

# Flood Risk Management Strategy

## Forth Local Plan District

This section provides supplementary information on the characteristics and impacts of river, coastal and surface water flooding. Future impacts due to climate change, the potential for natural flood management and links to river basin management are also described within these chapters.

Detailed information about the objectives and actions to manage flooding are provided in Section 2.

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## 3.1 Introduction

In the Forth Local Plan District, river flooding is reported across two distinct river catchments. Coastal flooding and surface water flooding are reported across the whole Local Plan District.

A summary of the number of properties and Annual Average Damages from river, coastal and surface water flooding is outlined in Table 1.

	Total number of properties at risk <sup>1</sup>	Annual Average Damages	Local authority
<b>River catchments</b>			
River Forth catchment	430	£1.4 million	Stirling Council
Stirling catchment group	3,100	£4.1 million	Clackmannanshire Council Fife Council Perth and Kinross Council Stirling Council
<b>Coastal flooding</b>			
Forth coastal area	190	£240,000	Clackmannanshire Council Stirling Council
<b>Surface water flooding</b>			
Forth Local Plan District	950	£2.3 million	Clackmannanshire Council Fife Council Perth and Kinross Council Stirling Council

**Table 1:** Summary of flood risk from various sources within the Forth Local Plan District

<sup>1</sup> Total number of residential and non-residential properties at risk of flooding.

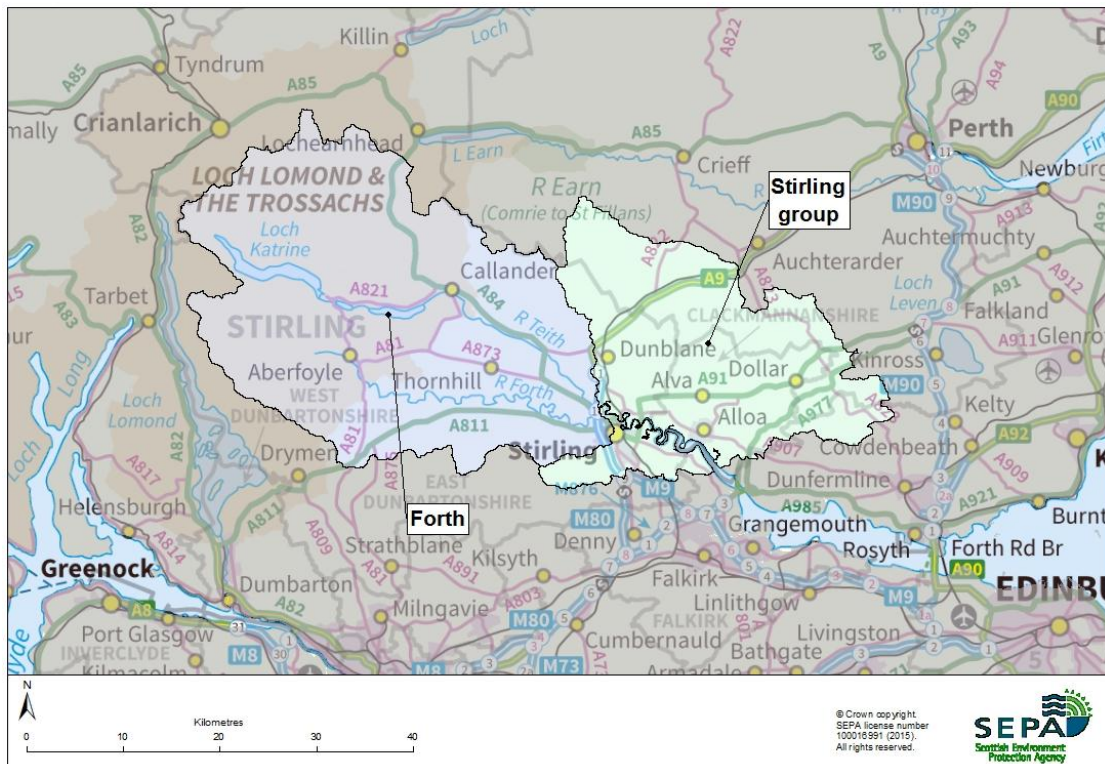
## 3.2 River flooding

### Forth Local Plan District

This section provides supplementary information on river flooding at the catchment level. It provides an overview of the catchment's natural characteristics, flood risk and the existing actions to manage flooding. It outlines the likely impact of climate change and the potential for natural flood management.

Detailed information about the objectives and actions to manage flooding are provided in Section 2.

In the Forth Local Plan District, river flooding is reported across two distinct river catchments, shown below.



**Figure 1:** River catchments within the Forth Local Plan District

## River flooding River Forth catchment

### Catchment overview

The River Forth drains a catchment area of 1,028km<sup>2</sup> before it discharges into the Forth Estuary. This is a large, predominately rural catchment with three main tributaries: the River Forth, the River Teith and the Allan Water. The rivers have very steep headwaters before flowing across expansive floodplains and joining immediately upstream of Stirling.

Land use in the low-lying parts of the catchment is dominated by agriculture. In the south of the catchment there are large areas of rough grassland and coniferous woodland. The north of the catchment is dominated by acid grassland, upland heather and montane habitats.

The largest lochs in the catchment include Loch Katrine, Loch Lubnaig and Loch Venachar, all of which are in the River Teith catchment.

The annual rainfall for this catchment is average for Scotland, with 900-1000mm falling in the lower catchment, rising to 2000-3000mm in the upper catchment.

### Flood risk in the catchment

Within the River Forth catchment approximately 310 residential properties and 120 non-residential properties are at risk of river flooding. It is estimated that 76% of these properties are located within Potentially Vulnerable Areas. There are two Potentially Vulnerable Areas at risk of river flooding in this catchment area (Figure 1):

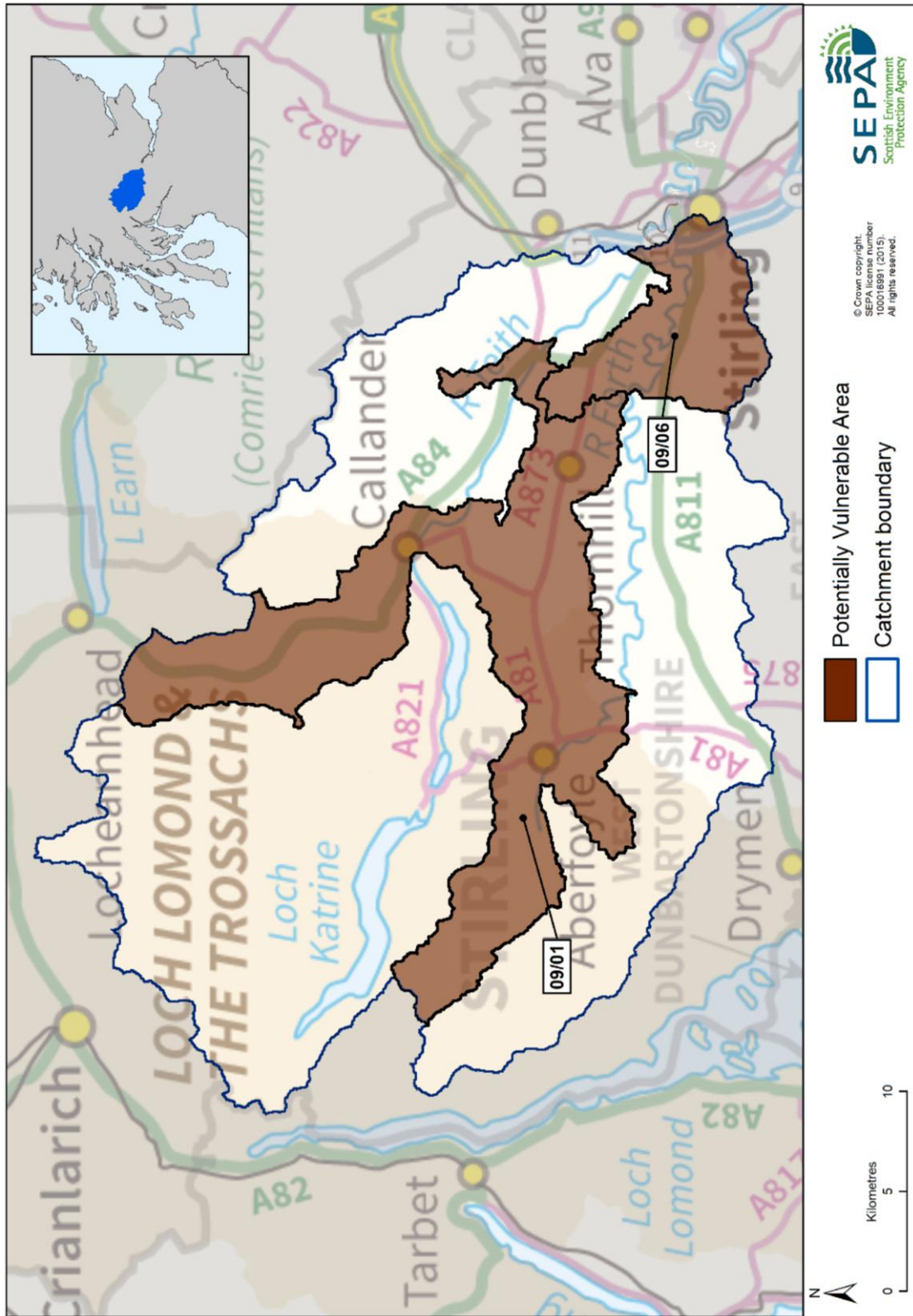
- Trossachs (09/01)
- Gargunnock (09/06).

