Preliminary Flood Risk Assessment for England

Report: October 2018

We are the Environment Agency. We protect and improve the environment.

We help people and wildlife adapt to climate change and reduce its impacts, including flooding, drought, sea level rise and coastal erosion.

We improve the quality of our water, land and air by tackling pollution. We work with businesses to help them comply with environmental regulations. A healthy and diverse environment enhances people's lives and contributes to economic growth.

We can't do this alone. We work as part of the Defra group (Department for Environment, Food & Rural Affairs), with the rest of government, local councils, businesses, civil society groups and local communities to create a better place for people and wildlife.

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Executive summary

At least one in six properties is at risk of flooding in England. We work with flood risk partners to plan for, respond to and reduce this risk. The first step we take is to identify the risk of flooding. This report provides the most up to date risk assessment for river, sea and reservoir flooding. We will use this information to raise awareness and work with others to manage it.

This report meets our requirements under the Flood Risk Regulations (2009) to produce a preliminary flood risk assessment for river, sea and reservoir flooding. We have also used the information to identify nationally significant flood risk areas.

The European Floods Directive (2007/60/EC) sets certain requirements for EU member states to assess and map flood risk and plan for managing it. These requirements are transposed into the Flood Risk Regulations (2009), which set out a process to complete and assessment of flood risk (known as a preliminary flood risk assessment (PFRA)) and produce supporting maps of river catchments. The Regulations require us to use this information to identify areas where there is a significant risk of flooding from rivers, sea or reservoirs. For these flood risk areas (FRAs), we must then undertake flood risk and hazard mapping and produce flood risk management plans. Undertaking a PFRA involves considering past and potential future floods that have had significant consequences for human health, the economy, the environment and cultural heritage.

In England, the Regulations direct the Environment Agency to do this work for river, sea and reservoir flooding. We have worked closely with Natural Resources Wales and the Scottish Environment Protection Agency, who are responsible for managing flood risk in Wales and Scotland respectively, to prepare the assessment. We have presented this assessment at a large river catchment scale and these areas are known as River Basin Districts (RBDs). This report covers the English only RBDs, which also include the English part of the Solway and Tweed, Severn and Dee catchments. To get a complete picture for these RBDs you will need to read this with the Scottish, Severn and Dee PFRAs.

England has experienced major flooding from rivers and the sea in the past. We have identified the floods since 2011 that have had significant harmful consequences at a national level to human health, the economy, the environment and cultural heritage. These are also the floods that have significantly changed how we understand and manage flood risk. This includes river and/ or sea flooding in 2012, winter 2013/14, winter 2015/16 and early 2017. In England, we use information on past flooding to update our historic flood mapping, inform the accuracy of computer generated flood risk maps and learn lessons to change our approaches to managing flood risk.

We use computer modelling to map floodplains, so we can understand the areas most likely to flood in future. This gives us a consistent understanding of what areas may be at risk of flooding across the country. We then consider the effect of flood defences and use

maps of properties and environmental and cultural heritage sites to tell us about the consequences of flooding. Flood risk across RBDs in England varies because they are different sizes, have different levels of development and they are vulnerable to different types of flooding. For example, the Thames RBD has a particularly high risk to people, because some of the largest urban areas, like London are there.

Flood risk changes over time. There are many reasons for this - population increase, new development and changes in the way land is managed – but the main reason is climate change. Our climate is influenced by both naturally occurring variations in the climate system and human activity, such as increasing greenhouse gas emissions. General climate change projections show an increased chance of warmer, wetter winters and hotter, drier summers with a higher likelihood of more frequent and intense rainfall. We expect to see an increase in severe events, such as flooding. At the same time, sea levels are gradually rising, as the oceans warm up and ice caps melt. How we respond and adapt as a nation to this, such as how much and when we invest in flood defences, flood resilience measures for communities and a range of other flood risk management interventions, will also affect future flood risk.

FRAs are areas where the risk of flooding is likely to be significant at a national scale for people, the economy or the environment (including cultural heritage). We used the latest information on flood risk to assess which areas are the most significantly affected from river and sea flooding. These areas have been checked by local experts and we have identified 116 areas that are at significant risk of river and sea flooding in England. Humber RBD has the highest number of FRAs, followed by the Thames, Anglian and South West RBDs. There are fewer than 10 FRAs in the North West, Severn and South East RBDs and the Dee, Northumbria and Solway Tweed RBD have no FRAs. There are two FRAs that overlap neighbouring RBDs: Weston-Super-Mare and Whitstable.

We will continue to plan for and manage the risk of flooding to all communities, whether they are in a FRA or not. There are many local reasons why we would pursue a flood risk management intervention for a particular community.

We will produce flood risk and hazard mapping by the end of 2019 and flood risk management plans by the end of 2021 for FRAs to meet our requirements under the Regulations. Flood risk management plans must include objectives and measures to address the risks within FRAs. We will do this work together with lead local flood authorities, who will need to do this for FRAs from surface water, smaller watercourse and groundwater flooding.

There has been no reservoir flooding in England resulting in a loss of life since 1870. Reservoir flooding is extremely unlikely to happen. All large reservoirs must be inspected and supervised by specialist reservoir engineers. We enforce the Reservoirs Act (1975) in England and we make sure that reservoirs are inspected regularly and important safety work is done. We have not identified any FRAs for reservoir flooding because the likelihood of reservoir flooding is much lower than for river and sea flooding.

Contents

Maps

These are available separately to the report. You can find them on data.gov.uk

Preliminary flood risk assessment maps for each river basin district

There is a map for each River Basin District (that shows the parts in England). These show:

– the river basin district boundary
– the coastline
– watercourses
– main roads and railways
– the way land is used, and
– topography (how the height of the land varies)

You can turn different data sets on and off because the maps are interactive.

Map of proposed flood risk areas

This map shows how the proposed flood risk areas are distributed around England. It is a larger version of the map you can find in Chapter 5 of this report.

1. Introduction and working together

This report has been written to meet the requirements of the Flood Risk Regulations (2009). We have worked closely with other organisations that manage flood risk in England and Natural Resources Wales (NRW) and the Scottish Environmental Protection Agency (SEPA) on this report. This report covers flooding from rivers, the sea and reservoirs.

About preliminary flood risk assessments

The European Floods Directive (2007/60/EC) sets certain requirements for EU member states to assess and map flood risk and plan for managing it. These requirements are transposed into the Flood Risk Regulations (2009), which set out a process to complete an assessment of flood risk (known as a preliminary flood risk assessment (PFRA)) and produce supporting maps of river catchments. The Regulations require us to use this information to identify areas where there is a significant risk of flooding.

Flood risk areas (FRAs) are areas where the risk of flooding is likely to be significant for people, the economy or the environment (including cultural heritage). By risk we mean not just the chance that flooding will occur (the probability), but also the impact of the flooding.

For these FRAs, we will undertake flood risk and hazard mapping and produce flood risk management plans (FRMPs). We will use FRAs to help us identify those locations where engagement and partnership working to develop a FRMP will help resolve complex flooding issues.

In England, the Regulations direct the Environment Agency to undertake PFRAs and identify FRAs for river, sea and reservoir flooding. Lead local flood authorities (LLFAs) need to do this work for surface water, smaller watercourses and groundwater flooding. The cycle of work repeats every six years. Flood hazard and flood risk maps are due in 2019 and FRMPs in 2021 for this cycle. LLFAs completed PFRAs and an assessment of FRAs in 2017 and you can find these on GOV.UK
Lead local flood authority preliminary flood risk assessments and flood risk areas (https://www.gov.uk/government/publications/preliminary-flood-risk-assessments-and-flood-risk-areas/preliminary-flood-risk-assessments-and-flood-risk-areas).

About river basin districts

This work is being presented at a large river catchment scale and these areas are known as river basin districts (RBDs). A RBD covers an entire river system, including rivers, lakes, groundwater, estuaries and coastal waters.

We also use RBDs to plan water quality work through river basin management plans (RBMP). RBMPs set out how organisations, stakeholders and communities will work together to improve the water environment. RBMPs were published in 2015 and you can

find them online on GOV.UK River basin management plans 2015 (https://www.gov.uk/government/collections/river-basin-management-plans-2015).

