SEPA
Scottish Environment Protection Agency

# National Flood Risk Assessment

## Methodology

# Contents



# Appendices

## 1. Introduction

The Flood Risk Management (Scotland) Act 2009 (FRM Act) transposes European Directive 2007/60/EC (i.e. the Floods Directive) into Scots Law. It introduces a framework for the holistic and sustainable management of flood risk across Scotland from all sources.

The FRM Act places duties on SEPA to prepare flood risk assessments for each flood risk management district. SEPA's approach has been to develop a national flood risk assessment (NFRA) to identify those areas most vulnerable to the impacts of flooding (Potentially Vulnerable Areas – PVAs), flood hazard and flood risk maps for these areas and national flood risk management plans outlining objectives and measures to reduce the overall flood risk.

This paper aims to provide a comprehensive summary of the methodology undertaken in order to produce the NFRA for Scotland.

### 1.1. National Flood Risk Assessment (NFRA)

The first stage in the sustainable management of flood risk is the preparation of a national flood risk assessment (NFRA). This is a high level screening tool that SEPA is responsible for developing which assesses the relative adverse consequences of flooding across the country. It must be based on reliable, available and readily derivable information and will inform the identification of those areas most vulnerable to the impacts of flooding (PVAs). The NFRA should also provide sufficient information to inform the early development of draft objectives and measures to manage flood risk.

The Floods Directive and the FRM Act requires a consideration of all sources of flooding. The NFRA has been developed so that it can accommodate a range of return periods from all sources of flooding when information becomes available. By utilising the information currently available in this first cycle, the NFRA concentrates on flooding from rivers, the coast and heavy rainfall with a further consideration of the influence of groundwater.

A flood risk assessment is dependent upon the consideration of factors representing physical, social, economic and environmental elements. The NFRA principles of estimating flood risk follow definitions in the Floods Directive and FRM Act[1] while the definition of individual components of flood risk are informed by studies commissioned by the European Community[2]. Flood risk can be described by a range of factors to provide a more refined understanding of potential adverse consequences. Box 1 (below) provides an indication of the elements comprising an assessment of flood risk:

**Box 1**

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

*(FLOODsite reports (www.floodsite.net))*

Vulnerability can be assessed as a factor of susceptibility (the propensity of a receptor to suffer harm from flooding) and resilience (the ability of a receptor to recover from damage incurred as a result of flooding).

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

[2] FLOODsite reports (www.floodsite.net)

## 1.2. NFRA Principles

The following principles have been developed to define the overall approach to the creation of a national flood risk assessment.

- **Predictive approach** – the NFRA will take a predictive, proactive approach to assessing flood risk by focusing on the identification of areas of significant flood risk arising from information on where flooding is predicted to occur rather than reacting to information on past floods.

- **Climate change** – in assessing flood risk the NFRA will consider the sensitivity of catchments to climate change (this will develop existing UK studies on catchment characterisation with a particular Scottish focus). The NFRA will therefore seek to characterise the sensitivity of Scottish catchments and coasts to climate change and develop new information to improve the overall understanding of future flood risk.

- **A verified approach** - historic flood information will be collated in a national repository and used to validate the output of the future flood assessment. This will provide further information on areas previously affected by flooding and, where reliable information indicates significant past flooding or clusters of flood events, SEPA will endeavour to take this into account when identifying PVAs.

- **Multiple flood sources** – the NFRA will consider flood sources as mutually exclusive of each other. However, it will endeavour to identify and understand the links and interaction between multiple sources to enable a more detailed, focussed assessment of the interaction of multiple sources in the most at risk areas. Therefore, as further information becomes available through the production of detailed flood hazard and risk maps, the NFRA will be reviewed.

- **Flood defences and residual risk** – the true performance of defences – including the protection they afford and the chance that they may be overtopped or fail – will be built into the NFRA.

- **Catchment characteristics** – the NFRA will seek to consider the impacts catchment hydrology and geomorphology will have in relation to flood risk. The NFRA will also characterise natural features that may have a role managing flood risk.

- **Reservoirs** – the NFRA will take account of reservoirs and other impounded water sources in the assessment of risk – including the chance of failure and resulting consequences. This will be done in line with current SEPA security requirements as reliable and consistent information becomes available. Consideration of risk from Reservoirs will not be included in this first NFRA cycle.

- **Links to other planning systems** – the information produced by the NFRA will provide a link to existing and new planning systems, assisting in the proactive identification of development potential for land use planning, surface water management, river basin and national & local flood risk management plans.

- **Understanding uncertainty** – the NFRA will be based on best available and readily derivable information that is considered as being reliable. It will utilise information held at a national level by SEPA, Scottish Government and associated organisations such as Historic Scotland and Scottish Natural Heritage.

The NFRA will be delivered at a scale that is appropriate for a nationally-applied methodology using national level datasets. However, SEPA will endeavour to record elements of uncertainty, improve its understanding of uncertainty and how this is communicated.

- **Draft objectives and measures** – a proactive assessment of flood risk will drive the development of the identification of those areas most vulnerable to the impacts of flooding. Appropriate information will be made available from the NFRA to inform the early consideration of draft objectives for the most vulnerable areas and measures that can be taken to reduce flood risk.

- **Flood probability** – the NFRA will utilise the best available flood hazard mapping information (i.e. the Indicative River and Coastal Flood Map) and incorporate derived information on other flood sources (i.e. indicative pluvial and groundwater hazard mapping information). The NFRA will focus on 200-year flood events but will be extended to incorporate other events as we develop our knowledge and technical capacities. In this first NFRA cycle, the 1 in 200 year fluvial, coastal and pluvial return periods will be utilised.

## 1.3. Flood Risk Receptors and Indicators

The NFRA must utilise available and readily derivable information that is considered reliable, and therefore the NFRA uses national datasets held by SEPA, the Scottish Government or associated organisations to provide information on the potential adverse consequences of flooding.

The FRM Act requires that the impact of flooding is assessed in terms of potential adverse consequences on human health, economic activity, the environment and cultural heritage. It was deemed necessary to further split the receptor categories to ensure a like for like assessments (e.g. to avoid assessing transport and agricultural in the same analysis). This will also provide further information on issues and benefits to the FRM planning process. The receptor groups were therefore categorised as:

1. **Human Health (A) – People** (No. of Residential Properties and the social vulnerability of the area)

2. **Human Health (B) - Community** (Important facilities that could cause community disruption if affected e.g. schools, hospitals)

3. **Economic Activity (A) - Businesses** (No. of business properties and the estimated weighted annual average damage related to the property)

4. **Economic Activity (B) - Transport** (Roads, railways and airports)

5. **Economic Activity (C) - Agriculture** (Agricultural land and forestry areas)

6. **The Environment** (Areas designated for natural heritage purposes and their vulnerability to flooding)

7. **Cultural Heritage** (Cultural sites such as UNESCO World Heritage Sites)

## 1.4. Flood Risk Receptor Weightings

A weighting has been applied to each category in terms of the influence each receptor may have on the output of the NFRA. This weighting has been applied by restricting which receptors can be assessed at each risk level. The receptors have been assessed using the below risk categories from Very Low to Very High.

The below table illustrates the score each type of receptor may receive. For example, a post office (Human Health (B)) within a flood extent will be given a 'Low' score. A grid cell containing a post office will therefore be attributed with a score of 0.5. A hospital (Human Health (A)) within a flood extent will be given a 'Very High' score. A grid cell containing a hospital will therefore be attributed with a score of 250.

For residential properties and non-residential properties, a continual scale is used. This score is dependant on the number of properties within a cell, and the vulnerability/damage score associated with those properties. Further detail on the scoring for each receptor is provided in the next chapters.

