FLOOD RISK MANAGEMENT AND CLIMATE CHANGE

1. Summary

Future climate changes may have significant influence on changes in flows in Scottish river catchments. This report provides a summary of a detailed report prepared by Centre for Ecology and Hydrology (CEH) on behalf of SEPA. Its **key points** include:

- Catchment-averaged information on changes in peak flow is available for each of the 10 main river basins in Scotland
- Time horizons considered are the 2020s, 2050s and 2080s
- Peak flow changes are available for a range of likelihoods of occurrence; i.e. from those "very likely to be exceeded" to those "very **un**likely to be exceeded"
- The 'traditional' allowance of 20% increase in peak flows for climate change is shown as no longer being conservative.

2. Introduction

Changes in our climate are likely to affect the nature and frequency of flooding. Understanding the potential changes is a significant challenge given the uncertainty in climate predictions and the consequent response of different flooding mechanisms. Understanding the characteristic responses of Scotland's river catchments to future climate change enables us to better consider the impact on changes in river flows. To manage the uncertainty in predictions a probabilistic approach is likely to be more effective than a deterministic approach.

This report provides a summary of research undertaken for SEPA by the Centre for Ecology and Hydrology (CEH) which builds on previous work in the rest of the UK. It establishes a method for characterising river catchment response to future climate change and provides the information to allow an identification of future changes in flood flows for a range of climate scenarios and time horizons.

This report is intended as a technical summary of the main CEH report - An assessment of the vulnerability of Scotland's river catchments and coasts to the impacts of climate change *(Kay, A.L, et al, 2011)*. While it can be read independently of it, it is recommended that the full CEH report is referenced for specific detail on the method.

3. Background

The Flood Risk Management (Scotland) Act 2009 (FRM Act) transposes the EC Floods Directive into Scots Law. It includes an explicit requirement to consider climate change in delivering the National Flood Risk Assessment, detailed flood hazard maps and flood risk management planning. Supporting guidance reinforces the need to consider climate change appropriately in the provision of a robust flood risk management planning system.

The Scottish Government published its Sustainable Flood Risk Management Guidance (SFM) in 2011. It supports the implementation of the FRM Act and outlines key requirements in delivering sustainable flood risk management. In relation to flood risk and climate change it sets key elements:

- Flood management actions should be tested against long term trends;
- Responsible Authorities should work to establish approaches to examining future scenarios that can be applied consistently across flood risk assessments and management decisions;

- A range of future scenarios should be examined, including a 'worst case' scenario;
- Actions to tackle flood risk should be planned over a long time period (50-100 years);
- The impacts of the changing climate should be taken into account consistently in appraisals using up to date robust evidence and in accordance with Scottish Government guidance, the objectives of the Climate Change Adaptation Framework and accompanying Water Environment and Resources Action Plan.

The National Flood Risk Assessment (NFRA) represented the first substantive deliverable of the FRM Act in December 2011 and included a consideration of climate change based on the CEH report. The report however presents a more extensive consideration of the potential change in peak flows as a result of climate change:

- It considers the most recent information on climate change and provides outputs for a wide range of United Kingdom Climate Projections 2009 (UKCP09) across emissions scenarios [1] (High [A1F1], Medium [A1B] and Low [B1]) and time horizons (2020s, 2050s and 2080s);
- It recognises a range of catchment types and their sensitivity to climate change
- It provides catchment-averaged regional outputs of future changes in flood peak across 10 Scottish river basins
- A full range of probabilities of flood peak threshold exceedance is possible from the outputs

SEPA recognises the breadth and depth of information on the potential impact of climate change on flooding. It has ensured that its suite of flood hazard maps includes an appropriate climate change scenario (based on the CEH report) while Flood Risk Management Strategies seek to establish the adaptability of Actions to a changing climate.

There is clearly significant uncertainty in climate change predictions and their impacts on future flood flows. This is expected given the complexity of the assessments required, scale of modelling and available calibration data.

This summary provides a general background to the definition of risk in the context of climate change and flooding. In addition it provides an overview of the CEH report, the application of the methodology and interpretation of outputs to enable the information to be utilised by a wider audience in support of flood risk management.

EMISSIONS SCENARIOS

1. **What climate scenarios are considered?**

UKCP09 provides details on the emissions scenarios used in estimating future climate change (http://ukclimateprojections.metoffice.gov.uk/media.jsp?mediaid=87884&filetype=pdf). It is recommended that the relevant reports are reviewed; however, the following section provides a brief summary.

UKCP09 makes some assumptions about future emissions of greenhouse gases and other pollutants in order to make projections of UK climate change. A number of possible scenarios are used which are selected from the IPCC Report on Emissions Scenarios (SRES) (Naki´cenovi´c and Swart, 2000). These relate to a series of global 'stories' that define the driving forces of change in future emissions.

[1] Sampled Data for the time horizons and emissions scenarios can be downloaded from the UKCP09 user interface (ukclimateprojections-ui.defra.gov.uk/ui/admin/login.php)

Each scenario is established along one of these stories; thus those used to inform potential changes in future flood risk are outlined below.