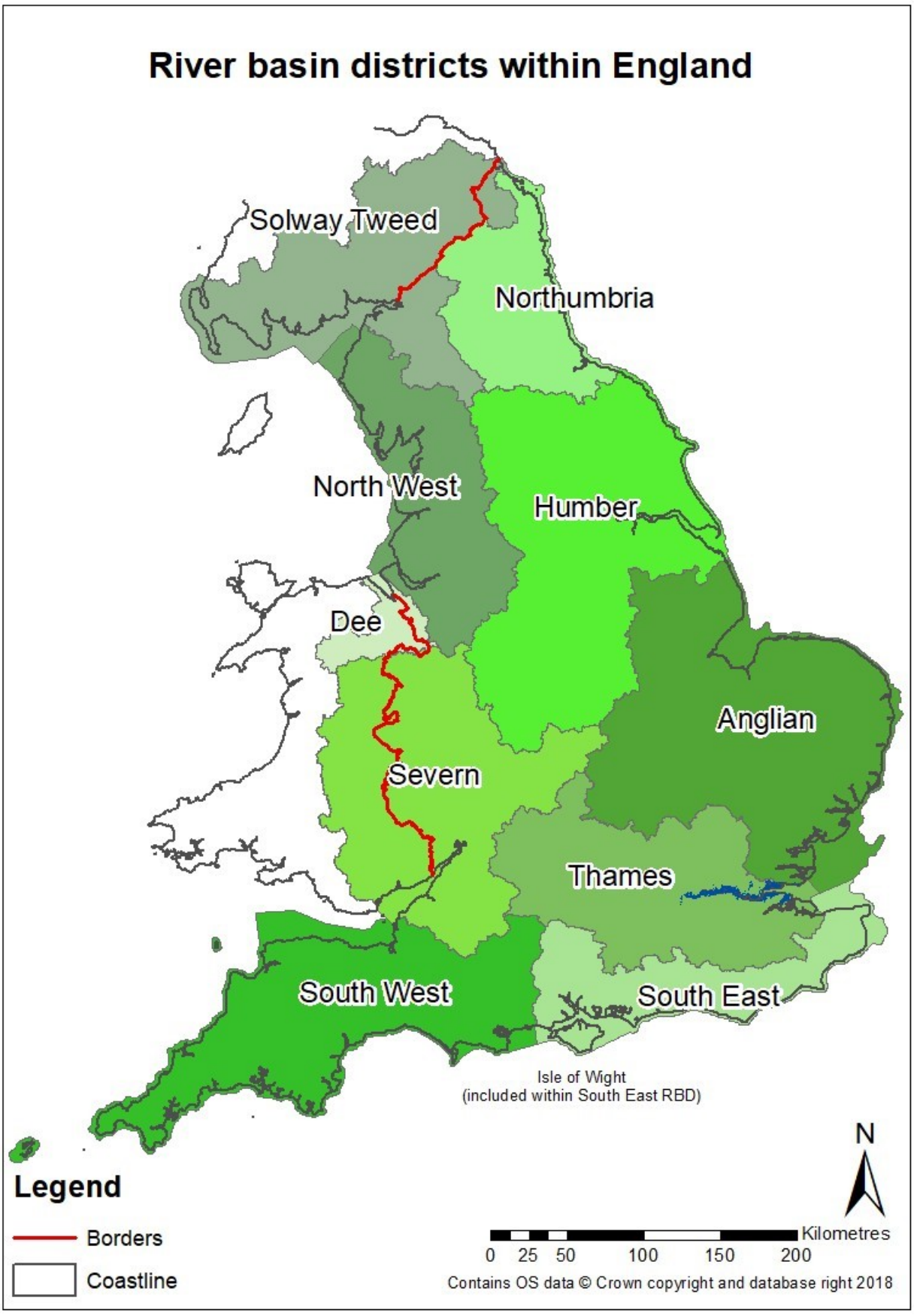
RBDs are similar to the catchment boundaries used by Regional Flood and Coastal Committees (RFCCs). RFCCs are committees established by the Environment Agency under the Flood and Water Management Act (2010). They are made of members appointed by LLFAs and independent people with relevant experience. The Environment Agency must consult with RFCCs about flood and coastal risk management work in their region and take their comments into account.

The maps below show the difference between RBD and RFCC boundaries.

There are ten RBDs wholly or partly in England. Separate interactive maps have been prepared for each RBD that show:

- RBD and sub RBD boundaries
- the coastline
- land use
- topography

You can download these maps from data.gov.uk. These fulfil the requirement for PFRA maps in the Regulations.


River basin districts within England
Solway Tweed
Northumbria
North West
Humber
Dee
Anglian
Severn
Thames
South West
South East
Isle of Wight
(included within South East RBD)
N
Legend
Borders
Coastline
Kilometres
0 25 50 100 150 200
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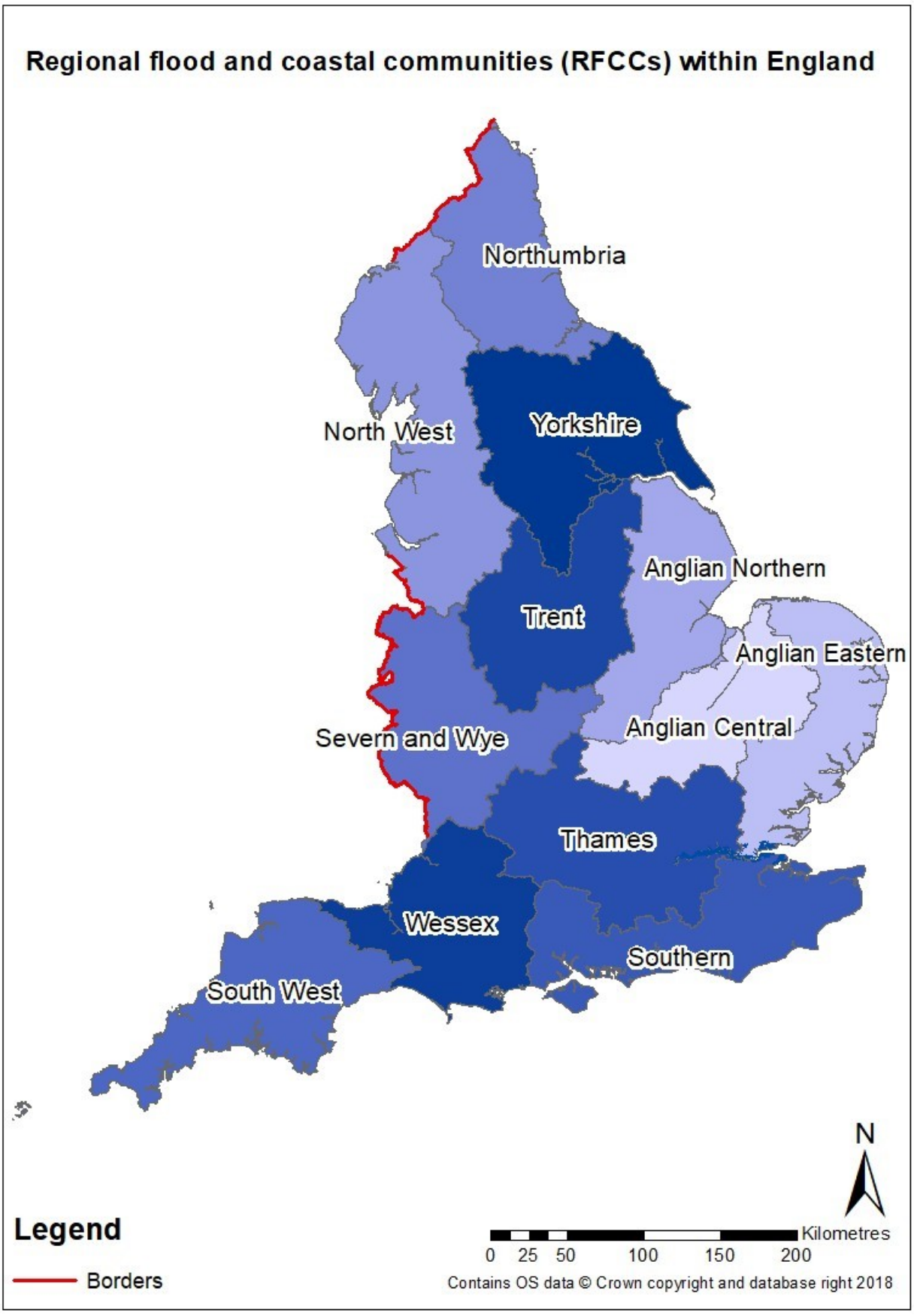


Figure 1. Maps of RFCC and RBD boundaries

River basin districts that cross national boundaries

There are three RBDs that cross national boundaries:

- the Severn RBD (England and Wales)
- the Dee RBD (England and Wales)
- the Solway Tweed RBD (England and Scotland)

We have worked closely with NRW and the SEPA who are responsible for managing flood risk in Wales and Scotland respectively, to prepare the preliminary assessment report.