The scores allocated to each receptor type have been subject to sensitivity testing to ensure that the risk is represented appropriately.

| | Very Low | Low | Medium | High | Very High |
|---|---|---|---|---|---|
| | Cell Score: 0 | Cell Score: 0.5 | Cell Score: 2.5 | Cell Score: 25 | Cell Score: 250 |
| **Human Health (A) People** | No residential properties located within a flood extent | Continual scale dependant on number of residential properties per 1km² cell and social flood vulnerability score in cell → | | | Maximum number of residential properties per 1km² cell |
| **Human Health (B) Community** | No community services located within a flood extent | Post offices/GPs/dentists | All waste water treatment works/water pumping facilities/police/fire stations ***and*** post offices/GPs/Dentists located in a rural area | All residential homes/education facilities ***and*** police/fire stations located in a rural area | All hospitals/ambulance depots ***and*** residential homes/education facilities located in a rural area |
| **Economic Activity (A) Businesses** | No non-residential properties located within a flood extent | Continual scale dependant on number of non-residential properties per 1km² cell and weighted annual average damage score in cell → | | | Maximum number of non-residential properties per 1km² cell |
| **Economic Activity (B) Transport** | No roads or rail links located within a flood extent | Minor roads ***or*** main roads/rail in less rural areas | B' Roads ***or*** minor roads in rural areas ***or*** main roads/rail in less rural areas | Motorway/ 'A' Road/Railway ***or*** other roads in rural areas | Airports |
| **Economic Activity (C) Agriculture** | Natural vegetation, forests, scrub and/or herbaceous vegetation associations and open spaces with little or no vegetation | Pastures, complex cultivation patterns and agro-forestry areas | Arable land, permanent crops and annual crops | | |
| **Cultural Heritage** | No cultural sites located within a flood extent | Category C Listed Buildings | Category B Listed Buildings, Gardens and Designed Landscapes | UNESCO World Heritage Sites, Scheduled Monuments, Category A Listed Buildings | |
| **Environment** | Designated areas containing species/habitats deemed to be of very low' vulnerability (resilience x susceptibility) | Designated areas containing species/habitats deemed to be of low vulnerability (resilience x susceptibility) | Designated areas containing species/habitats deemed to be of medium vulnerability (resilience x susceptibility) | Possible to get a high score but no designated areas resulted in a score higher than medium | |

## 1.5. Hazard and Grid Data

In relation to the definition and assessment of future flood risk, hazard is considered as the geophysical event that could result in harm (to flood receptors). It is therefore regarded as a function of the characteristics of a flood (e.g. depth, velocity, etc).

SEPA's 1 in 200 year indicative river and coastal flood extents[3] were utilised for the assessment (these are readily available datasets within SEPA).

A national indicative pluvial dataset and a national indicative groundwater dataset have been developed have been integrated into the assessment. Pluvial extents generated using a 0.1m depth contour and a 0.3m depth contour were used within the assessment.

The assessment follows a grid based approach which offers a standard geographical-sized unit from which comparisons of flood risk across Scotland may be made.

A 1km² grid cell provides a relatively high resolution for analysis within a national scale assessment. At this scale, small settlements (e.g. population ~1000) are still individually identified. This resolution and data size is much more efficient than at an even higher resolution such as a 500m² grid cell scale. At larger scales (e.g. 2km² and 5km² cell size) the granularity of the assessment is not as great, which ultimately leads to a less accurate assessment. Discussions at SAIFF[4] with regards to the various grid resolution options informed the decision that the 1km² grid cell was the most suitable cell size for the national assessment.

A similar grid cell resolution also informs approaches used by the Environment Agency (England and Wales), and by the Rivers Agency (Northern Ireland) in their preliminary Flood Risk Assessments.

## 1.6. Probability

The NFRA framework allows the consideration of flooding from a range of sources and therefore a range of probabilities. Separate assessments were carried out for each source of flooding in order to identify where areas are impacted by multiple flood sources. As the 1 in 200 year return period has been utilised for the Fluvial, Coastal and Pluvial flood extents, the annual exceedance probability factor of 0.5 was applied. This ensures that the method is expandable if and when different return periods are incorporated in the future.

## 1.7. Catchment approach

The first stage of producing the NFRA is to identify areas potentially at risk at a 1km$^2$ grid level. However, in order to translate this output into catchment units of management, the Inter Confluence Catchments (ICCs) dataset has been utilised. ICCs are generated from each confluence on the baseline river network, i.e. where two or more rivers, each with a catchment area greater than 10 km², meet. They are derived from the work undertaken to generate the Water Framework Directive river

[3] SEPA Flood Maps http://map.sepa.org.uk/floodmap/map.htm
[4] SAIFF - Scottish Advisory and Implementation Forum on Flooding – incorporating advisory and task & finish groups

typology dataset and the sub-catchment level of information represented by ICCs will be the unit of management used to derive PVAs.

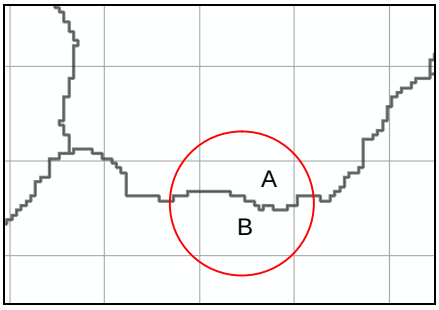
Various other units of management were considered in discussion at SAIFF (e.g. amalgamation of grids, 'buffered areas' etc.). SAIFF regarded the sub-catchment/ICC approach as the most appropriate option. ICCs translate the NFRA grid output to a sub-catchment level, allowing future measures and objectives to be related to catchments as required by the principles of the FRM Act.

Before use within the NFRA assessment, the ICC dataset was reviewed, tested and amended to ensure it was appropriate for use. The resulting 'Sub Catchment Unit' dataset (SCU) is an amended version of the ICCs, created for the purposes of the NFRA.

A large range of thresholds and methods have been tested to ensure that that the resulting categorisation most accurately represents flood risk in Scotland. The preferred process of transferring the grid outputs to the sub catchment level involves splitting the 1km grid by the Sub Catchment Units before any analysis is carried out. All scores are therefore attributed depending on the receptors that are located within each split cell area.

Example:

*1km grid split using SCU boundaries. Receptor A's score would be attributed to the north portion of the cell, receptor B's score would be attributed to the south portion of the grid.*




The 7 NFRA grid outputs in table 1 below, for fluvial, coastal and pluvial flooding sources, are combined to provide a total score for each cell and a groundwater factor has been included for areas which have been classified to have a High or Very High susceptibility to groundwater flooding. The final grid scores are used to inform the categorisation of SCUs as per below (*Table 1*):

**Table 1**

| | | |
|---|---|---|
| Human Health (A) Score | Greater of the two Human Health Scores | Final cell score is sum of 4 outputs |
| Human Health (B) Score | | |
| Economic Activity (A) Score | Greatest of the three Economic Activity Scores | |
| Economic Activity (B) Score | | |
| Economic Activity (C) Score | | |
| Cultural Heritage Score | Cultural Heritage Score | |
| Environment Score | Environment Score | |

## 2. Human Health

### 2.1 Human Health (A) - People

| |
|---|
| Flood risk in terms of Human Health (A) has been assessed as a factor of *Exposure x Vulnerability* where:<br><br>Exposure: Number of residential properties (RPs) per km²<br>Vulnerability: Social Vulnerability of the area using a Social Flood Vulnerability Index (SFVI) |

'Exposure' and 'Vulnerability' was applied to the grid cells and the overall output score was calculated as *Exposure Score x Vulnerability multiplier*

Property point data used for this assessment was the OS MasterMap Addresspoint dataset. The number of Residential Properties (RPs) within the hazard (flooded area) per cell was calculated and equates to the exposure score.

In order to assess the Vulnerability aspect, a Social Flood Vulnerability Index (SFVI) (Tapsell et al. 2002)[5] has been utilised as a means of deriving social vulnerability. The SFVI methodology was developed as a means of measuring impacts that flooding can have on a community and uses three social characteristics and four financial deprivation indices:

| | |
|---|---|
| Social Characteristics: | Long Term Sick<br>Lone Parents<br>Elderly (over 75 years old) |
| Financial Indices: | Unemployment<br>Overcrowding<br>Non-car ownership<br>Non-home ownership |

Information on the above categories was obtained from census data (2001) and relates to the census 'Datazones' which are geographic areas defined according to key characteristics common to the population in that grouping, used by the Scottish Government.

In order to assign a vulnerability score to each Datazone, the scoring method below (defined by Tapsell et al.) was used:

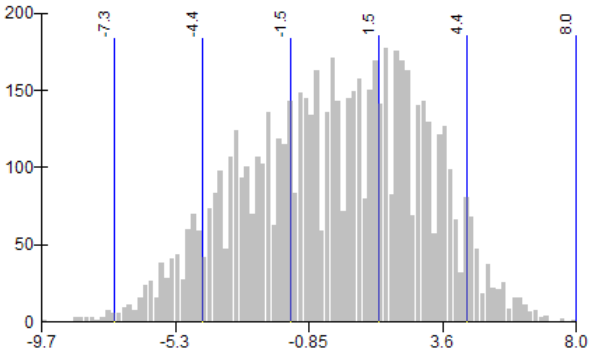
| |
|---|
| *SFVI Score = ((Unemployed + Overcrowding + Non-car ownership + Non homeownership) / 4) + Single Parents + Over 75s + Long Term Sick))* |

This equation considers percentages and z-scores (a standard score used to compare means from different normally distributed sets of data), with resulting scores ranging from -9.7 (low vulnerability) to 8 (high vulnerability).

