Indicators and trends

Monitoring climate change adaptation

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How is climate change affecting flooding of buildings and infrastructure?	Version
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Flooding is already significant and widespread in Scotland. It affects homes, communities and businesses directly, and also disrupts vital services, resource flows and transport networks along with many cultural heritage assets. Floods can cause not only major economic losses, but also disruption and misery to those affected by them.

Estimates of the cost of flood damages to property in Scotland vary from £200 - £250 million per year. Individual flooding events can have a huge cost - losses of £30 million were estimated for the Tay / Earn flood in 1993 and £100 million for the Strathclyde flood in 1994. These events damaged homes, businesses and communities, disrupted transport, and caused local economic losses. Agriculture and the environment may also be affected.

Annual rainfall in Scotland increased by 27% between 1961 and 2011, with an even greater percentage increase in average winter rainfall: 45% nationally, and over 50% in the north of Scotland. There is also evidence of increasing rainfall intensity in this period. Such trends are projected to continue, although the exact magnitude and timing is uncertain. Future increases in the volume and intensity of rainfall have the potential to increase the frequency and severity of pluvial and fluvial floods. Rising sea level, as well as possible increases in storm surge, will increase risk of coastal flooding.

In addition to climate, several factors under the control of individuals, communities and government affect flood risk. These include:

- Planning and land-use (the extent to which communities, property, roads and utilities are sited in areas at risk of flooding). Planning has a critical role to play in ensuring that development is in areas free from flood risk
- Drainage design and capacity, and the use of 'Sustainable Urban Drainage' (SUDS), to ensure that drainage can take the rainfall volumes and intensities predicted for the future
- In urban areas, the extent of hard surfacing rather than porous surfacing
- The use of river catchment management to reduce flood risk (using natural flood management (NFM) to reduce flood intensity and spread)

Adaptation options

National Policy and Guidance

Scotland's approach and management of flood risk is set out in The Flood Risk Management (Scotland) Act 2009 (FRM Act), which promotes joint working between responsible agencies across catchment-based areas.

The FRM Act has required SEPA to develop flood hazard modelling. This is used by SEPA in its advice to planners on development and planning decisions. It has also informed the development of **Scotland's Flood Risk Management Strategies** (FRM strategies) by showing the severity and likely frequency of the flood risk. The FRM Strategies coordinate efforts to tackle flooding. They set the national direction of future flood risk management, helping to target investment and coordinate actions across public bodies. Each of Scotland's 14 Local Plan Districts has an FRM

strategy, which is used as a basis for better decision-making across flood risk management organisations. At present, the FRM strategies include 42 formal flood protection schemes and 134 Flood Protection Studies. The cost of the 42 schemes to date is estimated to be around £235 million. The FRM Strategies will be updated every 6 years.

Local Flood Risk Management Plans are due to be published in June 2016 and will provide local detail about flood management actions from 2016-2021. Both Local Flood Risk Management Plans and the Flood Risk Management Strategies will be updated every six years. It is anticipated that both mid-term and final reviews will be conducted, giving a 3-yearly review cycle.

Scottish Planning Policy sets out a robust policy position for development that could be affected by flooding. Planning authorities are expected to use this to help steer new development away from areas that are at flood risk. A risk framework is to be applied to development and developers should take into account flood risk and the ability of future occupiers to insure development before committing themselves to a site or project, as applicants and occupiers have ultimate responsibility for safeguarding their property.

The Scottish Government's Planning and Architecture Division regularly engages with planning authorities to ensure that flooding is adequately addressed within their development plans in accordance with SPP. This is supported by expert advice provided separately by SEPA. Planning policy also requires authorities to consider the need for robust coastal planning, provision of green networks, climate change mitigation and sustainable development. This will also have some relevance to managing flood risk.

SEPA's FRM Strategies maps should be used for local development planning purposes. Where planning authorities choose not to comply with SEPA's flood risk advice, they may be required to notify such decisions to the Scottish Government. This allows Scottish Ministers to consider whether to call-in the application for their own decision.

Where necessary, enforcement actions (undertaken by the relevant planning authority) should help address any breaches of planning policy, for example the use of non-permeable hard standing where permeable materials should have been used.