Climate Scenario	Equivalent Reference	Description
A1F1	High	Very rapid economic growth; rapid population increase; regional convergence; high use of fossil fuels
A1B	Medium	As above but with an intermediate scale use of fossil fuels
B1	Low	Economic growth towards a service economy; rapid population increase; regional convergence

Table 1 Summary of UKCP09 climate scenarios informing the assessment of potential change in flood risk study

WHAT IS RISK?

4. Risk definition

Risk is generally considered to be a function of an external influence acting on a receptor and resulting in (adverse) consequences. In relation to flood risk management this has been further defined thus:

Flood Risk = f (likelihood, hazard, vulnerability, exposure, value)

The hazard is therefore taken to be a flood of a given rarity (and thus magnitude of flow). The consequences of that flood are dependent on the exposure of receptors to the flood and their characteristics (i.e. their susceptibility to damage and their value whether in monetary or quality terms).

In relation to the assessment of the vulnerability of river catchments to the impacts of climate change a similar model is applied:

Risk = f (hazard, sensitivity)

In this case:

- *Hazard* is determined from future climate change projections (i.e. from UKCP09) and is the change in climate (e.g. frequency of extreme rainfall, or summer temperatures)
- *Sensitivity* is the response of a catchment's flood regime to climate change
- *Risk* is determined as the potential change in flood flows resulting from the combination of sensitivity and hazard

It is important to recognise here that the 'flood' is considered as a consequence of the climate change hazard. This is a deviation from the norm where, in flood risk management, the characteristics of the flood define the hazard.

5. Regional Climate Change Impacts

In Scotland the impact of climate change on peak river flows has traditionally been considered as a standard uplift applied evenly across the country. Generally, a 20% increase on current peak flows is applied. However this does not account for any particular time horizon or regional differences which are identified by UKCP09 projections.

Implementing an effective, plan-led flood risk management planning system requires utilisation of the most recent information to enable the consideration of actions to mitigate future changes in flood hazard. Thus the outputs of UKCP09 are applied in this study providing a range of scenarios and time horizons. In addition, it enables the development of a risk-based approach to mitigating climate change impacts on flood hazard.

A brief overview of the method including definitions of the Hazard and catchment Sensitivity is provided in the following sections.

BASIS OF THE CLIMATE CHANGE STUDY

6. Climate Change Impacts on Flood Peak in Scotland

In 2009 DEFRA commissioned a project to assess the regional impacts of climate change on flood flows (FD2020 – "Regionalised impacts of climate change on flood flows"). This considered the response of catchments to climate change (e.g. frequency of extreme rainfall, or summer temperatures) and sought to develop a scenario-neutral approach. In 2011 DEFRA commissioned a successor project (FD2648 – "Practicalities for implementing regionalised allowances for climate change on flood flows"). This project took the initial work of the FD2020 project characterising catchment response type and applied UKCP09 scenarios to develop probabilistic estimates of the impact of climate change on flood flows.

These projects did consider Scottish catchments within a UK context. However, SEPA sought to better understand the specific nature of Scottish catchments. Thus the approaches applied in the FD2020 and FD2648 projects were applied to Scottish catchments to provide (a) a characterisation of Scottish catchments response type and (b) probabilistic estimates of changes in flood peaks across each region.

The following sections summarise the approaches applied and discusses the outputs in the Scottish context.

7. Method Overview

The method follows a common approach (Figure 1). First the hazard has to be defined; this is the (external) influence that will generate a response from the receptors it acts upon. Secondly, the nature and characteristics of the main receptor group needs to be defined. In this case the receptor group is Scottish river catchments, considering their sensitivity to the hazard. Finally, the risk is defined; this will provide a consideration of the potential increase in flood peak in each catchment for the range of hazard scenarios.

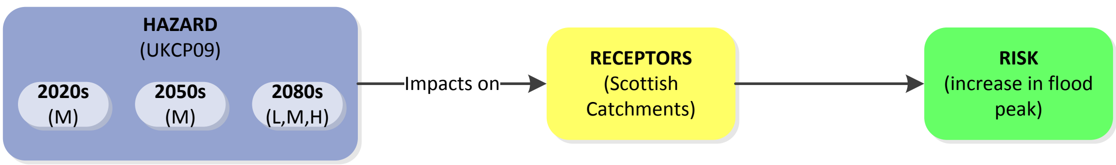

Figure 1 Overview of the methodology to evaluate the change in flood flows across Scottish catchments resulting from climate change

DEFINE THE HAZARD

8. UKCP09 ("Hazard")

The most recent climate predictions indicate the potential for a warmer and wetter future with clear implications for flood hazard and flood risk.