The scores were categorised as per below based upon a standard deviation classification:

| Cat | Score |
|---|---|

[5] 'Vulnerability to flooding: health and social dimensions', S. M. Tapsell, E. C. Penning-Rowsell, S. M. Tunstall and T. L. Wilson - *Flood Hazard Research Centre, Middlesex University, Queensway, Enfield, Middlesex EN3 4SF, UK, Published online 24 May 2002*




| | |
|---|---|
| VL | -9.7 to -4.4 |
| L | -4.3 to -1.5 |
| M | -1.4 to 1.5 |
| H | 1.6 to 4.4 |
| VH | 4.5 to 8 |

This classification method was reviewed, along with the general SFVI method, at the Department of Statistics at the University of Glasgow[6]. The outcome of the review was generally positive but suggested use of the standard deviation approach (as opposed to the Jenks Natural Breaks method previously utilised), and advised the use of 5 risk classes instead of the 3 used previously, in order to retain consistency with both the Tapsell method and with the general NFRA approach.

For each grid cell, the maximum score was calculated (i.e. the most vulnerable area within each cell) where a residential property within a hazard was located. A multiplier was then calculated as per below, using values recommended in the Multi-Coloured Handbook[7] (Table 4.6 in the Handbook) and scaled to a maximum of 1, in order to identify those properties that were located within an area deemed to be more socially vulnerable to the impacts of flooding.

| | |
|---|---|
| VH | 1.56 |
| H | 1.34 |
| M | 1 |
| L | 0.92 |
| VL | 0.61 |

The exposure score was then multiplied by the social vulnerability multiplier in order to derive a total score for Human Health (A) – People, which considers both the number of RPs within a cell and the maximum social vulnerability factor within the cell.

Example:

A cell containing 50 RPs, which is located in an area where the social vulnerability is scored as 'L' will be calculated as 50 x 0.92, with a total score of 46. This is then the score used to represent Human Health (A), and will be utilised to inform the categorisation of SCUs along with the final scores from the other receptors.

A Weighted Annual Average Damage (Weighted AAD) has been calculated and referenced to the catchment level. This has been calculated using the method outlined in the Multi-Coloured Handbook whereby a Weighted AAD of £5393 will be applied per RP. Properties in defended areas were given an appropriate Weighted AAD as per Table 4.4. in the Multi-Coloured Handbook. The outcome is a Weighted AAD total per SCU which will provide an indication of average potential costs to RPs, and will provide additional data for future planning purposes.

[6] Professor Marian Scott
[7] Multi-Coloured Handbook: The Benefits of Flood and Coastal Risk Management: A Handbook of Assessment Techniques, Middlesex University Press 2010, http://www.mdx.ac.uk/our-research/centres/flood-hazard/flood-hazard-research-centre-publications

## 2.2. Human Health (B) – Community

| | |
|---|---|
| Flood risk in terms of Human Health (B) has been assessed as a factor of *Exposure x Value* where: | |
| Exposure: | Where a community service exists within a hazard (Y/N or 'Off/On' approach) |
| Value: | Importance of the community service |

Community services have been defined as education facilities, healthcare facilities, emergency services (police/fire and ambulance services), post offices, water pumping facilities and waste water treatment works (WWTWs). These services have been considered due to the community disruption that may occur if impacted.

The community services were derived using the OS Points of Interest dataset which contains all non-residential properties (NRPs) categorised by business type and further classified into business categories i.e. Retail / Clothing. A Scottish Water Asset dataset was utilised to select WWTWs. The value (or importance) of a community service has been derived in terms of the potential disruption factor to a community, the number of people likely to be affected, and the type of organisation affected (i.e. whether the service is an emergency responder etc.). A risk score from 0 to 4 (0=VL, 1=L, 2=M, 3=H, 4=VH) was attributed to each type of community service (*see Appendix 1*).

Policy Planning Statement 25 (Development and Flood Risk) was also considered as a basis for ranking community services. While this is a set of policy guidelines for England it does however provide a comparative measure for Scotland[8]. The categories broadly align although there is insufficient information in some areas to classify extensively. Community Risk Registers for strategic coordinating groups in Scotland were also utilised to provide an indication of 'importance' of facilities. Scores have been assigned and input was provided by Scottish Water with regard to the risk categorisation of Waste Storage, Processing and Disposal and Water Pumping Stations.

Given the geography of Scotland, it was deemed necessary to take into consideration the difference in 'value' between urban and remote rural locations with respect to the community facilities. In this assessment, the importance (value) of certain facilities (education facilities, healthcare facilities, emergency services and post offices) is considered as being higher in remote locations due to the fact that there are fewer facilities available geographically, and therefore travel distances become much longer. The Scottish Government has created a dataset that classifies Scotland into categories based on population and drive times to urban centres (Urban/Rural Classification 2010 – *see Table 2*). This dataset was utilised to identify any of these community services that are located in remote or very remote areas and the 'value' score was upgraded by one category e.g. a police station located in a remote located was categorised as 'H'.

For more information on the Urban/Rural Classification see:
http://www.scotland.gov.uk/Resource/Doc/933/0103167.pdf

[8] Scottish Planning Policy (SPP) is not as explicit in assigning a community facility importance

**Table 2**

| | Classification | Description | Use in NFRA |
|---|---|---|---|
| 1 | Large Urban Areas | Population >125,000 | |
| 2 | Other Urban Areas | Population between 10,000 and 125,000 | |
| 3 | Accessible Small Towns | Population between 3000 and 10,000 and within a 30 min drive time to a settlement of 10,000 or more | |
| 4 | Remote Small Towns | Population between 3000 and 10,000 and a drive time between 30 to 60 mins to a settlement of 10,000 or more | Category used to increase scores |
| 5 | Very Remote Small Towns | Population between 3000 and 10,000 and a drive time over 60 mins to a settlement of 10,000 or more | Category used to increase scores |
| 6 | Accessible Rural Areas | Population <3000 and within a 30 min drive time to a settlement of 10,000 or more | |
| 7 | Remote Rural Areas | Population <3000 and a drive time between 30 to 60 mins to a settlement of 10,000 or more | Category used to increase scores |
| 8 | Very Remote Rural Areas | Population <3000 and a drive time over 60 mins to a settlement of 10,000 or more | Category used to increase scores |

The maximum score was applied to each cell where a service was located *(Exposure = 'On')* therefore the highest risk score present in a cell returns the cell value.

## 3. Economic Activity

### 3.1. Economic Activity (A) - Business

| |
|---|
| Flood risk in terms of Economic Activity (A) has been assessed in terms of the *Exposure x Value* of Non Residential Properties (NRPs) where<br><br>Exposure: Number of NRPs per km²<br>Value: Weighted Average Annual Damage (WAAD) Score |

The OS Points of Interest dataset has been used to select NRPs. Each point was attributed with a 'bulk class' using the Multi-Coloured Handbook. According to the handbook, there are 5 bulk classes (Retail, Warehouse, Office, Factory, Non-Bulk) and these can be used to derive an average floor space and weighted AAD. In order to relate each NRP to a single RP (i.e. NRPs vs. RPs), a factor relating the residential property weighted AAD (£5393)[9] was applied to the NRPs per cell using the below formula:

| |
|---|
| *NRP WAAD Score = (Bulk Class Average Flood Space (m²) x Bulk Class WAAD) / Residential Property WAAD* |

e.g.: Where Bulk Class is Retail: (Average Floor Space (194m²) x AAD (£69.40/m²)) / £5393 = NRP score of 2.49.

There is an option to use a 'with basement' figure, or a 'without basement' figure for calculating weighted AADs for NRPs (tables 5.1a and 5.1b in the Multi-Coloured Handbook). The 'with basements' figures were utilised for this assessment as these figures ensured a more precautionary approach.

Each cell was attributed with the sum of the NRP scores within the cell e.g. a cell containing 5 'retail' properties would have a total score of 12.45.

A weighted AAD total per SCU was also calculated. Both the 'with basement' and the 'without basement' figures were used and the inclusion of 2 sets of values allowed the generation of an upper and lower banding.

