Flood Risk Management (Scotland) Act 2009

Benefit Cost Analysis of Options to Manage Surface Water Flooding

Guidance to replace existing chapter 6 of Surface Water Management Planning Guidance
http://www.scotland.gov.uk/Publications/2013/02/7909

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6 Develop, describe and value options to manage surface water flood risk

6.1 Overview

This chapter provides guidance on how to identify the most sustainable option for managing surface water flooding, through the assessment of costs, flood risk reduction benefits, and wider positive and adverse impacts. This process will:

- Support compliance with the Flood Risk Management (Scotland) Act 2009 to deliver sustainable flood risk management
- Support achievement of the flood risk management outcomes for Scotland set out in the Scottish Government Guidance on sustainable flood risk management
- Ensure consistency with Scottish Government policy on appraisal for flood risk management
- Support decision making
- Provide evidence that the most sustainable option has been selected
- Ensure best use of public money.

This guidance is consistent with the principles in HM Treasury Green Book and Scottish Government guidance and policy on flood risk management. Further guidance can be found in the reference material listed in box 6.1.

Box 6.1 Reference material for options appraisal

Public sector appraisal guidance

- HM Treasury (2003) 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 Scottish Public Finance Manual: www.scotland.gov.uk/Topics/Government/Finance/spfm/Intro

Scottish Government flood risk management guidance and policy

- Scottish Government (2011) Delivering Sustainable Flood Risk Management: www.scotland.gov.uk/Publications/2011/06/15150211/0
- Scottish Government (2011) Sustainable Flood Risk Management – Principles of appraisal: a policy statement: www.scotland.gov.uk/Publications/2011/07/20125533/0
- Scottish Government (in preparation) Appraisal for Flood Risk Management: Guidance to support SEPA and the Responsible Authorities

SEPA strategic appraisal methodology for flood risk management

- SEPA (2013) Flood Risk Management Appraisal Methodology: www.sepa.org.uk

Detailed guidance on economic appraisal

- Penning-Rowsell et al. (2013) Flood and Coastal Erosion Risk Management: A Manual for Economic Appraisal. Flood Hazard Research Centre, University of Middlesex.

The process consists of the following steps:

- **Identify** and screen a long list of potential actions to meet the objectives of the surface water management plan (SWMP), thereby producing a shortlist for further investigation
- **Develop** 'options' from the shortlist of actions (see box 6.2)
- **Estimate** the whole life costs of the options
- **Describe** flood risk reduction benefits of the options, and quantify or monetise these benefits where practicable
- **Describe** wider significant positive and adverse impacts of the options, quantifying these impacts where appropriate
- **Summarise** the findings, using tools such as benefit-cost ratio and appraisal summary tables.

A linear process is presented for simplicity, but in reality the process is likely to be iterative: options will be generated and progressively refined.

The process is best conducted in collaboration with partner organisations and the guidance identifies some key steps in the appraisal that should be agreed within the SWMP partnership. These include:
- Criteria for screening the long list
- Shortlist of options for detailed appraisal
- Modelling requirements
- Method for appraising costs and benefits and wider impacts
- How to record the results.

Box 6.2 What is a flood risk management option?

An **option** is one or more flood risk management actions developed to meet an objective of the SWMP.

An **action** may consist of a single intervention (e.g. build a storage reservoir; policy for opportunistic retrofitting of sustainable urban drainage systems (SUDS) or could be two or more interdependent interventions, where the presence of one is essential to the success of another (e.g. demountable defences and flood warning system). See appendix 6 for a list of potential actions.

6.2 Risk based approach and confidence in outputs

As with all stages of the surface water management planning process, the level of detail in the appraisal should be proportionate and will be influenced by a number of factors (table 9):

- The level and complexity of flood risk
- The availability of and confidence in hazard and risk modelling and mapping
- availability of and confidence in other data such as whole life costs and wider impacts
- The type of action and information required to differentiate between actions
- Resources available or required

Less detail may be needed where the choice between options is clear, whereas more detail is likely to be required where there are complex issues, where differentiation is more difficult and where a lot of resources may be invested. A simplified analysis should not, however, be interpreted as one that lacks rigour. For example, a simple problem and solution (e.g. raising a kerb to protect a small number of properties from flooding from road run off) is unlikely to require a detailed assessment of costs and benefits. However, a more complex problem (e.g. using multiple actions above and below ground) might require manipulation of flood damages data (or even remodelling of flood hazard maps) alongside a more detailed consideration of costs and wider impacts.

Table 9: Risk based approach and confidence in different stages of appraisal

Stage in appraisal	Level of detail	Effort / Resources	Confidence in outputs
Hazard and risk data to support appraisal	Level of confidence in available hazard and risk data will influence level of detail in the appraisal	Increasing	Increasing
Identify long list and screen to produce a shortlist	Level of detail in screening exercise will be proportionate to: • the level and complexity of flood risk • the availability of and confidence in hazard and risk modelling and mapping • the type of action	Increasing	Increasing
Describe flood risk reduction benefits of the options	Method chosen to assess flood risk reduction benefits will be proportionate to: • the level and complexity of flood risk • the availability of and confidence in hazard and risk modelling and mapping • the type of action	Increasing	Increasing
Describe wider significant positive and adverse impacts	Method chosen to assess wider positive and adverse impacts will be proportionate to: • 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 data on wider benefits • the type of action	Increasing	Increasing
Estimate the whole life costs of the options	Method chosen to estimate whole life costs will be proportionate to: • 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 whole life cost data • the type of action	Increasing	Increasing
Summarise the findings, using tools such as benefit-cost ratio and appraisal summary tables	The confidence in the appraisal should be recorded as this may influence the outcome of the next stage; prioritising funding and implementing actions.		

The level of detail undertaken at each stage of the appraisal is likely to be proportionate to the effort invested in previous stages. For example if a detailed assessment of the flood risk reduction benefits of an action has been undertaken, then a similar amount of detail and effort is likely to be appropriate for assessing the whole life costs of the action.

The confidence in the appraisal should be recorded as this may influence the outcome of the next stage: prioritising funding and implementing actions. However innovative solutions should not be compromised in comparison to more traditional solutions just because there might be more confidence in the results of the assessment. If more innovative solutions have potentially greater benefits, trials should be considered and evidence gathered on their costs and benefits. Most actions (perhaps with the exception of the most simple) will require a detailed assessment prior to the implementation stage.

Sensitivity analysis can be used to help take account of any uncertainties identified during the appraisal by testing 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 stacks up if the costs and benefits are different to those estimated. This avoids the need to try and collect additional data (thus helping to keep the appraisal proportionate in terms of the effort and costs involved).

Further guidance on proportionality can be found in Scottish Government flood risk management appraisal guidance (see box 6.1).

6.3 Identify and screen long list of actions

6.3.1 Approach

This step will identify a broad range of feasible actions that could help to meet the objectives of the SWMP (which in turn should be consistent with the objectives set in the Flood Risk Management Strategies and Local Flood Risk Management Plans; see chapter 5). A long list of actions should be identified with the following points in mind:

Meeting the objectives

- Consider all actions that could partially or completely address the risk of flooding (probability[1] and consequence) that is predicted or has been observed.
- Consider actions which are effective at the property, neighbourhood or catchment scale, as appropriate.
- Consider whether there are opportunities to combine surface water management actions with actions to address river and coastal flood risk management objectives (as identified in the Flood Risk Management Strategies and Local Flood Risk Management Plans).