Flood Management Options

Management of flood risk may be portrayed as a hierarchy that follows the progression shown below. In general terms, avoidance is preferable to control or mitigation measures. However, avoidance is not always possible so adaptation actions may occur at any of the steps in the flood risk management hierarchy:

Avoid: The use of flood hazard mapping and flood risk assessments to ensure that new developments are sited in areas of low flood risk wherever possible

Protect: The use of flood management and flood protection measures, including flood defences, Sustainable Urban Drainage (SUDS) and Natural Flood Management (NFM)

Prepare: The use of measures such as flood warning systems and emergency planning

All of these approaches are being used in Scotland and are co-ordinated through the FRM Strategies.

Existing Developments

Whilst the planning system can help to address the impacts of flooding on new development, there are many existing settlements that are affected by flooding due to their locations (e.g. on

the coast or next to rivers). To help address this, the Scottish Government is working with key agencies and local authorities on implementation of the 14 FRM Strategies across Scotland.

At an individual site or property level, flood-resilient design and the retro-fit of property-level-protection (PLP - e.g. raised wiring, flood-resilient flooring) can reduce flood damage. There is some uptake of this in Scotland. Utility service providers are required to devise, develop and fund their own flood management plans and site-level protection for their assets (for example power stations, water treatment works).

At the community or settlement level, flood warnings and the preparation of communities and emergency services help to reduce the impact of floods and flood damage, and speed up post-flood recovery. Flood management includes warning systems, emergency and recovery services, river catchment management, upgrading of surface water drainage and reducing impermeable surfacing, and hard defences. Hard flood defences are very costly and the decision for investment is generally decided on a case-by-case basis.

Some management of river (fluvial) flows can be achieved through catchment management, for example by restoring the natural river course where it has been straightened (re-meandering) and using other NFM techniques. This approach is only likely to be used if there is access to funding, expertise, guidance and recompense for landowners, for example through the Scottish Rural Development Programme. NFM is being widely rolled out in the Scottish Borders (through the Tweed Forum) and in other areas, such as the part of the River Dee catchment in North-East Scotland.

Strategic relocation or managed retreat may be prudent in some cases, where the cost of other action is prohibitive, or where it is not possible to save an important asset. Some iconic built heritage may fall into this category (for example, Skara Brae on Orkney).

All of the above approaches are used in Scotland, and latest proposals are laid out in the 14 FRM Strategies.

New developments

SEPA and the planning authorities have a critical role to play to ensure that new developments are in areas free from flood risk, or that the flood risk is at an acceptable level. SEPA produce flood maps which are one of a number of assessments used to steer areas identified for development in Development Plans away from areas at risk of flooding.

Scottish Building Standards specifies that buildings must be designed so that there is no threat to either the building or the occupants as a result of flooding or groundwater.

As well as the Flood Risk Management Act 2009, legislation controlling drainage design, urban surfaces and SUDS is also important (for example, The Water Environment (Controlled Activities) (Scotland) Regulations 2011). All new developments in Scotland must use SUDS to control surface water run-off (unless run-off is from a single dwelling or is to coastal waters). Planning Advice Note (PAN) 61 - Planning and Sustainable Urban Drainage Systems gives good practice advice for planners and developers on SUDS.

Utilities and Services

The policy and regulation that drives adaptation and flood resilience for service providers is largely achieved through the utility sector regulators. Utility regulators enforce financial penalties for service disruption. This encourages utility service providers to invest in adaptation and resilience measures to minimise such incidents.

An additional driver for resilience and adaptation measures for the utility sector is that of *reputation.* Energy, water, telecoms and other utility companies prefer to avoid reputational damage, and so try to minimise service disruptions, and to restore service swiftly in the event of disruption.

The siting of major utility assets (such as power stations) is subject to rigorous risk assessments that include flood risk. In addition, power stations are built to withstand extreme flood events as required by the planning system, and so may generally be considered robust in the face of flooding. The trend towards more distributed, renewable generation and the development of additional interconnector capacity between Scotland and England are also factors that will increase energy security and resilience.

The energy sector is regulated by Ofgem, with input from DECC (Ofgem covers power and gas supply, but not the wholesale fuel sector, which is covered by the Health and Safety Executive). The Office of Nuclear Regulation governs nuclear power generation.

What do the indicators tell us?

RISK INDICATORS

The indicators that track the underlying flood risk to property, infrastructure and services are based on the flood hazard modelling developed by SEPA. Over time, these indicators will help show whether the planning system is effective in keeping new developments away from flood risk areas. They can also help to inform decisions about suitable adaptive policies and actions by showing the extent and likely frequency of the flood risk.