What this report covers

This preliminary assessment report provides information on past and future floods from main rivers, reservoirs and coastal flooding. You can find more information about main rivers and a map online at information on the main river map for England (https://www.gov.uk/government/collections/main-river-map-for-england-proposed-changes-and-decisions).

We have reviewed past flooding events and used our understanding of flood risk to assess what could be affected by flooding. We then have used this information to identify significant FRAs. We then set out the work we are going to do next to meet the requirements of the Regulations.

To find information on flooding from surface water, smaller watercourses and groundwater flooding, please view the LLFA PFRAs.

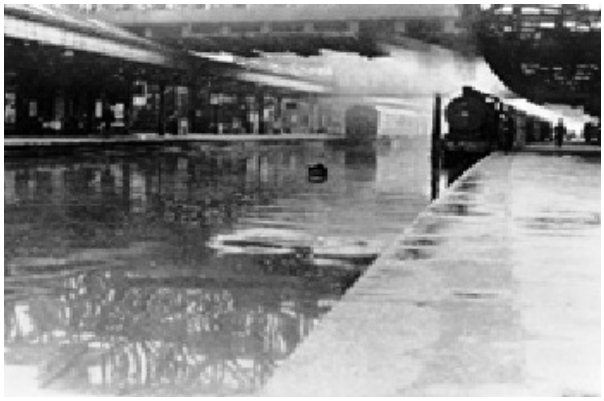
2. Past flooding

England has experienced major flooding from the rivers and the sea in the past. We have explored here the most significant floods in recent history that have helped us to learn more as a nation about the nature of flooding.

Historic records tell us that flooding has occurred dating back hundreds (and even thousands) of years. This information is largely based on historical information, such as newspaper stories and pictures, rather than scientific records.

A brief history of recent flooding in England from rivers and the sea

We know most about the flooding that has happened in the last 50-100 years because better records have been kept. We have hundreds of records about flooding that have informed what we know about the causes and consequences of it happening. The main sources are flooding from the sea and flooding from rainfall that lasts a long time, flooding from thunderstorms and flooding from snow that melts very quickly. We have explored these in more detail below.



Although unusual in England, rapidly melting snow can cause major and widespread flooding and loss of life. For example in January 1928, high tides combined with heavy rainfall and rapidly melting snow caused 14 deaths, made thousands homeless and major gas works were damaged in London. In the winter of 1946-1947, heavy snow fell for 55 days. This melted rapidly in March 1947, leading to widespread flooding in the Midlands and Yorkshire. Photo shows Nottingham in the Trent RBD, 1947 (photo credit: West Bridgford Library. Copyright reserved).

Thunderstorms can cause flash flooding in smaller river catchments. In August 1952, torrential rainfall led to torrents of floodwater and debris hitting Lynton and Lynmouth on the north Devon coast, costing 34 lives and destroying 100 buildings. In August 2004, a similar storm affected Boscastle in Cornwall when two billion litres of water rushed down the valley with little warning. A major rescue operation was implemented. Floodwater seriously damaged houses, shops and pubs and bridges were washed away. In September 1968, heavy thunderstorms in the south east flooded more than 14,000

homes, destroyed bridges and caused widespread disruption to transport, including the temporary closure of Gatwick Airport.

Combined high tides and a sea surge during storms causes the most severe flooding on the coast. There was devastating flooding on the East Coast in January 1953; 307 people died and over 24,000 properties were affected. This event helped inform our understanding of coastal flooding and the government made a significant investment in coastal defences and flood warning afterwards. In 1978, major flooding hit the East Coast again and whilst over 1,000 homes were still flooded, the defences built since 1953 protected many thousands more from flooding and advance warning enabled people to evacuate. Photo shows Whitstable, Kent in the Thames RBD, 1953 (photo credit: Keystone Pictures USA / Alamy Stock Photo).

Continuous heavy rainfall over a long time causes major and widespread flooding, especially when this follows earlier rainfall and the ground is already wet. In Easter 1998, heavy rain fell in the Midlands, causing 5 deaths and over 4,000 properties to flood. Autumn 2000 was the wettest recorded in the British Isles and rivers rose to record levels. The 2000 flood event was the most extensive flooding experienced since March 1947.

Over 10,000 homes and businesses were flooded across the Thames, Trent, Severn, Wharfe and Dee catchments. More recently in 2007, prolonged heavy rainfall caused 13 deaths, 55,000 properties to flood across the Midlands, northern and south eastern England and there was major infrastructure damage. Widespread flooding also occurred in Cumbria in 2005, in Northumbria in 2008 and in Cumbria and the South during 2009.

Photo shows Tewkesbury in the Severn RBD, 2007.

In accordance with the Regulations, we have summarised below the most significant flood events to have affected England from 2011, which is when the first cycle of FRMPs started. These floods had significant harmful consequences at a national level to human health, the economy, the environment and/or cultural heritage. They have also significantly improved our understanding of flood risk and changed how we approach and manage flooding.

2012 was one of the wettest years on record. The flooding started in April and prolonged and intense rainfall increased the risk of flooding from rivers and surface water for long periods throughout the year. All RBDs were affected and the impacts were worst in the South West, Yorkshire and Northumbria RBDs.

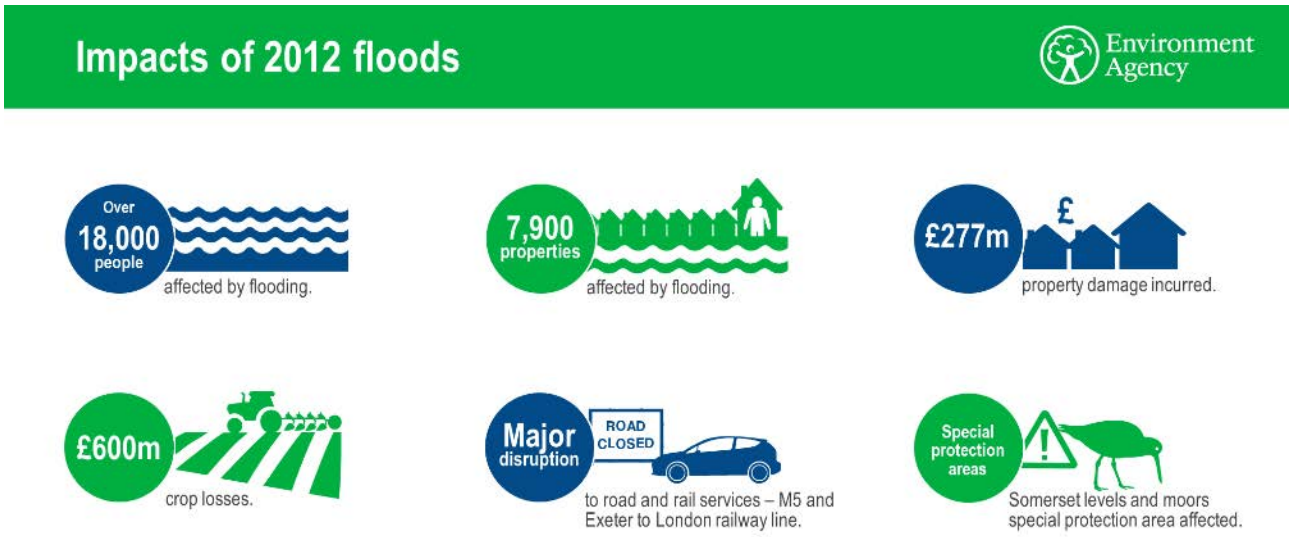


Figure 2. The impacts of the 2012 floods.

The winter of 2013 to 2014 broke records. It started with a coastal surge at the start of December. This brought sea levels on many parts of the coast (in places greater or the same as seen in 1953). A series of 12 storms then worked their way across the Atlantic Ocean, causing both river and coastal flooding. It became the wettest winter for 250 years. An estimated 11,000 properties were flooded and economic damages were around £1.3 billion. Around 1.4 million homes and businesses and 2,500 square kilometres of farmland were protected by flood schemes and the operational response to the flooding. All RBDs were affected and the impacts were worst in the South West, Anglian and Thames RBDs.

Figure 3. The impacts of the 2013 coastal surge.