### Main areas at risk

The main areas with a risk of river flooding can be seen in Table 1. The table shows the number of properties at risk and the Annual Average Damages caused by river flooding. This includes damages to residential and non-residential properties, transport and agriculture.

	Residential and non-residential properties at risk of river flooding	Annual Average Damages
Aberfoyle	100	£320,000
Callander	70	£88,000
Gargunnock	50	£120,000
Strathyre	20	£71,000
Balquhidder	10	£46,000

**Table 1:** Main areas at risk of river flooding



**Figure 1:** The River Forth catchment

## Economic activity and infrastructure at risk

The Annual Average Damages caused by river flooding in the River Forth catchment are approximately £1.4 million. The damages are distributed as follows:

- 45% residential properties (£630,000)
- 35% non-residential properties (£480,000)
- 8% emergency services (£110,000)
- 6% agriculture (£90,000)
- 4% roads (£60,000)
- 2% vehicles (£30,000).

Figure 2 shows the Annual Average Damages throughout the catchment. The highest damages can be seen south of Aberfoyle, Gargunnock and in north west Stirling.

Table 2 shows further information about infrastructure and agricultural land at risk of flooding within this catchment.

	Number at risk	Further detail
<b>Community facilities</b>	<10	Includes: educational buildings and emergency services.
<b>Utility assets</b>	<10	Includes: electricity substations, fuel extraction sites and telephone exchanges.
<b>Roads (excluding minor roads)</b>	14	1 M road (M9) at 8 locations 6 A roads at 220 locations 7 B roads at 176 locations
<b>Railway routes</b>	0	
<b>Agricultural land (km<sup>2</sup>)</b>	45.6	

**Table 2:** Infrastructure and agricultural land at risk of river flooding

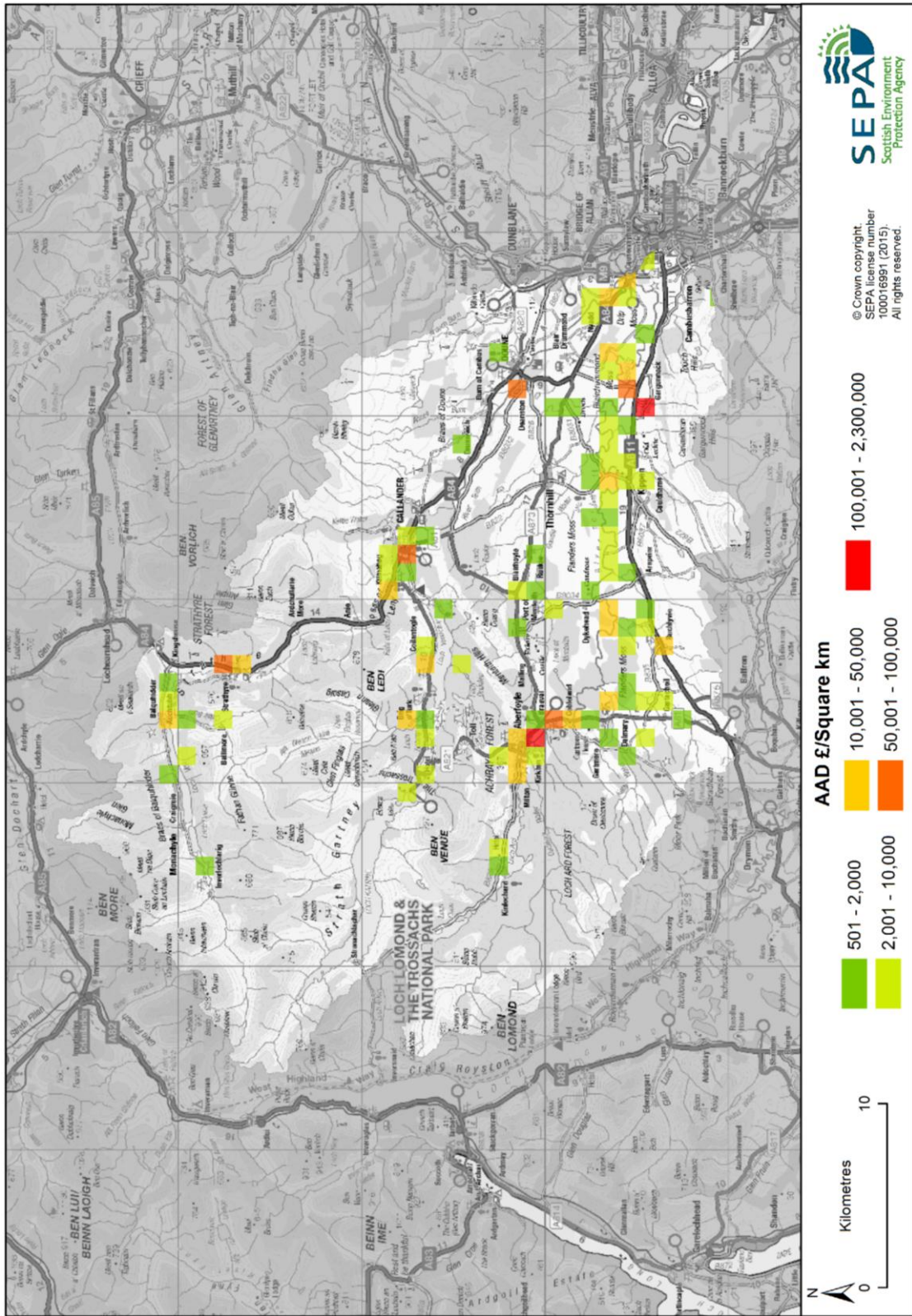
## Designated environmental and cultural heritage sites at risk

Within the catchment it is estimated that 41 designated cultural heritage sites are at risk of river flooding. These sites include scheduled monuments, gardens and designed landscapes, battlefield sites and listed buildings.

Approximately 26 environmental designated areas have a risk of river flooding. This includes three Special Areas of Conservation, a Special Protection Area and 22 Sites of Special Scientific Interest, including Flanders Moss, Ben Lomond and the Trossachs Woods.

The Loch Lomond and the Trossachs National Park is located within the boundary of the River Forth catchment. The National Park is recognised for the outstanding national importance of its natural and cultural heritage and some of these features may be at risk of flooding.





**Figure 2:** Annual Average Damages from river flooding

## History of river flooding

The River Forth has a long history of flooding. The highest river level recorded at the SEPA's Craigforth gauging station on the River Forth was in December 2006, where the river level reached 3.97m above normal levels. This caused significant flooding from the River Allan, River Teith and the River Forth with properties and infrastructure affected in Stirling (Riverside, Bridgehaugh and Cornton), Bridge of Allan, Dunblane, Aberfoyle (Main Street) and Callander (Main Street). The campsite flooded at Strathyre and the A84 closed between Strathyre and Callander.

A recent flood occurred on 19 November 2012 with flooding to Main Street, Aberfoyle and Loch Ard Road from the River Forth. The flood affected five residential properties, 10 businesses, an electricity sub-station, a Scottish Water pumping station and the B829 road. People required rescue by boat on the main street in Aberfoyle.

The earliest flood on record occurred in June 1905 when several properties on Main Street and Leny Road in Callander flooded from the River Teith.

Further detail about the history of flooding in this area is available in the relevant Potentially Vulnerable Area chapters.

## Managing flood risk

A range of public bodies have responsibility for managing flood risk in Scotland and they are working closer than ever before to target action in the areas where the greatest benefit can be gained. Members of the public also have a role to play and are the first line of defence against flooding by taking action to protect themselves and their property from flooding. Further information about roles and responsibilities is provided in Section 1.

This section describes the existing actions that are in place to manage flood risk and are in addition to the information presented in the relevant Potentially Vulnerable Area chapters.

