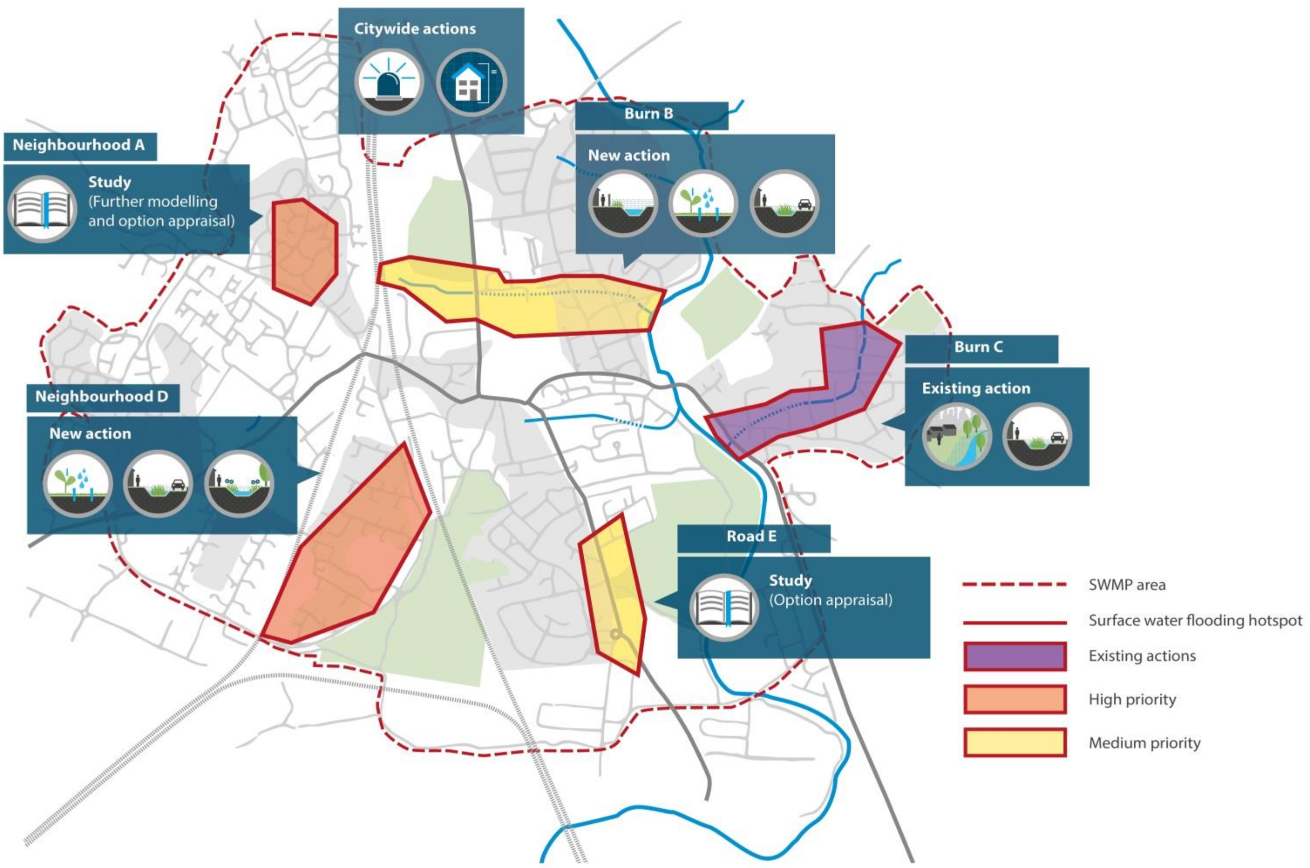

Figure 8.1 Example SWMP actions

Table 8.1 Example SWMP action plan and SMART objectives

Objective	Action	Status	Responsibility	Funding	Implementation date	Standard of protection	Number of homes and businesses better protected
Avoid an increase in surface water flood risk in Whole Town	Land use planning policy.	Existing	LA	LA revenue	On-going	N/A	
	Clarify ownership and responsibilities for existing surface water management infrastructure.	New	LA	LA revenue	2015-2021	N/A	
Reduce surface water flood risk in Whole Town	Update emergency response planning with new pluvial flood information.	New	LA	LA revenue	2015-2021	N/A	
Improve understanding of surface water flood risk in Neighbourhood A	LA and Scottish Water to carry out more detailed modelling in localised area, followed by an option appraisal.	New	LA and Scottish Water	Scottish Water Q&S and LA revenue	2015-2021	N/A	
Reduce surface water flood risk from Burn B	Option appraisal identified potential for infiltration and conveyance combined with watercourse engineering. Funding not confirmed. Take to detailed design and implementation at later date.	New	LA	Not confirmed	Not confirmed, potentially 2021-2027	1:200 yr	25
Maintain existing structure at Burn C	Maintain existing surface water flooding conveyance and storage.	Existing	LA	LA revenue	On-going	1:100 yr	22
Reduce surface water flood risk in Neighbourhood D	Local management of surface water above ground (source control, conveyance and storage), potential to integrate with and improve the urban environment.	New	LA	LA revenue	2015-2021	1:100 yr	25
Reduce surface water flood risk at Road E	Further study – validation with observed events required and option appraisal, potential to integrate with cycle path and blue / green network development.	New	LA	Not confirmed	Not confirmed, potentially 2021-2027	N/A	

9 Finalise and communicate plan

Finalise and communicate plan: considerations and example outputs	
Considerations	**Example outputs**
• An SWMP report should be produced that summarises key findings and outputs, and includes proposals for monitoring, implementation, reviewing and updating the plan. • The report should provide sufficient information for those implementing the plan. • Communication materials for other partners and the public should be considered.	• Detailed SWMP report that clearly communicates findings of each stage, including a summary of any other outputs (e.g. any detailed option appraisal documentation), plus proposals for monitoring implementation and reviewing and updating the plan. Sufficient information for those implementing the plan should be provided. • Summary report, including maps and an action plan for communicating clearly with others, e.g. the public. • A 'data pack' to share key information with stakeholders and help communication and co-ordination (e.g. key GIS outputs, maps, action plan).

A report should be produced that clearly communicates the findings of each stage. It should provide enough detail to help those implementing and monitoring the plan, and be clearly communicated to other stakeholders and the public.

The SWMP should contain a summary of findings and key outputs from each stage of its development (Table 9.1). It should also include maps and other material that can help to clarify the information it contains, such as summary reports for different audiences. A data pack with key outputs should also be shared amongst key stakeholders, e.g. SEPA to update the FRMPS, lead local authority to feed into the LFRMP, and Scottish Water and LA land use planners to help co-ordinate any relevant work.

In addition to the SWMP report and key data (Table 9.1), various supporting documentation is likely to have been produced during the SWM planning process. This may include:

- Collected data (e.g. flood hazard, flood risk, maps of culverts).
- Models (if further modelling is carried out).
- Output from models (including outputs from SEPA modelling).
- Technical reports on flood hazard and risk assessments (e.g. for any new modelling carried out).
- Technical reports on the option appraisal process and actions to be implemented.

Table 9.1 Example SWMP report content

Preparatory work

- Summary of data used in the SWMP.
- Outcome of data validation (overview of confidence in data).

Understanding of surface water flood risk

- Any significant surface water flood events.
- Natural drainage features (e.g. watercourses and their catchments, including small urban burns, culverted watercourses).
- Artificial drainage systems (e.g. Scottish Water sewer catchments, areas of combined sewers, areas of separate surface water and waste water sewers).
- Any interactions between the natural and artificial drainage systems and pluvial / other sources of flooding (e.g. any known locations where land drainage, watercourses or the sea affect surface water drainage or enter the combined sewer).
- Current flood risk:
  - Surface water flood hazard in the SWMP area (e.g. this may include a summary of main sources, flow pathways and depths of flooding).
  - Main adverse impacts (risk) of surface water flooding, areas with greatest flood risk (flooding hot spots) at the neighbourhood or street scale – this should include a summary of receptors at risk at appropriate spatial scales (e.g. for the LA area, the SWMP area, flooding hotspots).
- Future flood risk – may include information on the impacts of climate change, urban creep and population change on flood risk.
- Existing actions to manage surface water flood risk.