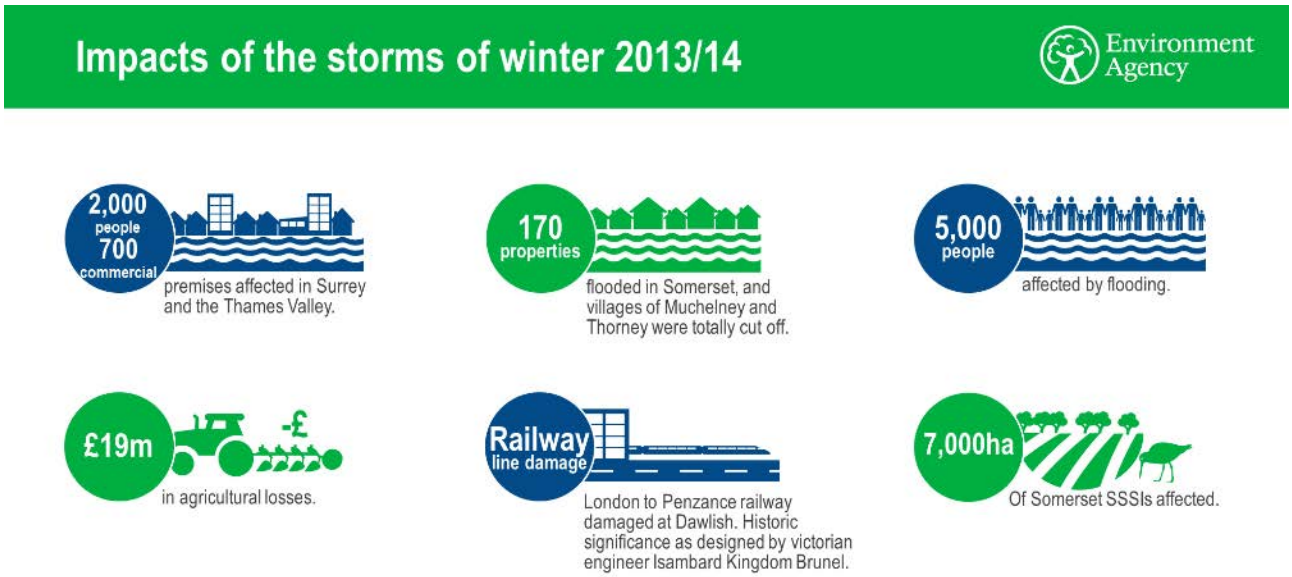


Figure 4. The impacts of the storms of winter 2013/14.

Winter 2015 to 2016 also brought widespread flooding. A reported 17,000 properties across the north of England were affected by storms Desmond, Eva and Frank making December 2015 the wettest month ever recorded. The total economic damages for England were estimated to be £1.6 billion. The RBDs worst affected were North West, Northumbria and Humber.

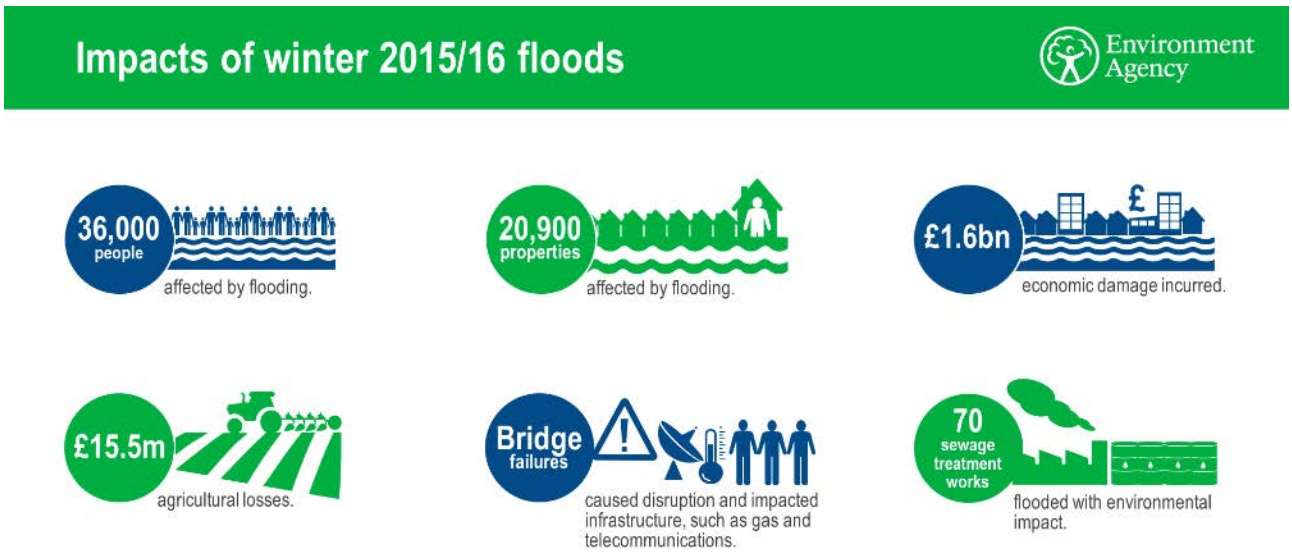


Figure 5. The impacts of the winter 2015/16 floods.

January 2017 saw a significant tidal surge event. On 13 and 14 January, communities along the east coast of England were warned to be prepared for large waves and potentially significant flooding. The Environment Agency issued 17 severe flood warnings (meaning risk to life) along the coast of East Anglia. The actions taken by the Environment Agency and partners helped to minimise the impact on communities. Together they protected over 555,000 properties from flooding. Compared to the 2013 surge, the impacts were much lower. Around 20 properties and businesses were affected in Yorkshire and there was localised disruption to infrastructure. No major impacts on environmental or cultural heritage sites were reported.

How do we use information on past flooding?

Our understanding of flood risk is not static and it has changed over time with each major flood. We learn more about what causes flooding and how severe it might be by observing our weather conditions, how flooding happened and recording where flooded. We use this information to:

- Map the largest recorded extent of flooding known to have happened. We call this our historic flood map
- Understand how extensive the flooding was, the depth and flow, what it affected and the route flooding took (conveyance routes). This information is often very detailed and locally specific. Such information can sometimes be found on LLFA websites in their flood investigation reports
- Inform estimates of the highest rainfall totals, maximum river flows and highest tide levels that might be expected over a given time period. We use this to inform our computer models that generate floodplain extents and inform our predictive flood maps

– After major floods, such as 1953, 1998, 2000 and 2007, the government commissioned lessons learnt reports. These document what happened and have informed how we and others have adapted our approaches to managing flood risk over time. You can find these reports on GOV.UK

Anecdotal information like flood markers on bridges and buildings can help us understand how severe past flooding was and help us plan for future flooding. Photo shows flood levels at Blakeney, Norfolk

Reservoir flooding

Reservoir flooding is extremely unlikely to happen. All large reservoirs must be inspected and supervised by specialist Reservoir Engineers. We enforce the 1975 Reservoirs Act in England and we make sure that that reservoirs are inspected regularly and important safety work is done.

Our legislation is also kept under review to ensure reservoirs are managed to high standards by third parties and a consistent level of operation is maintained.

There has been no reservoir flooding in England resulting in a loss of life since 1870, when a reservoir at Rishton, Lancashire failed. The last event in England causing major loss of life was slightly earlier in Yorkshire in 1864, when the Dale Dyke Reservoir failed whilst it was being filled for the first time, leading to 250 fatalities in the Sheffield area. The government made reforms to reservoir standards following the tragedy.

3. Potential flooding

We use computer modelling to map floodplains so that we can understand the areas most likely to flood. And we use historic records to check our results are representative of what we know has happened in the past. This helps us to have a consistent understanding of flood risk across the country regardless of the records available for a given area. We also consider the flood risk impacts of climate change and planned development. We use this information to inform actions that we and others take to manage flood risk and to raise awareness in communities that could be affected.