Delivering integrated drainage

- The actions should aim to deliver integrated drainage (see section 1.5).
- Consider the impact that actions will have on surface water flood risk now and in the future. Actions to manage flood risk should reflect the needs of future generations and be adaptable to a changing climate and other drivers of changing flood risk (Appendix 8).
- Consider actions which could deliver wider benefits such as better places for people to live (e.g. amenity), improved environment (e.g. improvement or prevention of deterioration in water quality), improved biodiversity, or reducing costs of water purification or treatment.

[1] Scottish Government guidance on Delivering Sustainable Flood Risk Management does not specify design standards: instead, it emphasises the importance of identifying the most cost beneficial options.

- Consider opportunities to improve existing actions e.g. change maintenance regimes or enhance / replace existing actions.

Working with stakeholders

- Consider actions which would be delivered by the full range of stakeholder organisations.
- Actions may be added to or refined by the Local Flood Risk Management Partnerships, the Local Advisory Groups or through engagement with all stakeholders.

6.3.2 Identify actions

A broad range of non-structural and structural actions should be considered (appendix 6).

Non-structural actions may include, for example, development of new land use planning policy, consideration of surface water flooding through settlement strategies in development plans and planning decisions, an identified need for more detailed flood risk assessment, or flood forecasting and warning.

Structural actions may include, for example, a surface water storage structure or managed overland flow pathway to protect properties from flooding. Actions that seek to manage water at source or on the surface (as these actions help to reduce surface water run-off and are more adaptable to climate change) should be considered before actions that involve creating larger pipes or subsurface storage.

Initially, the descriptions of actions will be relatively generic; more detail (e.g. location, storage volume, materials, construction methods) will be considered later in the planning process should the actions progress beyond long listing.

6.3.3 Criteria for screening long-list of actions

The long-list of actions should be screened to remove any that are clearly unfeasible to produce a short-list of potential actions for further appraisal. This guidance recommends three main criteria (technical, legal and economic) to screen out unfeasible actions (table 10).

Table 10. Screening criteria

Feasibility	Description	Metric
1. Technical	Removal of any actions that are not technically feasible e.g. permeability of ground insufficient for infiltration	Categorical - Y/N Expert judgement
2. Legal	Removal of any actions that represent insurmountable legal issues, including health and safety.	Categorical - Y/N Expert judgement
3. Economic	At this stage, is there evidence that the costs will be disproportionate compared to the benefits? (Do not reject actions that can deliver significant flood risk reduction benefits to other receptors or actions that also deliver wider social, environmental and/or economic benefits)	Categorical - Y/N Rapid assessment of estimated build and maintenance costs of action versus benefits to economy (direct economic benefits to property). (This should not be a detailed benefit-cost analysis.)

The screening process relies heavily on expert judgement. It is important to reach agreement with SWMP partnerships on which actions are discarded at this stage. Where there is doubt, an action should be retained for further evaluation as part of the shortlist. All decisions and reasoning should be clearly set out and recorded.

At this stage, identification of actions should not be constrained by concerns over funding or delivery mechanisms. Agreements over funding and responsibilities should be made once the most sustainable actions have been identified (see chapter 7).

6.3.4 Technical Feasibility

A number of technical issues might preclude an action from further consideration, for example:

- **Ground permeability:** source control relying on ground infiltration should consider ground permeability.
- **Topography:** water must flow downhill and hence areas set aside for the temporary storage of surface water must be positioned down slope from the areas generating runoff.
- **Existing land use:** for example:
    - Using carriageways or entire roads for the conveyance or storage of surface water may be incompatible with their use as strategic routes and road safety;
    - Exceedance flow management may increase flood risk downstream;
    - Above ground storage reservoirs may not be feasible because of a shortage of space to allow for required storage volumes and appropriate and safe access for maintenance. Innovative ideas for creating space, or for combining public space with storage areas, however, should not be overlooked.
- **Flood forecasting:** SEPA currently offers surface water flood guidance through the Scottish Flood Forecasting Service partnership with the Met Office in the daily Flood Guidance Statement, and alerting at the regional scale. This currently depends on interpretation of probabilistic rainfall forecasts though more targeted forecasting techniques are in development. However, forecasts and warnings are likely to remain either probabilistic or with 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.)

6.3.5 Legal Feasibility

There are various legal constraints on what actions can be progressed or, more specifically, the manner in which they are progressed. These mainly deal with the impact on people and the natural or built environment; for example:

a. Health and Safety

Actions can introduce significant health and safety risks whether during construction, under maintenance or in use. Likewise actions can contribute to an overall reduction in risks to health and safety by reducing flood risk itself or by removing / replacing structures which are inherently hazardous to maintain (e.g. culvert trash screens). The screening process needs to take a pragmatic approach with regard to actions and not exclude those actions which introduce additional risks during construction, under maintenance and in use provided that those additional risks can be managed in line with the legislation (e.g. The Health and Safety at Work etc Act 1974; The Construction (Design and Management) Regulations 2007).

b. Environmental and Heritage protection

There may be situations where the impact on an aspect of the natural or built environment (e.g. designated sites, protected species, ground water, or heritage features) may be such that legally the action cannot be progressed. The aim is to remove any actions that raise insurmountable environmental problems, e.g.

- An action is considered to have an adverse impact on the conservation objectives of a designated site such that the site integrity itself is compromised, and mitigation will not prevent the adverse impact.
- The action introduces a risk of pollution to groundwater that is deemed to be unacceptably high and cannot be mitigated.

Adverse impacts on natural or the built environment do not necessarily mean an action should be screened out at this stage as a sensitively designed action may be able to mitigate adverse impacts or provide benefits to the environment. Assessing wider positive and adverse impacts is considered again later in the appraisal process (see section 6.5.4).

6.3.6 Economic feasibility

The screening for economic feasibility aims to remove any actions where the costs of the action are clearly disproportionate to the benefits. This may be done using professional judgement or by making a relatively rapid assessment of costs (lower range of the whole life cost estimate (section 6.5.5)) and benefits (flood damages avoided to properties (box 6.3 and section 6.5.2)). Great care should be taken not to reject actions that can deliver significant flood risk reduction benefits to other receptors or actions that also deliver wider social, environmental and/or economic benefits.

Where it is obvious that the action will incur significant additional costs, this can be considered as part of the screening, e.g.

- 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.

Box 6.3 Damages

Annual average damage (AAD)
The annual average damage is the estimated average flood damage per year over a very long period of time. It is based on estimates of the likely damages from a flood of a particular depth, rather than actual observed damages at any given location. To calculate AAD, the appraiser will require estimates of the depth of flooding during a number of flood events (of differing probabilities).

Reference: Penning-Rowsell et al. (2013) Flood and Coastal Erosion Risk Management: A Manual for Economic Appraisal. Flood Hazard Research Centre, University of Middlesex.

Scottish Pluvial Annual Average Damage Estimates (SPAADEs)
Where there is no reliable estimate of the depth of flooding, SEPA's Scottish Pluvial Annual Average Damage Estimates (SPAADEs) should be used. These figures provide an estimate of the average pluvial flood damages to an individual property per year.

For a residential property, the SPAADE is £1,116; for a non-residential property, the SPAADE is £1,692. These values are lower than the corresponding values (Weighted Annual Average Damage) used to estimate fluvial flood damages. This reflects the differing characteristics of pluvial flooding, which is often shallower and more localised than fluvial flooding.