Properties in defended areas were given an appropriate weighted AAD as per tables 5.1a and 51.b. in the Multi-Coloured Handbook. The outcome is a weighted AAD total lower and upper band per SCU. This will be for information purposes and will provide additional data for future planning purposes.

[9] Figure from *Multi-Coloured Handbook: The Benefits of Flood and Coastal Risk Management:A Handbook of Assessment Techniques, Middlesex University Press 2010* http://www.mdx.ac.uk/our-research/centres/flood-hazard/flood-hazard-research-centre-publications

### 3.2. Economic Activity (B) - Transport

| | |
|---|---|
| Flood risk in terms of Economic Activity (B) has been assessed in terms of the *Exposure x Value x Vulnerability* where | |
| Exposure: | Where a road, railway or airport exists within a hazard (Y/N or 'Off/On' approach) |
| Value: | Importance of road/railway/airport i.e. the road classification |
| Vulnerability: | Rural vs. Urban location of road/railway |

The matrix below has been used to derive an overall score for Economic Activity (B) using the Value and Vulnerability score. However due to the fact that motorways are a key transport facility for the public and importantly for businesses, it is considered that they should be identified as 'high' regardless of the vulnerability rating. Similarly, airports were attributed as Very High regardless of the vulnerability due to the potentially massive economic impacts that may be incurred if affected.

Exposure in terms of Transport has been assessed as an 'on/off' factor, i.e. where a transport link is located in a flood extent, the grid cell has been identified. This method has been used instead of determining the length/area of road affected. There are many uncertainties related to the data such as unknown number of lanes, whether a road is raised etc. In future cycles it is proposed that this information is derived and utilised, however at present an 'on/off' approach provides a simple method of identifying possible risks, and uncertainties are mitigated in later stages of the process.

*Value x Vulnerability matrix for non-motorway roads and rail links:*

*Vulnerability*

| | | | |
|---|---|---|---|
| **H(3)** | 3 | 6 | 9 |
| **M(2)** | 2 | 4 | 6 |
| **L(1)** | 1 | 2 | 3 |
| | **L(1)** | **M(2)** | **H(3)** |

*Value*

*Where:*

| | |
|---|---|
| 1 to 2 | **L** |
| 3 to 6 | **M** |
| 7 to 9 | **H** |

The data utilised for this aspect of the assessment was OS MasterMap Integrated Transport Network (Roads), OS Meridian 2 (Rail) and OS MasterMap (Airports).

Roads within the OS MasterMap ITN are categorised as:

Motorway, A Road, B Road, Minor Road and Local Roads

An assessment was carried out to decide whether to include Local Roads (i.e. residential streets). The outcome was very similar when Local Roads were not included and it was deemed worthwhile **not** to include Local Roads at this time due to increased processing time/data size. Grid cells were selected where either a road link, rail link or airport was located within a hazard.

The ‘value’ of a road or rail link has been defined as the importance of the road/railway. For the purpose of this assessment, Value is related to the road classification/type of transport link where:

| | |
|---|---|
| **VH** | Airport |
| **H** | Motorway or ‘A’ Road, Railway |
| **M** | ‘B’ Road |
| **L** | Minor Road |

It should be noted that a road classification exists (trunk roads only) based on the economic, social and integrated transport factors (Transport Scotland). This information is currently unavailable but it is intended that this dataset or similar should be used to refine this assessment in future cycles.

In addition, Transport Scotland has provided data for the ‘Number of Road Users’ per day. This was investigated for use as an indicator for ‘value’. However, a large amount of manual work is required to ensure monitoring sites are attributing the correct roads, and that erroneous counts such as ‘9999’ are removed from the assessment. This dataset is also only provided for trunk roads. After an initial review, it was decided that further investigation was required to ensure this dataset could be used effectively and that the required level of reliability from the dataset was not readily derivable. This may impact the ‘importance’ level of the road network in future cycles.

Grid cells were attributed with the maximum value per cell i.e. the most important value per cell.

Vulnerability in terms of transport can be determined by the vulnerability to road users/communities that may be affected by road closures. Rural areas will be most impacted as diversion routes are likely to be longer if available at all.

Using the Scottish Government Urban/Rural Classification (*see Table 2*), a vulnerability score was applied as below (*Table 3*) to ensure roads in ‘very remote’ areas were classed with a ‘H’ vulnerability score, whilst roads in ‘remote’ areas were classed with an ‘M’ vulnerability score:

**Table 3.**

| | **Classification** | **Vulnerability Score** |
|---|---|---|
| 1 | Large Urban Areas | **L** |
| 2 | Other Urban Areas | **L** |
| 3 | Accessible Small Towns | **L** |
| 4 | Remote Small Towns | **M** |
| 5 | Very Remote Small Towns | **H** |
| 6 | Accessible Rural Areas | **L** |
| 7 | Remote Rural Areas | **M** |
| 8 | Very Remote Rural Areas | **H** |

Using the matrix illustrated above a risk score was applied considering both the value and the vulnerability of the transport link.

Transport Scotland has reviewed the approach and datasets used, and has provided a broad approval. It will continue to be involved in the process to help ensure that the best available datasets are utilised.

### 3.3. Economic Activity (C) – Agriculture

| | |
|---|---|
| Flood risk in terms of Economic Activity (C) has been assessed in terms of the *Exposure x Value* where | |
| Exposure: | Where an area of agricultural land exists within a hazard (Y/N or 'Off/On' approach) |
| Value: | Importance of land class |

The CORINE Land Cover Map (CLC2000)[10] was selected for analysis in terms of calculating the area of agricultural land affected by flooding. CORINE 2000 is the year 2000 update of the first CLC database which was finalised in the early 1990s as part of the European Commission program to COoRdinate INformation on the Environment (Corine). It provides consistent information on land cover changes during the past decade across Europe. The CLC2000 database covers 32 countries.

CLC2000 was derived from the Land Cover Map 2000 (LCM). The LCM2000 is a more detailed dataset however the CLC2000 provided a simpler version which was more useable for the purposes of this assessment. A third alternative dataset 'Land Cover of Scotland 1988' (Macaulay Land Use Research Institute) was deemed to be less reliable because of the age of the dataset, although the resolution is good.

It should also be noted that there are some potential new datasets that could be utilised when available such as the year 2007 version of the LCM and a new land use dataset currently being created by the Scottish Government. These will be reviewed and considered for future NFRA updates.

Grid cells were selected where any area of agricultural land/forestry was located within a hazard.

In order to derive an estimated land value, SEPA's Environmental Economy Department classified the CORINE agricultural and forestry land categories using average land values which were assumed to be a reasonable reflection of agricultural land values in Scotland. These were used to classify the data into broad 'value' categories (*see Appendix 2*).

Using these values the above CORINE land classes were assigned a risk category from Very Low to Medium. The maximum value per cell was used.

An estimated AAD total per catchment has also been calculated. Table 9.8. in the Multi-Coloured Manual presents estimates of costs from a single flood according to an Agricultural Land Class (ALC). In order to create a national estimate of damage to agriculture, a value has been calculated based on areas within a range of flood envelopes and with a range of land classes. Initial values have been weighted using an estimate of the percentage of land within different return period flood envelopes (values derived from the Multi-Coloured Handbook, Table 4.5). These values were

[10] http://www.eea.europa.eu/data-and-maps/data/corine-land-cover-2000-clc2000-seamless-vector-database

then multiplied by the percentage of land within Scotland which falls within each ALC[11]. The value for each ALC was then summarised to give a value of £538/ km$^2$.

## 4. The Environment

| | |
|---|---|
| The impacts of flooding on the natural environment have been considered in this assessment as a factor of the *Exposure x Vulnerability* of protected areas (and the species and habitats within these areas) where: | |
| Exposure: | Where an area of designated land exists within a hazard (Y/N or 'Off/On' approach) |
| Vulnerability: | A factor of the susceptibility of the species/habitat to flooding and the resilience of that species/habitat |

To support the development of appropriate methods, the identification of appropriate datasets and he establishment of a Vulnerability rating, an Environmental Risk Receptor Working Group (ERRWG) was set up which includes key SEPA staff from Ecology and representatives from Scottish Natural Heritage.

The below datasets were utilised for this element of the assessment. These were readily available and were deemed the most suitable by the ERRWG:

- SACs (Special Areas of Conservation) – EU Legislation
- SPAs (Special Protection Areas) – EU Legislation
- SSSIs (Sites of Special Scientific Interest) – UK Legislation

Grid cells were selected where any of the above designated areas were located within a hazard. Vulnerability in terms of the natural environment has been assessed as a function of 'Susceptibility' x 'Resilience'.