Risk of flooding from main rivers and the sea

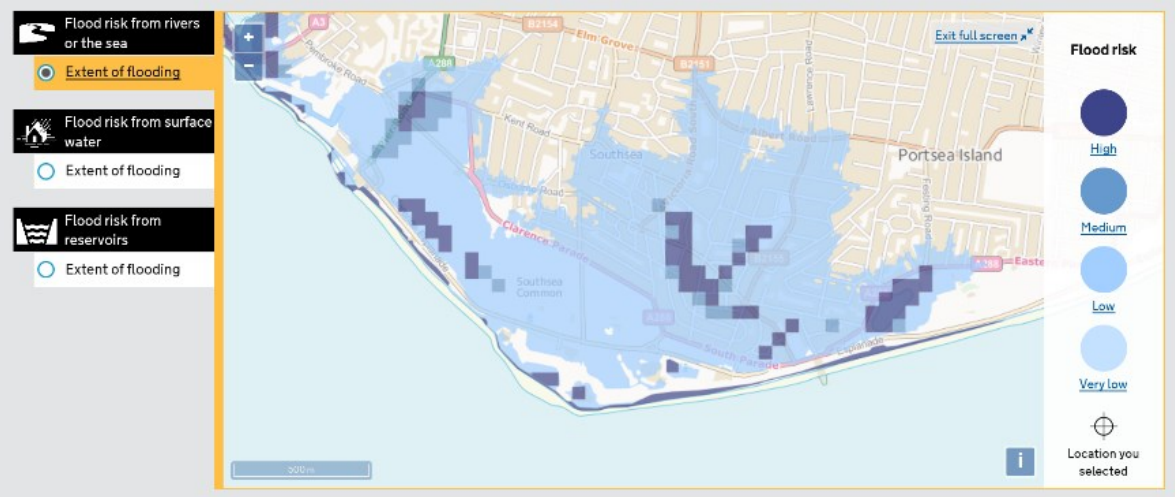
The Environment Agency undertake a national assessment of flood risk across the entire country, taking into account the likelihood of flooding and potential consequences known as the National Flood Risk Assessment (NaFRA). NaFRA has recently been updated to include the results of the survey of all the flood defences in England we completed after the winter 2013/14 flooding. The NaFRA tells us how risk levels vary across the floodplain and shows the reduction in risk where we have defences. We have assessed different scenarios so that we could see how much difference current flood defences and maintenance work make to flood risk. We now use this information to make decisions about future investment in flood defences and other interventions to increase the resilience of local communities.

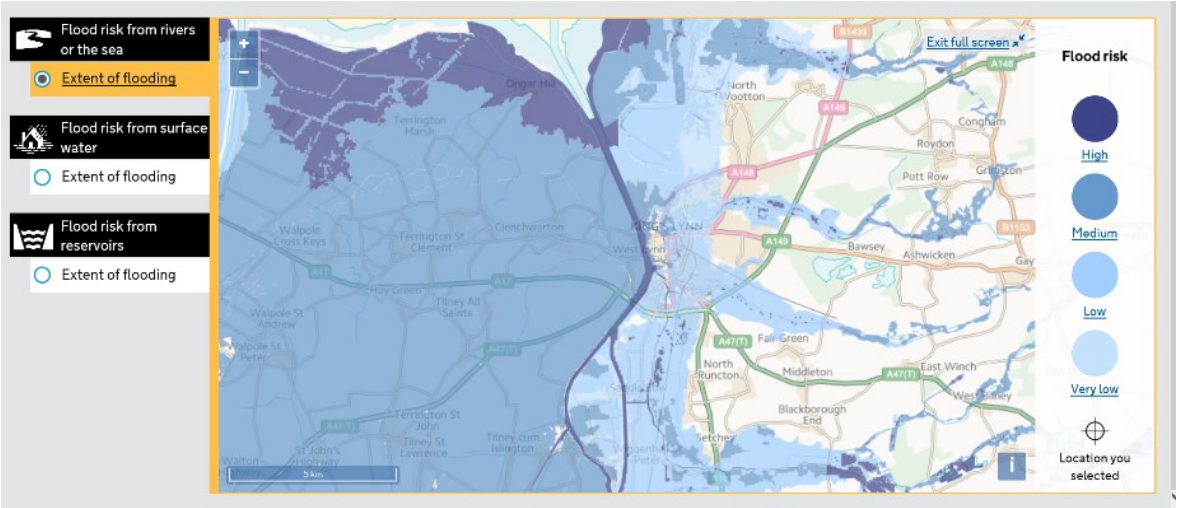
The Risk of Flooding from Rivers and the Sea map

The Risk of Flooding from Rivers and the Sea map is a summary version of the NaFRA that we publish on the government website. It shows the chance of flooding from rivers and the sea presented in categories that take account of flood defences and the condition they are in. The categories are:

- high risk means that each year, there is a 3.3% chance or greater of flooding
- medium risk means that each year, there is between a 1% and 3.3% chance of flooding
- low risk means that each year, there is between a 0.1% and 1% chance of flooding
- very low risk means that each year, there is less than 0.1% chance of flooding

Figure 6. Extracts from the risk of flooding from rivers and the sea



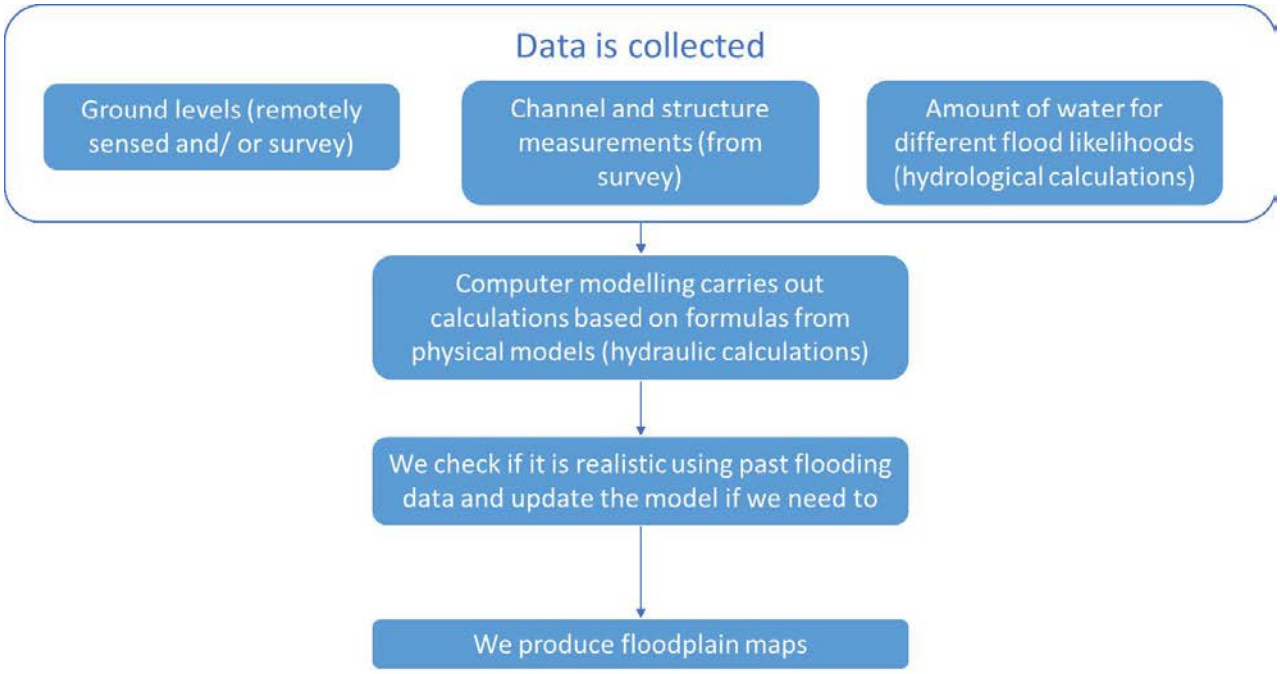


You can view this map at [find out if you're at risk of flooding in England](https://www.gov.uk/check-flood-risk) (https://www.gov.uk/check-flood-risk).

How we map floodplains for river and sea flooding

How we map floodplains has changed over time from plotting the extent of previous floods to taking full advantage of modern technology and using computers to process large amounts of data. We have summarised how we do this below.

Figure 7. How we model floodplains



The Environment Agency publishes a national scale map of mapped floodplains known as 'the flood map for planning'. This is available through GOV.UK and is a collection of local detailed modelling, high level national scale modelling and historic flood extents. Developers and local planning authorities use this map to help make decisions on the locations and suitability of planned future development, so the most vulnerable development can be located to areas with the lowest likelihood of flooding.