Reference: SEPA (in preparation) Flood Risk Management Appraisal Methodology – update from v1.

6.4 Shortlist of actions: Developing options

The screening exercise will have removed any unfeasible actions from the long list, leaving a shortlist of actions for further assessment. This shortlist of actions should be used to build up viable options to meet the objectives of the SWMP.

'Do minimum' option
The starting point will be to develop a 'do minimum' option, against which the 'do something' options will be compared. The 'do minimum' is the minimum required actions to adhere to statutory duties and responsibilities e.g.:

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

The 'do minimum' option is an appropriate baseline to use where 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 assumes that the baseline model drainage capacity (e.g. 1:5 year drainage capacity for 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 are replaced.

Under the 'do minimum' option, flood risk is likely to increase over time due to climate change, urban creep and new development (section 6.5.3).

'Do something' options
'Do something' options will build on the do-minimum option. The 'do something' options should be developed by initially looking for opportunities to use non-structural actions and best-practice actions that seek to manage water at source or on the surface (e.g. retro-fitting SUDS, flow reduction strategies, deculverting, land management) (see appendix 6 for list of individual actions) in the first instance, in preference to more costly and complex below ground solutions

'Do-something' options may include one or more of the following types of actions (see table 11):

A. Non structural (e.g. actions related to development planning, self help, property level protection, changing maintenance regimes)
B. Managing water at source (e.g. land management, retrofit SUDS)
C. Managing water on the surface (e.g. exceedance flow management)
D. Managing water underground, including improving conveyance (e.g. larger sewers and drains) and providing under-ground storage (e.g. tanks).

Options should be identified using an iterative process to build up viable options to meet the flood risk management objectives. Table 11 provides a simple illustration, where adding complexity and more features might reduce flood risk but add to cost. The purpose of appraisal is to identify the best balance between the outcomes.

Table 11: Illustration of building up options

Option	Minimum	A	B	C	D	Flood risk	Costs
Do minimum: baseline	✓					Increasing ↑	Increasing ↓
Do something 1	✓	✓					
Do something 2	✓	✓	✓				
Do something 3	✓	✓	✓	✓	✓		

6.5 Describing and valuing the costs, benefits, and wider positive and adverse impacts

6.5.1 Framework

The options should undergo a robust and transparent appraisal of costs and benefits, positive and adverse impacts. It should inform decision making (rather than dictate it), and provide evidence of a sound decision making process.

Components for the appraisal
The following components will be required:

1. Assessment of impacts on flood risk (section 6.5.2):
2. Assessment of adaptability to climate change and other drivers of future flood risk (section 6.5.3);
3. Assessment of wider positive and adverse impacts (section 6.5.4);
4. Estimate of whole life costs of the option (section 6.5.5);
5. Assessment of uncertainty in costs and benefits (section 6.2).

The appraisal should be carried out for each option as a whole. In addition, information on the costs and impacts of individual actions should be provided. The summing of costs and impacts for whole options will require some degree of judgement, as varying levels of detail may be available for individual actions.

Valuing impacts

The flood risk impacts and wider impacts should be described, and where appropriate / possible, assessed in quantitative or monetary terms. There are advantages to estimating the impacts in monetary terms: these impacts can be readily compared with whole life costs to estimate the likely return on investment by calculating net present values and benefit-cost ratios (section 6.6).

However, some impacts can be difficult to value on monetary terms and/or may require a disproportionate effort. It is therefore crucial that significant impacts that are not valued in monetary terms are always described, quantified (if possible) and brought into the appraisal through appraisal summary tables (section 6.7). Understanding these impacts is critical to selecting sustainable options and they should not be ignored simply because they are difficult to value.

The decision as to whether to try to quantify or monetise the assessment therefore depends on:

- proportionality (relatively to complexity of problem and the information required to enable the preferred option to be identified)
- availability and robustness of data
- availability and robustness of a methodology

Determining a proportionate approach can be largely dependent on the level of expertise of the appraisers, which is essential to recognise and record.

Setting boundaries for the appraisal

The objectives may seek to manage flood risk at different scales, from individual problem sites within each SWMP or a whole area within each SWMP, or at a district or national scale. It may also include coordination of options from more than one SWMP, for example property level protection from surface water flooding as a regional or national option. The SWMP partnership should therefore agree the boundaries for the appraisal. As a minimum the appraisal should include the zone of influence of the option. Other scales may also be desirable: e.g. local authority boundary where this information may be important when determining funding.

The boundaries for SWMPs will not necessarily be the same as the boundaries for the Potentially Vulnerable Areas (PVAs). However, the implementation plan set out in the Local Flood Risk Management Plan will seek to address all sources of flood risk (surface water as well as river and coastal) and will be assessed at a PVA level. It is therefore important to record which PVA(s) will benefit from surface water management options but it is not necessary to recalculate the costs and benefits for PVA boundaries.

To enable comparisons of options (within the SWMP and with all flood risk management options in the Flood Risk Management Strategies and Local Flood Risk Management Plans), a 100 year appraisal period should be used. If the anticipated lifespan of an option (or one of the actions that makes up the option) is less than 100 years, the appraisal should assume that capital maintenance occurs to make the lifespan up to 100 years and this recurring cost is included within the appraisal (e.g. the replacement of 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.

6.5.2 Assessing impacts on flood risk

Guidance is provided here on how to estimate the impacts on flood risk of different options. The impacts are the economic and social damages caused by flooding. The benefits of the 'do something' options are presented as the difference in flood impacts compared to the impacts under the 'do minimum' baseline.

A risk based approach should be used for selecting the flood risk impact method. Four approaches are proposed, which progressively add greater certainty to the assessment but require more detailed analysis at each stage (table 12).

The choice of approach (fig. 10) 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
- The type of action.

Table 12: Approaches for assessing flood risk impacts

Approach	Description	Effort / Resources	Confidence in outputs
1. Simple	Simple and pragmatic assessment of the number of properties removed from flood risk. Economic benefits assigned using the Scottish Pluvial Annual Average Damage Estimates (SPAADEs; see box 6.3) per property.	Increasing ↓	Increasing ↓
2. Map-based	Mapping based approach utilizing SEPA pluvial baseline appraisal maps and data (chapter 5). Expert judgement is used to assess the standard of protection.		
3. Simplified modelling	Simplified modelling approach based on re-simulations (by the SWMP partnership) of the SEPA regional pluvial model data, varying assumptions regarding drainage capacity, runoff coefficients or digital terrain model (DTM).		
4. Detailed modelling	Detailed modelling approach based on more detailed modelling that may be available e.g. integrated urban drainage modelling and the explicit modelling of actions and their effect.		

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, the replacing of a screen that is less susceptible to blockage may ensure proper operation of a culvert and essentially remove the risk of flooding from four properties.

Approach 2: Map-based
This approach is makes most use of existing flood damage data and does not require additional modelling or mapping. It uses professional judgement to estimate the effectiveness of an option and links it to a standard of protection. For example, professional judgement may estimate that changes to maintenance regimes may improve drainage to achieve no flooding in the 1:30 year event.

It is suitable for many situations where the SEPA's regional pluvial mapping is a fair representation of likely flooding. It may also be suitable where SEPA's regional pluvial models have been amended and re-run to recalculate baseline flood risk (chapter 4). A worked example is provided in appendix 7.