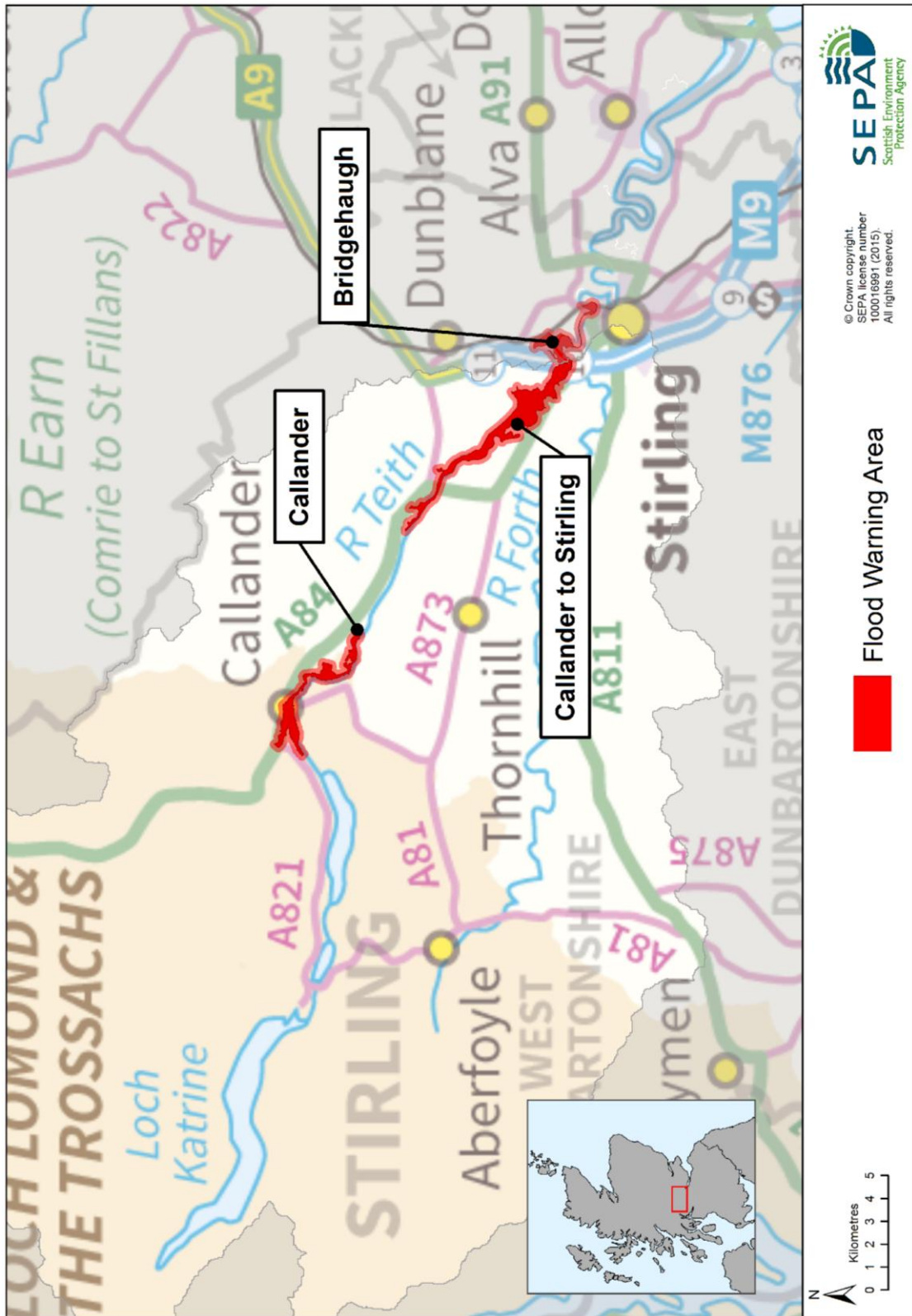
### River flood warning schemes

There are two river flood warning areas within this catchment as shown in Table 3 and Figure 3. Table 3 shows the total number of properties in the flood warning area and the percentage of those properties that have signed up to receive flood warnings. Please note that this is not the number of properties at risk of flooding.

Flood warning area (FWA)	River	Number of properties within FWA	% of properties registered July 2014
Bridgehaugh	River Forth	39	44%
Callander	River Teith	238	29%
Callander to Stirling	River Teith	59	12%

**Table 3:** Flood warning areas





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 Protection Agency

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Flood Warning Area

**Figure 3:** Flood warning areas

## Awareness raising campaigns and community groups

The following community groups are known to be active within this catchment:

- Callander Flood Action Group established in 2012
- Aberfoyle Flood Forum established in 2013.

## Property level protection

Each local authority has its own incentives or subsidies to help property owners with property level protection.

## Climate change and future flood risk

The UK Climate Projections (UKCP09) report predicts that climate change may lead to warmer and drier summers, warmer and wetter winters with less snow, and more extreme temperature and rainfall events. The predicted increase in rainfall and river flows may increase the potential for river flooding.

Under the UKCP09 high emissions scenario for 2080, average peak river flows for the River Forth catchment may increase by 33%<sup>1</sup>. This would potentially increase the number of residential properties at risk of river flooding from approximately 310 to 410 and the number of non-residential properties from approximately 120 to 180.

The predicted increases in flood risk are solely based on the impact of a changing climate on the magnitude of flooding; they do not take into account any potential increase due to population change, development pressures or urban creep, nor do they take into account any mitigation as a result of actions contained in this or future Flood Risk Management Strategies.

## Potential for natural flood management

The assessment of the potential for natural flood management is shown on SEPA's flood maps (<http://www.sepa.org.uk/environment/water/flooding/flood-maps/>). The maps indicate the potential for runoff reduction, floodplain storage and sediment management. They show areas where natural flood management could be effective and where further detailed assessment should take place. This information was used to identify where local authorities could include natural flood management as part of flood risk management schemes and studies. The proposed schemes and studies are listed in the relevant Potentially Vulnerable Area chapters of this document.

Natural flood management initiatives are already underway in this catchment:

- Allan Water natural flood management project
- Duchray catchment natural flood management study
- Callander optioneering report.

## Runoff reduction

As might be expected, there is potential for runoff reduction in the upper reaches of tributaries in the Trossachs Potentially Vulnerable Area (09/01). These opportunities are either partially or wholly located within Loch Lomond and The Trossachs National

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<sup>1</sup> From the study 'An assessment of the vulnerability of Scotland's river catchments and coasts to the impacts of climate change' (CEH, 2011)

Park. The Duchray catchment, Loch Voil catchment and Loch Katrine catchment all show significant areas of moderate and high runoff reduction potential, which may help to reduce flows within this Potentially Vulnerable Area. There is also a small runoff potential site upstream of the Gargunnock Burn in the Touch Hills. The viability of these potential runoff sites would first require local assessment before quantifying the expected flow reduction benefits.

### **Floodplain storage**

There is potential for floodplain storage within the Duchray catchment, which is currently the subject of a detailed natural flood management study. Prominent moderate and high potential sites are also situated on the Goodie Water upstream of Gargunnock Potentially Vulnerable Area (09/06).

### **Sediment management**

Across the catchment, high sediment deposition and erosion have been identified on the River Forth, River Teith, Loch Ard and Duchray Water. Some of these have been modified by human activity, mainly on the Goodie Water and in southern tributaries of the River Forth. This could partly account for some of the high sediment erosion and deposition but further detailed investigation would be required to determine whether sediment management would be beneficial.

## River flooding Stirling catchment group

### Catchment overview

The Stirling catchment group covers an area of 581km<sup>2</sup> and comprises a number of smaller watercourses. The main rivers in this group include the lower River Forth where it meets the Forth Estuary, Bannock Burn, Allan Water, River Devon and Black Devon.