UKCP09 provides climate projections, consisting of 10,000 sets of monthly, seasonal or annual changes in a number of climate variables. These are available for three emissions scenarios (Low, Medium and High) as changes from the baseline time-slice (1961-1990) to a number of future, 30-year time-slices:

- 2020s (2010-2039)
- 2050s (2040-2069)
- 2080s (2070-2099)

The resolution of the projections is 25km over the land area of the UK, (Figure 2a). However, due to the methodology used to produce the data there are differences between each 25km grid such that they cannot be readily averaged over several grid squares to produce data for a region, like a river catchment. However, UKCP09 also provides data processed for two different sets of aggregated areas: administrative regions and river-basin regions (Figure 2b). It is the data from the river-basin regions which are used in this study as they will be consistent across the whole of any river catchment (that is, the river-basin regions were designed in such a way that no catchment will be contained partly in one river-basin region and partly in another river-basin region). 10 UKCP09 river-basin regions cover Scotland:

- Orkney & Shetland
- North Highland
- West Highland
- North East Scotland
- Argyll
- Tay
- Clyde
- Forth
- Solway
- Tweed

Examples of UKCP09 grid-box and river-basin regions are shown in Figure 2.

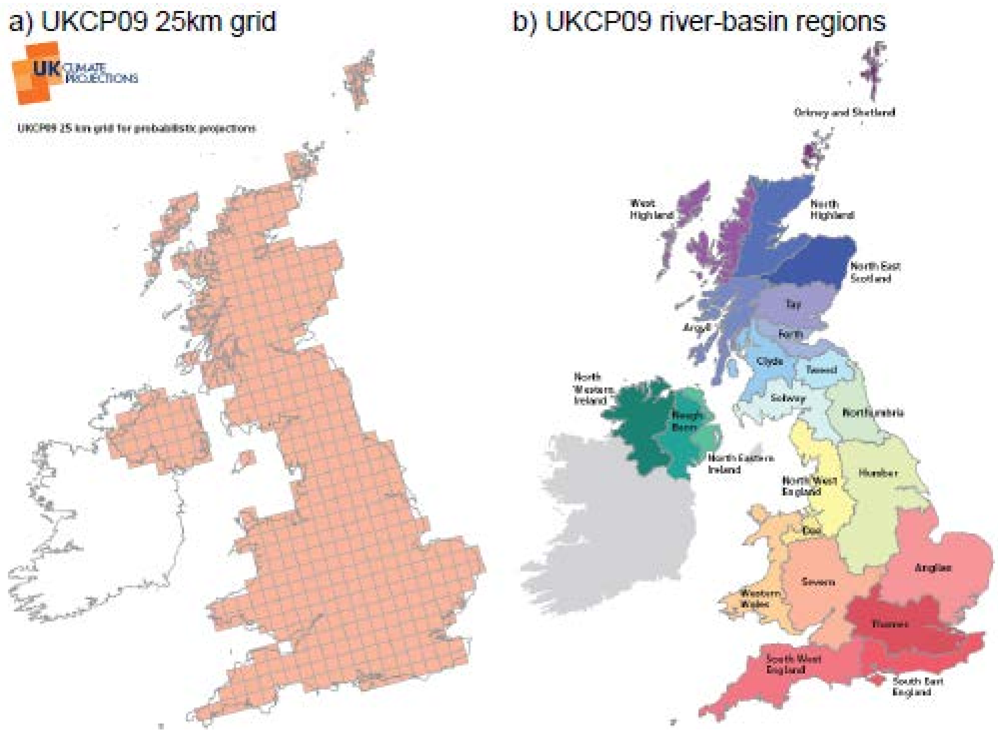

Figure 2 Areas over which the UKCP09 projections are available

DEFINITION OF THE VULNERABILITY OF RECEPTORS

9. Catchment Response Type ("Sensitivity")

FD2020 summary

In contrast to a standard climate change impact assessment, FD2020 took a **scenario-neutral** approach. That is, a 'sensitivity framework' was designed, which consisted of a fixed, regular set of changes to rainfall and temperature (and potential evaporation). The response of each catchment was then modelled under the fixed framework, resulting in plots ('**response patterns**') summarising each catchment's sensitivity to the same changes in their climatic inputs. FD2020 modelled 154 catchments in total (45 in Scotland).

FD2020 then grouped the catchment response patterns, according to similarity, resulting in nine '**response types**' each with average response patterns. Furthermore, using information on physical and climatic catchment properties, sets of rules were developed to allow the estimation of the response type of un-modelled catchments. Uncertainty in the method was considered and, following analysis, extra uncertainty allowances were developed.

Given the response patterns, the impact (risk) of a given set of climate change projections (hazard) can be estimated by overlaying the projections on the response patterns. FD2020 thus developed a methodology for the rapid estimation of the change in four flood indicators (daily peak flows at the 2-, 10-, 20- or 50-year return periods) under any climate change projection (or set of projections), for any catchment in Britain where the required catchment properties are available.

Taking a scenario neutral approach removes any (catchment) spatial variation in hazard. It also provides a fixed reference point without the requirement to re-evaluate the response type with updates to climate change scenarios. The output is thus a set of 9 response types (Table 1) with further information on each type Appendix A.