The ERRWG applied a score (0 to 3 where 0=VL and 3=H) for susceptibility and for resilience to each broad category that was identified as being located within a designated area, within the floodplain.

A total score was applied to each broad category using the below matrix:

*Resilience*

| | | | | |
|---|---|---|---|---|
| **H (3)** | 0 | 3 | 6 | 9 |
| **M (2)** | 0 | 2 | 4 | 6 |
| **L (1)** | 0 | 1 | 2 | 3 |
| **VL(0)** | 0 | 0 | 0 | 0 |
| | **VL(0)** | **L(1)** | **M(2)** | **H(3)** |

*Susceptibility*

*Where:*

| | |
|---|---|
| 0 | **VL** |
| 1 to 2 | **L** |
| 3 to 6 | **M** |
| Over 6 | **H** |

[11] Figure from the Macaulay Land Use Research Institute - The Potential use of the Land Capability for Agriculture Classification for Determining Support to Disadvantaged Areas of Scotland (2006)

The maximum score was applied to each designated area, and in turn to each grid cell. For example, a designated area containing a species deemed to have a 'M' vulnerability score, and a species deemed to have a 'L' vulnerability score would get an overall score of 'M'. The grid cell containing this designated area would therefore also get a score of 'M'.

## 5. Cultural Heritage

| |
|---|
| The impacts of flooding on the cultural heritage have been considered in this assessment as a factor of the *Exposure x Value* of cultural sites where:<br><br>Exposure: Where a cultural site exists within a hazard (Y/N or 'Off/On' approach)<br>Value: Importance or level of designation of the cultural site |

The below datasets were utilised for this element of the assessment. These were readily available and were deemed the most suitable by Historic Scotland.

- Listed Buildings (All categories)
- Scheduled Monuments (Monument of national importance)
- World Heritage Sites
- Gardens and Designed Landscapes

Grid cells were selected where a listed building, scheduled monument, world heritage site or garden and designed landscape site was located within a hazard.

The method of applying a value to Cultural Heritage Receptors has been informed by the 'Cultural Importance' of a site based on recognised designations of local, regional, national and international importance. A measure of this has been undertaken in the SEPA Water Framework Directive guidance paper 'Assessing the significance of Impacts – Social, Economic, Environmental (WAT-SG-67) whereby an indicative guide to assessing the importance of an impacted built heritage interest as been created. The categories produced (with relevance to this exercise) are as below:

| | |
|---|---|
| Low | Listed Buildings Grade C(s) |
| Medium | Listed Buildings Grade B |
| High | Scheduled Monuments<br>Listed Buildings Grade A |
| Very High | UNESCO World Heritage Site for which Built heritage was an important factor in its designation |

A categorisation of the available data utilised for this assessment has been derived from this as below:

| | VL | L | M | H |
|---|---|---|---|---|
| **Score** | 0 | 1 | 2 | 3 |
| **Description** | Listed Buildings/WHS /Monuments not located within defined hazard | **Listed Buildings Category C** | **Listed Buildings Category B, Gardens and Designed Landscapes** | **Scheduled Monuments, Listed Buildings Category A, UNESCO WHS** |

Using these values the grid cells were assigned a risk category from Low to High.

Historic Scotland has been involved throughout the assessment process by reviewing the methods and datasets as well as providing expert input. Historic Scotland has also been involved through its role in SAIFF task and finish groups and in future it is hoped that this area of the assessment can be developed in partnership in order to attain a 'vulnerability' score based on the susceptibility and resilience of the site to impacts of flooding.

## 6. Flood Defences

A number of options were considered as to how Flood Protection Schemes (FPS) could be incorporated into the NFRA. The complexity of the issue and the available data were taken into consideration to identify the method which was deemed to be the most appropriate. The approaches taken by the other UK Agencies were also investigated.

The selected method investigates the impact of FPS in two phases: the first phase provides a quantitative assessment for schemes with available data, identifying the protection offered by the defences; the second phase is a qualitative assessment, which will be undertaken for all FPS.

There are currently 113 formal schemes in Scotland as recorded in the Scottish Flood Defence Asset Database (SFDAD) and of these, 40 have been assessed at a detailed level. Data identifying the 'areas of benefit' for these 40 schemes, which illustrates the area behind a defence that benefits from the protection, has been supplied by consultants Jeremy Benn Associates (JBA) that hosts and maintains this dataset for the Scottish Government. This data was used to identify the potential benefit offered by the 40 schemes.

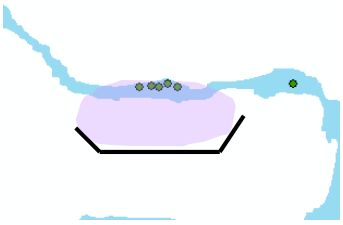
The phase 1 assessment identifies receptors within the 'area of benefit'. The receptors utilised for this stage of the assessment are residential properties (RPs) and non-residential properties (NRPs). Generally, these are the receptors for which defences were originally created to protect and are most likely to benefit from existing defence schemes. These are also the most influential elements of the assessment. The RPs and NRPs located within the 'areas benefiting' were selected, and form a new set of receptor data, to identify protected properties.

To supplement these areas an assessment of the defence has also been conducted, based on the scheme age, condition, standard of protection and any reduction of the stated standard of protection, which allows the development of a 'defence category'. Those deemed to require further maintenance or those where the information is unreliable or incomplete have been identified as requiring further review in phase 2.

A weighting based on the defence category has been applied to the properties benefiting from defence. This value output has been subtracted from the original assessment for these two receptors to provide a new receptor figure.

**Very Good**: 1
**Good**: 0.75
**Fair**: 0.5
**Poor**: 0

Example:



Original score for ICC = 250

44 Properties within the area benefitting from defences

Defence Category = Good (0.75)

Cell score for this receptor (e.g. Human Health (A) = (250-(44*0.75)) = 217

This will be the score used to take through to the PVA assessment

The second phase of the FPS assessment has been carried out within the Sub Catchment Unit Review process (section 12). This includes a consideration of among other things: required maintenance of the FPS and residual risk posed by the structures. The rating of that Sub Catchment Unit could then be upgraded or downgraded, based on the criteria below.

- rating of the defence
- the number of properties behind the defence
- maintenance history /cost
- defence height

**7. Climate Change**

SEPA has coordinated a project to assess the vulnerability of Scotland's river catchments and coasts to the impact of climate change. For fluvial flooding, this was assessed as a Scotland-focused version of the established DEFRA[12] method, and the impact to the Scottish coastline was assessed through the development and deterministic assessment of a series of Coastal Behavioural Systems.

The sensitivity of catchments is identified by the Scotland focused method. This estimates a catchment's sensitivity to climatic change then combines it with information on climatic hazard in order to estimate the risk in terms of the impacts on peak river flows. As part of this work, catchment sensitivity (response type) was estimated from catchments' properties. This study allowed the response type to be more applicable to Scotland. This approach is intended to be scenario-neutral (i.e. based on catchment response rather than the time-varying outcome of individual scenarios) in order to provide a strong base assessment of the potential impact of climate change and thus secure confidence in setting future objectives and measures.

The coastal element of the study included a review of the implications of climate change on coastal landforms and processes around Scotland and an assessment of future behaviour and vulnerability of the coastline. The approach included the definition of climate change predictions, coastal behaviour systems and associated sensitivity analysis, identification of assets exposed to hazards and finally an assessment of coastal vulnerability.

The sensitivity of catchments has been considered in the definition and characterisation of SCUs which will inform the identification of Potentially Vulnerable Areas. A factor relating to the potential impacts that climate change would cause has been applied to each SCU. The factor is based on the increase in economic costs

[12] Department for Environment, Food and Rural Affairs

which would be expected due to a greater flooding depth to identified receptors. The factor does not include additional receptors being placed in the floodplain[13].

**8. Future Development within Flood Risk Areas**

The FRM Act requires the adoption of a forward looking approach that considers future developments. Information of future strategic developments has been obtained from the National Planning Framework 2 and data identifying the locations of

strategic areas of development has been created. This data has been used in combination with other information such as climate change impacts, to aid in the definition of PVAs.

As the assessment of potential future climate change is improved SEPA will seek to consider the potential future impacts on flood risk in planning appropriate measures and objectives.