Approach 3: Simplified modelling (using SEPA regional pluvial models)
This approach requires re-simulation of SEPA's regional pluvial models to estimate the effectiveness of an option. It is suitable where SEPA's regional pluvial mapping is a fair representation of likely flooding, and also where SEPA's regional pluvial models have been amended and re-run to recalculate baseline flood risk (chapter 4). The effectiveness of certain options can be modelled and remapped by adjusting parameters in the pluvial models (see section 4.3.2). Flood damages should be recalculated using the principles in SEPA's appraisal method[2].

For example, drainage capacity can be increased locally to simulate the effect of an improved drainage system providing a 1 in 10 year or 1 in 30 year standard of protection. Runoff coefficients can be varied locally to account for the use of permeable surfaces or green space within urban neighbourhoods. Local topographical changes (such as high kerbs or bunds) can be represented by altering the Digital Terrain Model (DTM).

Approach 4: Detailed modelling
This allows for the most comprehensive representation of options and requires an experienced modeller and engineer to work together. It applies where more detailed models (e.g. integrated urban drainage model) are required to replicate known flood mechanisms and achieve good agreement between observed and modelled floods. These models are likely to have been developed earlier in the process to establish the study area for the SMWP (see chapter 4).

A detailed model can be used to optimise the effectiveness of combinations of actions in options including detail such as: the capacity of individual sewers and storage areas; the management of flow moving across the surface; the effect of source control at a property level. Flood risk impacts should be estimated using SEPA's appraisal method or other locally agreed methods which enable an estimate of flood management impacts.

[2] SEPA (2013) Appraisal Method for Flood Risk Management Strategies v1. www.sepa.org.uk

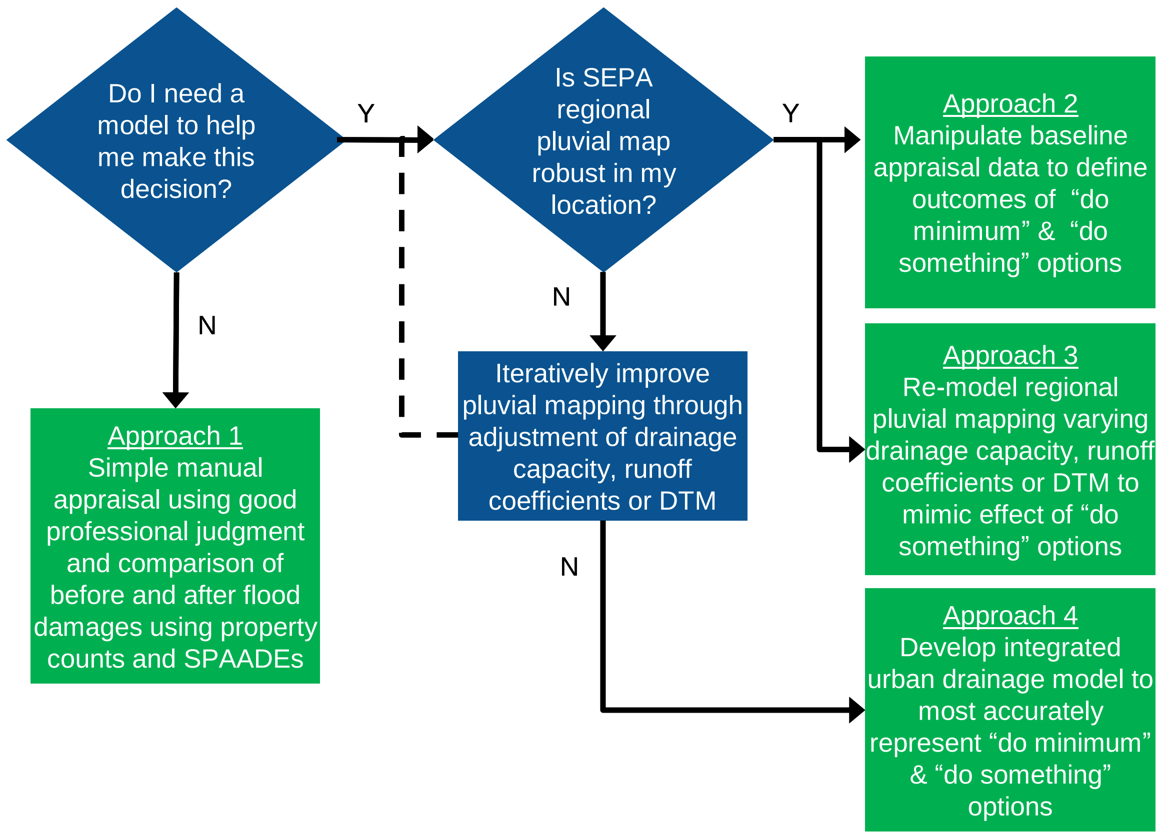

Figure 10. Flow chart to support the selection of an appropriate technique for assessing flood risk impacts

Economic and social flood risk indicators

There are a range of social and economic indicators that can be used to appraise the flood risk impacts of options. The risk based approach described above can be applied to help decide whether (and how) to assess the impacts on different receptors.

For a simplified approach (e.g. approach 1), the flood risk impacts can be quickly and simply expressed based on numbers of properties (or other receptors) removed from flood risk. The assessment of economic impacts may be limited to use of the Scottish Pluvial Annual Average Damage Estimates (SPAADEs) per property.

Where SEPA pluvial models are used (approaches 2 and 3), it is anticipated that the range of indicators used will reflect those used in the SEPA pluvial baseline appraisal (table 12).

Significant flood risk impacts (e.g. benefits to human health through reducing the stress and anxiety) that have not been quantified should be described.

Locally agreed methods to estimate flood risk management impacts (approach 4) may choose to report a different range of impacts, or may choose to report a greater range of impacts in monetary form. Further guidance on determining a proportionate approach can be found in Scottish Government (2011) Sustainable Flood Risk Management – Principles of appraisal: a policy statement (www.scotland.gov.uk/Publications/2011/07/20125533/0); and Scottish Government (in preparation) Appraisal for Flood Risk Management: Guidance to support SEPA and the Responsible Authorities.

The economic indicators will be represented as an estimate of the economic cost of the damages caused by flooding. The economic benefits of any option are presented as the difference in Annual Average Damages of a 'do something' option compared with the 'do minimum' baseline (appendix 7). Net present value and benefit-cost ratios are then used to assess the balance of benefits and costs over a longer period (section 6.6).

Table 12: Flood risk indictors assessed in SEPA's pluvial baseline appraisal

Category[3]	Receptors	Flood Risk Indicators	Applied to:
Economic	Non residential properties	Direct economic impacts expressed in monetary damages (£s)	National and Regional models
	Residential properties	Direct and indirect economic impacts expressed in monetary damages (£s)	
	Transport	Direct damages to transport (road) infrastructure (£s)	Regional models only
	Vehicles	Direct damages to vehicles (£s)	
	Emergency Services	Additional assessment of indirect impacts expressed in monetary damages (£s)	
Social	Human Health	Social vulnerability score for residential properties	National and Regional models
	Community Facilities	Count of community facilities by type	
	Utilities	Count of utilities by type	
	Transport	Length of roads and rail flooded Count of airports flooded	
	Cultural Heritage	Area or count of cultural heritage sites flooded	

6.5.3 Adaptability to future flood risk

Considering surface water management options against future change in flood risk is essential to be able to select sustainable actions that will stand the test of time. Drivers of future change include climate change, urban creep and demographic change. Each option should be assessed on its adaptability to climate change and other factors that the SWMP partnership considers may significantly affect future surface water flood risk.