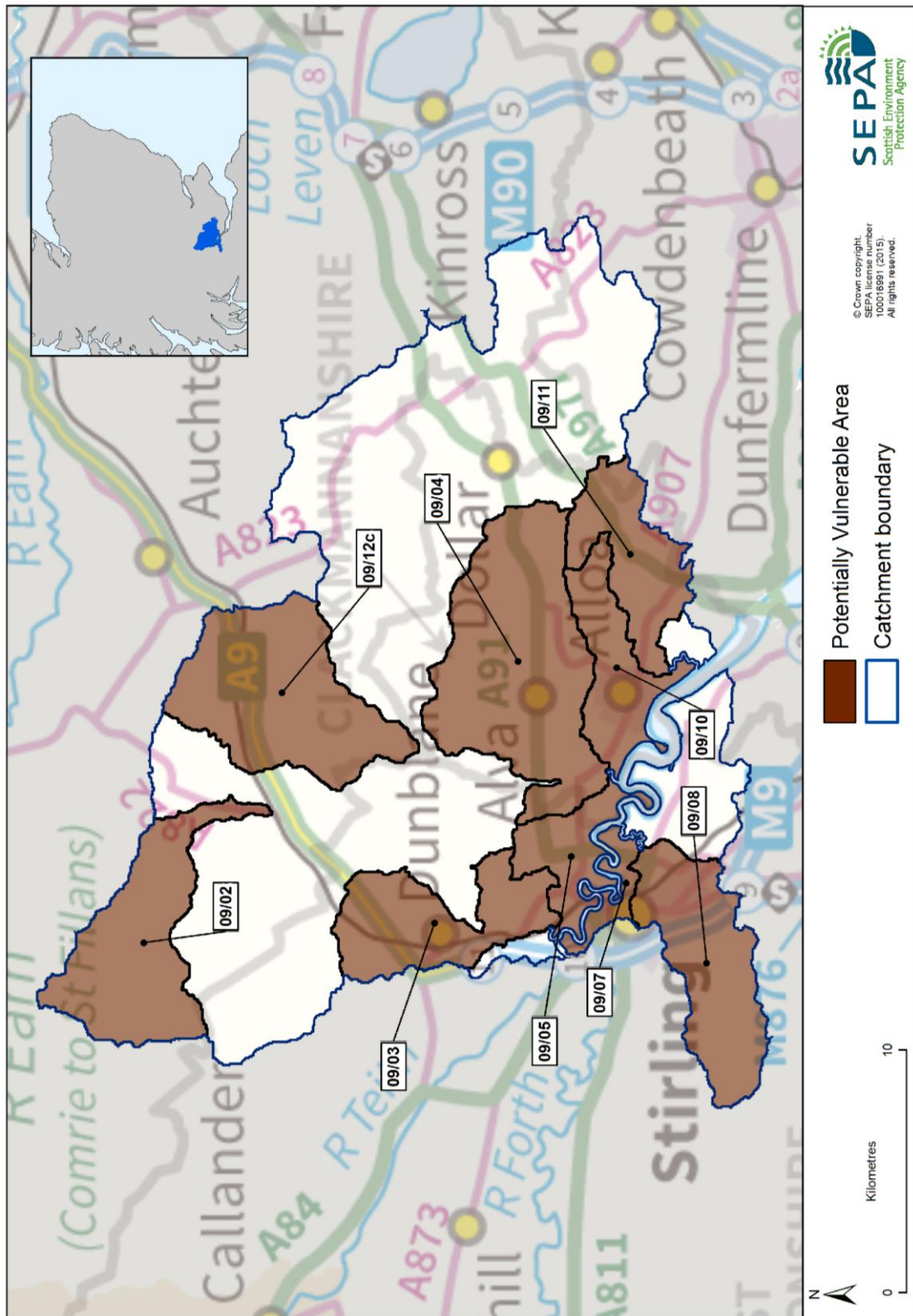
Most of the rivers in this group are relatively steep, flowing from a peak of 721m in the Ochils. These steeper rivers are characteristic of rapid water runoff and can therefore be prone to flash flooding. The lower valleys tend to be broad and relatively flat.

The annual rainfall for this catchment is average for Scotland, with 900mm-1000mm falling in the lower part of the catchment, rising to 1500mm-2000mm in the upper catchment.

### Flood risk in the catchment

Within the Stirling catchment group approximately 2,200 residential and 300 non-residential properties are at risk of river flooding. It is estimated that 96% of these properties are located within Potentially Vulnerable Areas. There are nine Potentially Vulnerable Areas and one candidate Potentially Vulnerable Area (09/12c) at risk of river flooding in this catchment group (Figure 1):

- Braco (09/02)
- Dunblane and Bridge of Allan (09/03)
- Hillfoots Villages (09/04)
- Stirling (Cornton and Causewayhead) (09/05)
- Stirling (Raploch and Riverside) (09/07)
- Stirling (Broomridge and St Ninians) (09/08)
- Stirling (Eastern villages) (09/09)
- Cambus, Alloa and Sauchie (09/10)
- Clackmannan and Forestmill (09/11)
- Blackford (09/12c).



**Figure 1:** The Stirling catchment group



## Main areas at risk

The main areas with a risk of river flooding can be seen in Table 1, along with the number of properties at risk and the Annual Average Damages caused by river flooding. This includes damages to residential and non-residential properties, transport and agriculture.

	Residential and non-residential properties at risk of river flooding	Annual Average Damages
Stirling	1,100	£1.0 million
Tillicoultry	420	£540,000
Bridge of Allan	300	£320,000
Alloa	210	£1.1 million
Menstrie	160	£250,000
Alva	80	£47,000
Blackford	70	£260,000
Braco	30	£26,000
Dollar	20	£150,000
Dunblane	20	£19,000
South Alloa	10	£27,000
Greenloaning	10	£26,000
Forestmill	<10	£33,000
Clackmannan	<10	£33,000
Cambus	<10	£11,000

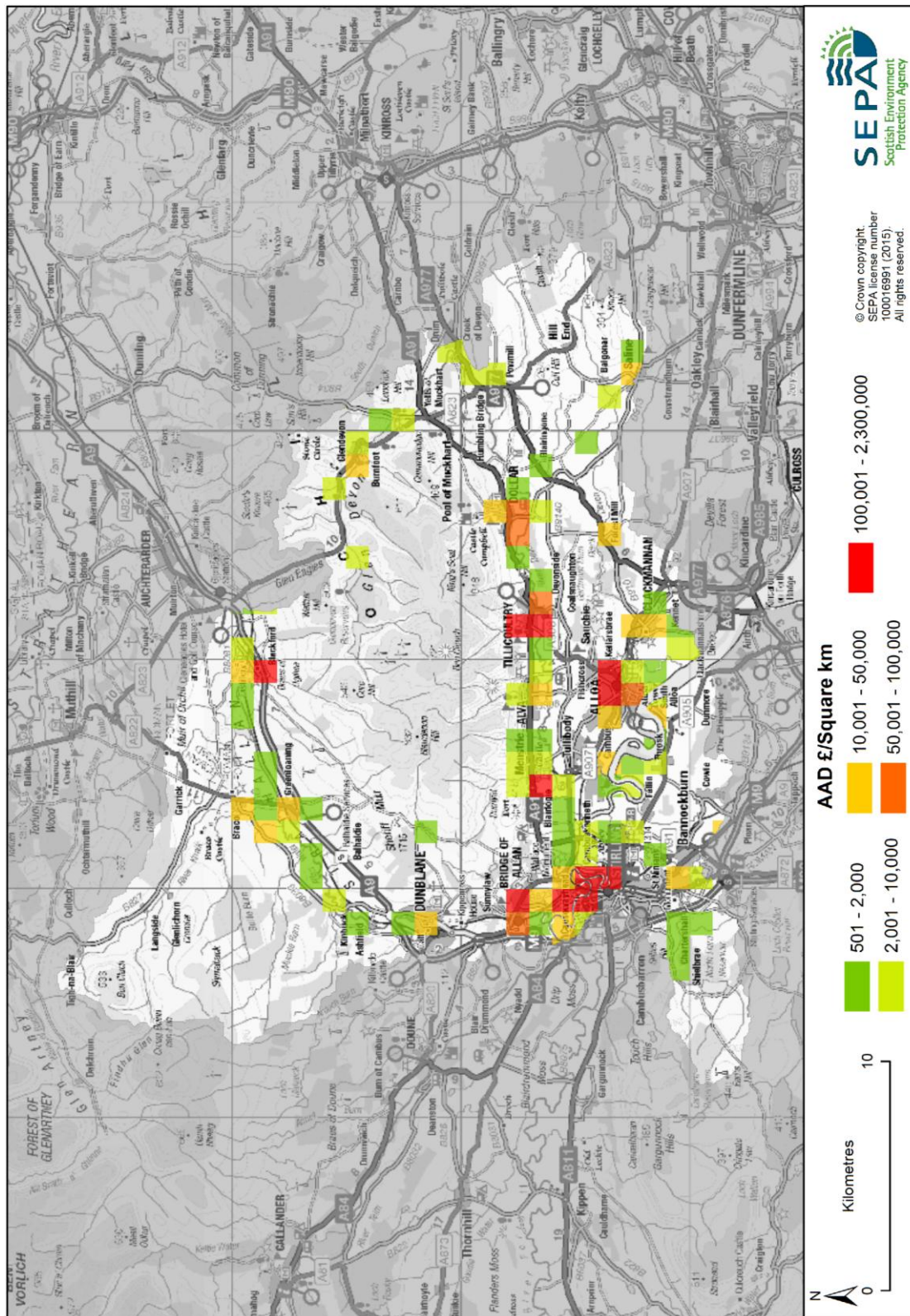
**Table 1:** Main areas with a risk of river flooding

## Economic activity and infrastructure at risk

The Annual Average Damages caused by river flooding in the Stirling catchment group are estimated to be approximately £4.1 million. The damages are distributed as follows:

- 54% residential properties (£2.2 million)
- 36% non-residential properties (£1.5 million)
- 6% emergency services (£240,000)
- 2% vehicles (£100,000)
- 1% agriculture (£50,000)
- 1% roads (£40,000).