Response Type	Climate Change Signal Description
Neutral	Neutral
Damped-Low (*Damped L*)	Slightly damped
Damped-High (*Damped H*)	Very damped
Damped-Extreme (*Damped E*)	Extremely damped
Enhanced-Low (*Enhanced L*)	Slightly enhanced
Enhanced-Medium (*Enhanced M*)	Enhanced
Enhanced-High (*Enhanced H*)	Very enhanced
Sensitive	Sensitive
Mixed	Mixed

Table 2 Catchment response types defined by the FD2020 methodology

Uncertainty with the method was quantified to account for natural variability, simplification of the approach and assumptions taken in defining the framework and an appropriate factor included. Figure 3 provides a schematic of the response types indicating relative vulnerability to the effects of climate change.

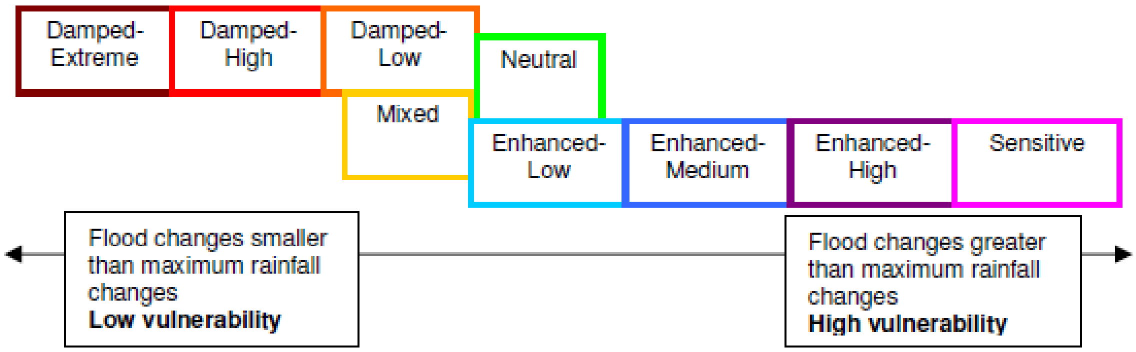

Figure 3 Schematic of the nine catchment response types to changes in climate

Understanding the response type of catchments across the country enables an understanding of where relatively positive and negative impacts might be expected to result. With the hazard defined (UKCP09 scenario outputs) and receptor vulnerability understood (catchment response type) it is possible to evaluate the risk (in terms of regional changes in peak flow).

ASSESSMENT OF THE RISK

10. Risk of Regional Increases in Flood Peak

The risk is defined as the potential for increase in flood peaks across catchments. The risk is therefore provided on a river basin/regional basis given the application of the UKCP09 hazard inputs. This provides a powerful decision matrix from which changes in peak flow can be considered against the specific nature of each river basin for a range of scenarios and considering the likelihood of the peak threshold being exceeded.

The following sections provide an overview of the results and their interpretation.

RESULTS OF THE ASSESSMENT

11. Results

The study provides averaged outputs for the 10 river basins. It provides a characterisation of catchment response type and, when the hazard is considered (UKCP09 scenarios), the risk in terms of **probabilistic changes in flood peaks**. Risk is presented as a series of cumulative distribution functions (cdfs) for the 4 return periods (Figure 4).

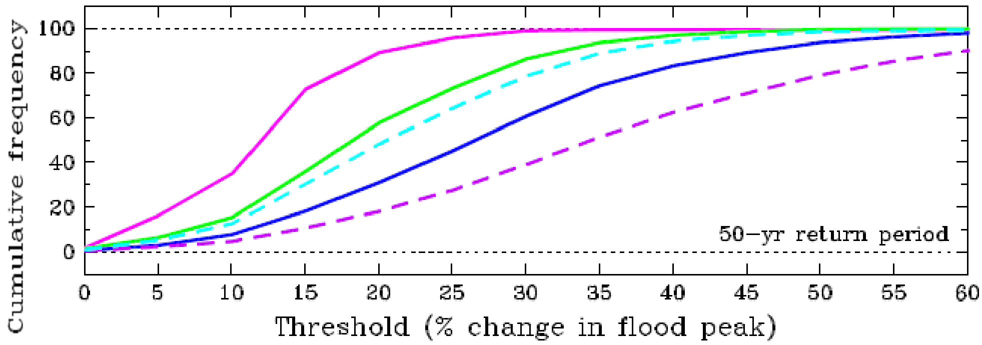

Figure 4 Example cdf curve

The curves are based on the percentage of the 10,000 simulated projections with impacts less than or equal to a defined threshold (cumulative frequency) and the potential change in flood peak for the region (%).

So, for all Scottish river basins it is possible to evaluate the potential change in flood peaks for a range of return periods considering the background of a series of climate change scenarios. The following section outlines how to interpret the outputs.