Because of the uncertainties in future projections of climate change, urban creep and demographics, wherever possible, it is preferable to design actions that can be adapted in future rather than to design for climate change and other changes up front. However, this may not be possible for large one-off interventions, where building in climate change and other future adaptations at the start might be the only option.

[3] SEPA's pluvial appraisal baseline does not include an assessment of flood risk impacts to the environment

A short description of the level of intervention, the costs and feasibility associate with ensuring the action can respond to changing conditions should be provided (table 13). It may be helpful to present this information as a class or score within any appraisal summary table.

Further guidance can be found in appendix 8.

Table 13 Adaptability to future flood risk	
Drivers	**Assessment may include:**
Climate Change Adaptation and adaptation to other future flood risks	• Describe impacts on adaptability to climate change - whether an option enables natural systems to adapt to a future changing climate, e.g. changes in rainfall patterns. Each option will be assessed on its adaptability to climate change. • Describe impacts on adaptability to other future flood risks; urban creep and demographic change. • In addition, information on the level of intervention, costs and feasibility associated with ensuring the option can respond to changing flood conditions will be taken into account.

6.5.4 Assessing wider positive and adverse impacts

In addition to the flood risk impacts (section 6.5.2), impacts of the option on the wider economy, society and environment should also be assessed. These wider impacts are the impacts arising from a particular option that are not related to changes in flood risk. For example, improvements to water quality would be considered a wider impact, whereas health benefits (and subsequent savings) arising from reducing the exposure of people to flooding would be considered a flood risk impacts. Understanding these wider impacts is important to finding sustainable options and achieving multiple benefits. It is therefore essential that such impacts are identified and assessed alongside flood risk reduction benefits.

The assessment should focus on those impacts that are likely to be significant and have the potential to affect decision making. The following points may help to determine which impacts to assess and how to assess 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 well as 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, positive or adverse impact) of change?
- Will the option help to address potential future economic, social and environmental pressures (such as the drivers identified in appendix 8)?
- How important is the receptor that is impacted: is it locally, regionally, nationally or internationally important?
- Do impacts occur along the flow pathway?
- How long will the impact last[4]?
- How important are the significant impacts likely to be to local stakeholders and communities?
- Are the impacts important enough to affect the final decision?

[4] In some cases, it may be deemed to be acceptable to incur some temporary adverse environmental impacts whilst the programme of works is implemented.

Deciding which impacts to assess (and how) should be agreed in advance by the SWMP partnership. The approach should be proportionate and risk based – for example, simple small scale options are unlikely to require an extensive assessment whereas, large and complex options may require a more detailed consideration. Table 14 focuses on the types of impacts most likely to arise from surface water management and further information can be found in appendix 9. The guidance does not provide an exhaustive list and other significant impacts (e.g. impacts on the historic environment) must also be identified and described.

The wider impacts will be usually described in a non-monetised manner and in a short descriptive statement, rather than being quantified in detail. In general, these impacts may not be suited to or can be difficult to define in monetary terms. However, appraisers may choose to monetise some impacts if approaches are readily available and it is deemed important to do so by the SWMP partnership.

Where helpful, SWMP partnerships may decide that it is helpful to use a simple classification or scale to summarise the wider impacts relative to the 'do minimum' option.

Table 14 Likely significant wider positive and adverse impacts of SWMPs

Receptor	**Assessment may include:**
Human Health	• Describe significant impacts relating to making better places for people to live (e.g. recreation, outdoor access, wildlife watching opportunities) Describe significant impacts on opportunities to promote healthy lifestyles. This should include consideration of both the physical and mental health benefits of access to greenspace and promotion of active travel
Economy	• Describe the potential for providing wider economic benefits e.g.: - enhancing local economic opportunities by improving urban amenity - enabling redevelopment by freeing up capacity in waste water systems - reducing water purifying and treatment costs
Water (esp. water quality and hydromorphology)	• Describe significant impacts on the water environment • Identify any opportunities to help achieve WFD Objectives (for example, to restore habitat / straightened channels, open up culverts, or reduce the frequency of Combined Sewer Overflow spills) including preventing deterioration of the water environment (for example, by avoiding an increase in the frequency of Combined Sewer Overflow spills in future) • Describe significant impacts on other objectives and natural processes not captured under WFD (e.g. bathing water quality)
Biodiversity, Habitats and Species	• Describe any significant impacts on habitats and species, such as degradation of habitats or improvements to habitat connectivity • Describe significant impacts on ecosystem health
Climate change mitigation	• Describe whether the construction of the option gives rise to greenhouse gas emissions during the construction and subsequent maintenance / repair stages (e.g. through use of building materials, construction traffic etc or change in land use) • Describe any positive longer term reduction in greenhouse gas emissions (e.g. through reducing water treatment or pumping)
Any other relevant impacts e.g. air quality	• This is not an exhaustive list: any other significant relevant impacts should be assessed

6.5.5 Whole Life Costs

Whole life costs are the total costs of an option over its whole life. They takes account of design costs, initial capital costs (including mitigation), operation, maintenance and repair, and (where significant) disposal. 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 taken now.

The whole life cost will be expressed in Present Value (PV) terms. They 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). The discount rate that will be used to determine Present Values will be assigned according to the social time preference discount rate as recommended in HM Treasury Green Book. This is for a discount rate of 3.5% to be used for years 1 to 30; a discount rate of 3% to be used for years 31 to 75; and a discount rate of 2.5% to be used for years 76 to 100.

Allowing contingency for cost overruns and optimism bias

When estimating costs, contingencies needs to 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 at an early stage of consideration (including strategies). At the more detailed project stage, a figure of 30% is more 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 recommendation is that final whole life costs should be subject to sensitivity testing in relation to key variables including levels of capital costs; duration of works; and levels of operating costs.

Information on whole life costs

The approach to estimating whole life costs should be risk based and proportionate: in some cases, professional judgement may be sufficient, whereas in others, a more detailed estimate may be required (table 15). Appraisers should select the most appropriate source of information, including the sources listed below and costs from previous studies and works (e.g. estimates from Local Authority departments). The source of the cost estimates should be recorded.

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

Table 15: Potential sources of information on whole life costs

Type of estimate	Examples	Effort / Resources	Confidence in outputs
Expert judgement	Local Authority or Scottish Water officers; Consultants	Increasing	Increasing
Strategic estimates	JBA (2013) Costs of flood risk management actions. Report commissioned by SEPA (contact: flooding@sepa.org.uk).		
Previous studies and works	Local Authority Departments		
Detailed estimates	SUDS Working Party (2012) SUDS for Roads Whole Life cost tool www.scotsnet.org.uk/best-practice.php		

6.6 Calculating the Benefit-Cost Ratio

Benefit-cost ratios are a way of expressing benefits as a ratio of costs, and can be used to examine the relative return of an option for every pound spent. It is the Present Value of all benefits divided by the Present Value of all costs (box 6.4).

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. However, appraisers should always give due consideration to significant non-monetised impacts as these are important for identifying sustainable solutions. The benefit-cost ratio should therefore not be the sole criterion for decision making (see chapter 7).