Objectives

Description of initial objectives and indicators, including priority objectives if relevant.

Options

- Summary of options considered.
- Confidence in the appraisal.
- Reasons for selecting preferred option(s).
- Clear action plan including SMART objectives – this may include more detailed information on the priority actions to be implemented in the shorter term and less detail on longer term ones (e.g. responsibility for source of funding for longer term actions may not be known yet). The action plan should include information on those responsible for them, the funding mechanism, the implementation dates and key information on actions (particularly structural actions).

Implementation and monitoring

Outline of proposals for implementing and monitoring the plan.

Review and update

Outline of proposals for reviewing and updating the plan.

Data

SWMP 'data pack' of key outputs to share with stakeholders and aid co-ordination and communication, e.g. GIS data showing SWMP area, areas at greatest risk, information on objectives and action plan.

10 Implement and monitor plan

Implement and monitor plan: considerations and example outputs	
Considerations	**Example outputs**
• Implementing actions and monitoring to determine progress towards achieving objectives. • Identifying key information to capture relating to actions to compare against the objectives, e.g. standard of protection, number of homes protected, completion date and so on. • Monitoring actions to determine how effective they are at managing surface water and realising multiple benefits. • Using the above to review and update the plan, e.g. to ascertain what actions are complete and objectives achieved, what type of actions have been successful and can be replicated, or recognise where progress is slow and where the plan needs to be modified.	• Each authority to follow its own project management procedures for implementing actions. • Updated summaries of all actions and their status (e.g. a 'live implementation plan') to aid co-ordination and communication, in particular to confirm when an action has been completed. • For completed actions, recorded key information that can be shared with partners if required, e.g. GIS files showing as-built structural details; the area where flood risk has been reduced (area of benefit); key statistics on flood risk benefits (e.g. standard of protection, number of properties better protected, economic damages avoided); and other key information (e.g. volume of water stored, area of green space and so on).

Once implemented, actions can be monitored to determine progress towards achieving objectives. Monitoring can also determine how effective actions are at managing surface water and realising multiple benefits. As more information is gathered, over time, other actions can be implemented and improved.

Updated summaries of all actions and their status (e.g. 'live implementation plan') should be maintained to help co-ordination and communication. The summaries should confirm when an action has been completed and capture key information about that action. Key data (e.g. standard of protection, number of properties protected etc.) on completed structural actions in particular should be collected and shared with stakeholders, including SEPA and the lead local authority. This will help to confirm the status of any relevant actions that are in the LFRMP and FRM Strategy and also allow reduction in flood risk to be collated, quantified and communicated to monitor progress against the objectives of reducing flood risk. SEPA can be contacted for further advice on what key data should be provided for completed actions.

11 Review and update plan

Review and update plan: considerations and example outputs	
Considerations	**Example outputs**
• The SWMP is a long-term process that should follow the FRMP cycle. • When updating an SWMP, the development process should be repeated and any required changes made.	• Updated SWMP document summarising the findings of each stage, including progress on implementing actions and meeting objectives. • Updated or new outputs, e.g. technical reports and option appraisal reports. • Summary of updated SWMP to be communicated with others, e.g. the public. • Updated 'data pack' to share key information with others and help co-ordinate with other plans, e.g. GIS outputs, maps in other formats and Information required for LFRMP review.

Flood risk management planning follows a six-year cycle, with stages covering understanding flood risk, setting objectives and implementing actions to achieve objectives. SWMPs should be reviewed and updated with LFRMP and FRM Strategy timescales in mind.

When reviewing and updating an SWMP, the development process should be repeated and any required changes made, e.g. to update understanding of flood risk, objectives and actions.

Key drivers of a review may include:

- Updated flood hazard and risk information.
- The occurrence of a flood.
- FRM Strategy publications (containing updated SWMP areas and confirmed funding of actions).
- Outcome of investment decisions by partner agencies that deviate from the preferred plan.
- Monitoring of the implementation of actions, e.g. indicating where changes can be made to replicate success and / or improve outcomes where actions have not been successful.
- New development or other changes in the area that affect surface water flooding.

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- River Basin Management Plans (RBMP): www.sepa.org.uk/water/river_basin_planning.aspx
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Case studies
Managing surface water flooding and integrating with and enhancing the urban landscape:

- Copenhagen climate change adaptation plan http://en.klimatilpasning.dk/
- Proposals for the Nørrebro neighbourhood of Copenhagen by SLA landscape architects: http://www.sla.dk/en/projects/hanstavsenspark
- Rotterdam climate change adaptation:
- http://www.rotterdamclimateinitiative.nl/documents/2015-en-ouder/Documenten/20121210_RAS_EN_lr_versie_4.pdf
- Water square in Benthemplein, Rotterdam by De Urbanisten landscape architects: http://www.urbanisten.nl/wp/?portfolio=waterplein-benthemplein
- Glasgow and Clyde Valley Green Network web guidance on Integrating Green Infrastructure and case studies in the Scottish land use planning system: www.gcvgreennetwork.gov.uk/igi/introduction

Examples of run-off reduction strategies and reducing surface water in the sewer:
- Philadelphia Green City, Clean Waters programme (combination of grey and green infrastructure to reduce CSO spills): http://www.phillywatersheds.org/what_were_doing
- Portland CSO reduction programme 1991-2011 (combination of grey and green infrastructure to reduce CSO spills) and continued green streets policy: https://www.portlandoregon.gov/bes/31030
- Welsh Water RainScape (project to reduce surface water in the sewers): http://www.dwrcymru.com/en/My-Wastewater/RainScape.aspx

Appendix 2 Roles and responsibilities for surface water flooding

Further information on the main roles and responsibilities for drainage and surface water flooding are given below. The list is provided for information purposes and is not exhaustive.

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) in their area, including implementing actions set out in local flood risk management plans, 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 (usual rainfall is currently interpreted to mean up to the 1:30 year rainfall event), and comes under the jurisdiction of Scottish Water. In reality, surface water flooding is often a complex interaction of flooding from many different sources, requiring close working between partner organisations to resolve. Many of the actions identified through the SWMP process can help to manage surface water flooding and flooding solely from a sewerage system.
- Sections 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 clearance and repair works described in the schedule of clearance and repair works, in specific circumstances.
- Section 1 requires all responsible authorities (including local authorities), when exercising their flood risk functions, to manage flood risk in a sustainable way and to co-operate with all responsible authorities.
- Section 41 requires all public bodies and office-holders to have regard to flood risk management plans and local flood risk management plans, which often encompass surface water flooding, when exercising functions that affect a flood risk district.

Roads (Scotland) Act 1984

- Roads authorities (including local authorities) have powers under the Roads (Scotland) Act 1984 to provide drainage of public roads (for normal circumstances), and for road safety. The latter may involve signage and traffic diversions in the event of flooding.
- Section 31 gives roads authorities power to drain a public road or proposed public road, or otherwise to 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, filth, dirt or other offensive matter from, or any percolation of water through, the land onto the road.
- Section 21 refers to the need for consent for anybody other than a roads authority to build a new road. Where a developer is seeking to petition the roads authority, any proposed layout and construction of roads, including road and surface water drainage, must satisfy current design standards.

Sewerage (Scotland) Act 1968

- Section 7 allows roads authorities (including local authorities) and Scottish Water to enter into agreements on providing, managing, maintaining or using their sewers or drains for conveying water from the surface of a road or surface water from premises.

Town and Country Planning (Scotland) Act 1997

- This Act gives planning authorities (including local authorities) powers to grant or refuse planning applications.

Planning etc. (Scotland) Act 2006

- Part 2 requires the planning authority to exercise its planning function with the objective of contributing to sustainable development.
- Part 2 also states that a strategic development plan should set out the infrastructure of the area concerned, including communications, transport and drainage systems, and systems for the supply of water and energy.
- Part 2 further 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 systems, and systems for the supply of water and energy.