12. Interpreting the Results

The results provided are probabilistic in nature. This enables a consideration of a range of likelihoods and thus a consideration of how likely it is that a particular increase in peak flow might be exceeded for a given emissions scenario (for example this can enable a broad range of thresholds to be considered in determining what climate change uplifts might be applied). It is therefore useful to determine what the probability curves represent. For example, the impact threshold at the 50% probability level is called the median and is the impact that is as likely as not to be exceeded (i.e. the 'central estimate' using UKCP09 terminology). The impact threshold at the 90% probability level is that which is '**very unlikely** to be exceeded' (UKCP09 terminology), whilst the impact threshold at the 10% probability level is '**very likely** to be exceeded'. To provide a further consideration SEPA proposes a consideration of intermediate levels (33% and 67% levels) as noted in Table 3.

Emissions Scenario	Time Horizon	Likelihood of change in peak flow (%)	Exceedence Description
High	2080	10	Very likely to be exceeded
		33	Likely to be exceeded
		50	Is as likely as not to be exceeded
		67	Unlikely to be exceeded
		90	Very unlikely to be exceeded

Table 3 Description of the probability of an increase in flood peak being exceeded as a result of a particular climate change scenario and time horizon

In understanding the probability representation it is possible to consider the likelihood of exceedance of a particular flow peak increase across a range of climate scenarios. There follows an example of how the curves are interpreted.

Example of the Interpretation of the cdf curves:

In the example that follows, the below legend supports Figures 5 and 6. Each graph represents the curves for one region.

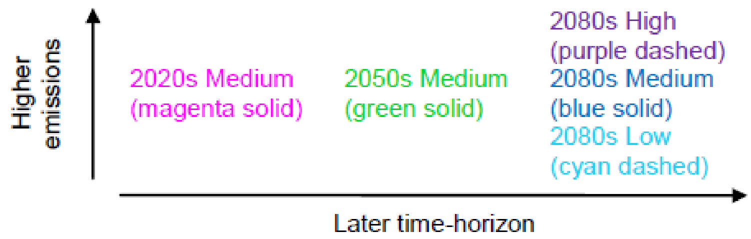

Figure 5 Legend to support Figures 1 and 3

The method provides the cdf curves for a range of scenarios:

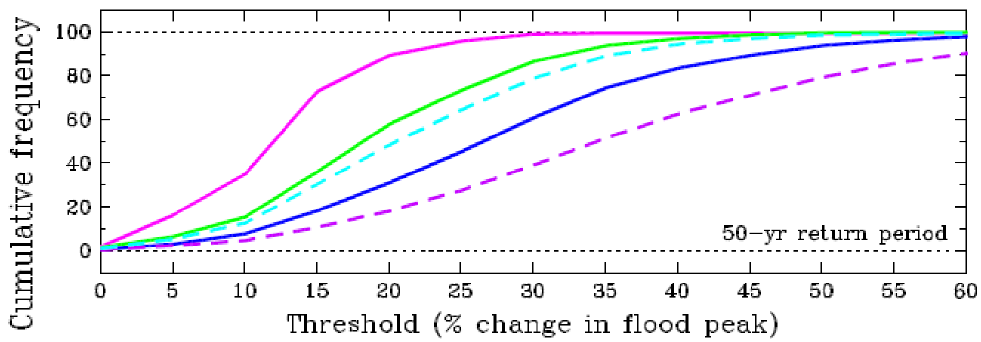

Figure 6 Example CDF curve

So, consider a range of probabilities and thus determine a range of peak flow increases that include those that may be more or less likely to be exceeded. Figure 7, below, provides an example of the 33%, 50% and 67% likelihood of the respective increases in flood risk being exceeded for the 2080s scenarios (i.e. it indicates the flow increases that are likely to be exceeded, as likely as not to be exceeded and unlikely to be exceeded).

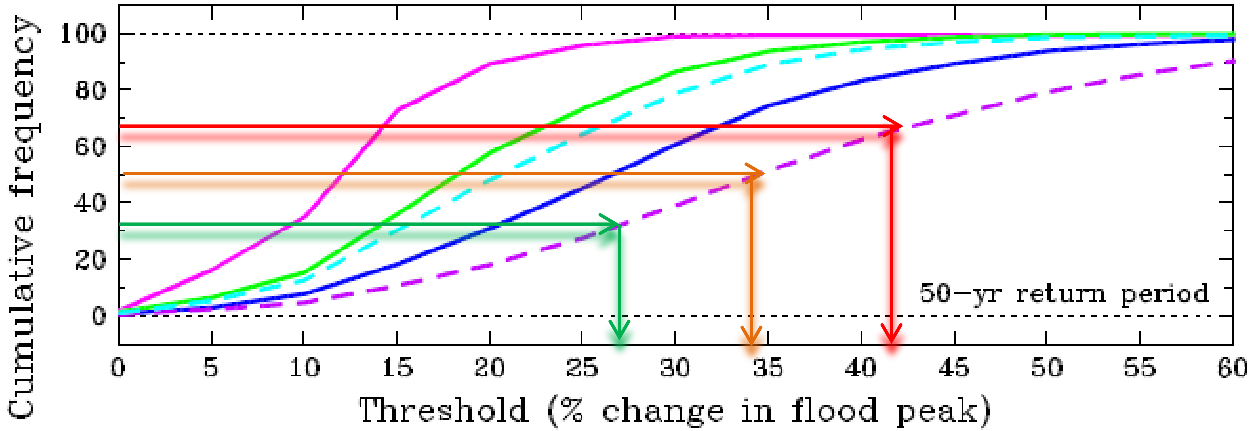

Figure 7 Extraction of potential increases in flood peak from a regional cdf curve focussed on the 2080s High emissions scenario