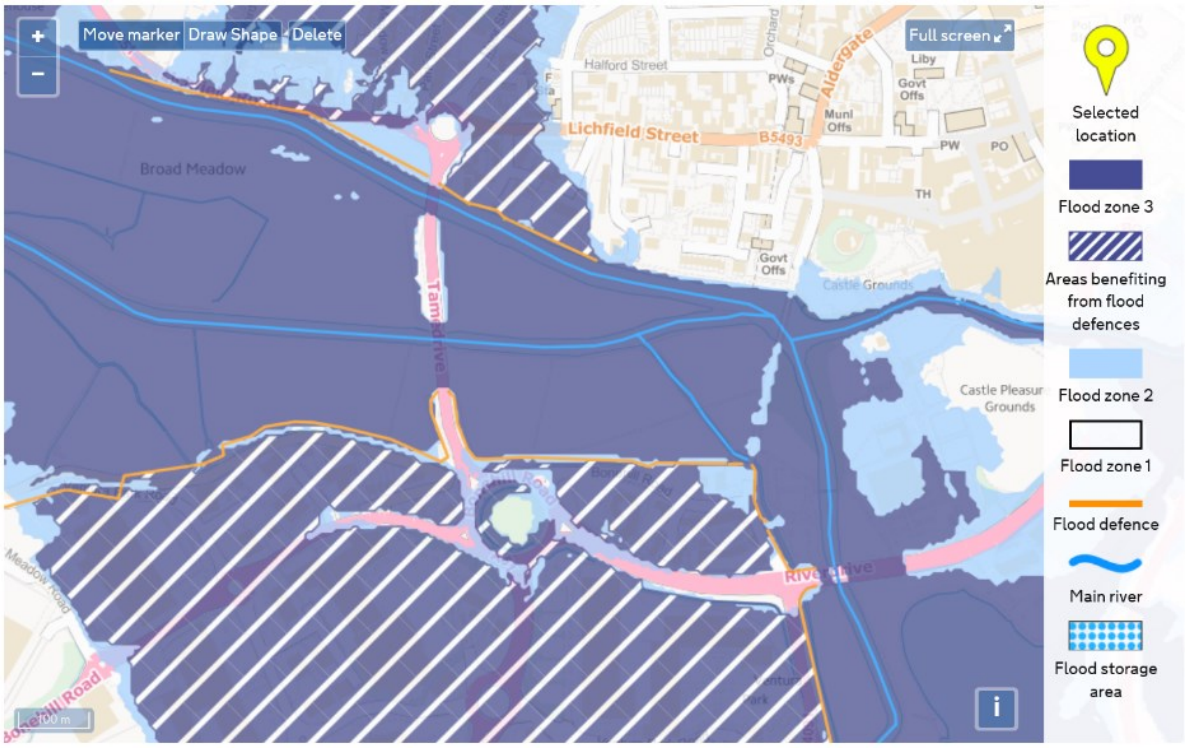
The flood extents don't take into account flood defences and so they are precautionary. This is because not all flood defences are the same: they offer different standards of protection and are in different conditions. There is always a chance that flooding could occur behind defences if they are overtopped in an extreme flood and/ or fail. The flood map for planning allows us to take this into account in long term land use planning decisions.

The flood map for planning

The flood map for planning shows river and sea flooding across different flood zones. These flood zones have different flood likelihoods. National planning policy tells planners and developers how to use these flood zones to inform planning decisions. This map shows:

- Flood zone 1: Low probability: less than a 0.1% chance of main river and sea flooding in any given year
- Flood zone 2: Medium probability: between a 1% and 0.1% chance of main river flooding in any given year or 0.5% and 0.1% chance of sea flooding in any given year
- Flood zone 3: High probability: greater or equal to a 1% chance of main river flooding in any given year or greater than a 0.5% chance of sea flooding in any given year
- the routes of major flood defences
- areas that benefit from major flood defences
- main rivers: the larger rivers that we undertake flood risk management on
- flood storage areas (none on this example)

Figure 8. Extract from the flood map for planning



You can view this map at flood map for planning (https://flood-map-for-planning.service.gov.uk/).

How we check the modelling is realistic

We use data from past flooding to check that the outputs of our river models are realistic. The data can include:

- recorded flood levels and flows from river gauging stations
- the amount of rain that fell
- recorded flood extents e.g. from photos and mapping where a flood has left debris behind, and
- recorded flow paths e.g. from accounts of how things flooded

If the checking shows that the predicted flooding for flood event that is a similar size to one that has been experienced is not quite right, we amend our model until we get it to represent as closely as possible what happened. The amount of data available to check our models varies from place to place and this affects how much we can check our models.

Often there is less information available to check models for extreme flood events. After the flooding in winter 2015-16, when some flood defences were overwhelmed, we wanted to understand more about how extreme flooding could get. Scientists did this by calculating the most likely extreme rainfall and sea levels we might get and mapping the extent of flooding that would happen. The extents of flooding compared well to the existing extreme flooding information that the emergency services use to plan for flood response. This gives us confidence that our extreme flood outlines (a combination of flood zones 2 and 3 on the flood map for planning) represent realistic severe fluvial and tidal flooding.

The impact of climate change and long-term developments

Flood risk changes over time. There are many reasons for this - population increase, new development and changes in the way land is managed – but the main reason is climate change. Our climate is influenced by both naturally occurring variations in the climate system and human activity, such as increasing greenhouse gas emissions. General climate change projections show an increased chance of warmer, wetter winters and hotter, drier summers with a higher likelihood of more frequent and intense rainfall. We expect to see an increase in severe events, such as flooding. At the same time, sea levels are gradually rising, as the oceans warm up and ice caps melt. For example, we already know that:

- 2017 was the fifth warmest year over land in a record that began in 1910
- nine of the ten warmest years in the UK have been since 2002 and the top ten have all occurred since 1990

- seven of the ten wettest years for the UK have been since 1998
- sea levels have risen by about 16cm since the beginning of the twentieth century, when corrected for land movement. (This is the way that the land mass of the England is changing after the last ice age. The huge mass of the ice weighed down the land and it is now readjusting, rising in the north west and sinking in the south east)

Damages from flooding and coastal change are already high, averaging an estimated £1 billion per year in the UK. The Climate Change Risk Assessment says that under the 4°C warming scenario (by this we mean the scenario for the 2050s that shows average temperatures are 4°C warmer than today), the number of households at a significant chance of flooding (3.33% chance of flooding in any one year) is projected to increase from 860,000 today to 1.9 million by the 2050s. Whilst government is committed to limit global warming to well below 2 ºC, planning for a reasonable worst case scenario (4 ºC) allows us to take a risk based approach.

The Environment Agency has published climate change guidance on GOV.UK which sets out how to make an allowance for climate change when estimating future river flows, sea levels and rainfall intensity. We and others use this when designing new flood and coastal defences and making decisions about the safety of new developments. The guidance is based on climate change projections from 2009 and different scenarios of carbon dioxide (CO2) emissions to the atmosphere. There are different allowances for different periods of time over the next century. It is important to remember though that there is uncertainty about future climate change and the exact way this will affect flood risk.

Scientists are currently updating the climate change projections for the UK. These are due to be published in late 2018 and will give greater regional detail. We will consider the impact the new projections will have on future flooding and reissue the guidelines after publication for the full set of river, sea and rainfall projections.

As well as climate change, flood risk in the future will also be affected by:

- new developments that can generate more and faster runoff from rainfall that enters our rivers
- the number of properties that will be built on floodplains
- population growth, as more people live and work in areas at risk
- ageing assets, like flood embankments and underground culverts that are more likely to fail as they age

Decisions about investment in flood defences and the range of different actions we take to adapt to climate change will also affect future flood risk. We will need to invest in measures that work alongside traditional flood defences to help manage future flood risk. This includes property resilience, natural flood management and temporary barriers. We must continue to increase our understanding of flood risk under a changing climate and maintain policy and implementation by the Environment Agency, local authorities and developers to manage future flood damages and create resilient places. Current policy steers the most vulnerable development away from areas at high risk of flooding, but

where development does need to go ahead there are policy safeguards to ensure development will remain resilient to the long-term effects of flooding, including climate change impacts.

4. RBD flood risk information

How we assess the consequences of potential floods

The information below describes the metrics we have used in this section and how these meet our requirements to explore flood consequences in the Regulations.

Human health consequences

How we have measured it: The number of people at risk of flooding, based on how many residential properties could be affected and multiplying this using statistical evidence on how many people live in these properties.

Other indicators: The impacts on both physical and mental human health are wide ranging. Flooding can also affect people in different ways, for example, depending on their age and levels of social deprivation. This information is harder to measure consistently at a national and strategic level.

Economic consequences

How we have measured it: The number of non-residential properties (businesses) and key services at risk of flooding. This can tell us the scale of the likely impact on the local economy at a nationally consistent scale. However, locally it does not tell the full picture as some businesses are larger than others e.g. large local employers compared to small independent businesses.

Other indicators: There are many other measures of economic damage, such as the financial losses to businesses, agriculture and due to infrastructure loss. The length of road and rail affected can also be calculated.

Impacts can also be felt wider than the immediately flooded area e.g. when roads are closed and people struggle to get to work or when gas lines are disrupted, affecting fuel supplies.

However, given the national and strategic nature of this report, the location of businesses and key services provides a high-level overview of economic impact.