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

- Regulation 25 and Schedule 5 require that planning authorities consult SEPA where a development is likely to result in a material increase in the number of buildings at risk of damage by flooding. Planning authorities must take into account SEPA's advice, along with the development plan and other material considerations, when determining planning applications incurring flood risk.
- The regulations require key agencies, including SEPA, to co-operate with strategic development plan authorities and planning authorities when compiling the main issues reports, strategic and local development plans, and action (including 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. When preparing strategic development plans and local development plans, planning authorities must have regard to any approved or finalised flood risk management plan that impinges on the strategic or local development plan area.

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

- This requires planning authorities to notify Scottish Ministers of any application where SEPA has either advised against granting planning permission or recommended conditions concerning flood risk which the planning authority does 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 to 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 an emergency occurring, including surface water flooding.
- Part 4 requires Category 1 responders to maintain plans and 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 actions, enabling the council and partner agencies to construct a co-ordinated and flexible response 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 local authorities, in exercising their functions, to have regard to the River Basin Management Plan.

Building (Scotland) Act 2003

- Section 8 refers to the issuing of building warrants for construction work and, in conjunction with Part 3, covers compliance and enforcement.
- Under Building (Scotland) Regulations 2004, 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 that surface water is disposed of without threatening the building and / or the health and safety of the people in and around it; and
    - Have facilities for separating and removing silt, grit and pollutants.

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 and 38 require lead local authorities to review the plan and to report on progress on implementing the actions therein.

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 functions, to manage flood risk in a sustainable way and to co-operate with all responsible authorities.

- Section 41 requires 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 surface water flooding.

Sewerage (Scotland) Act 1968

- Sections 1 to 8 state that Scottish Water must design and fully maintain public sewers to ensure that they remain capable of effectively draining surface water.
- Section 12 sets out Scottish Water's right to refuse permission to or impose conditions on a private owner to connect with and drain into public sewers.
- Section 21 specifies that Scottish Water must vet building applications to ensure that no building that could interfere with or obstruct a sewer is constructed over it.
- Other Sections (as amended by the Water Environment and Water Services Act 2003 and in particular Schedule 3) give Scottish Water responsibility for maintaining SUDS, which are defined as facilities that attenuate, settle or treat surface water from two or more premises (whether or not together with road water), where they have been designed and completed to a required standard.
- Section 7 allows roads authorities and Scottish Water to enter into agreements for providing, managing, maintaining or using their sewers or drains for conveying water from the surface of a road or surface water from premises.

Water Industry (Scotland) Act 2002

- Section 50 states that Scottish Water must, in exercising its functions, seek to ensure that its resources are used economically, efficiently and effectively.
- Section 51 compels Scottish Water to act in a way that contributes to achieving sustainable development.
- Under Section 53, Scottish Water must have regard to protecting cultural heritage, natural beauty / flora / fauna and geological sites of special interest.
- Under Section 54, Scottish Water must consult Scottish Natural Heritage (SNH) and National Park authorities (NPAs) when carrying 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 their 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 (PVAs).
- 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 to 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

- The Act gives SEPA (as a key agency) the duty to co-operate in preparing 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 actions to achieve them.

Civil Contingencies Act 2004

- SEPA is a category 1 responder under this Act.

Transport Scotland

Roads (Scotland) Act 1984

- To ensure 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 for providing, managing, maintaining or using their sewers or drains for conveying water from the surface of a road or surface water from premises.

Police

Civil Contingencies Act 2004

- The police are a Category 1 responder under this Act, responsible for co-ordinating emergency services in the event of flooding.

The Fire and Rescue Service

Civil Contingencies Act 2004

- The Fire and Rescue Service is a Category 1 responder under this Act. Its duty is to save lives in the event of serious flooding that 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 minimise flood damage to land or property. Members of the public have an important role in sharing local knowledge and taking part in flood protection actions for their areas.

Appendix 3 Validating existing surface water flood hazard and risk data

We use modelling tools to predict flood hazard (e.g. location, extent, depth, likelihood) of surface water flooding. Because surface water flooding is not a regular occurrence it cannot be fully understood simply by observing it. Instead, predictive models help us to understand where flooding could occur if there was heavy rain, examine how it might change with climate change and test the effectiveness of actions to manage the risk. Using the modelled flood hazard an assessment can then be made of the adverse impacts of that flooding, such as the types of building or infrastructure that would be affected. Flood risk is calculated in the same way for both simple and complicated models: multiple simulations of events for different likelihoods are used to estimate the adverse consequences of flooding on human health, the environment, cultural heritage and economic activity.

For further information on pluvial flood hazard modelling see SEPA's flood modelling guidance[15] and regional pluvial hazard mapping methodology.[16]

This section is concerned with validating SEPA's regional pluvial modelling carried out in 2013 and shared with responsible authorities. Nevertheless, the principles set out here can be applied to other modelling that may be available, e.g. Scottish Water Section 16 modelling or modelling by local authorities.

In order to validate the regional pluvial hazard models, they should be compared with observed flood history. SEPA's pluvial maps model an event occurring over a wide urban area. In reality, pluvial flooding can be highly localised and a flood event is unlikely to occur everywhere at the same time. The regional pluvial maps should be validated against areas known to flood that may be more localised, e.g. street and neighbourhood scale. This should help to pinpoint locations where:

- Flooding is predicted by the model and has been observed – good alignment between observed and modelled flooding locations is ideal, even if predicted flooding is not matched by observations elsewhere. Where there is good alignment and the flooding mechanisms are understood, higher confidence can be put in the modelled data.
- Flooding is predicted but has never occurred – in this case the model may be accurate but there has been no flood event in the given location to validate it. Just because a location has not experienced flooding in the past does not mean that it is not at risk of flooding.
- Flooding has occurred but is not predicted – in this case the model is failing to predict observed flooding and further information is likely to be required.

If the modelled flooding is not predicting observed flooding, professional judgment should be applied to ascertain the reasons why. Doing so will help to inform what further data collection / modelling is required.

It is likely that confidence in the model will vary throughout an area, depending on what scenarios are being modelled and the flooding mechanisms involved.

If the pluvial modelling fails to replicate observed flood history over wide urban areas, SEPA should be informed to determine whether updates to the strategic modelling can be made.

[15] SEPA Flood modelling guidance for responsible authorities: http://www.sepa.org.uk/media/219653/flood_model_guidance_v2.pdf

[16] SEPA (2014) *Derivation of a regional pluvial flood hazard dataset, Scotland* – Methodology Report provided to responsible authorities with regional pluvial hazard data.

A3.1 Reasons why modelled flooding might not be predicting observed flooding

SEPA carried out regional pluvial hazard mapping using standard inputs for a range of modelling parameters. All will influence the outputs of, and hence confidence in, the pluvial flood hazard in an area. The parameters can be adjusted or new data gathered to improve validation and confidence in the model. The parameters and key influences are:

- Model resolution (and model type)
- DTM vertical accuracy, resolution, and representation of features
- Sub-surface drainage
- Percent run-off (infiltration)
- Manning's coefficient (roughness)
- Rainfall inputs
- Other sources of flooding and interactions with other sources.

Digital Terrain Model (DTM)

Having a DTM that accurately represents the topography and flow pathways is one of the most important factors influencing confidence in pluvial models.

The DTM used by SEPA for the regional pluvial hazard maps is based on LiDAR and NextMap, and has been processed to remove false blockages and introduce building footprints (as 0.3 m heights) as indicated on Ordnance Survey data. No 'ground truthing' of the DTM was undertaken. Hence in some cases the DTM may not accurately represent flow paths because of:

- Inaccuracies in the DTM – LiDAR was used for the majority of the modelling but where it was not available NextMAP was used which has lower vertical accuracy and lower resolution. In urban areas the DTM is typically processed to remove buildings and other structures. The process involves interpolation, which can introduce errors. Changes in catchment since the DTM was collected may also mean that it no longer accurately represents the current ground surface.
- Missing features – features such as kerbs and walls may not be picked up in LiDAR. Some false blockages may not have been identified. Existing flood management structures have not been explicitly added to the DTM, but some may have been picked up by LiDAR.