The values extracted from the regional graph provide a range of potential increases in peak flow (Table 3).

River Basin	Time Horizon	Likelihood of change in peak flow (%)	Exceedence Description	Increase in Flood Peak (%) High
Example 1	2080	33	Likely to be exceeded	26
		50	Is as likely as not to be exceeded	35
		67	Unlikely to be exceeded	44

Table 4 Information extracted from the cdf curve for the Example river basin considering the 2080s, High emissions scenario

It is therefore possible to establish a range of potential climate change allowances for increased flows. This provides the decision-maker with flexibility in how it applies climate change uplifts considering the sensitivity of any development activity.

A more specific example for the Clyde river basin is provided below.

Taking the cdf curves for the 2080s and Low, Medium and High emissions scenarios, the potential increases in peak flow are extracted for a range of probabilities. These are plotted on Figure 8 with the extracted values displayed.

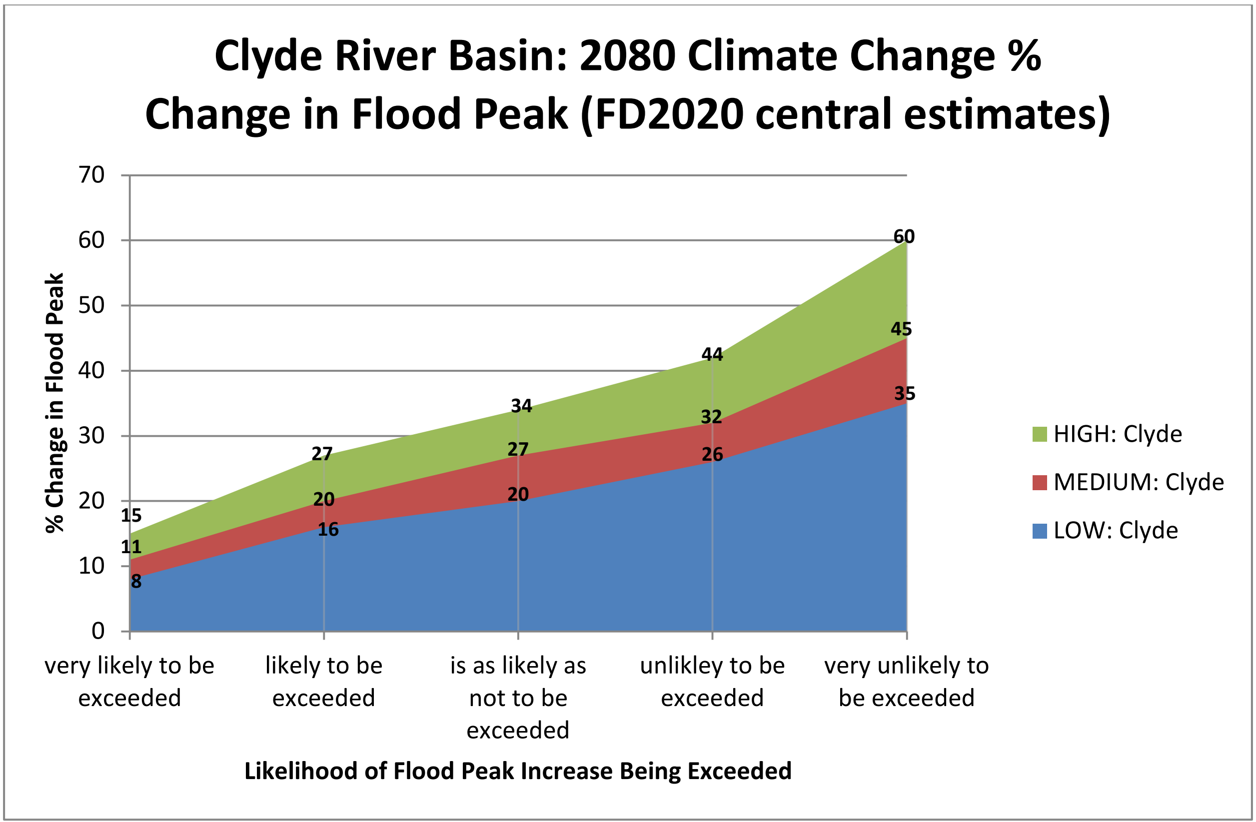

Figure 8 Results of the Clyde river basin for the 2080s and a range of emissions scenarios

The data extracted from the curves and is tabulated below (Table 5).