Figure 2 shows the Annual Average Damages throughout the catchment group. The highest can be seen around Stirling due to the high density both residential and non-residential properties at flood risk from the River Forth.



**Figure 2: Annual Average Damages from river flooding**

Table 2 shows further information about infrastructure and agricultural land at risk of flooding within this catchment group.

	Number at risk	Further detail
<b>Community facilities</b>	<10	Includes: educational buildings, public services and emergency services.
<b>Utility assets</b>	30	Includes: electricity substations, gas regulation and telephone exchanges.
<b>Roads (excluding minor roads)</b>	19	1 M road (M9) at 12 locations 9 A roads at 198 locations 9 B roads at 138 locations
<b>Railway routes</b>	2	Dunblane to Stirling/ Larbert (17 locations at risk), Dundee to Dunblane (25 locations at risk).
<b>Agricultural land (km<sup>2</sup>)</b>	27.1	

**Table 2:** Infrastructure and agricultural land at risk of river flooding

### Designated environmental and cultural heritage sites at risk

Within this catchment group it is estimated that approximately 16 designated cultural heritage sites are at risk of river flooding. These sites include scheduled monuments, gardens and designed landscapes, battlefield sites and listed buildings.

Approximately 18 environmental designated areas are at risk of river flooding. These include three Special Areas of Conservation, two Special Protection Areas and 13 Sites of Special Scientific Interest. Amongst these areas are Kippenrait Glen, Shelforkie Moss and Back Burn Wood and Meadows.

### History of river flooding

The River Forth and the River Devon have a long history of flooding. One of the most significant floods occurred in December 2006 when the highest flood level was recorded at the SEPA Craigforth gauging station from the River Forth with a peak level of 3.97m above normal levels. This caused significant flooding throughout the area from the River Allan and River Forth with properties and infrastructure affected in Stirling (Riverside, Bridgehaugh and Cornton), Bridge of Allan and Dunblane. At Alva, roads crossing the River Devon, including the B908, were impassable due to out of bank flow. During the same event, areas in Perth and Kinross were also affected and Blackford and the surrounding flooded affecting properties.

The highest flood level on record from the River Devon occurred in January 2011 with a peak level of 4.23m above normal levels at Glenochil. All of the main access roads to the Hillfoots Villages were closed due to flooding and a caravan park flooded at Dollarfield, Dollar.

A recent flood occurred on 29 August 2012 when the Menstrie Burn flooded approximately 20 properties and Menstrie House care home required evacuation. The A91 road was closed and a landslide blocked the railway line about half a mile north of Bridge of Allan.

The earliest floods on record date back to November 1786 when a boy was swept away when crossing a bridge in the vicinity of Tillicoultry and in 1785 when the bridge over the River Devon collapsed at Racks Mill, Dollar.

Further detail about the history of flooding in this area is available in the relevant Potentially Vulnerable Area chapters.

## **Managing flood risk**

A range of public bodies have responsibility for managing flood risk in Scotland and they are working closer than ever before to target action in the areas where the greatest benefit can be gained. Members of the public also have a role to play and are the first line of defence against flooding by taking action to protect themselves and their property from flooding. Further information about roles and responsibilities is provided in Section 1.

This section describes the existing actions that are in place to manage flood risk and are in addition to the information presented in the relevant Potentially Vulnerable Area chapters.

### **Flood protection schemes**

There are two formal flood protection schemes to reduce the risk of river flooding:

- Bridge of Allan Flood Prevention Scheme
- Tillicoultry Mixed Leisure Route embankment raising that provides protection to the properties of Elistoun Drive from the River Devon.

### **River flood warning schemes**

There are 12 river flood warning areas within this catchment as shown in Table 3 and Figure 3. Table 3 shows the total number of properties in the flood warning area and the percentage of those properties that have signed up to receive flood warnings. Please note that this is not the number of properties at risk of flooding.

### **Community groups**

The following community groups are known to be active within this catchment group:

- Tillicoultry Flood Action Group (Elistoun Drive)
- Cochrane Crescent/ Grodwell Drive Community Flood Action Group (Alva)
- The Charrier, Menstrie Flood Action Group.

### **Property level protection**

Each local authority has its own incentives or subsidies to help property owners with property level protection.

Flood warning area (FWA)	River	Number of properties within FWA	% of properties registered July 2014
Bridge of Allan	Allan Water	353	27%
Bridgehaugh	River Forth	39	44%
Cornton	River Forth	746	28%
Dunblane	Allan Water	95	19%
Glenfoot Bridge at Marchglen	River Devon	7	29%
Menstrie Industrial Site	River Devon	2	100%
Rackmill Dollar	River Devon	17	65%
Raploch	River Forth	371	18%
River Devon at Alva	River Devon	36	14%
River Devon at Cambus Weir	River Devon	0	N/A
Riverside and Cambuskenneth	River Forth	647	45%
Sterling Mills Tillicoultry	River Devon	138	28%

**Table 3:** River flood warning areas

### Climate change and future flood risk

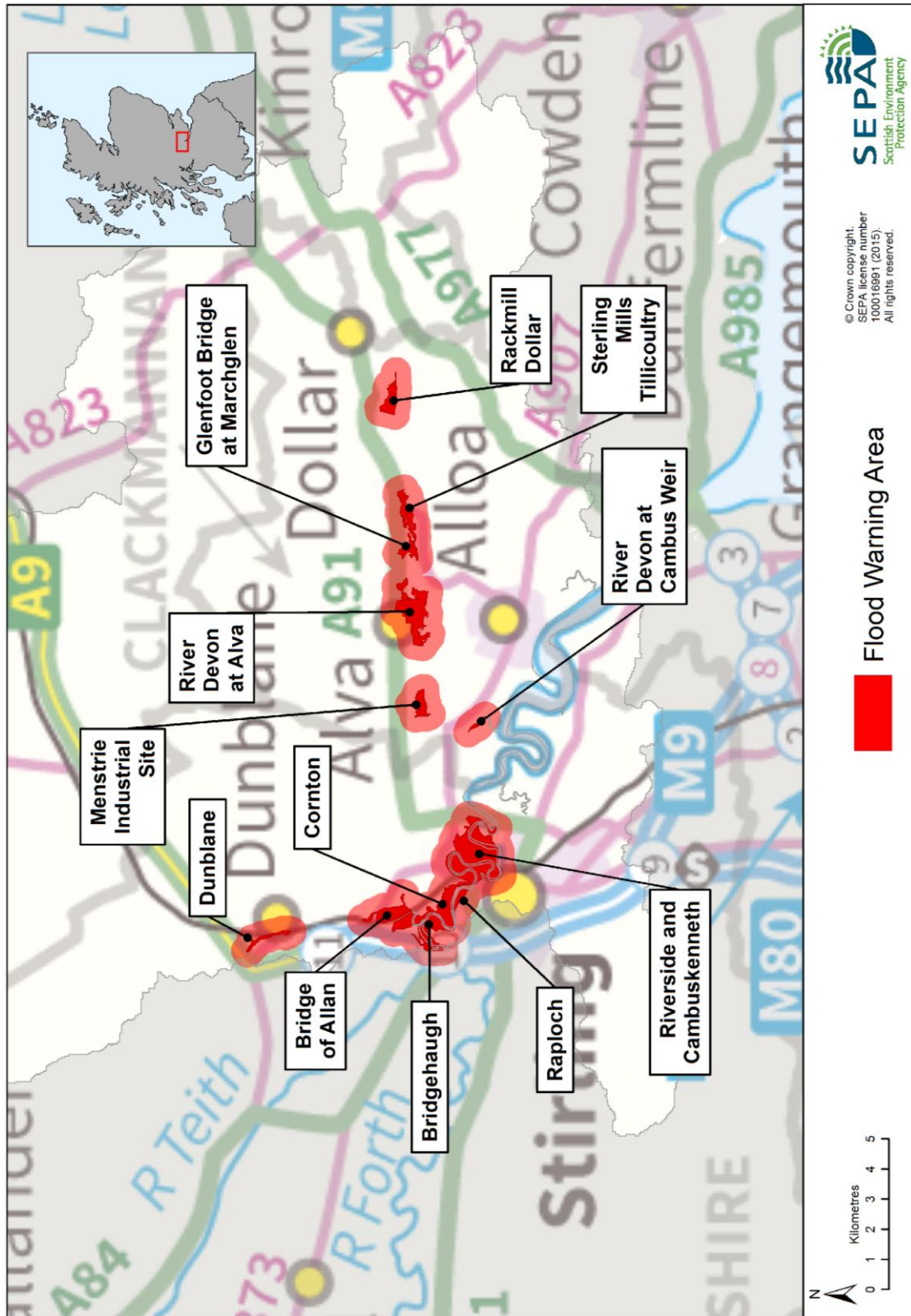
The UK Climate Projections (UKCP09) report predicts that climate change may lead to warmer and drier summers, warmer and wetter winters with less snow, and more extreme temperature and rainfall events. The predicted increase in rainfall and river flows may increase the potential for river flooding.