Known false blockages identified from mapped data can be removed from the DTM. Where it is thought that local topography or other structures are not represented in the DTM but are having an impact on surface water flow routes and flooding locations, existing surveys or new topographical surveys can be carried out and the results added to the DTM. For example, where roads are known to convey significant flows they can be modelled in the DTM as depressions. Other features too, can be added, such as flood management structures, kerb-lines / heights, low walls, additional buildings and known flow routes (Option A in Table A3.1).

Further information can be found in CIWEM Urban Drainage Group's modelling guide.[17]

[17] CIWEM (2009) Integrated Urban Drainage Modelling Guide 2009, CIWEM, London. www.ciwem.org/wp-content/uploads/2016/05/Integrated-Urban-Drainage-Modelling-Guide.pdf

Model resolution

Flow pathways that are narrower than the model resolution may not be resolved. Generally, the model grid size has to be half the width of a flow pathway in order for it to be resolved. This can cause problems with features like vennels and closes in urban areas. Although model resolution can be increased to resolve flow pathways, doing so can significantly increase model run times. For instance, halving the grid cell size generally leads to an eightfold increase in run times.

Sub-surface drainage

Sub-surface drainage is represented in the regional pluvial model rainfall hyetographs by assuming a 1:5 year drainage capacity in urban areas and deducting this from the input rainfall (rural areas assume no drainage). This assumption may not accurately represent the influence of drainage in an area, and actual drainage capacity is likely to vary across an SWMP area.

The regional pluvial modelling may also be inaccurate because it does not correctly represent the dynamic interaction of above- and below-ground flows; 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.

Section 16 sewer flooding mapping (where available) is useful for determining local drainage capacity. This can help to inform whether the default 1:5 year return period drainage capacity is appropriate. Scottish Water may also have other information on drainage capacity.

Additionally, Section 16 results can be used to determine the critical duration of drainage exceedance. Knowing the critical duration, which varies with gradient and other factors, will help to inform which SEPA mapping scenario – a one-hour or three-hour storm event duration – would be more appropriate to use. If, in consultation with Scottish Water and other partner agencies, it is clear that none of the default drainage capacity or event duration scenarios is suitable, further pluvial modelling using data supplied by SEPA (Option A in Table A3.1) should be considered.

Percent run-off (infiltration)

Percentage run-off is represented in SEPA's regional pluvial model rainfall hyetographs by assuming 70% in urban areas and 55% in rural areas. (Whether an area is designated urban or rural areas is based on the 2007 land cover map.) In reality, infiltration rates will vary at a smaller spatial scale and over the course of a flood event. If the infiltration rates used in the regional pluvial modelling are considered inappropriate, the models can be re-run with different infiltration rates. See Option A in Table A3.1 for further information on re-running the regional pluvial hazard models.

Other sources of flooding and interactions

SEPA's regional pluvial modelling does not show flooding from culverts or pipes. It may, though, represent flooding from smaller urban burns that are not culverted and are featured in the DTM. Higher confidence in the model is likely where the drainage capacity is exceeded and most flooding is from overland flow.

Neither is the impact of high river or sea levels on pluvial flooding or the drainage network taken into account in the modelling. These interactions 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 type of model, often called an 'integrated urban drainage model', should be developed for high risk areas or where the option appraisal requires more detailed understanding of these interactions (Option B or C in Table A3.1).

Rainfall inputs
SEPA's 2013 pluvial modelling used the Flood Estimation Handbook (FEH) 1999 depth duration frequency (DDF) model for rainfall. A new version of the DDF model (FEH 2013) was released in 2015, after SEPA's pluvial hazard maps were published, and replaced the existing DDF model (FEH 1999) for an entire range of return periods and durations. FEH 2013 incorporates a significant amount of additional data and uses an enhanced statistical model. As a result, it has greater depths for short-duration rainfall (< 6 hours) for most locations in Scotland up to the 0.1% annual exceedance probability (AEP) event (1:1000 year rainfall event). Further information on the development of the FEH 2013 model can be found in Defra's technical report Reservoir Safety.[18] Rainfall depths in FEH 1999 and FEH 2013 could be compared for one- and three-hour durations at a number of locations across the SWMP area to determine whether the FEH 1999 in SEPA's pluvial modelling is significantly underestimating rainfall depths.

A3.2 Options for further modelling

This section describes options for further modelling in more detail. As described above, further modelling will be required if SEPA's flood hazard maps do not reflect observed flooding. The type of modelling required will depend on why it is not reflecting observed flooding. Further information on undertaking a flood modelling study can be found in SEPA's flood modelling guidance for responsible authorities.[19]

A risk-based approach should be adopted to select the modelling method. The approach applied should be the simplest one that allows subsequent decisions to be made with confidence. Modelling can be improved for more localised areas (e.g. highest risk neighbourhoods) or be recommended as a future requirement in an SWMP.

SEPA should be contacted if the pluvial modelling fails to replicate observed flood history over wide urban areas, in order to determine whether updates to the strategic modelling can be made.

It is anticipated that most SWMPs can be developed effectively with the SEPA 2013 regional pluvial flood modelling and Section 16 sewer flooding, without having to undertake further modelling in the first stages.

[18] Stewart, et al. (2010) *Reservoir Safety – Long Return Period Rainfall.* Technical report by Defra.
[19] SEPA Flood modelling guidance for responsible authorities:
http://www.sepa.org.uk/media/219653/flood_model_guidance_v2.pdf

Table A3.1 Options for further hazard modelling (NB: once new hazard maps are available the adverse impacts of flooding / flood risk will need to be assessed)	
A) Re-run regional pluvial hazard model	The regional pluvial hazard mapping models can be re-run with updated information on: • DTM • Model resolution • Drainage capacity • Percent run-off (infiltration) • Roughness • Rainfall (e.g. use of FEH13). SEPA can provide the original input data (to local authorities or consultants acting on behalf of local authorities) using a range of software platforms. In order to gain a more accurate representation of pluvial flooding, the model parameters and key influences listed above and in Section A3.1 can be adjusted to better reflect real conditions using data or knowledge from local authorities or Scottish Water. (SEPA can also be contacted for advice.) This can either be via an adjustment to the SEPA model, that can be supplied to the local authority, or the local authority can apply an alternative modelling approach using the available data. Where both observed flood event data and rainfall data are available for a particular event, models may be run to compare observed rainfall data with observed flooding. This may help to increase confidence in the model and identify the source of any discrepancies between the modelled and observed flooding. SEPA agrees with the principle of sharing models and model data, but recognises that the ability to do so is dependent on licensing conditions. Licensing conditions will apply to the model themselves, the inputted datasets and the outputs generated by the contractor. This may limit what information SEPA can share until licensing conditions are agreed with licensors. Re-running the regional pluvial models is the simplest approach. However, as the regional pluvial modelling does not include an explicit representation of the drainage system, it will only be appropriate in areas where the sub-surface drainage system is believed not to be an important factor influencing flooding.
B) Sewer and pluvial modelling	The coupled 1D (underground sewer network) and 2D (above ground) model allows water to flow across the modelled urban surface and re-enter the sewer network where there is an inlet and underground capacity. This will be appropriate in areas where the sub-surface drainage system is important but where there are minimal interactions with other sources of flooding (e.g. rivers, sea).
C) Integrated Catchment modelling	This usually involves combining existing sewerage models with watercourse models and a 2D representation of the urban surface. It can also be used to model the influence of other sources of flooding, including river and coastal flooding, on surface water flooding. This approach is costly and time-consuming, and requires a high degree of collaboration between partner agencies. It is already being applied in areas of very high risk (e.g. Glasgow) and in other Integrated Catchment studies.