Environmental consequences

How we have measured it: The area of Special Area of Conservation (SAC) has been used as an indicator at a national level of internationally significant conservation sites that could be affected by flooding.

Other indicators: There are other environmental designations such as regionally and nationally important sites e.g. Sites of Special Scientific Interest (SSSI), international designations such as RAMSAR and Special Protection Areas (SPAs) and information on protected species.

However, given the national and strategic nature of this report, the area of SAC affected provides a high-level overview of environmental impact.

Cultural heritage consequences

How we have measured it: The number of listed buildings (LBs) at risk has been used as an indicator at a national level of significant cultural heritage sites that could be affected by flooding.

Other indicators: There are other cultural heritage designations such as World Heritage Sites, Scheduled Monuments and Registered parks and gardens.

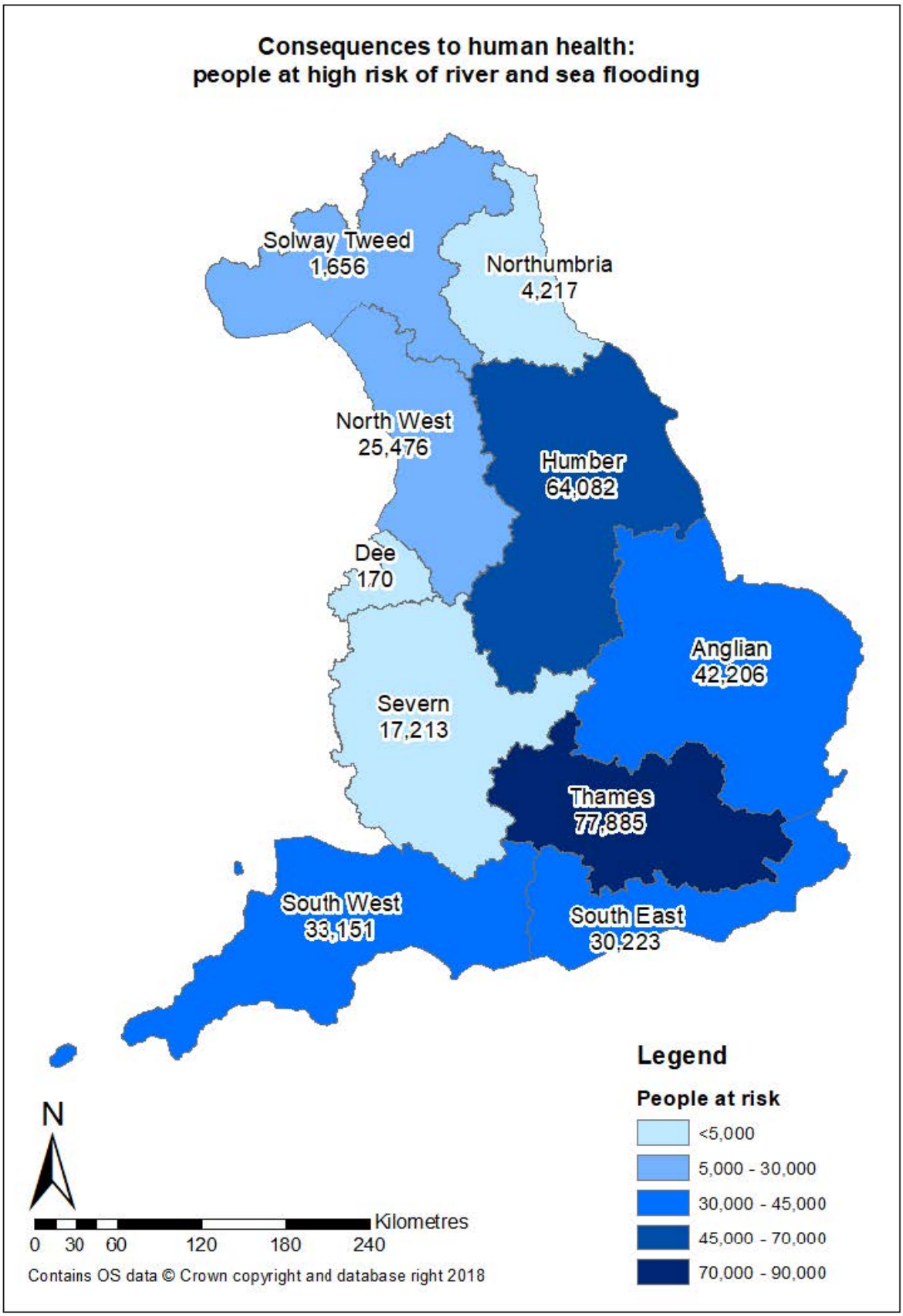
However, given the national and strategic nature of this report, the number of LBs affected provides a high-level overview of the scale of impact of flooding on cultural heritage.