Under the UKCP09 high emissions scenario for 2080, average peak river flows for the Stirling catchment group may increase by 39%<sup>1</sup>. This would increase the number of residential properties at risk of river flooding from approximately 2,200 to 4,300 and the number of non-residential properties from approximately 300 to 600.

The predicted increases in flood risk are solely based on the impact of a changing climate on the magnitude of flooding; they do not take into account any potential increase due to population change, development pressures or urban creep, nor do they take into account any mitigation as a result of actions contained in this or future Flood Risk Management Strategies.

<sup>1</sup> From the study 'An assessment of the vulnerability of Scotland's river catchments and coasts to the impacts of climate change' (CEH, 2011)





**Figure 3:** River flood warning areas

## Potential for natural flood management

The assessment of the potential for natural flood management is shown on SEPA's flood maps (<http://www.sepa.org.uk/environment/water/flooding/flood-maps/>). The maps indicate the potential for runoff reduction, floodplain storage and sediment management. They show areas where natural flood management could be effective and where further detailed assessment should take place. This information was used to identify where local authorities could include natural flood management as part of flood risk management schemes and studies. The proposed schemes and studies are listed in the relevant Potentially Vulnerable Area chapters of this document.

### Runoff reduction

Areas with potential to reduce runoff are scattered throughout the catchment group. Most notable are those located centrally in the Ochil Hills in the north west of the catchment, and north of the Allan Water and Dunblane. These sites in particular could play a role in managing flood risk within the Hillfoots villages (09/04) and Braco (09/02) Potentially Vulnerable Areas.

### Floodplain storage

The potential floodplain storage sites are scattered throughout the catchment. A number of sites indicate high storage potential and these are located along the length of the lower River Forth, the River Devon and the Allan Water. These sites in particular lie either wholly or partly within the boundaries of Potentially Vulnerable Areas and could help reduce flooding to Dunblane and Bridge of Allan (09/03), Tillicoultry and Alva (09/04), Blackford (09/12c) and Stirling (09/05 and 09/07). However, previous studies carried out by Stirling Council have indicated that natural floodplain storage for Stirling is limited in this area and would not provide the required standard of protection.

### Sediment management

Sediment erosion and deposition occurs throughout the catchment. High deposition occurs in several locations, including the upstream and downstream reaches of the Black Devon, north east of Clackmannan and south of Alloa. Further deposition occurs upstream of the Allan Water and south of the River Devon where it meets the Menstrie Burn. While much of this may be attributed to natural processes, there may be some locations that could benefit from sediment management such as improvement of bank side vegetation.

## 3.3 Coastal flooding

### Forth Local Plan District

This chapter provides supplementary information on flooding for coastal areas. It provides an overview of the natural characteristics of the coast, a summary of flood risk within the coastal area and a brief history of flooding. It also outlines the likely impact of climate change and the potential for natural flood management.

Information about the objectives and actions to manage flood risk are provided in in Section 2.

#### Coastal overview

The Forth Local Plan District has 74km of coastline. It includes the lower reaches of the River Forth and River Devon and centres on Stirling where the River Forth meets the Forth Estuary. It includes the inner Firth of Forth and extends out to Alloa along the north bank and to Dunmore along the south bank.

The interaction between coastal and river flooding on the River Forth and River Devon is important. It is less influenced by waves due to the sheltering effects of the estuary but is still influenced by storm surges.

#### Flood risk

Within the Forth Local Plan District approximately 150 residential properties and 30 non-residential properties are at risk of coastal flooding. It is estimated that 98% of residential and non-residential properties at risk of coastal flooding are located within Potentially Vulnerable Areas. There are five Potentially Vulnerable Areas in this Local Plan District that have a risk of coastal flooding (Figure 1):

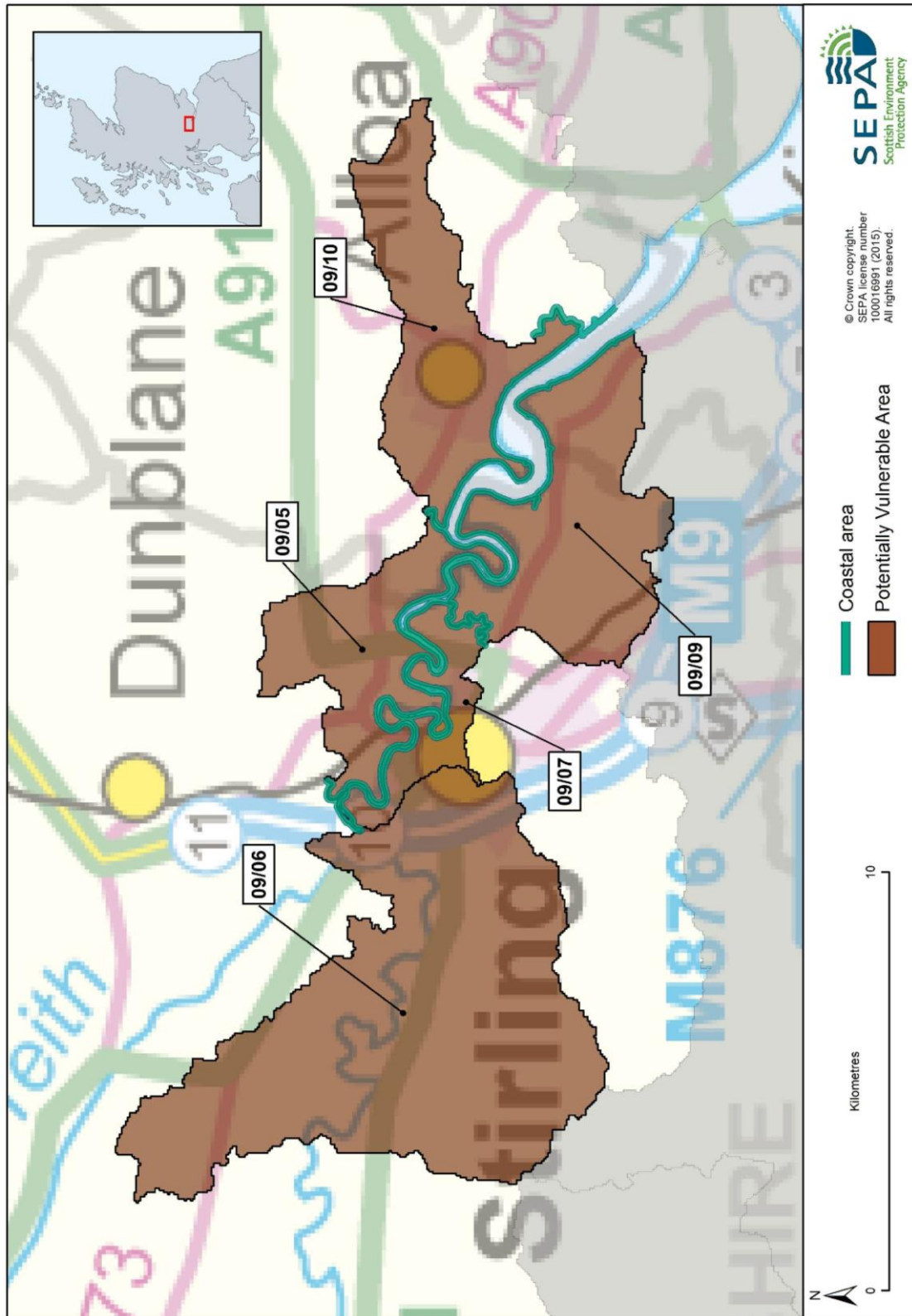
- Stirling (Cornton and Causewayhead) (09/05)
- Gargunnoch (09/06)
- Stirling (Raploch and Riverside) (09/07)
- Stirling (Eastern villages) (09/09)
- Cambus, Alloa and Sauchie (09/10).

#### Main areas at risk

The main areas at risk of coastal flooding, the number of properties at risk and the total Annual Average Damages caused by coastal flooding are shown in Table 1. The Annual Average Damages include damages to residential and non-residential properties, transport, emergency services and agriculture.

	Residential and non-residential properties at risk of coastal flooding	Annual Average Damages
Stirling	140	£110,000
South Alloa	10	£70,000
Alloa, Cambus, Blackgrange	<10	£10,000

**Table 1:** Main areas at risk of coastal flooding



**Figure 1:** Forth Local Plan District coastal area and Potentially Vulnerable Areas with a coastal flood risk

## Economic activity and infrastructure at risk

The Annual Average Damages caused by coastal flooding in the Forth Local Plan District are approximately £240,000. The damages are distributed as follows:

- 68% residential properties (£160,000)
- 10% non-residential properties (£23,000)
- 7% roads (£17,000)
- 6% agriculture (£15,000)
- 5% emergency services (£12,000)
- 4% vehicles (£10,000).