Appendix 4 List of potential actions

Table A4.1 List of potential non-structural actions

	Action	Action description	References
	Land use planning policy - adhere to existing	Ensure that new development is not at risk of surface water flooding and does not increase flooding elsewhere. To achieve this, surface water (drainage and flooding) should be managed sustainably above ground and should integrate with and enhance the urban landscape (i.e. should form part of the 'green and blue' infrastructure of the development).	Scottish Government's Scottish Planning Policy: http://www.gov.scot/Publications/2014/06/5823 Scottish Government's Planning Advice: http://www.gov.scot/Topics/Built-Environment/planning/publications/pans Scottish Government (2011) Green Infrastructure: Design and Placemaking: www.scotland.gov.uk/Publications/2011/11/04140525/0 Glasgow and Clyde Valley Green Network web guidance on integrating green infrastructure and case studies in the Scottish land use planning system: www.gcvgreennetwork.gov.uk/igi/introduction Susdrain resource on sustainable drainage http://www.susdrain.org/
	Land use planning policy - implement more stringent policies where required	New developments may have the potential to reduce existing flood risks. Where this is possible local policies (e.g. in supplementary planning guidance) to implement this should be put in place for development planning and development management.	
	Clarify responsibilities for new surface water management infrastructure	Clarify ownership and vesting processes for all surface water management infrastructure in new developments (drainage and flooding up to 1:200 year rainfall event), and set out how they will work with the land use planning system to meet required planning policies.	
	Clarify responsibilities for existing surface water management infrastructure (including SUDS)	Clarify and agree ownership and responsibilities for maintaining existing surface water management infrastructure (including SUDS).	
	Emergency response plans	Use information about surface water flood risk to improve emergency response plans.	

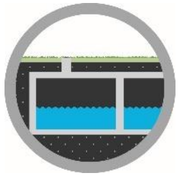
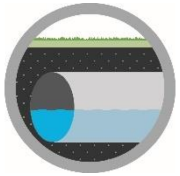
Table A4.1 List of potential non-structural actions			
	Action	**Action description**	**References**
	Study - improve understanding	Carry out modelling and other assessments to improve knowledge of flood hazards and risk (adverse impacts).	SEPA's Flood modelling guidance for responsible authorities: http://www.sepa.org.uk/media/219653/flood_model_guidance_v2.pdf CIWEM (2009) Integrated Urban Drainage Modelling Guide 2009: www.ciwem.org/wp-content/uploads/2016/05/Integrated-Urban-Drainage-Modelling-Guide.pdf
	Study - option appraisal and design	Further study to appraise management options in more detail or take a preferred option to detailed design.	See Chapter 7 Option appraisal. Scottish Government (2011) Principles of appraisal: a policy statement: www.scotland.gov.uk/Publications/2011/07/20125533/0 Scottish Government (2016) Options appraisal for flood risk: guidance to support SEPA and the responsible authorities: http://www.gov.scot/Publications/2016/06/4633
	Study - improve information on surface water flood events	Improve data collection on surface water flood events when they occur, to improve knowledge of surface water flood risk and improve confidence in surface water flood models.	SEPA can be contacted for advice on collecting information on flood events.
	Self-help - business continuity planning	Increase the resilience of individuals and businesses through self-help actions, helping to ensure that people, communities and businesses are prepared for flooding, know what action they can take and can recover more quickly afterwards.	Scottish Government's research on assessing the flood risk management benefits of property level protection: http://www.gov.scot/Topics/Environment/Water/Flooding/resources/research
	Self-help - community flood action groups and resilient community plans		
	Self-help - flood insurance		
	Self-help - awareness- raising		
	Self-help - property-level protection		
	Self-help - property-level resilience (retrofit)		

Table A4.1 List of potential non-structural actions

	Action	Action description	References
	Flood forecasting and warning	Develop surface water flood forecasting, alerts and warning schemes. SEPA issues surface water flood forecasting and alerts but does not currently provide surface water flood warnings. Other authorities may contact SEPA for advice on putting in place any local schemes.	CREW's surface water flood forecasting for urban communities: http://www.crew.ac.uk/publication/surface-water-flood-forecasting-urban-communities-review
	Asset management and maintenance	Review and change existing systems for inspecting and maintaining surface water management infrastructure, e.g. culverts, SUDS, sewers and road drainage.	
	Watercourse management and maintenance	Review and change existing systems for inspecting and maintaining urban burns.	
	Relocation	Relocate properties or infrastructure away from flood risk areas.	

Table A4.2 List of potential structural actions			
Managing water on the surface			
	Action	Action description	References
	Infiltration (and evapotranspiration)	For managing 'every day rain' – maximise the use of permeable surfaces and plants to allow rain to infiltrate the ground and evaporate into the atmosphere where it lands (at source), creating little or no surface water run-off. Generally, most above-ground management of surface water will require a combination of source control, conveyancing and storage in all rainfall events.	Scottish Government (2011) Green Infrastructure: Design and Placemaking: www.scotland.gov.uk/Publications/2011/11/04140525/0 Glasgow and Clyde Valley Green Network integrating green infrastructure and case studies: www.gcvgreennetwork.gov.uk/igi/introduction Greenspace Scotland (2011) Scotland's greenspace map http://greenspacescotland.org.uk/1scotlands-greenspace-map.aspx Susdrain resource on sustainable drainage: http://www.susdrain.org/ • CIRIA publications www.ciria.org • CIRIA C753 (2015) The SUDS Manual. • CIRIA C728 (2014) Managing urban flooding from heavy rainfall – encouraging the uptake of designing for exceedance. • CIRIA C713 (2012) Retrofitting to manage surface water. • CIRIA C635 (2006) Designing for exceedance in urban drainage: good practice. Examples of managing surface water and enhancing the urban landscape: • Copenhagen climate change adaptation plan proposals for the Nørrebro neighbourhood of Copenhagen by SLA landscape architects: http://www.sla.dk/en/projects/hanstavsenspark • Rotterdam climate change adaptation, water square in Benthemplein, Rotterdam by De Urbanisten landscape architects: http://www.urbanisten.nl/wp/?portfolio=waterplein-benthemplein
	Conveyance	For managing 'usual rainfall' - collect, delay and convey rainfall and resultant surface water above ground to watercourses using green infrastructure techniques. Generally, most above-ground management of surface water will require a combination of source control, conveyancing and storage in all rainfall events.	
	Storage	For managing 'extreme rainfall' - delay, store and convey surface water above ground to watercourses using green infrastructure techniques. Generally, most above-ground management of surface water will require a combination of source control, conveyancing and storage in all rainfall events.	
	Restoring urban watercourses	Restore urban watercourses (e.g. restoring floodplains and deculverting) to reduce flooding from the watercourse itself and provide more opportunities to convey surface water into the natural environment.	SEPA's Natural Flood Management Handbook: http://www.sepa.org.uk/media/163560/sepa-natural-flood-management-handbook1.pdf

Table A4.2 List of potential structural actions			
Managing water on the surface			
	Action	Action description	References
	Urban watercourse engineering	Put in place, for example, storage (on-line or off-line storage), embankments, walls or flood diversion channels in urban burns, all of which can reduce flood risk from the watercourse itself.	
	Run-off reduction strategy	Develop what is typically a long-term plan for making whole urban areas more 'green' and permeable and reducing impermeable and 'grey' surfaces (often referred to as de-paving strategies). Using green infrastructure techniques allows more rain to infiltrate the ground and encourages evapotranspiration in the atmosphere, reducing run-off rates and volumes. This can often help to manage frequent and usual rainfall events, mitigate urban creep and adapt to climate change. Because this strategy is most effective for frequent and usual rainfall events, Scottish Water and local authorities should work together to realise multiple benefits.	UKWIR (2014) Framework for developing a stormwater management business case: https://www.ukwir.org/eng/UK-water-industry-research (Provides information on assessing benefits and costs of run-off reduction and reducing water in sewerage systems.) Welsh Water RainScape (project to reduce surface water in the sewers): http://www.dwrcymru.com/en/My-Wastewater/RainScape.aspx Examples of run-off reduction strategies and reducing surface water in the sewer: • Philadelphia Green City, Clean Waters programme (combination of grey and green infrastructure to reduce CSO spills): http://www.phillywatersheds.org/what_were_doing • Portland CSO reduction programme 1991-2011 (combination of grey and green infrastructure to reduce CSO spills) and continued green streets policy: https://www.portlandoregon.gov/bes/31030
	Reducing surface water in the sewer	Identify opportunities to reduce surface water in sewers. Scottish Water is responsible for the sewer network and should therefore be contacted regarding any proposals. For example, Scottish Water may identify opportunities to meet sewer network requirements, while local authorities may see opportunities when managing surface water flooding or where sewer network overflows may be contributing to surface water flooding problems. There are many different ways to reduce surface water in the sewer and Scottish Water and local authorities should co-ordinate work to realise multiple benefits.	
	Land management	Implement land management actions that reduce the rate and volume of run-off. Run-off from more rural land ('the urban fringe') can flood homes, businesses and infrastructure directly and, by significantly increasing flows to the urban area, drainage systems and watercourses can raise flood risk further downstream.	SEPA's Natural Flood Management Handbook: http://www.sepa.org.uk/media/163560/sepa-natural-flood-management-handbook1.pdf

Table A4.2 List of potential structural actions			
Managing water below ground			
	Action	Action description	References
	Underground storage	Divert surface water to storage tanks or by providing storage in the existing drainage / flood management network.	
	Underground conveyance	Increase capacity or build new underground pipes for surface water.	
	Modification of culverted watercourses	For example, increase the capacity of culverted watercourses or divert culverted watercourses.	