**9. Historic Flood Events**

The FRM Act requires the inclusion of significant past flood events as part of the NFRA to ensure that any areas previously affected by flooding are considered. SEPA has gathered information on historic flood events from Local Authorities, Scottish Water, Network Rail and SEPA data held internally. An exercise was also carried out to collect historical flood event data from archived information. This data has been collated and reviewed, as part of the review process the significance of the flood recorded has been determined. Significant flood events have been identified using a scoring method that considers the impact, source and reliability of the recorded event.

In some instances a general location of a flooding record has been provided, referenced by town or street rather than individual properties. As a result it is more appropriate to include this information at the catchment unit level rather than grid level when flooding incidents may be incorrectly attributed.

The historical flood event data was used in the validation of the NFRA grid output, in order to ensure that significant past flood events have been a) identified and b) analysed to inform the categorisation of SCUs and therefore the definition of PVAs.

**10. Infrastructure**

The presence of utility infrastructure within a flood extent has been utilised to inform the definition of PVAs. The Ordnance Survey Points of Interest Dataset has been used to identify energy production sites (power stations, generating stations etc.), telecommunications features (broadcasting stations, exchanges etc.) and oil extraction, refinery and product manufacture sites (e.g. oil refineries). This is a fully available dataset derived from a range of sources and provides spatial information on commercial features across Great Britain highlighting location and function information, with a postal address for all addressable points.

[13] Factor derived from Multi-Coloured Handbook Appendix Chapter 4 http://www.mdx.ac.uk/our-research/centres/flood-hazard/flood-hazard-research-centre-publications

The location of these sites have helped inform the PVA creation decision making process. More details can be found in the Sub Catchment Unit Categorisation chapters (section 12) of this document.

## 11. Uncertainties

The NFRA grid output has been created using readily available and derivable data as specified in the Flood Risk Management (Scotland) Act 2009. Whilst the best available data has been utilised, there remain uncertainties associated with developing any flood risk assessment methodology. The main areas of data uncertainty are presented below.

### Hazard Data

- **Fluvial and Coastal**

The Indicative 1 in 200 year fluvial and coastal flood maps have been utilised as a hazard for the NFRA. Uncertainty contained within this data and therefore the derived outputs is present within this assessment, due to issues such as the vertical error associated within the digital terrain model (Nextmap DTM).

- **Pluvial**

SEPA has derived a national scale pluvial flood modelling programme, the goal of which was to generate a pluvial flood map for Scotland. The greatest uncertainties associated with this work are the inaccuracies in the ground model used (Nextmap DTM) and losses to sewer systems. The modelling software used (ISIS FAST) has a functionality which allows for sewer system losses, which has been assumed to be 12mm per hour which is a standard loss figure currently being used in England, Wales and Northern Ireland.

- **Groundwater**

There are inherent uncertainties in mapping groundwater flood hazards at a national scale. Uncertainties are associated with the groundwater data that was derived using a variety of sources, including SEPA's 1 in 200 year fluvial and coastal flood maps, which were used as a proxy to indicate areas vulnerable to flooding in low lying areas. Limitations with certain geology datasets (e.g. karstic limestone and fracture zones) were identified and the geological mapping in urban areas is uncertain due to the effect that building processes can have by potentially disturbing or removing the natural occurrence of geological deposits. However, the best available geological and aquifer mapping information has been used within this methodology.

### Climate Change Data

In terms of flooding, climate change impact is based on the probability of increased likelihood of floods occurring, and is therefore inherently uncertain. There is also an inherent uncertainty within climate change models. SEPA has undertaken a Scotland-specific project to determine the likely changes in flow based on the best available data and methodologies. The wide ranging sensitivity analysis approach to assess the catchment response to climate change adopted by the project takes account of a number of the uncertainties.

**Receptor Data**

- **Land Use Data**

The land use dataset utilised for aspects of the economic assessment (CORINE) has data uncertainties especially related to scale and level of detail. The areas are broad, and categories at a low resolution. However the accuracy of the data was validated by comparing to other imaging types, such as ground based photography and written observations. The exercise shows that the database exceeded the 85% accuracy requirement set down in its technical guidelines[14]. This dataset was deemed to be the most appropriate readily available dataset.

- **Property Point Data**

Point data utilised for Human Health (A), Human Health (B) and Economic Activity (A) has associated uncertainties related to the use of the points within the NFRA. Risk has been assessed using the location of points (i.e. points located in a flood extent), however building polygons (footprints) have not been considered. The actual physical area of a building at risk from flooding and the size of the building is therefore not known. This has been partly accounted for in Economic Activity (A) by identifying the building 'type' and the associated average floor space, however this is a broad categorisation that results in a proxy floor space figure.

- **Transport Data**

With regards to Economic Activity (C) – transport, the assessment of the impact of flooding to transport may be overestimated due to the numerous river crossings made by both the road and rail networks. Although it would be possible to remove all of these areas from the assessment there is a possibility that certain structures could cause flooding if blocked or capacity is exceeded. No data currently exists to enable a strategic assessment of the capacity of each structure therefore these areas have been included within the NFRA. There are also limitations in terms of transport associated with the Indicative River and Coastal Flood Maps, in that the maps do not currently account for man-made structures such as bridges.

- **Cultural Sites and Environmental Data**

Data utilised for the Cultural Heritage and Environment aspects of the assessment contains uncertainties related to its use within the NFRA. It is recognised that more work is required to further analyse the data to ensure the risk value attached to each feature is correct. For example, the location of a cultural site may be accurate, but its vulnerability to flooding has not yet been assessed and therefore may over/under influence the assessment. It is intended that work will be carried out with Historic Scotland in the future to address this. Similarly, the designated areas used in the Environment assessment correctly depict the areas spatially, but the location of species and habitats within the designated areas is not known.

Finally, the use of risk categories within the NFRA also contains a certain amount of uncertainty. The approach of categorising risk by counts/values etc. contains some subjectivity, however this has been minimised by employing various internal and external experts who have reviewed and input into the categorisation and methods. A peer review was carried out to examine the methodology and specific aspects of the assessment (i.e. the SFVI method), and additionally a series of workshops were held with Local Authorities and SEPA staff to ensure a robust approach.

[14] http://www.eea.europa.eu/highlights/Ann1151398593

## 12. Sub Catchment Unit (SCU) Categorisation

The grid output provides a semi-quantitative analysis of the impact of 'future' and historic (recorded) floods could have to Human Health, Economic Activity, Environment and Cultural Heritage, from strategic flooding information. The catchment analysis is based on reliable information that is available or readily derivable and provides a nationally consistent data set which can be used to prioritise areas and identify where further work may be required.

Strategic studies by their nature cannot replicate the detail of local studies and some generalisations are required at both the hazard and receptor level. These uncertainties within the data, identified in the previous chapter, are taken into consideration within the Sub Catchment Unit categorisation process. In order to consider the uncertainty, an initial categorisation of SCUs based on the grid output alone has been used to determine the required review process and additional data required to identify the area as a PVA. During the process it is possible for areas to be upgraded or downgraded based on further national or local information.

The method for categorising Sub Catchment Units is a two stage process:

1. SCUs categorised (from 'Very Low' to 'Very High') using the scores from the grid output
2. Manual review of SCUs undertaken that considers supplementary catchment-scale information

The sections below detail the methods undertaken in each of these stages (*See Appendix 4 for the Sub Catchment Unit Categorisation Process Diagram*).

### 12.1. Sub Catchment Unit Category from Grid Scores

Given the definition of flood risk and the need to consider a range of flood risk receptors, the setting of catchment unit categories must be done sensitively and with consideration as to how these might influence the identification of measures and objectives for management planning and future investment.

Chapter 1.4 of this paper highlights the maximum score possible from the different receptor categories. In summary the five categories of catchment units are determined from the initial threshold assessment:

| | |
|---|---|
| **Very High** | Areas with combined complex flooding issues where more than one receptor is at very high risk |
| **High** | Areas with predominately single source flooding issues where either one category shows a very high flood risk or a number of categories show a high flood risk |
| **Medium** | Areas with predominately single source flooding issues where either one category shows a high flood risk or a number of categories show a medium flood risk |
| **Low** | Areas which show some risk of flooding to a number of categories |
| **Very Low** | Areas which show limited flood risk to a small number of categories |

The below table (*Table 4*) illustrates the initial categorisation of the SCUs using the grid output:

Table 4.

| Category | Description of Sub Catchment Unit Receptor Risk | Total Grid Score |
|---|---|---|
| **Very High** | Two or more Very High | >500 |
| **High** | One Very High or multiple (10) High receptors | 250 – 500 |
| **Medium** | Five High receptors | 125 - 250 |
| **Low** | Two High receptors | 50 – 125 |
| **Very Low** | | 0 - 50 |

These categories were used to identify the assessments required to define an area as a PVA.