Figure 2 shows the distribution of Annual Average Damages throughout the coastal area. The highest Annual Average Damages are found around Stirling and South Alloa due to the high density of businesses and residential properties.

Table 2 shows further information about infrastructure and agricultural land at risk of coastal flooding.

	Number at risk	Further detail
<b>Community facilities</b>	0	
<b>Utility assets</b>	<10	Includes electricity substations
<b>Roads (excluding minor roads)</b>	6	1 M road (M9) at 2 locations 4 A roads at 8 locations 1 B road at 1 locations
<b>Railway routes</b>	1	Dunblane to Stirling/Larbert (4 locations at risk)
<b>Agricultural land (km<sup>2</sup>)</b>	7.7	

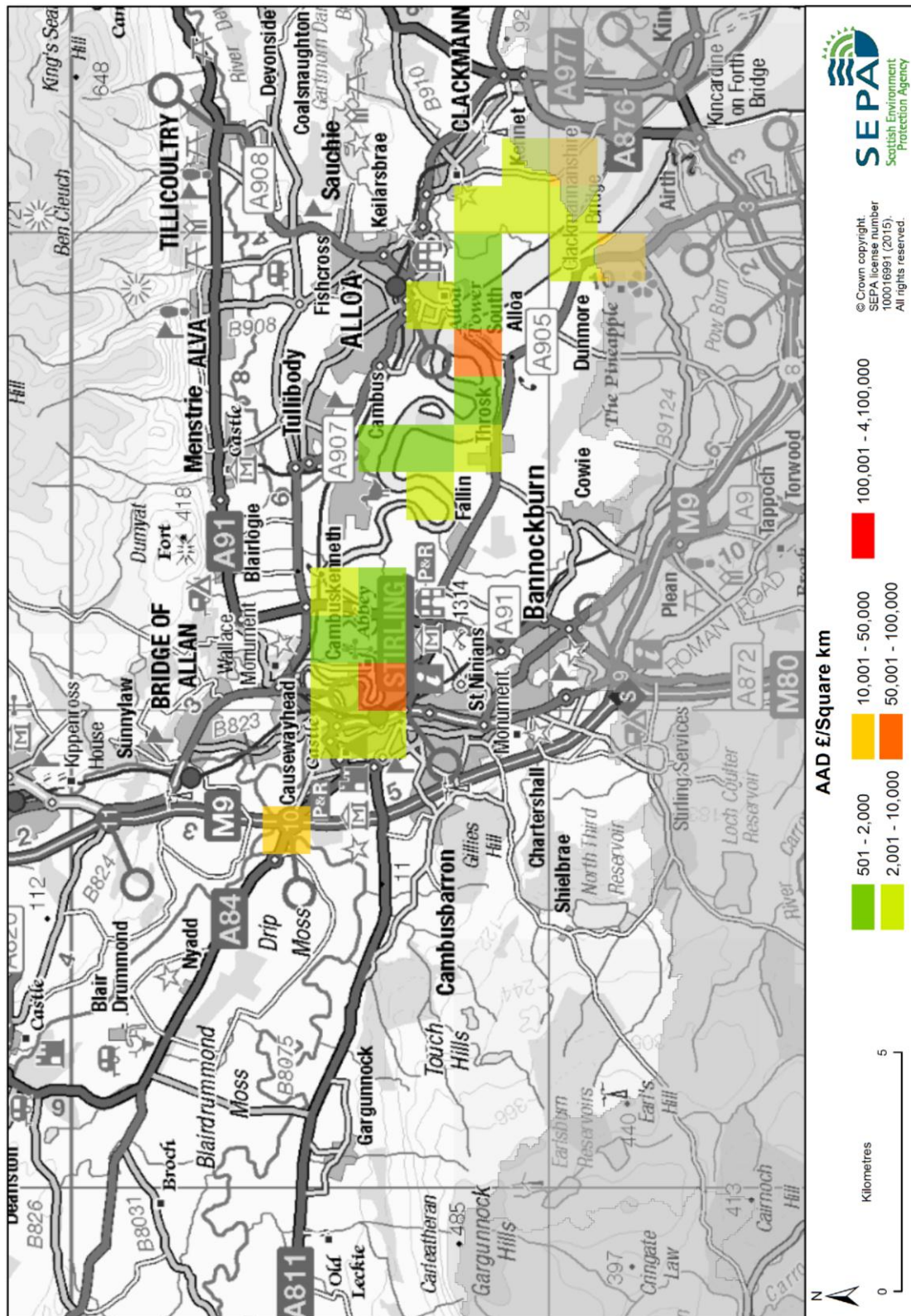
**Table 2:** Infrastructure and agricultural land at risk of coastal flooding

## Designated environmental and cultural heritage sites at risk

Within the coastal area there are approximately nine designated cultural heritage sites at risk of coastal flooding. These include scheduled monuments, battlefield sites and listed buildings.

Approximately three environmental designated areas are at risk of coastal flooding. These include a Special Area of Conservation, a Special Protection Area and a Site of Special Scientific Interest, comprising of the River Teith and the Firth of Forth.





**Figure 2:** Annual Average Damages from coastal flooding

## History of coastal flooding

Probably the most damaging coastal flood occurred on 25 January 1890 when Alloa harbour experienced flooding to non-residential properties due to the highest tide in 17 years.

A recent coastal flood occurred in January 2014 with Alloa affected by high tide/storm surge event in the Firth of Forth. However, no damages were recorded.

The earliest coastal flood on record dates back to 1 October 1849 when Alloa Harbour flooded due to a high tide event.

Further details about the history of flooding in this area are available in the relevant Potentially Vulnerable Area chapters in Section 2.

## Managing flood risk

A range of public bodies have responsibility for managing flood risk in Scotland and they are working closer than ever before to target action in the areas where the greatest benefit can be gained. Members of the public also have a role to play and are the first line of defence against flooding by taking action to protect themselves and their property from flooding. Further information about roles and responsibilities is provided in Section 1.

This section describes the existing actions that are in place to manage flood risk and are in addition to the information presented in the relevant Potentially Vulnerable Area chapters.

### Coastal flood warning schemes

There are no coastal flood warning areas in the Forth Local Plan District. However, some of the river flood warning areas around Stirling take into account coastal and tidal data. These river flood warning areas are Riverside, Cambuskenneth and Raploch.

### Property level protection

Each local authority has its own incentives or subsidies to help property owners with property level protection.

## Climate change and future flood risk

UK Climate Projections (UKCP09) predicts that climate change may increase sea levels. The magnitude of sea level rise varies around the coastline.

For the UKCP09 high emissions scenario, the predicted average increase for inner Firth of Forth is 0.47m by 2080. This may increase the number of residential properties at risk of coastal flooding from approximately 150 to 370 and the number of non-residential properties from approximately 30 to 50. Coastal flood modelling by SEPA has not taken into account the impacts of a future climate on wave overtopping or storminess, which could increase the number of people affected by coastal flooding.

The predicted increases in flood risk are solely based on the impact of a changing climate on the magnitude of flooding; they do not take into account any potential

increase due to population change, development pressures or urban creep, nor do they take into account any mitigation as a result of actions contained in this or future Flood Risk Management Strategies.

## **Potential for natural flood management**

The assessment of the potential for natural flood management is shown on SEPA's flood maps (<http://www.sepa.org.uk/environment/water/flooding/flood-maps/>). The maps indicate the potential for wave attenuation and estuarine surge attenuation. They show areas where natural flood management could be effective and where further detailed assessment should take place.

This information was used to identify where local authorities could include natural flood management as part of flood risk management schemes and studies. The proposed schemes and studies are listed in the relevant Potentially Vulnerable Area chapters.

### **Wave energy**

The assessment for the Forth coastal area shows that there is medium to high potential for estuarine surge attenuation along the inner Firth of Forth coastline. This may help to manage coastal flood risk around Alloa and Stirling.

## 3.4 Surface water flooding

### Forth Local Plan District

This section provides supporting information on surface water flooding across the Local Plan District. It provides an overview of the main areas at risk and the history of surface water flooding. The predicted impacts on infrastructure are also identified. The impacts on environmental sites and agricultural land have not been assessed. Information about the objectives and actions to manage flood risk are provided in Section 2.

#### Flood risk

Within the Forth Local Plan District approximately 700 residential properties and 260 non-residential properties are at risk of surface water flooding. It is estimated that 96% of these properties are located within Potentially Vulnerable Areas.

#### Main areas at risk

The main areas at risk of surface water flooding can be seen in Table 1, which shows the number of properties at risk and the Annual Average Damages caused by surface water flooding. The damages include impacts to residential and non-residential properties, vehicles, emergency services and roads.