Appendix 5 Example of estimating flood risk damages to properties

This example shows a simplified method for using SEPA data to estimate the flood damages avoided when implementing an option to reduce the probability of flooding to an assumed level or 'standard of protection'. The approach, an example of 'approach 2' described in Section 7.5.1, does not require further modelling and uses the regional pluvial risk data (baseline appraisal) derived from SEPA's regional pluvial hazard mapping.

Figure A5.1 is an example of an output from regional pluvial hazard and risk data showing flood extents from the 1:30 and 1:200 year return period rainfall events. Coloured dots indicate the residential properties at risk from surface water flooding.

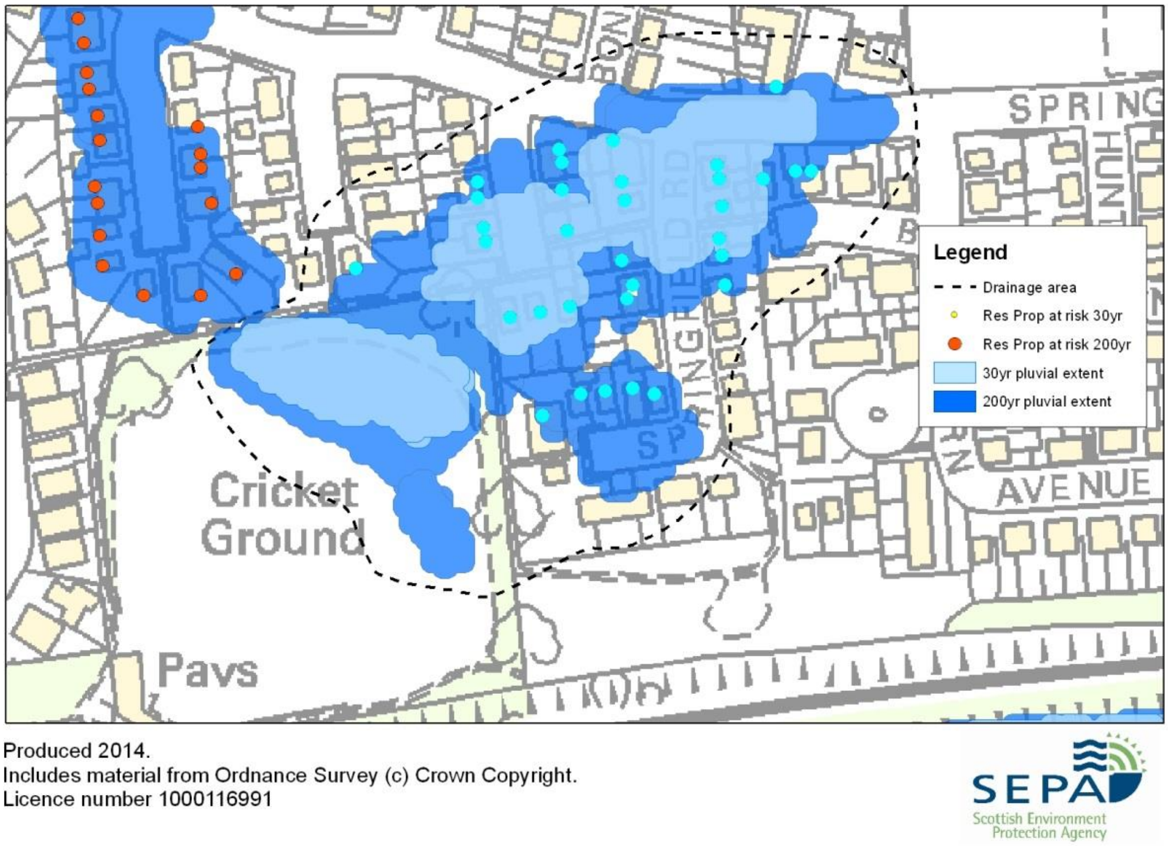


Figure A5.1 SEPA regional pluvial hazard and risk data showing properties predicted to flood

Step 1: Table A5.1 is an extract from the regional pluvial risk data summarising the direct flood damages[20] for the 33 properties highlighted in Figure A5.1. Damages are reported for five return periods (10, 30, 50, 100, 200 year) based on the predicted depth of flooding in each property, the type of property and its plan area. The final column presents the calculated Annual Average Damage; this is the damage that might be expected annually given the probability of each constituent event occurring. Summing the Annual Average Damages for the whole area over all return periods gives the total Annual Average Damage. The baseline Annual Average Damage across the area is £49,227. In the baseline situation, all properties flood in the 1:200 year event but only 13 flood in the 1:10 year event.

Table A5.1 Illustration of calculating the baseline Annual Average (direct) Damage from SEPA regional pluvial risk data

Building reference	Direct damages					Annual Average (Direct) Damage
	1:10 year	1:30 year	1:50 year	1:100 year	1:200 year	
138	£0	£0	£0	£0	£4,200	£42
136	£0	£0	£0	£0	£28,254	£283
130	£0	£0	£0	£0	£28,254	£283
134	£0	£0	£0	£0	£19,770	£198
132	£0	£0	£0	£19,770	£39,629	£495
100	£39,629	£39,629	£53,352	£53,352	£53,352	£4,329
102	£28,254	£39,629	£53,352	£53,352	£53,352	£3,950
104	£0	£4,200	£39,629	£53,352	£53,352	£1,431
124	£0	£0	£0	£0	£11,738	£117
122	£0	£0	£0	£17,036	£23,482	£320
170	£0	£0	£0	£0	£11,738	£117
72	£0	£0	£0	£0	£4,200	£42
120	£0	£0	£39,629	£47,762	£53,352	£1,235
172	£2,619	£2,619	£23,482	£31,099	£31,099	£933
98	£31,099	£32,923	£32,923	£34,681	£34,681	£3,258
174	£11,738	£17,036	£28,057	£31,099	£31,099	£1,867
106	£39,629	£39,629	£53,352	£53,352	£53,352	£4,329
96	£28,057	£28,057	£31,099	£31,099	£32,923	£2,905
176	£53,352	£53,352	£53,352	£56,926	£56,926	£5,389
118	£47,762	£47,762	£53,352	£53,352	£56,926	£4,961
94	£0	£2,619	£11,738	£23,482	£28,057	£640
108	£0	£0	£28,254	£39,629	£53,352	£1,061
92	£0	£0	£0	£2,619	£17,036	£183
116	£28,057	£28,057	£31,099	£32,923	£32,923	£2,914
178	£28,057	£28,057	£31,099	£32,923	£32,923	£2,914
14	£0	£0	£4,200	£28,254	£39,629	£587
12	£0	£0	£0	£0	£17,036	£170
10	£0	£0	£0	£0	£2,619	£26
180	£28,057	£28,057	£31,099	£32,923	£32,923	£2,914
110	£0	£0	£2,619	£23,482	£28,057	£429
112	£0	£0	£2,619	£11,738	£23,482	£324
114	£2,619	£2,619	£2,619	£17,036	£23,482	£543
117	£0	£0	£0	£2,531	£2,531	£38
TOTAL	**£368,930**	**£394,245**	**£606,925**	**£783,772**	**£1,015,729**	**£49,227**
Count of properties flooding	13	15	20	24	33	

[20] The SEPA data also includes indirect damage data that can be included in this calculation. Indirect damage data includes the impact on vehicles and emergency services, and the costs of drying flood-damaged homes.