Risk indicators for Property: At present under 1% of all property is at high risk (i.e. at risk of flooding once every 10 years), and just over 3% is at medium risk (i.e. at risk of flooding once every 200 years). Both the frequency and extent of this flooding is likely to increase over time. This could lead to difficulties in obtaining insurance for some households and businesses. See *Property at risk of flooding (BB1 residential, BB3 non-residential)*

Community services are also at fairly low risk– under 6% are in areas at risk of a 1 in 200 year flood. This includes hospitals, care homes, GP and dental surgeries, education and emergency services. Nonetheless, any disruption to such services will have consequences for health and wellbeing, particularly where recovery takes a long time. See *Number of community services at significant risk of flooding CRS12*

Scotland's built cultural heritage includes iconic, internationally recognised assets and sites, most of which are irreplaceable and immoveable. Information about flood risk and the wider management of climate risks by Historic Environment Scotland is presented in *Cultural Heritage in Flood Risk Areas BB6*

Vulnerable groups such as those on low incomes, the disabled and the elderly are a particular concern. Once data is available this will be covered by:

- Households in deprived communities at risk of flooding

An additional risk indicator on costs will also be developed once data becomes available.

Risk indicators for Utility Services: Energy and water utility companies have programmes of assessment and management of assets for flood risk. At present, flooding poses a relatively minor risk for power supply and water / wastewater services, with less than 5% of assets or customers at

medium risk (i.e. at risk of a 1 in 200 year flood event). Nonetheless, it is likely that additional investment in flood defences for all types of utility sites will be needed to keep flood risks at this level as the climate changes in future.

Water treatment works are less likely to be at flood risk than other assets as they are sited high in catchment areas. 18% are in areas of medium flood risk (equating to a 1 in 200 year flood), but there is no record of flooding at these works to date. See *Water treatment works in areas at flood risk BW5.*

Wastewater treatment may still function when flooded (albeit with a reduced effluent quality), so there is usually no direct impact on communities. Records show that only 2% have flooded in the past, and 22% are in areas of medium risk (equating to a 1 in 200 year flood). See *Wastewater treatment works in areas at flood risk BW4.*

Power stations may generally be considered robust in the face of flooding. See *Major power stations in areas at flood risk; Energy capacity of power stations in areas at flood risk; Power stations in areas at flood risk with flood protection BE 1/2/3.*

The power supply may also be compromised by the flooding of substations. Existing data suggests that less than 4% of substations are in areas at risk of a 1 in 200 year flood event. Note that on-site protection will reduce this risk – see the substation action indicators in the section below.

Some 'critical' customers could be affected by this (such as hospitals, water and wastewater pumping stations and underground stations). Many such critical sites and Emergency Service control rooms have back-up capacity – either in the form of diesel generators (hospitals, Scottish Water key sites), or battery back-up (telecoms service providers and some mobile masts). See *Electricity substations located in areas at flood risk BE5* and *Customers reliant on substations in areas at flood risk BE6.*

Risk indicators for Transport Infrastructure: Flood risk to transport networks has implications for mobility, and access to services and goods. Flood disruption is of particular significance to communities in remote regions that lack alternative routes, as it may effectively cut off services and resources. Roads and rail routes in 'Potentially Vulnerable Areas' highlight this risk. Over 40% of the trunk roads in areas classed as 'very remote' appear to be at flood risk (it should be noted that roads and railways located in areas at flood risk may be raised above the ground level so modelled figures may over-estimate the risk). See *Road Network at risk of flooding BT2.*

The risk of road travel disruption is also assessed by combining flood risk data with service usage. At present less than 2% of the trunk road network is at risk of high levels of disruption from flooding, located mainly in the Central Belt. See *Risk of traffic disruption as a result of flooding BT17*

Around 12% of the Scottish Rail network is in areas of medium flood risk (1 in 200 year event) though again this figure may over-estimate risk as railways located in areas of flood risk may be raised above the ground level. See *Railway network at risk of flooding BT8.*

The risk of rail travel disruption from floods is assessed by combining flood risk data with service usage. This shows that the risk of disruption is fairly low, with only 2% of the network at risk of moderate disruption. See *Disruption risk to railway services as a result of flooding BT9.*

IMPACT INDICATORS

Tracking flood impacts helps show whether adaptation actions are effective. Some of the direct impacts of flood events on power and transport infrastructure are captured in the indicators

below. However, there is currently a lack of suitable data regarding the impact of flood events on residential and non-residential property. It is anticipated that insurance data on the cost of flood damage to property will be available in future. See *Number of flood incidents attended by SFRS each year CRS20* (A proxy for number of households / services and critical assets actually flooded each year).