### 12.2. Manual Review of Sub Catchment Units

As mentioned previously, the SCU review process has been designed to take account of uncertainties within the grid output stage. During the review process it is possible for areas to be upgraded or downgraded based on further national or local information. The review process includes an assessment based on historical flooding records, catchment characteristics, further review of flood protection schemes and identified infrastructure, and review on the range of receptors that have been identified within each catchment unit and additional supplementary data.

The final assessment on additional local information has been carried out only for areas which have a Medium rating but do not enough strategic information available to classify the area as a PVA.

The steps involved in the Sub Catchment Unit manual review process are detailed below.

#### 12.2.1. Initial Screening - Economic

| Required for **Low** and **Very Low** Sub Catchment Unit categories |
|---|

The grid assessment includes a strategic economic assessment based on the weighted Annual Average Damages (AAD) values within the MCM. These values represent a strategic level appraisal of the impact of flooding to the key receptors of residential properties and non residential properties. An AAD has also been applied to agricultural areas at this stage, utilising information sourced from Table 9.8 in the Multi-Coloured Manual. These values are used to ensure that no areas are categorised as Very Low or Low while there is potential for a large economic impact.

The AAD threshold level has been set at equivalent to 50 residential properties within the Catchment Unit (£269,650). The flooding can be from a single or multiple sources. Catchment Units with a potential economic value above this AAD level were upgraded to Medium and therefore included within further analysis. ‘Medium’ is the risk threshold of significance (i.e. used to define PVAs) and therefore it is important that SCUs are included at Medium or above where appropriate. High and Very High categories remain the same (score taken from grid output only).

#### 12.2.2. Initial Screening – Flood Protection Scheme review

| Required for **Low** and **Very Low** Sub Catchment Unit categories |
|---|

Further analysis on the location of existing and planned FPS has been carried out to ensure all areas with schemes are included within the Sub Catchment Unit review.

The first phase of the defence assessment is outlined in the grid methodology in chapter 6. The Sub Catchment Unit review has been carried out for all areas with a FPS regardless of the information held. All areas with a FPS were upgraded to a Medium category to ensure that further assessment of flooding in the area is made. These areas were upgraded in part due to the previously identified flood risk in the area but also due to the ongoing maintenance that may be required to retain scheme effectiveness.

### 12.2.3. Initial screening – Infrastructure

| Required for **Low** and **Very Low** Sub Catchment Unit categories |
|---|

An assessment on infrastructure was initially made to identify any area containing these features (energy production sites, oil extraction and refineries, telecommunications features) within the floodplain. Due to the lack of accompanying information held on these features (i.e. resilience and vulnerability to flooding), these Sub Catchment Units will remain as 'Low' or 'Very Low' categories until the asset owners can provide evidence to prove that these Sub Catchment Units should indeed be included for further analysis. A workshop was held with asset owners and no 'important' assets were identified outside of PVAs.

### 12.2.4. Historic Data Review

| Required for **Low** Sub Catchment Unit category |
|---|

SEPA has gathered information on historic flood events from Local Authorities, Scottish Water, Network Rail and SEPA data held internally. An exercise was also carried out to collect historical flood event data from archived information. This data has been collated and reviewed, as part of the review process the significance of the flood recorded has been determined. Significant flood events have been identified using a scoring method that considers the impact, source and reliability of the recorded event.

This data has been used to identify the number of recorded flood events within each Sub Catchment Unit, the review identifies those areas which have not been picked up by the future floods assessment but have records of flooding. Assessment of the source, significance, spatial information and date of the flood record will be made before increasing the category of the Sub Catchment Unit. Based on this data a Sub Catchment Unit category can be upgraded from Low to Medium

### 12.2.5. Catchment Characteristics

| Required for **Medium and High** Sub Catchment Unit categories |
|---|

Catchment Characteristics have been taken into consideration within the grid assessment during the generation of hazard outlines namely within the hydrologic inflows for Fluvial and Pluvial extents calculated from FEH[15] parameters. In addition SEPA has undertaken a separate study to identify the hydrological characteristics of a Sub Catchment Unit and the Morphological Pressures within each of these areas.

The output of this study has been used to inform the decision making process within the Sub Catchment Unit review.

[15] Flood Estimation Handbook

### 12.2.6. Supplementary Strategic Information

| Required for **Medium and High** Sub Catchment Unit categories |
|---|

There is a large amount of data held within the NFRA and which contribute to the overall assessment. The detail within these projects has been utilised within the supplementary strategic information review.

The data used within this assessment includes

- categorisation of flood defences and the requirement to maintain these defences
- flood warning systems currently in place
- the financial cost of flooding based on Human Health (A) and Economic Activity (A) including impact of flood defences and flood warning areas
- a full breakdown of the grid assessment
- information on future development within flood risk areas

The review for a particular Sub Catchment depends on the issues within the Sub Catchment Unit based on any areas of uncertainty and sources of flooding. Areas have been upgraded or downgraded based on the supplementary information. This review has been used in conjunction with the catchment characteristics information to determine if a) the flood risk has been underestimated within the grid output and b) if this area is likely to have a significant flood risk in the future.

### 12.2.7. Single Receptor Review

| Required for all Sub Catchment Unit categories above **Very Low** |
|---|

Sub Catchment Units which have a large value based primarily from one receptor type may be falsely categorised due to uncertainties or characteristics of the data. For example a road that is in the floodplain for a number of kilometres may provide a large Sub Catchment Unit value although the real impact of the road closure is only felt once *(see Figure 1)*

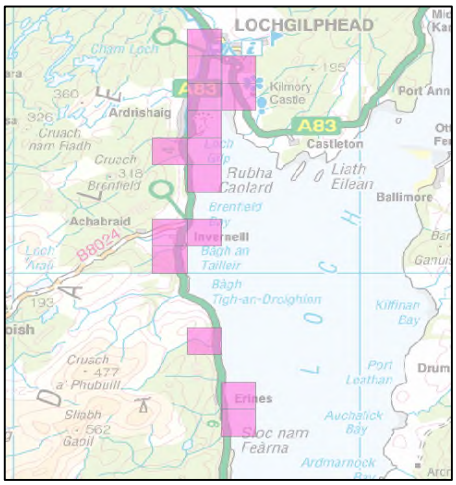



***Figure 1. Illustrates a road that has been identified multiple times in the grid assessment, which may exaggerate the total score of the Sub Catchment Unit to which it belongs.***

The single receptor review is intended to identify any areas that have a large value based on one receptor and whether uncertainties which have come from the receptor data or hazard data have raised the Sub Catchment Unit category falsely.

The single receptor review has been carried out for Sub Catchment Units where Cultural Heritage, Economic Activity (B) - Transport or Environment receptors contributed to 30% or more of the Sub Catchment Unit value. The reason for this is that these three receptor datasets and grid outputs have the most uncertainty is related to them.

Any areas which show Sub Catchment Unit values based on Human Health A or B primarily have been left as is - no additional information can be obtained to influence a manual review. This is also the case for Economic Activity (A) – Businesses and Economic Activity (C) – Agriculture.

Economic Activity (B) -Transport Review:

Sub Catchment Units which are shown to have a value based largely from the impact to transport have been reviewed and may be downgraded by up to three categories

based on the source of flooding and presence of alternative routes. The rationale behind this is that the grid assessment may overestimate the impact of flooding. For example a road closure may have the same impact if it is closed in one location or five locations depending on the number / presence of detours. In addition a known area of uncertainty within the assessment occurs at structures. Only a simple assessment of this risk can be made at this stage as further local information would be required however, at present, all road bridges have been identified as a potential risk although this may not be a true reflection of the actual risk to transport routes. Any Sub Catchment Units that have been downgraded to below medium have been reviewed by Transport Scotland and in those cases where the receptor is actually vulnerable to the impacts of flooding the Sub Catchment Unit has been upgraded back to medium.

Environment Review:

Sub Catchment Units that are shown to have a value based largely from the impact to environmental designations may be downgraded by up to two categories, based on the source of flooding, the location and the designation. This is due to the broad scale information contained within the environmental designation and the fact that the grid assessment uses the highest vulnerability designation to derive the scores. The assessment considers if the designation is likely to occur within the floodplain. For example, some areas are designated due to features only found in upland areas, and others where the same areas are designated more than once (i.e. as an SPA and also an SSSI). Any Sub Catchment Units that have been downgraded to below medium were reviewed by Scottish Natural Heritage and where the receptor is considered as actually being vulnerable to the impacts of flooding, the Sub Catchment Unit was upgraded back to medium.