Step 2: This step requires an understanding of the likely flood mechanisms in order to propose a 'standard of protection' that is achievable under a flood risk management option. Engineering judgment and experience should be used to determine this. In this example, the proposal is that local improvements are made to maintain highway drainage and the capacity of the sewer network in order to delay the onset of flooding at all properties until after the 1:30 year event. In this simplified methodology, a new direct damage is calculated by removing the 1:10 and 1:30 year damages from the calculation. The impact of this change is illustrated in Table A5.2. The revised total Annual Average Damage is now reduced to £21,159. Note how the simplified approach conservatively assumes that the impact of less frequent floods remains unaltered.

Table A5.2 Illustration of calculating Annual Average (direct) Damage for a flood risk management option by manipulating SEPA regional pluvial risk data (option removes all damages up to 1:30 year event, as highlighted)

Building reference	Direct damages					Annual Average (Direct) Damage
	1:10 year	1:30 year	1:50 year	1:100 year	1:200 year	
138	£0	£0	£0	£0	£4,200	£42
136	£0	£0	£0	£0	£28,254	£283
130	£0	£0	£0	£0	£28,254	£283
134	£0	£0	£0	£0	£19,770	£198
132	£0	£0	£0	£19,770	£39,629	£495
100	£0	£0	£53,352	£53,352	£53,352	£1,423
102	£0	£0	£53,352	£53,352	£53,352	£1,423
104	£0	£0	£39,629	£53,352	£53,352	£1,263
124	£0	£0	£0	£0	£11,738	£117
122	£0	£0	£0	£17,036	£23,482	£320
170	£0	£0	£0	£0	£11,738	£117
72	£0	£0	£0	£0	£4,200	£42
120	£0	£0	£39,629	£47,762	£53,352	£1,235
172	£0	£0	£23,482	£31,099	£31,099	£740
98	£0	£0	£32,923	£34,681	£34,681	£904
174	£0	£0	£28,057	£31,099	£31,099	£794
106	£0	£0	£53,352	£53,352	£53,352	£1,423
96	£0	£0	£31,099	£31,099	£32,923	£848
176	£0	£0	£53,352	£56,926	£56,926	£1,476
118	£0	£0	£53,352	£53,352	£56,926	£1,458
94	£0	£0	£11,738	£23,482	£28,057	£535
108	£0	£0	£28,254	£39,629	£53,352	£1,061
92	£0	£0	£0	£2,619	£17,036	£183
116	£0	£0	£31,099	£32,923	£32,923	£857
178	£0	£0	£31,099	£32,923	£32,923	£857
14	£0	£0	£4,200	£28,254	£39,629	£587
12	£0	£0	£0	£0	£17,036	£170
10	£0	£0	£0	£0	£2,619	£26
180	£0	£0	£31,099	£32,923	£32,923	£857
110	£0	£0	£2,619	£23,482	£28,057	£429
112	£0	£0	£2,619	£11,738	£23,482	£324
114	£0	£0	£2,619	£17,036	£23,482	£351
117	£0	£0	£0	£2,531	£2,531	£38
TOTAL	**£0**	**£0**	**£606,925**	**£783,772**	**£1,015,729**	**£21,159**
Count of properties flooding	0	0	20	24	33	

Box A5.1 Calculating Annual Average Damage

The formula for calculating Annual Average Damage (AAD) at each property from the data is:

AAD = ((DDMG10) + (DDMG30))/2*(1/10-1/30) +
((DDMG30) + (DDMG50))/2*(1/30-1/50) +
((DDMG50) + (DDMG100))/2*(1/50-1/100) +
((DDMG100) + (DDMG200))/2*(1/100-1/200) +
((DDMG200) + (DIRINFIN))/2*(1/200-0)

Where:

DDMG 10, 30, 50, 100, 200 is the direct damage for each return period event; and
DIRINFIN = (DDMG200) + ((DDMG200) - (DDMG100)) *((1/200-0)/(1/100-1/200))

This notation is used in the baseline appraisal information. The formulae can be pasted from this guidance directly into a spreadsheet.

Appendix 6 Adaptation to future flood risk

A6.1 Introduction

This appendix provides further guidance on considering adaptation to future flood risk in an options appraisal. It covers three main influences on future flood risk:

- Climate change
- Urban creep
- Demographic change.

The information available on these different factors will vary and should be summarised at the 'Understand flood risk' stage. Authorities should consider all influences in an integrated way where possible.

Further guidance on considering adaptation in option appraisals can be found in:

- Scottish Government (2016) Options appraisal for flood risk management: Guidance to support SEPA and the responsible authorities: http://www.gov.scot/Publications/2016/06/4633/1
- Defra (2009) Appraisal of flood and coastal erosion risk management: A Defra policy statement: https://www.gov.uk/government/publications/appraisal-of-flood-and-coastal-erosion-risk-management-a-defra-policy-statement-june-2009
- Environment Agency (2010) Flood and coastal erosion risk management: Appraisal guidance: https://www.gov.uk/government/publications/flood-and-coastal-erosion-risk-management-appraisal-guidance
- Metropolitan Glasgow Strategic Drainage Partnership (2011) Climate Change Technical Guidance: (www.mgsdp.org/index.aspx?articleid=2016)
- JBA (2013) Costs of flood risk management actions (Report commissioned by SEPA; contact: flooding@sepa.org.uk). Contains an assessment of the adaptability of flood risk management actions to climate change.
- ClimateXChange (2012) Flexible adaptation pathways: (http://www.climatexchange.org.uk/adapting-to-climate-change/flexible-adaptation-pathways/)

Two climate change adaptation approaches are described in the Defra 2009 policy statement and in Chapter 7 Option appraisal: managed adaptive and precautionary. Both can also be applied to ensure that options are adaptable to changes in land use (urban creep) or population growth and new development.

A6.2 Information on the impacts of climate change on rainfall

When designing options, allowance should be made for climate change. What allowance to include will vary, depending, for example, on the type or location of the option and whether a managed adaptive or precautionary approach is being taken.

SEPA's 2013 pluvial model climate change scenarios assumed a 20% uplift in rainfall intensity for 2080. This assumption was based on Defra 2006 guidance and subsequently updated EA 2016 guidance, which represented the best understanding at that time. UKWIR (2015) rainfall intensity for sewer design has estimated uplifts for different regions of the UK, showing that for the east in particular larger uplifts may be more appropriate. UKCP18 should further refine our understanding of climate change impacts on rainfall, outputs from which are expected in 2018.

Industry design manuals (e.g. CIRIA 753 (2015) SUDS manual and Scottish Water Sewers for Scotland) may also contain guidance on climate change allowance when designing infrastructure.

Information on the impacts of climate change on rainfall include:

- Environment Agency (2016) Adapting to climate change: guidance for risk management authorities. This is supplementary information to Defra's 2009 Appraisal of flood and coastal erosion risk management: A Defra policy statement, and the Environment Agency's 2010 Flood and coastal erosion risk management: Appraisal guidance (updating Defra 2006 and EA 2011 supplementary information on climate change): https://www.gov.uk/government/publications/adapting-to-climate-change-for-risk-management-authorities
- Bennett J, Blenkinsop S, Dale M, Fowler H and Gill E (2015) Rainfall Intensity for Sewer Design - Guidance for water companies. UKWIR, London: https://www.ukwir.org/
- UK Climate Projections: http://ukclimateprojections.metoffice.gov.uk/

A6.3 Information on rate and impact of urban creep

When designing options, some allowance for urban creep can be included. What allowance to include may vary, depending, for example, on the type and location of the option and whether a managed adaptive or precautionary approach is being taken.

Information on rates of urban creep, which will vary, may not be available for a local area. Instead modelling can be carried out to estimate the impacts of different urban creep scenarios on flood risk for various options. Whatever approach is used is likely to call for an increase in impermeable area in the model. This could be a fixed percentage increase, as per the 10% allowance in hydraulic design for urban creep recommended in the CIRIA C753 (2015) SUDS Manual and Scottish Water's Sewers for Scotland, for example.