Impact indicators for Transport Networks: Flooding impacts on transport networks, and access to services and goods appear to be well managed in Scotland. (The main cause of journey disruption in Scotland is congestion, followed by roadworks.) Over 20 times more road closures are caused by broken-down vehicles and accidents than by flooding. However, summary data on flooding may mask some important local variation. Just over 50% of the trunk road floods were in 'Potentially Vulnerable Areas' (PVA's), and thus more likely to affect remote communities where flooding may have more impact. See *Flood events affecting the trunk road network BT4.*

Disruption to the rail network from flooding can be tracked by the penalty payments incurred by Network Rail. This shows that almost a fifth (18%) of the penalties incurred for weather-related disruptions were caused by flooding. See *Flood events affecting the railway network BT12*

Impact indicators for Utility Services: There have been no recorded power outages due to flooding of power stations in Scotland. Disruption to the power supply due to flooding of sub-stations is very rare, and caused only 0.034% of the annual 'customer minutes lost' in 2011. (Lightning strikes and high winds are far more common causes of power disruption). See *Electricity supply disruption due to flooding BE4 / 14.*

Data on the cost of flood damage to property, business and transport infrastructure is not yet available. The following indicators will be developed if such data does become available in future.

- Annual cost of flood damage claims for property (residential and commercial)
- Annual cost of flood damage to transport infrastructure

ACTION INDICATORS

Defensive flood control measures are generally very costly, and so the decision to invest in such defences normally requires some sort of cost benefit analysis. Alternatives are to act at an earlier stage in the 'Avoid / Protect / Prepare' flood management hierarchy.

***Action indicators on planning and flood risk*:**

Data on the compliance of Planners with SEPA's flood risk advice for new developments for the most recent period suggests that the planning system is working well to avoid flood-risk areas. See *Planning Decisions that do not reflect SEPA's flood risk advice BB11.*

Analysis of the amount of impermeable surfacing in urban areas shows that no local authority has been able to reduce the area of sealed land and many urban areas have seen a significant net increase which has the potential to impact on flood risk in these areas. See *Proportion of local authority areas under impermeable surfaces; Change in impermeable surfacing in built-up areas BB13*.

The data needed to track a range of other adaptive actions related to planning and land use is not yet available. However, the following indicators will be developed if data does become available.

- Rate of development in flood risk areas
- Installation of SUDS in new / existing developments
- Extent of Greenspace in urban areas

Action indicators on protection: Flood protection may be provided by utility companies, asset and property owners, or by local or national government.

The electricity network is well protected. All 43 major substations in flood risk areas had completed or planned flood risk assessments, and of the substations for which data was available, 19 out of 22 have planned or implemented flood protection works. See *Substations in areas at flood risk with completed Flood Risk Assessments BE7* and *Substations in flood risk areas with completed / planned flood protection works BE8*

Around 6% of the trunk road network is protected by area-based flood management schemes. See *Trunk road network benefitting from fluvial flood protection BT6.*

Of the railway network at risk of fluvial flooding, 9% benefits from area-based flood management schemes. See *Rail network benefitting from fluvial flood protection BT16.* Data is not yet available for the protection to transport networks provided by asset-specific schemes.

The data needed to track a range of other actions related to flood protection measures is not yet available. However, the following indicators will be developed if such data does become available.

- Properties / cultural heritage at flood risk benefitting from flood defence schemes
- Uptake of flood defensive measures
- Delivery of flood management measures specified in Flood Risk Management Strategies
- Households in flood risk areas retrofitting property level flood protection

Action indicators on preparation: Improving society's awareness of flood events can be tracked by the number of users signed up for SEPA's flood forecasting service. This was set up in 2011 now has over 18,500 registered users. See *Number of registrations for flood warnings/alerts CRS34*.

Other relevant indicators

Heavy rainfall is a cause not only of flooding but also of landslides, which mainly affect the road network. This is covered under the narrative *'Climate Change and Extreme Weather'* which includes a range of indicators relating to landslides and other extreme weather.

Rainfall that coincides with strong winds can cause wind driven rain to penetrate buildings and cause internal dampness. This is also covered under the narrative *'Climate Change and Extreme Weather'.*

Flooding can cause distress and well-being issues, and this is covered in the narrative on '*Climate change risks to society and our capacity to adapt'* along with reference to the preparation and response of the emergency services.