Box 6.4 Comparing costs and benefits

Present Value The value of future costs or benefits, in present day terms. The future costs or benefits are converted to present day terms by using a discount rate.

Net Present Value (NPV) identifies the net benefits of an option to demonstrate whether the economic benefits outweigh the costs, and the magnitude of the benefits. It is the present value of the benefits minus the present value of the costs.

Benefit-cost analysis (BCA) examines the relative return on investment for every pound spent. It is the present value benefits divided by the present value costs. Assuming all benefits and costs are monetised, projects and strategies are only economically worthwhile if the benefits exceed the costs (the ratio of benefits to costs is greater than one).

References: Scottish Government (in preparation) Appraisal for Flood Risk Management: Guidance to support SEPA and the Responsible Authorities; HM Treasury (2003) The Green Book: Appraisal and Evaluation in Central Government

6.7 Summarising the costs, benefits and wider impacts of each option

The information generated for each option will be presented in appraisal summary tables. The flood risk reduction benefits will be calculated across several flood events of varying return periods and presented as an Annual Average Damage value. The benefits will also be presented to show predicted impacts during target flood events.

The impacts should be calculated and presented for specific target areas (e.g. SWMP area) as well as for the whole zone of influence of the option. This enables the SWMP partnerships to judge the effectiveness of the option in meeting specific objectives of the SWMP, and to take into account other significant wider impacts (both positive and negative).

The purpose of the appraisal summary tables is to allow decision makers to select the most sustainable option to achieve the objectives set at the start of the appraisal process, i.e. objectives of the SWMP (or those set by the Flood Risk Management Strategies and Local Flood Risk Management Plans). The decision will be based on the information presented in the appraisal summary tables and supporting documents, and should be clearly documented with reasoning and justification provided.

Appendix 6 Long list of actions

Table A6 Potential actions to address surface water flooding	
Action	**Description**
NON-STRUCTURAL ACTIONS	
National planning policy and planning advice notes	Adherence to statutory requirements: ▪ Scottish Planning Policy; ▪ Planning Advice Note 61 – Planning and Sustainable Urban Drainage Systems ▪ Planning Advice Note 69 – Planning and Building Standards Advice on Flooding ▪ Planning Advice note 79 – Water and Drainage
Planning regulations, circulars and protocols	Adherence to statutory requirements for flood risk and drainage: ▪ SEPA Planning Authority Protocol (Policy 41) ▪ SEPA interim Statement on Planning and Flooding ▪ The Town and Country Planning (Development Management Procedure) (Scotland) Regulations 2008 – Schedule 5.1.1 ▪ Development Planning Circular 6/2013 – Paragraphs 32 and 57 / Regulations 3 and 10 ▪ Water Environment (Controlled Activities) (Scotland) Regulations 2011 (as amended) (sets out the general binding rules that dictate SUDS requirements.)
Strategic Development Plans – Policies	Adherence to recommendations and statutory requirements in SEPA Land Use Planning System (LUPS) Guidance Note 11
Local Development Plan - Policies	Adherence to recommendations and statutory requirements in SEPA Land Use Planning System (LUPS) Guidance Note 11 Develop LDP policies with: ▪ Reference to SEPA land use vulnerability framework (LUPS GU24) ▪ Inclusion of set-aside of land within allocations for Green / Blue Corridors. ▪ Inclusion of SUDS ▪ Allocation of land for strategic SUDS in larger urban areas (i.e. those requiring a master plan).
Strategic Flood Risk Assessment	Promote use of Strategic Flood Risk Assessment (as set out in SEPA LUPS 23 and LUPS11) for both Strategic and Local Development Plans.
SEPA procedures for Development Planning and Management consultation	Adherence (by SEPA) to procedures on responding to development allocations and applications within the low and medium probability extents of the surface water hazard maps.
Monitoring of number of properties at risk (from pluvial flooding)	Monitoring of properties at risk
Relocation of receptor	Relocation of properties / infrastructure away from flood risk areas
Emergency Response plans	Use information of surface water flood risk to improve emergency plans e.g. identify emergency routes on roads not at risk of surface water flooding.

Table A6 Potential actions to address surface water flooding	
Action	**Description**
Self help actions: ▪ Business continuity planning ▪ Flood insurance ▪ Community flood actions groups and resilient community plans ▪ Awareness raising	Self help actions can help ensure people, communities and businesses are prepared for flooding, know what action they can take, and can recover more quickly after flooding.
Site protection plans	Development of plans to protect individual sites (e.g. trunk roads, railways, airports, cultural heritage sites, utilities). Should be developed in collaboration with site owners / managers.
Property level protection	Temporary, demountable defences at the property level
Resilient property design (retrofit)	Flood resilient building materials and methods of construction
Asset management and maintenance	Changing the existing inspection and maintenance of urban burns, culverts, SUDS, sewers and road drainage.
Flood forecasting and warning	Further development of surface water flood forecasting, alerts and warning schemes
Improved Understanding	Modelling and other assessments to improve knowledge of flood hazards and impacts Identification of development sites constrained by surface water flood risk
MANAGING WATER AT SOURCE	
Retrofit SUDS	Retrofitting SUDS to reduce the rate and volume of surface water run-off. This may include: - Individual SUDS actions - Strategic implementation of retrofitting e.g. in priority drainage areas - Opportunistic implementation of retrofitting e.g. policies that will ensure opportunities to retrofit are taken when they arise. - Retrofitting SUDS alongside other actions as part of a wider strategy to separate surface water run-off from the combined sewerage system.
Agreement between responsible authorities adoption of new and/or existing SUDS	This may include review of responsibilities and policy development for adoption of new SUDS and /or adopting existing (legacy) SUDS
Land management	Runoff from more rural areas can contribute significant flows to drainage systems and watercourses that can impact roads and areas further downstream. Land management actions that reduce the rate and volume of runoff should be considered.
MANAGING WATER ON THE SURFACE	
Surface water storage areas (above-ground)	Safe above-ground storage of water (e.g. permanent ponds, temporary sacrificial areas such as parks or recreation areas) from surface runoff from the urban area
Deculverting / river restoration	Deculverting and restoring urban watercourses
Watercourse storage (on-line or off-line)	Storage in urban burns, especially in areas where urban burns enter the sewer system (May be combined with deculverting and restoration of watercourses)

Table A6 Potential actions to address surface water flooding	
Action	**Description**
Managed overland flow pathways	Creating flow routes or using the road network as a flow pathway to control surface water flow through the urban environment
MANAGING WATER UNDERGROUND	
Storage tanks (underground)	Diverting surface water to storage tanks or by providing storage within the drainage network.
Increase size of drainage pipes (roads and sewer)	Increasing the capacity of the underground drainage pipes.
REFERENCE MATERIAL	

- Scottish Government 2011 Green Infrastructure: Design and Placemaking www.scotland.gov.uk/Publications/2011/11/04140525/0
- Glasgow and Clyde Valley Green Network web-based guidance on Integrating Green Infrastructure and case studies www.gcvgreennetwork.gov.uk/igi/introduction
- CIRIA publications www.ciria.org
  - CIRIA 2006 C635 Designing for exceedance in urban drainage: good practice
  - CIRIA 2014 C728 Managing urban flooding from heavy rainfall – encouraging the uptake of designing for exceedance
  - CIRIA 2007 C697 The SUDS manual
  - CIRIA 2012 C713 Retrofitting to manage surface water

Appendix 7 Example of estimate flood risk damages to properties

This example illustrates a simplified method for estimating the flood damages avoided when implementing an option to reduce the probability of flooding to an assumed level or ‘standard of protection’. The approach does not require further modelling. It is an example of ‘approach 2’ described in Section 6.4.2. It uses the baseline appraisal information derived from regional pluvial mapping undertaken by SEPA.