Kelly (2016)[21] showed that:

- Modelled increases in run-off are directly proportional to growth in impermeable cover – the contribution of existing paved front gardens to the overall urban drainage burden is already substantial.
- The effects of climate change are likely to exacerbate the problem further – higher rainfall in the future is likely to increase run-off from paved front gardens, putting additional strain on already struggling drainage systems.

Soil type is likely to influence the extent of future flood risk. Published data on rates of urban creep includes:

- UKWIR[22] data on average rates of urban creep in sample English cities showed between 0.4 and 1.1m2 per house per year.
- Wright et al (2011)[23] found a near quadrupling of the area of impermeable hardstanding in three typical residential areas of Edinburgh.

A6.4 Information on demographic change

It is important to adhere to land use planning policies to ensure that new development is not at risk of surface water flooding and does not increase elsewhere.

Further information, including projections for new homes, is available from local authority land use planners and National Records of Scotland (see Section 5.4 for further information).

Growth can be taken into account if deemed necessary (e.g. in areas of high growth) along with urban creep and loss of green space, and a managed adaptive or precautionary approach taken.

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[21] Kelly D (2016) Impact of paved front gardens on current and future urban flooding. *Journal of Flood Risk Management.* 12 February.
[22] UKWIR (2010) Impact of Urban Creep on Sewerage Systems.10/WM/07/14. Summarised in OFWAT (2011) *Future Impacts on Sewer Systems in England and Wales*: http://www.ofwat.gov.uk/wp-content/uploads/2015/11/rpt_com201106mottmacsewer.pdf
[23] Wright GB, Arthur S, Bowles G, Bastien N and Unwin D (2011) Urban creep in Scotland: stakeholder perceptions, quantification and cost implications of permeable solutions. *Water and Environment Journal* 25(4), 513–521. DOI: 10.1111/j.1747-6593.2010.00247.x

Appendix 7 Further guidance on assessing wider environmental, social and economic impacts

A7.1 Introduction

This appendix provides further guidance and references to sources of information on assessing the wider environmental, social and economic impacts of surface water management actions. It does not cover every impact, but focuses on those that are most likely to be significant for surface water management planning.

The following sources provide information on the range of impacts resulting from surface water management actions:

- Scottish Government (2011) Delivering Sustainable Flood Risk Management: www.scotland.gov.uk/Publications/2011/06/15150211/0
- Centre for Neighbourhood Technology (2010) The value of green infrastructure - A guide to recognising its economic, environmental and social benefits: www.cnt.org/repository/gi-values-guide.pdf
- Susdrain: Benefits of SUDS: http://www.susdrain.org/delivering-suds/using-suds/benefits-of-suds/SuDS-benefits.html
- CIRIA C753 (2015) The SUDS Manual: www.ciria.org

A7.2 Human health and wellbeing

Surface water management actions that integrate with and enhance the urban landscape can provide more attractive and inviting places for people.

Good design is essential to ensure that surface water management infrastructure realises multiple benefits and integrates and enhances the urban landscape. It is therefore important that multidisciplinary team that include landscape architects, as well as flood management and drainage engineers, are used.

Good design can bring about significant benefits for human health and wellbeing and improve quality of life. Maximising the use of plants (which also attracts wildlife) together with good landscape design can not only reduce the risk of flooding but provides more attractive and inviting places for people. Connecting to wider 'green and blue networks' such as footpaths and cycle paths can improve health and wellbeing by encouraging people to become more active. Improving the quality of the air and water in urban watercourses is also beneficial.

An additional aspect to be considered is whether the option enhances the urban landscape in deprived neighbourhoods, e.g. the lowest deciles of the Scottish Government's Scottish Index of Multiple Deprivation (see www.scotland.gov.uk/Topics/Statistics/SIMD). SEPA's regional pluvial flood risk data has information on social vulnerability to flooding, further information on which can be found in the accompanying guidance on using the data given to responsible authorities. Scottish Government has also mapped flood disadvantage in Scotland (see http://www.gov.scot/Topics/Environment/Water/Flooding/resources/research).

Further information on the health impacts of green space can be found in: Health Scotland, greenspace Scotland, Scottish Natural Heritage and the Institute of Occupational Medicine (2008) Health Impact Assessment of greenspace: a guide: www.greenspacescotland.org.uk/health.aspx

A7.3 Economy

Surface water management actions that integrate with and enhance the urban landscape can attract businesses and investment to an area.

Where local authorities and Scottish Water have co-ordinated work to reduce surface water in the sewer network, capacity in both the sewer network and the water environment, if water quality is also improved, can be expanded to cope with further growth. This could encourage sustainable economic growth in areas where development might otherwise be limited by sewer or environmental capacity. Actions may also help to bring about other economic benefits, such as reducing the costs of water pumping and treatment. (Contact Scottish Water for further information on sewer network capacity.)

A7.4 Water Quality

Surface water management actions that treat surface water run-off and restore urban watercourses can have significant beneficial impacts on river morphology and water quality, thereby helping to achieve the objectives of River Basin Management Plans (see www.sepa.org.uk/water/river_basin_planning.aspx). Impacts should be considered both at the location of the option and further down the flow path, and where relevant should include estuarine and coastal impacts.

When assessing impacts on RBMP objectives, the following points should be considered:

- Will the impact significantly extend the length/area of good (or better) status waters and / or will cumulative impacts of smaller-scale actions contribute to improvements in the water environment? Without detailed modelling impacts will be difficult to quantify, so in many situations a description of the likely direction and magnitude of change will be sufficient.
- Will the impact help to prevent deterioration of the water environment?
- Is the affected part of the water environment in a deprived neighbourhood? Impacts in the most deprived neighbourhoods in Scotland should as a rule be considered more significant than similar impacts in less deprived neighbourhoods.
- How long is the impact expected to last? As a rule, longer term impacts should be considered more significant than shorter terms impacts of similar scale (e.g. SEPA regulatory guidance).[24]

Where local authorities and Scottish Water have co-ordinated work to reduce surface water in the sewer network, the impact on CSO spills should be taken into account. Reducing CSO spills may improve (or prevent deterioration of) water quality in rivers and transitional or coastal waters, as well as bathing water quality at designated beaches. Describing the likely magnitude and direction of change in qualitative terms will be sufficient in the majority of cases. Detailed modelling, in consultation with Scottish Water, would be needed to quantify the change.

[24] SEPA WAT-SG-67: *Assessing the significance of impacts – social, economic and environmental*: https://www.sepa.org.uk/media/149801/wat_sg_67.pdf

A7.5 Biodiversity, habitats and species

Surface water management actions that maximise the use of plants can help to increase wildlife and enhance habitats, to the benefit of species and biodiversity. Habitat connectivity and ecosystem health also stand to gain. A description of the impacts, including magnitude and direction, is likely to be sufficient.

Note that there are specific legal requirements for the protection of habitats and species, which should be considered early in the appraisal process.

SNH has published a wide range of information and data on biodiversity, species and habitats, and habitat networks: www.snh.gov.uk/protecting-scotlands-nature. Local Biodiversity Actions Plans will also contain information on local biodiversity priorities: www.biodiversityscotland.gov.uk/area/lbaps/partnerships.

A7.6 Climate change mitigation

The Climate Change (Scotland) Act 2009 set targets to reduce Scotland's greenhouse gas emissions by at least 42% by 2020 and by 80% by 2050, from its 1990/1995 baseline. Public bodies must act in the way best calculated to contribute to the targets.

As a minimum, appraisers should describe whether or not the option is likely to lead to a net increase or decrease in greenhouse gas emissions. This could be through, for example, energy used for maintenance or pumping, or changes to land use and carbon sequestration. This qualitative approach is likely to suffice for most situations.

For large-scale works and more detailed studies, the SWMP partnership may deem it appropriate to quantify impacts on greenhouse gas emissions. The following document provides further guidance on how to do this:

- Susdrain: Benefits of SUDS: http://www.susdrain.org/delivering-suds/using-suds/benefits-of-suds/SuDS-benefits.html

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