Cultural Heritage Review:

Sub Catchment Units which are shown to have a value based largely from the impact to Cultural Heritage were downgraded by up to two categories, based on the source of flooding, the location and the designation. Any Sub Catchment Units that have been downgraded to below medium were reviewed by Historic Scotland and where

the receptor is actually vulnerable to the impacts of flooding, the Sub Catchment Unit was upgraded back to medium.

### 12.2.8. Supplementary Local Information

This is the final section of the Sub Catchment Unit review process. The NFRA provides a strategic assessment of flood risk within Scotland. The assessment has been carried out using reliable data that is available and readily derivable. Whilst the NFRA provides a good indication of the large scale flooding issues faced within Scotland it may miss some of the local issues which may have a significant impact. Historic records from Local Authorities have been collected and used to inform the Sub Catchment Unit categories however local flooding issues may contribute to increase the overall risk.

Supplementary information was therefore sought on local issues which may have not been included within the NFRA initially, and could increase flood risk. Data was provided by Local Authorities and includes:

- the presence of restrictive structures
- Further records of significant flooding
- Sewerage system flooding – identification of poor sewerage capacity
- Details of any planned Flood Protection Schemes
- Planned future developments within or close to the floodplain

Based on the above review the final categorisation of Sub Catchment Unit areas were generated. All Sub Catchment Units categorised as Very High, High or Medium categories were included as PVAs.

**Appendix 1.**

Human Health (B) Value Categories

| Community Service | Risk Category | Risk Score | Reasoning |
|---|---|---|---|
| Hospitals/Ambulance Depots * | VH | 4 | Potential for large number of people to be affected, highly vulnerable population, 24 hour occupation of building, required in the case of an emergency |
| Residential Homes (Care/Nursing/Elderly)** | H | 3 | Potential for large number of people to be affected, high number of vulnerable people located in property with buildings having 24 hour occupation |
| Education Facilities (Schools, Nurseries, Universities)** | H | 3 | Potential for large number of people to be affected, high level of community disruption if building closure occurs, some properties may have 24 hour occupation (i.e. boarding schools, halls of residence) |
| WWTWs, Water Pumping Stations | M | 2 | Potential to affect large population if site affected by flooding. Scottish Water advised these facilities should not be 'H' or 'VH' and PPS25[16] supports this. |
| Police Stations** | M | 2 | Potential for emergency responders to be affected, facility is well placed and better prepared for emergencies |
| Health Centres/Clinics** | M | 2 | Potential to cause relatively high levels of disruption to a number of people |
| Fire Stations** | M | 2 | Potential for emergency responders to be affected, well placed to deal with flooding (vehicles able to pass through flood water) |
| GPs/Dental Surgeries** | L | 1 | Low level community disruption a potential |
| Post Offices** | L | 1 | Low level community disruption a potential |
| Pharmacies** | L | 1 | Low level community disruption a potential |

***To be rated 'VH' until further information (Hospital Catchments) is made available from Scottish Government.***

****** Value score increased by a factor of one where located in a remote area***

[16] Policy Planning Statement 25 (Development and Flood Risk)

## Appendix 2.

Estimated Land Values

| Category 1 | Category 2 | Category 3 | Value | Value Assumptions |
|---|---|---|---|---|
| Agricultural areas | Arable land | Non-irrigated arable land | **Medium** | Cropping land - generally for sale at prices between £4,500 and £6,000/acre |
| Agricultural areas | Arable land | Permanently irrigated land | **Medium** | Given that it's permanently irrigated, assumption this is at least as valuable as non-irrigated land. |
| Agricultural areas | Permanent crops | Fruit trees and berry plantations | **Medium** | Assume 'specialist cropping' for which farm incomes are similar to those for specialist and general cereal farms. |
| Agricultural areas | Pastures | Pastures | **Low** | Combination of dairy (very valuable but not much of it in Scotland) and other low ground livestock (much lower value that arable farms) - permanent and arable/grass land usually retails for between £2,500 and £3,500/acre. |
| Agricultural areas | Heterogeneous agricultural areas | Annual crops associated with permanent crops | **Medium** | Crops are all high |
| Agricultural areas | Heterogeneous agricultural areas | Complex cultivation patterns | **Low** | If in the Western Isles then value likely to be low but have put 'medium' in case it incorporates a lot of proper productive arable ground |
| Agricultural areas | Heterogeneous agricultural areas | Land principally occupied by agriculture, with significant areas of natural vegetation | **Very Low** | Low if lots of natural vegetation |
| Agricultural areas | Heterogeneous agricultural areas | Agro-forestry areas | **Low** | Not sure about this - does it include biomass plantations? If so that would increase the value but given that there isn't much of this in Scotland then on average would probably be medium. |
| Forest and semi natural areas | Forests | Broad-leaved forest | **Very Low** | Forestry land values (for whatever purpose) are almost always <£1,000/acre so low when compared to the above categories. |
| Forest and semi natural areas | Forests | Coniferous forest | **Very Low** | Forestry land values (for whatever purpose) are almost always <£1,000/acre so low when compared to the above categories. |
| Forest and semi natural areas | Forests | Mixed forest | **Very Low** | Forestry land values (for whatever purpose) are almost always <£1,000/acre so low when compared to the above categories. |
| Forest and semi natural areas | Scrub and/or herbaceous vegetation associations | Natural grasslands | **Very Low** | Very low. |
| Forest and semi natural areas | Scrub and/or herbaceous vegetation associations | Moors and heathland | **Very Low** | |
| Forest and semi natural areas | Scrub and/or herbaceous vegetation associations | Sclerophyllous vegetation | **Very Low** | |
| Forest and semi natural areas | Scrub and/or herbaceous vegetation associations | Transitional woodland-shrub | **Very Low** | |
| Forest and semi natural areas | Open spaces with little or no vegetation | Sparsely vegetated areas | **Very Low** | |
| Forest and semi natural areas | Open spaces with little or no vegetation | Burnt areas | **Very Low** | Could be moorland - but still usually valued at <£1,000 acre. |

## Appendix 3.

Receptor Datasets

| Risk Receptor | Element | Indicator | Dataset | Owner |
|---|---|---|---|---|
| **Human Health (A) People** | Exposure | Number of People | OS MasterMap Addresspoint | Ordnance Survey |
| | Vulnerability | Susceptible Social Groups (SFVI score) | Scottish Flood Vulnerability Index (SFVI) | SEPA |
| **Human Health (B) Community** | Exposure | Schools/Hospitals/Fire Stations/Police/Post Offices/Services(WWTW/Water Pumping Facilities) within Hazard (y/n) | OS Points of Interest | Ordnance Survey |
| | Value | Importance of Community Service | OS Points of Interest | Ordnance Survey |
| **Economic Activity (A) Businesses** | Exposure | Number of Non Residential Properties | OS Points of Interest | Ordnance Survey |
| | Value | Weighted Average Annual Damage - based on bulk categories and average floor space as per MCM approach | OS Points of Interest | Ordnance Survey |
| **Economic Activity (B) Transport** | Exposure | Rail/Road/Airport affected (Y/N) | OS Meridian 2/OS MM ITN/OS Strategi | Ordnance Survey |
| | Vulnerability | Urban/Rural location (Road and Rail only) | Urban/Rural Classification (2010) | Scottish Government |
| | Value | Classification of Road/Type of Transport | OS Meridian 2 | Ordnance Survey |
| **Economic Activity (C) Agricultural** | Exposure | Agricultural Land affected (Y/N) | CORINE Land Cover Map | EEA |
| | Value | Land Value | Information supplied by SEPA's Environmental Economist on Land Value | SEPA |
| **Environment** | Exposure | Designated Land affected (Y/N) | SACs, SPAs, SSSIs | SNH |
| | Vulnerability | Species/Habitat type | Information from ERRWG* | SEPA |
| | Vulnerability | Propensity to adapt to change | Information from ERRWG* | SEPA |
| **Cultural Heritage** | Exposure | Cultural Sites (Y/N) | Listed Buildings, Scheduled Monuments, UNESCO WHSs, Gardens and Designed Landscapes | Historic Scotland |
| | Value | Importance of Asset (Local to International) | Listed Buildings, Scheduled Monuments, UNESCO WHSs, Gardens and Designed Landscapes | SEPA |

**Appendix 4.**

Catchment Unit Categorisation Process Diagram