Figure A6.1 is an example output from regional pluvial mapping showing flood extents from the 30 and 200 year return period rainfall events. Coloured dots indicate the residential properties at risk from surface water flooding.

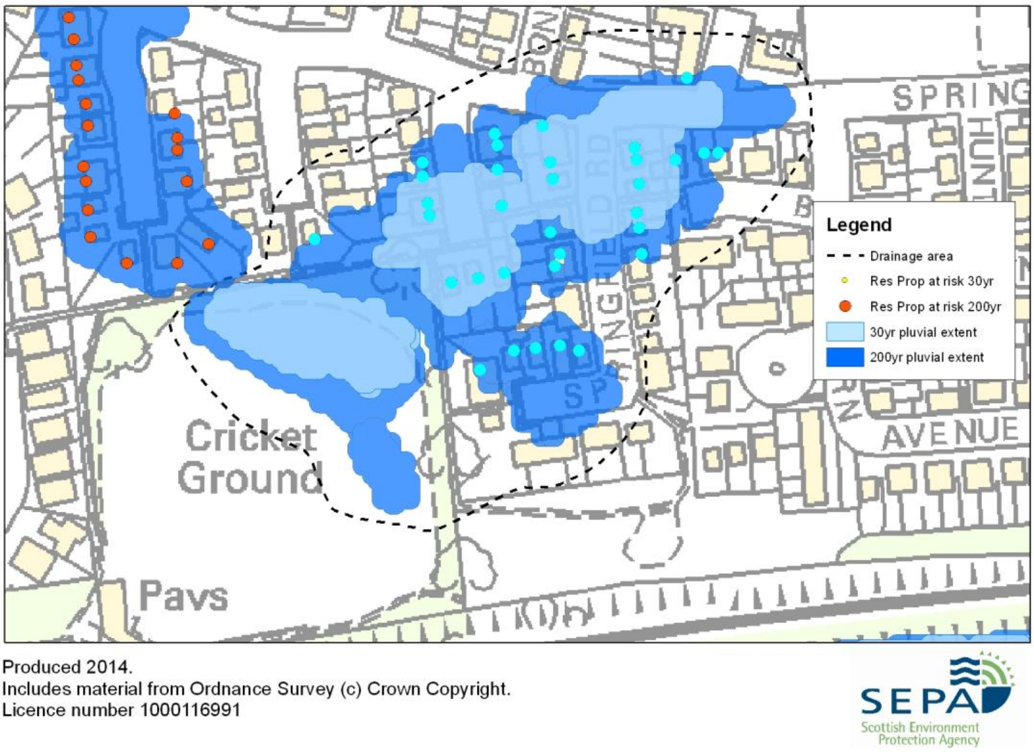

Figure A7.1 Properties predicted to flood in regional pluvial flood map

Table A7.1 is an extraction from the baseline appraisal information which summarises the direct flood damages[5] for 33 properties mapped in Figure A7.1. 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 gives the total Annual Average Damage. The baseline Annual Average Damage across this area is £49,225. In the baseline situation all properties flood in the 200 year event but only 13 flood in the 10 year event.

[5] Indirect damage data are also available and can be included in this calculation. Damages include the impact on vehicles, emergency services and the costs of drying flood damaged homes.

Table A7.1. Illustration of calculating baseline Annual Average (direct) Damage from baseline appraisal information						
Building Reference	**Direct damages**					**Annual Average (Direct) Damage**
	10 year	**30 year**	**50 year**	**100 year**	**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**	**£394,246**	**£606,926**	**£783,774**	**£1,015,731**	**£49,225**
Count of properties flooding	13	15	24	24	33	

Step 2 requires the planner (working collaboratively with partners) to understand likely flood mechanisms and propose a 'standard of protection' which would be achievable with a flood risk management option. Engineering judgment and experience should be used to make this determination.

In the example, it is proposed that local improvements to highway drainage maintenance and the capacity of the sewer network are required to delay the onset of flooding at all properties until after the 1 in 30 year event. In this simplified methodology a new direct damage is calculated by removing the 1 in 10 and 1 in 30 year damages from the calculation. The effect is illustrated in Table A7.2 which shows the impact of this change. The revised total Annual Average Damage is now reduced to £21,157. Note how the simplified approach conservatively assumes that the impact of less frequent floods remains unaltered.

Table A7.2 Illustration of calculating Annual Average (direct) Damage for a flood risk management option by manipulating baseline appraisal information

Building Reference	Direct damages					Annual Average (Direct) Damage
	10 year	30 year	50 year	100 year	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**	**£606,926**	**£783,774**	**£1,015,731**	**£21,157**
Count of properties flooding	0	0	24	24	33	

Box A7.1 Calculating Annual Average Damage

The formula for calculating Annual Average Damage (AAD) at each property from these 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:

DDMG10, 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 and the formulae can be pasted from this guidance directly into a spreadsheet to complete calculations.

Appendix 8 Adaptation to future flood risk

A8.1 Introduction

This appendix provides further guidance on appraising adaptability to changes in future flood risk.

The following sources provide additional information:

- Metropolitan Glasgow Strategic Drainage Partnership (2011) Climate Change Technical Guidance (www.mgsdp.org/index.aspx?articleid=2016)
- Scottish Government (2011) Delivering Sustainable Flood Risk Management: www.scotland.gov.uk/Publications/2011/06/15150211/0
- JBA (2013) Costs of flood risk management actions (Report commissioned by SEPA; contact: flooding@sepa.org.uk). Contains an assessment of adaptability of flood risk management actions to climate change.

A8.2 Climate change

The Climate Change (Scotland) Act 2009 places duties on public bodies, when exercising their functions, to act in the way best calculated to deliver any statutory adaptation programme. Specific actions for the water sector are set out in the sector action plan[6].

One indicator of potential future climate change impacts can be gained by comparing the current flood risk with a future scenario based on a notional climate change uplift. For example, the SEPA pluvial mapping has generated two climate change scenarios: the 1:30 year and 1:200 year events at the 2080 time horizon (based on a national peak rainfall uplift of 20% (67th percentile) in accordance with Defra 2006 guidance[7]). Key flood risk indicators (e.g. number of properties at risk within flood extent) can be estimated under the climate change scenarios and compared with the current day flood risk estimate.

This information can be used to:

- Identify the sensitivities of different areas and flag up highly susceptible areas that might warrant more detailed study later on to fully the define climate change benefits profile;
- Identify appropriate adaptation responses;
- Facilitate selection and prioritisation of options – for example, greater importance should be placed on adaptability for options in an area with high sensitivity to climate change.