	Residential and non-residential properties at risk of surface water flooding	Annual Average Damages
Alloa-Tullibody	210	£260,000
Stirling	200	£350,000
Alva	150	£340,000
Tillicoultry	100	£200,000
Dunblane	70	£120,000
Bridge of Allan	40	£53,000
Gargunnock	20	£76,000
Doone	20	£26,000
Dollar	<10	£12,000
Clackmannan	<10	£1,000

**Table 1:** Main areas at risk of surface water flooding

#### Economic activity and infrastructure at risk

The Annual Average Damages caused by surface water flooding in the Forth Local Plan District are approximately £2.3 million. The damages are distributed as follows:

- 56% roads (£1,300,000)
- 29% residential properties (£670,000)
- 11% non-residential properties (£270,000)
- 3% emergency services (£65,000)
- 1% vehicles (£18,000).

Figure 1 shows the distribution of Annual Average Damages throughout the Local Plan District. High economic damages from surface water flooding can be seen on the M9 motorway south of Stirling which is a major transport route for business travelling both north and south. High damages can also be found around the urban areas of Stirling and Alloa due to the high number of residential properties in these areas.

Table 2 shows the approximate numbers of further infrastructure assets which are at risk of flooding within this Local Plan District.

	Number at risk	Further detail
<b>Community facilities</b>	<10	Includes: educational buildings and healthcare services
<b>Utility assets</b>	60	Includes: electricity substations and fuel extraction sites
<b>Roads (excluding minor roads)</b>	40	2 M roads (M9 and M80) at 40 locations 15 A roads at 340 locations 24 B roads at 200 locations
<b>Railway routes</b>	2	Dunblane to Stirling/Larbert (20 locations at risk) Dundee to Dunblane (20 locations at risk)

**Table 2:** Infrastructure at risk of surface water flooding

### Designated environmental and cultural heritage sites at risk

Within the Local Plan District it is estimated that approximately 52 designated cultural heritage sites have a risk of surface water flooding. These sites include scheduled monuments, gardens and designed landscapes, battlefield sites and listed buildings.

The impact of surface water flooding on environmental sites has not been assessed and is assumed to be relatively low.

### History of surface water flooding

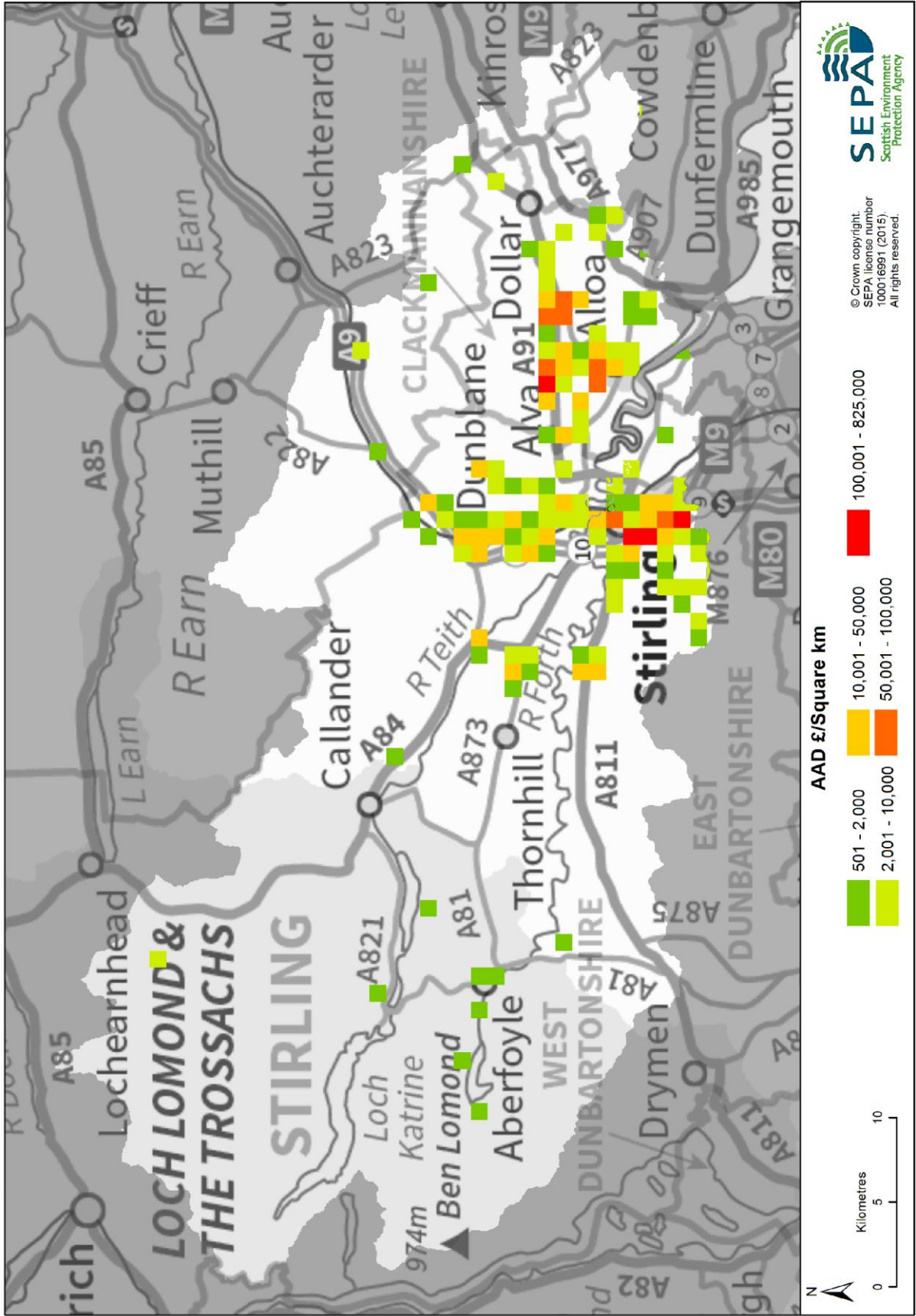
The flood records for surface water flooding in this area indicate flood events in January 2011 and widespread flooding in August 2012.

On 16 January 2011 heavy rainfall combined with snow melt caused many roads to close including Elistoun Drive, Tillicoultry. Local businesses were also affected in Alva and Dollar.

In August 2012 a number of locations were affected following very heavy rainfall. These included Dollar on 6 August and 21 August 2012 when heavy rainfall caused a large surface water flood and properties were affected around Princes Crescent, Tarmangie Drive, The Ness and White Wisp Gardens. On 29 August 2012 extreme rainfall (64mm within 2 hours) caused localised flooding in Bridge of Allan and Dunblane and flooding to properties and infrastructure. Approximately 25 properties were affected in Bridge of Allan and a further 10 properties in Dunblane. The railway was closed in Dunblane and a road was washed out in Bridge of Allan.

Further detail about the history of flooding is available in the relevant Potentially Vulnerable Area chapters of this document.





**Figure 1:** Annual Average Damages from surface water flooding

## Managing flood risk

A range of public bodies have responsibility for managing flood risk in Scotland and they are working closer than ever before to target action in the areas where the greatest benefit can be gained. Members of the public also have a role to play and are the first line of defence against flooding by taking action to protect themselves and their property from flooding. Further information about roles and responsibilities is provided in Section 1.

### Surface water management priority areas

The areas at highest risk from surface water flooding have been prioritised. These priority areas were identified using SEPA flood models, supplemented with historical flood information and, where available, more detailed modelling from local authorities. These priority areas require the preparation of surface water management plans, the details of which can be found in Section 2.

### Community groups

The following community groups are also known to operate within the Forth Local Plan District:

- Alva (Cochrane Crescent/Grodwell Drive) Community Flood Action Group
- Aberfoyle Flood Forum Group
- Callander Flood Forum
- The Charrier - Menstrie Flood Action Group
- Tillicoultry Flood Action Group.

### Property level protection

Each local authority has its own incentives or subsidies to help property owners with property level protection:

- Clackmannanshire Council has established a store with flood protection products (flood pod) at The Charrier, Menstrie with the agreement of the The Charrier, Menstrie Flood Action Group
- Clackmannanshire Council and Scottish Flood Forum have a joint project to promote resilience with Tillicoultry Flood Action Group
- Fife Council provides Aquasacs for use in emergencies and these are available from stores throughout Fife.

## Climate change and future flood risk

UK Climate Projections (UKCP09) predicts that climate change may lead to warmer and drier summers, warmer and wetter winters with less snow, and more extreme temperature and rainfall. The pluvial modelling undertaken considered climate change scenarios with a 20% increase in rainfall intensity.

Under these conditions it is estimated that the number of residential properties at risk of surface water flooding may increase from approximately 700 to 970 and the number of non-residential properties from approximately 260 to 390.

The predicted increases in flood risk are solely based on the impact of a changing climate on the magnitude of flooding; they do not take into account any potential increase due to population change, development pressures or urban creep, nor do they take into account any mitigation as a result of actions contained in this or future Flood Risk Management Strategies.