River Basin	Time Horizon	Likelihood of change in peak flow (%)	Exceedance Description	Increase in Flood Peak (%) Low	Increase in Flood Peak (%) Medium	Increase in Flood Peak (%) High
Clyde	2080	*10*	*Very likely to be exceeded*	*8*	*11*	*15*
		33	**Likely to be exceeded**	16	20	**27**
		50	**Is as likely as not to be exceeded**	20	27	**34**
		67	**Unlikely to be exceeded**	26	32	**44**
		90	*Very unlikely to be exceeded*	*35*	*45*	*60*

Table 5 Extracted potential increases in peak flows for the Clyde river basin for the High, Medium and Low emissions scenarios (values in bold are referenced in the main text below)

Given the example above, the study indicates that, for the High emissions scenario:

- an increase in peak flows of 27% is likely to be exceeded in future,
- an increase of 34% is as likely to be exceeded as much as it is not and,
- an increase of 44% is unlikely to be exceeded.

Appendix B provides a breakdown of extracted flow increases for a 2050s Medium and 2080s Low, Medium and High emissions scenario across a range of probabilities for all 10 river basins in Scotland.

CONCLUSION

The most recent information on potential future climate changes (i.e. future climate hazards) takes account of regionally-based information in UKCP09. The impacts will be received by the key receptors (i.e. river catchment across Scotland) resulting in a change in risk (i.e. change in peak flood flows).

The study undertaken by CEH takes the regional information and characterises catchments to understand their response to the changes in hazard. This scenario-neutral approach was considered in the development of the NFRA in 2011. More specific information can be obtained from the regional impact curves from which the likelihood of changes in peak flood flows are derived and this supported the development of SEPA's Flood Maps.

For a range of scenarios considering emissions (High, Medium, Low) and time horizons (2020s, 2050s, 2080s) it is possible to identify the percentage change in peak flood flows that may have a lower or higher likelihood of being exceeded. Focussing on the 2050s and 2080s, the study provides curves for 10 Scottish river basins from which the percentage change in peak flood flows can be extracted for defined likelihoods of exceedance (Refer to Appendix B).

It is now possible to apply a risk-based approach to the definition of climate change allowances on river flows. Further guidance will be developed in discussion with partners to consider how regional uplifts might be consistently applied and thus enable a consideration of future climate risk that is aligned with the best available information. As new climate information is developed (i.e. UKCP18) we will seek to update guidance to support flood risk management activity.

Appendix A – Catchment Sensitivity Characterisation

Response Type	Climate Change Signal Description	**Increase** in mean annual rainfall with **increase** in summer* rainfall	**Increase** in mean annual rainfall with **decrease** in summer* rainfall	**Decrease** in mean annual rainfall with **increase** in winter** rainfall	**Decrease** in mean annual rainfall with **decrease** in all months
Neutral	Neutral	Similar	Similar	Similar or lower	Decrease
Damped-Low	Slightly damped	Similar or higher	Similar or lower	Lower or much lower	Decrease
Damped-Medium	Very damped	Similar	Similar or lower	Much lower or decrease	Decrease
Damped-High	Extremely damped	Lower	Much lower	Much lower or decrease	Decrease
Enhanced-Low	Slightly enhanced	Higher	Similar or higher	Similar or lower	Decrease
Enhanced-Medium	Enhanced	Much higher	Similar or higher	Lower or much lower	Decrease
Enhanced-High	Very enhanced	Much higher	Similar to much higher	Lower to decrease	Decrease
Sensitive	Sensitive	Much higher	Much lower to much higher	Much lower or decrease	Decrease
Mixed	Mixed	Higher or much higher	Similar or lower	Much lower or decrease	Decrease

Similar – percentage increase in flood peak of similar magnitude to maximum monthly percentage increase in precipitation (ratio of 0.8 to 1.2)
Lower – percentage increase in flood peak lower than maximum monthly percentage increase in precipitation (0.5 to 0.8)
Much lower – percentage increase in flood peak much lower than maximum monthly percentage increase in precipitation (0 to 0.5)
Higher – percentage increase in flood peak higher than maximum monthly percentage increase in precipitation (1.2 to 1.5)
Much higher – percentage increase in flood peak much higher than maximum monthly percentage change in precipitation (more than 1.5)
Decrease – percentage decrease in flood peak
*Summer – at least one month from May to September; **Winter – at least one month from November to March
Change in rainfall derived from harmonic function with peak in January and trough in July

Appendix B – Potential increases in regional flood peak for High, Medium & Low scenarios for the 2080 time horizon. Increases in peak flow are given for a range of likelihoods that the given increase may be exceeded. Values extracted from Appendix B of *An assessment of the vulnerability of Scotland's river catchments and coasts to the impacts of climate change, Work Package 1 Report, CEH (2011)*