Note that current climate change uplift factors do not fully represent the high intensity rainfall events which are characteristic of pluvial flooding, so the scenarios recommended in the Defra 2006 guidance may underestimate future risk. Emerging science suggests the actual uplift in the 2080s may be much higher[8] and this will

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[6] Scottish Government Water Environment and Resource Sector Action Plan: www.scotland.gov.uk/Topics/Environment/climatechange/scotlands-action/adaptation/AdaptationFramework/SAP/WaterResourceManagement

[7] http://archive.defra.gov.uk/environment/flooding/documents/policy/guidance/fcdpag/fcd3climate.pdf

[8] Kendon, E. J., Roberts, N. M., Fowler, H. J., Roberts, M. J., Chan, S. C. and Senior, C. A. (2014) Heavier summer downpours with climate change revealed by weather forecast resolution model. Nature Climate Change 4: 570 - 576. DOI: 10.1038/nclimate2258.

inform future guidance on uplift factors. It is important to consider exceedance flows in more detail only where the solution demands very high precision.

It is also possible to estimate how frequently a modelled flood event might occur in future under climate change. The approach is being used by SEPA in the strategic appraisal of river and coastal flood risk options[9]. For very complex situations, including interactions with river and coastal waters, and for more detailed stages of design, remodelling may be required to better estimate the likely climate change impacts. This is beyond the scope of this guidance.

A8.3 Urban creep

Urban creep can make a significant contribution to increases in surface water flooding; therefore options (and costs) should be developed with consideration of additional allowance for urban creep. A strategic level of appraisal should describe the extent to which urban creep might occur in the study area, the likely impacts on flood risk, and whether the preferred option is still the most sustainable if flooding increases due to urban creep.

Published data on urban creep rates include:

- UKWIR[10]: average rates of urban creep in sample English cities were between 0.4 and 1.1m2/house/year
- Wright et al.[11]: a near quadrupling of the area of impermeable hardstanding in three typical residential areas of Edinburgh.

Remodelling can be undertaken to estimate the impacts of urban creep on flood risk, but for strategic level studies this is unlikely to be required. A fixed percentage increase could be considered - for example, the CIRIA (2007) SUDS Manual recommends adding 10 per cent allowance in hydraulic design for 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, and this can be taken into account.

If remodelling is undertaken to estimate the impacts of urban creep on flood risk, the approach is likely to involve increasing the impermeable area in the model. An appropriate value should be agreed with the SWMP partnership, for example, based on the published data or on assumptions used by Scottish Water[12] (10% increase in additional paved surface area for design of sewerage infrastructure).

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[9] SEPA (in preparation) Flood Risk Management Appraisal Methodology – update to V1.

[10] 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 www.ofwat.gov.uk/sustainability/climatechange/rpt_com201106mottmacsewer.pdf

[11] Wright, G. B., 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

[12] Scottish Water / WRc (2007) Sewers for Scotland – a design and construction guide for developers in Scotland. Second edition. WRc / Water UK. www.scottishwater.co.uk/business/connections/connecting-your-property/sewers-for-scotland-and-suds/sewers-for-scotland-2nd-edition

A8.4 Demographic change

Between 2012 and 2037, the number of households in Scotland is projected to increase by 23 per cent and the population to increase by 17 per cent[13]. These national changes (and regional variations) may significantly influence future flood risk. The relationship is not straightforward, however, as factors such as planning policy, development planning and development management will interact with demographic change to influence flood risk[14].

A strategic level of appraisal should describe how household and population are likely to change in the area (using information from the General Register Office for Scotland, and Local Authority Planners).

This information can be used to:

- Identify areas that are likely to experience greater growth in households / population or those areas marked for development.
- Facilitate selection of options – for example, where supplementary land use planning actions are likely to deliver the most benefits, or retrofit SUDS to help relieve pressure on waste water systems.
- Prioritise adaptable actions –for example, actions that can be easily adapted in future (as identified through climate change adaptability assessment) may be preferable for areas likely to experience greater population growth.

[13] General Register Office for Scotland (2014) Household Projections for Scotland. 2012 – based. www.gro-scotland.gov.uk/statistics/theme/households/projections/index.html
[14] See chapter six of Houston, D., Werritty, A., Basset, D., Geddes, A., Hoolachan, A. and McMilan, M. (2011) Pluvial (rain-related) flooding in urban areas: the invisible hazard. Joseph Rowntree Foundation. www.jrf.org.uk/publications/pluvial-flooding-invisible-hazard

Appendix 9 Further guidance on assessing wider environmental, social and economic impacts

A9.1 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 planning 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:

- Centre for Neighbourhood Technology (2010).The value of green infrastructure - A guide to recognising 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 C697 (2007) The SUDS Manual www.ciria.org

A9.2 Human Health

Surface water management actions can have a number of significant impacts on human health, such as opportunities for improving well-being, recreation and amenity, or the health benefits of water and air quality improvements. (Care should be taken not to double-count any impacts listed under water or air quality.)

An additional aspect for consideration is whether the option provides increased recreation or amenity for deprived neighbourhoods e.g. the lowest deciles of the Scottish Government's Scottish Index of Multiple Deprivation www.scotland.gov.uk/Topics/Statistics/SIMD.

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

A9.3 Economy

Surface water management actions can help to improve asset and environmental capacity, thus enabling sustainable economic growth in areas where development may be limited by capacity. Further information on asset capacity is available from Scottish Water: www.scottishwater.co.uk/you-and-your-home/connecting-your-property/strategic-asset-capacity-and-development-plan

Actions may also help to deliver other economic benefits e.g. reduced costs of water pumping and treatment.

A9.4 Water

The most likely impacts of surface water management actions will be on morphology and water quality objectives of River Basin Management Plans (RBMP) (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 including, where relevant, estuarine and coastal impacts.

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

- Will the impact make a significant change to the length/area of good status (or better) waters? Will cumulative impacts of smaller scale actions contribute to improvements to 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 impacted part of the water environment within a deprived neighbourhood? Impacts within the most deprived neighbourhoods in Scotland should generally be considered more significant than similar impacts within less deprived neighbourhoods.
- How long is the impact expected to last? Longer term impacts should generally be considered more significant than shorter terms impacts of similar scale (e.g. SEPA regulatory guidance[15]).

Options that reduce sewer overflow spills may make a contribution to improving (or preventing deterioration of) water quality in rivers, transitional and coastal waters, and to improving bathing water quality at designated bathing water beaches. The likely magnitude and direction of change should be described – this qualitative approach will be sufficient for the majority of situations. Detailed modelling, in consultation with Scottish Water, would be required to be able to quantify the change.

A9.5 Biodiversity, Habitats and Species

Surface water management actions can help to increase and improve habitats, with subsequent benefits for species and biodiversity. Habitat connectivity and ecosystem health can also benefit. A description of the impacts, including magnitude and direction, is likely to be sufficient to inform decision making.

Note that there are specific legal requirements related to the protection of habitats and species, and these 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 may also help identify local biodiversity priorities: www.biodiversityscotland.gov.uk/area/lbaps/partnerships.

A9.6 Climate change mitigation

The Climate Change (Scotland) Act 2009 sets targets to reduce Scotland's greenhouse gas emissions by at least 42% by 2020 and 80% by 2050, compared to the 1990/1995 baseline. Public bodies must act in the way best calculated to contribute to delivery of the Act's emissions reduction 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, for example through energy used for maintenance or pumping, or through changes to land use and

[15] SEPA WAT-SG-67: Assessing the significance of impacts – social, economic and environmental. www.sepa.org.uk/water/water_regulation/guidance/all_regimes.aspx

carbon sequestration. This qualitative approach is likely to be sufficient 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:

- SUDS Working Party (2012) SUDS for Roads Whole Life cost tool: www.scotsnet.org.uk/best-practice.php

A9.7 Other sources of information

Any other significant wider impacts not captured above must also be described.