				50-yr Return Period (proxy for 200-year)									
				% change in flood peak (thresholded based on exceedence likelihood)									
Scenario	Horizon	Probability (%)	**Exceedence Likelihood**	**LOW: Orkney/Shetland**	**LOW: N Highland**	**LOW: W Highland**	**LOW: NE Scotland**	**LOW: Argyll**	**LOW: Tay**	**LOW: Clyde**	**LOW: Forth**	**LOW: Solway**	**LOW: Tweed**
LOW	2080	10	very likely to be exceeded	15	7	12	2	12	4	8	5	6	5
		33	likely to be exceeded	20	14	23	10	23	12	16	13	13	11
		50	is as likely as not to be exceeded	27	18	30	13	30	16	20	17	18	14
		67	unlikley to be exceeded	30	24	36	16	36	20	26	22	23	19
		90	very unlikely to be exceeded	38	33	50	24	50	31	35	32	35	28
			Exceedence Likelihood	**MEDIUM: Orkney/Shetland**	**MEDIUM: N Highland**	**MEDIUM: W Highland**	**MEDIUM: NE Scotland**	**MEDIUM: Argyll**	**MEDIUM: Tay**	**MEDIUM: Clyde**	**MEDIUM: Forth**	**MEDIUM: Solway**	**MEDIUM: Tweed**
MEDIUM	2080	10	very likely to be exceeded	16	10	15	3	15	7	11	7	8	6
		33	likely to be exceeded	27	18	29	11	29	15	20	16	16	13
		50	is as likely as not to be exceeded	30	23	36	14	37	20	27	21	22	17
		67	unlikley to be exceeded	34	29	44	18	45	25	32	27	28	22
		90	very unlikely to be exceeded	45	40	60	28	60	37	45	40	45	32
			Exceedence Likelihood	**HIGH: Orkney/Shetland**	**HIGH: N Highland**	**HIGH: W Highland**	**HIGH: NE Scotland**	**HIGH: Argyll**	**HIGH: Tay**	**HIGH: Clyde**	**HIGH: Forth**	**HIGH: Solway**	**HIGH: Tweed**
HIGH	2080	10	very likely to be exceeded	18	12	20	4	20	11	15	11	13	9
		33	likely to be exceeded	29	23	36	12	36	20	27	22	25	18
		50	is as likely as not to be exceeded	33	29	45	17	45	26	34	28	32	23
		67	unlikley to be exceeded	41	37	56	24	56	35	44	40	44	33
		90	very unlikely to be exceeded	53	50	>60	33	>60	50	60	54	60	45

Appendix C – Potential increases in regional flood peak for the Medium scenario for the 2050 time horizon. Increases in peak flow are given for a range of likelihoods that the given increase may be exceeded. Values extracted from Appendix B of *An assessment of the vulnerability of Scotland's river catchments and coasts to the impacts of climate change, Work Package 1 Report, CEH (2011)*

				50-yr Return Period (proxy for 200-year)									
				% change in flood peak (thresholded based on exceedence likelihood)									
Scenario	Horizon	Probabilit	**Exceedence Likelihood**	**LOW: Orkney/Shetland**	**LOW: N Highland**	**LOW: W Highland**	**LOW: NE Scotland**	**LOW: Argyll**	**LOW: Tay**	**LOW: Clyde**	**LOW: Forth**	**LOW: Solway**	**LOW: Tweed**
LOW	2050	10	very likely to be exceeded										
		33	likely to be exceeded										
		50	is as likely as not to be exceeded										
		67	unlikley to be exceeded										
		90	very unlikely to be exceeded										
			Exceedence Likelihood	**MEDIUM: Orkney/Shetland**	**MEDIUM: N Highland**	**MEDIUM: W Highland**	**MEDIUM: NE Scotland**	**MEDIUM: Argyll**	**MEDIUM: Tay**	**MEDIUM: Clyde**	**MEDIUM: Forth**	**MEDIUM: Solway**	**MEDIUM: Tweed**
MEDIUM	2050	10	very likely to be exceeded	13	7	11	2	11	6	7	6	7	4
		33	likely to be exceeded	19	13	19	9	20	11	14	12	13	10
		50	is as likely as not to be exceeded	25	16	25	12	26	14	18	16	17	13
		67	unlikley to be exceeded	29	20	31	15	31	18	23	20	21	17
		90	very unlikely to be exceeded	34	29	42	21	42	27	32	29	30	24
			Exceedence Likelihood	**HIGH: Orkney/Shetland**	**HIGH: N Highland**	**HIGH: W Highland**	**HIGH: NE Scotland**	**HIGH: Argyll**	**HIGH: Tay**	**HIGH: Clyde**	**HIGH: Forth**	**HIGH: Solway**	**HIGH: Tweed**
HIGH	2050	10	very likely to be exceeded										
		33	likely to be exceeded										
		50	is as likely as not to be exceeded										
		67	unlikley to be exceeded										
		90	very unlikely to be exceeded										