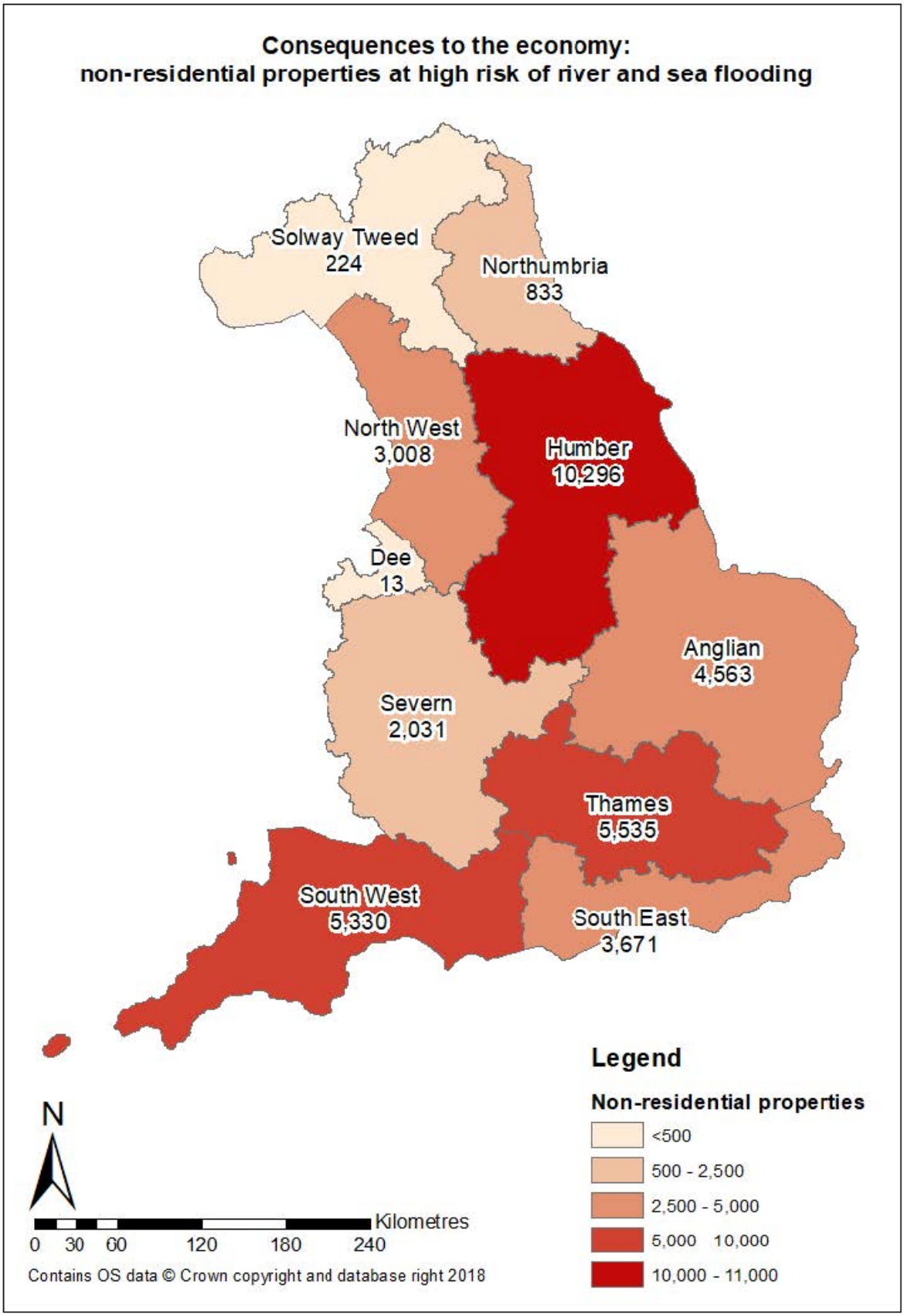
Rivers and sea

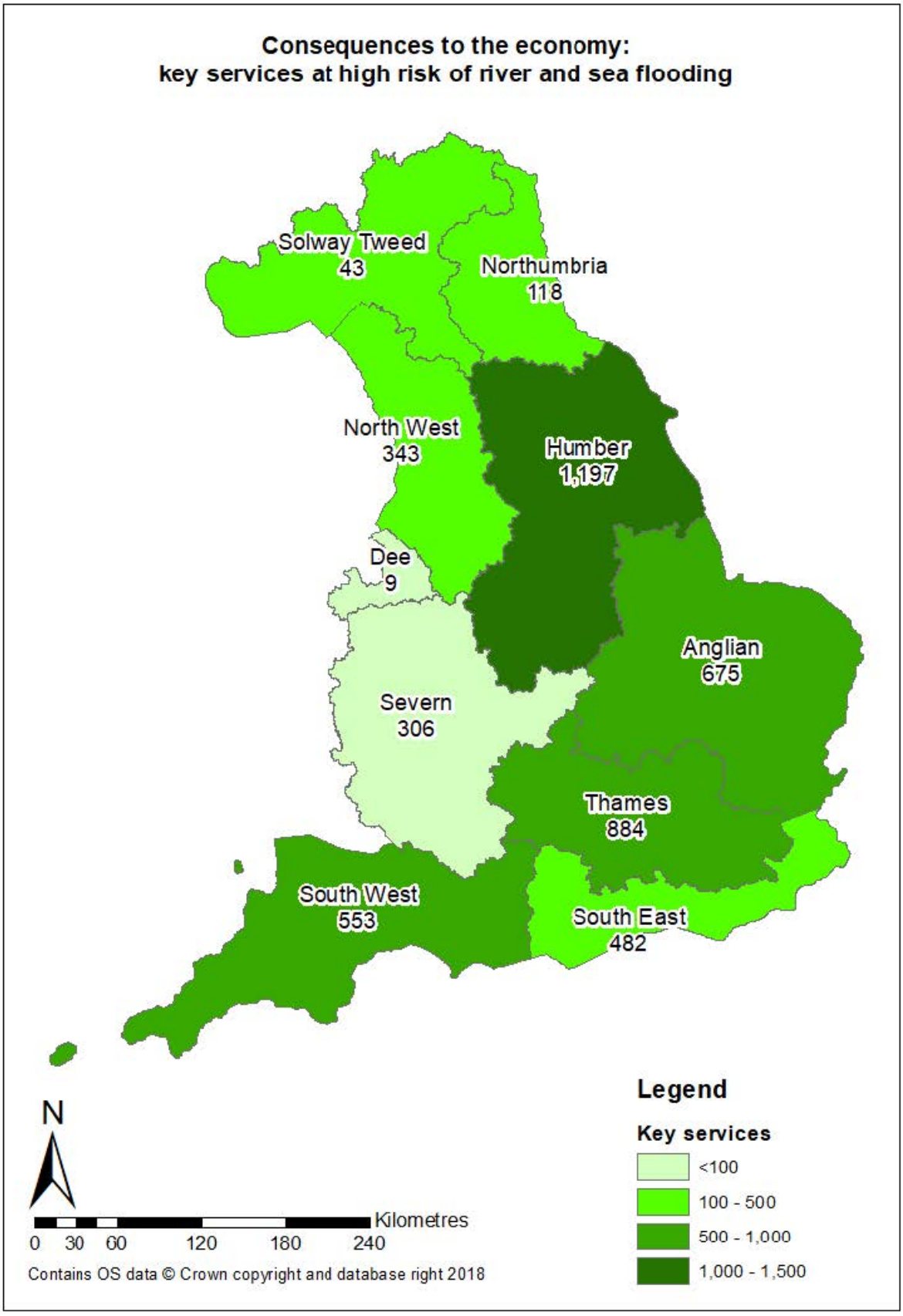
The maps below show the variation in risk to human health, the economy, the environment and cultural heritage across RBD in England for river and sea flooding. For the Severn and Dee RBD, the statistics do not include Wales:

- The Solway Tweed, Northumbria and Dee RBDs have the lowest number risk to people and economy. Flood risk to human health is highest for the Thames and Humber RBD. Flood risk to the economy is highest for the Humber, South West and Thames RBDs.
- The North West RBD has the largest area of SACs at high risk of being flooded at nearly 18,000 hectares. The Anglian RBD also has a relatively high amount at risk. The risk to SACs is lowest in the Thames RBD.
- The risk is highest to cultural heritage in the South West RBD, followed by the Humber and Thames RBDs. The risk is lowest in the Dee, Northumbria and Solway Tweed RBDs.

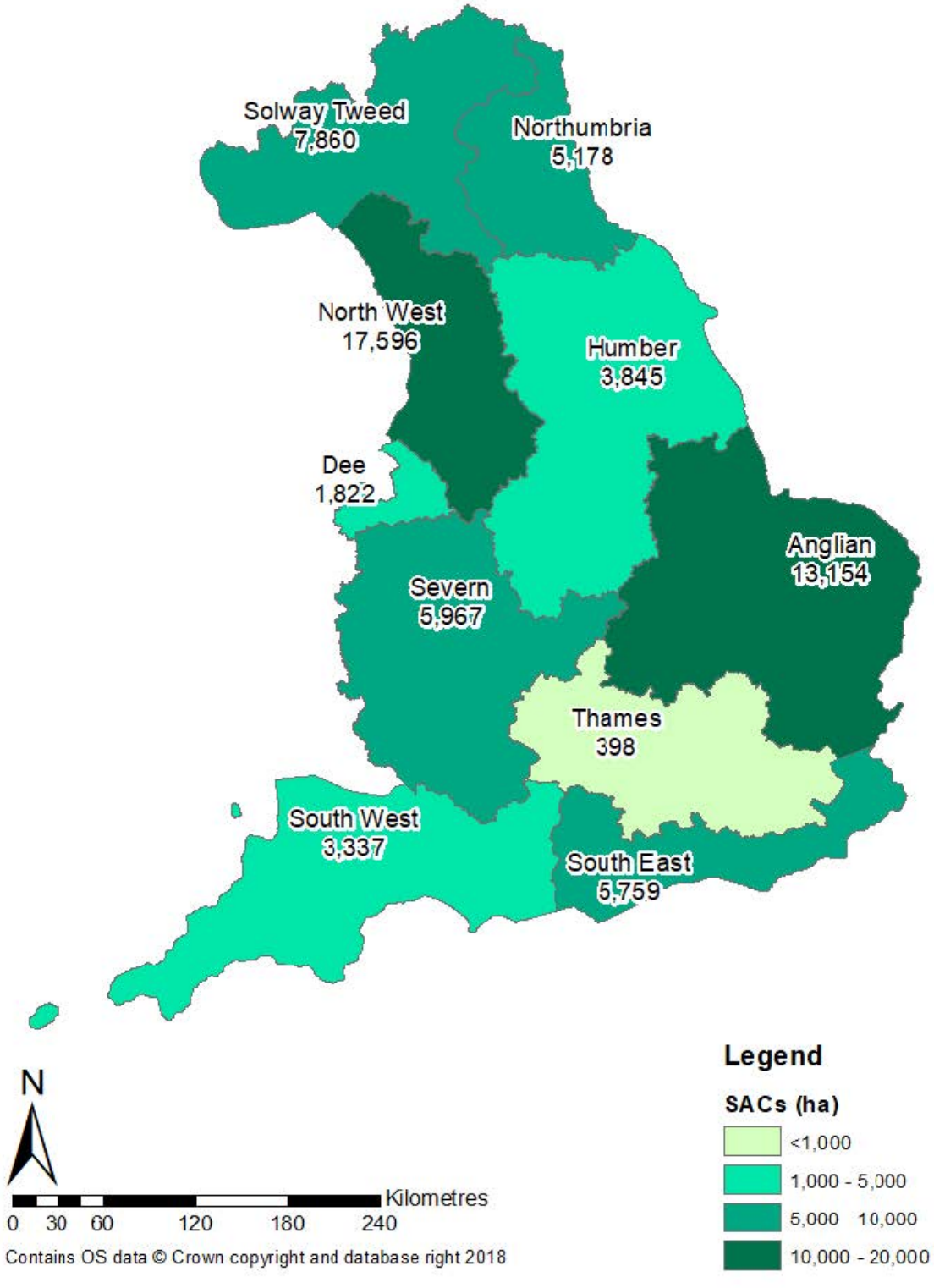
Figure 9. Consequences of flooding per RBD

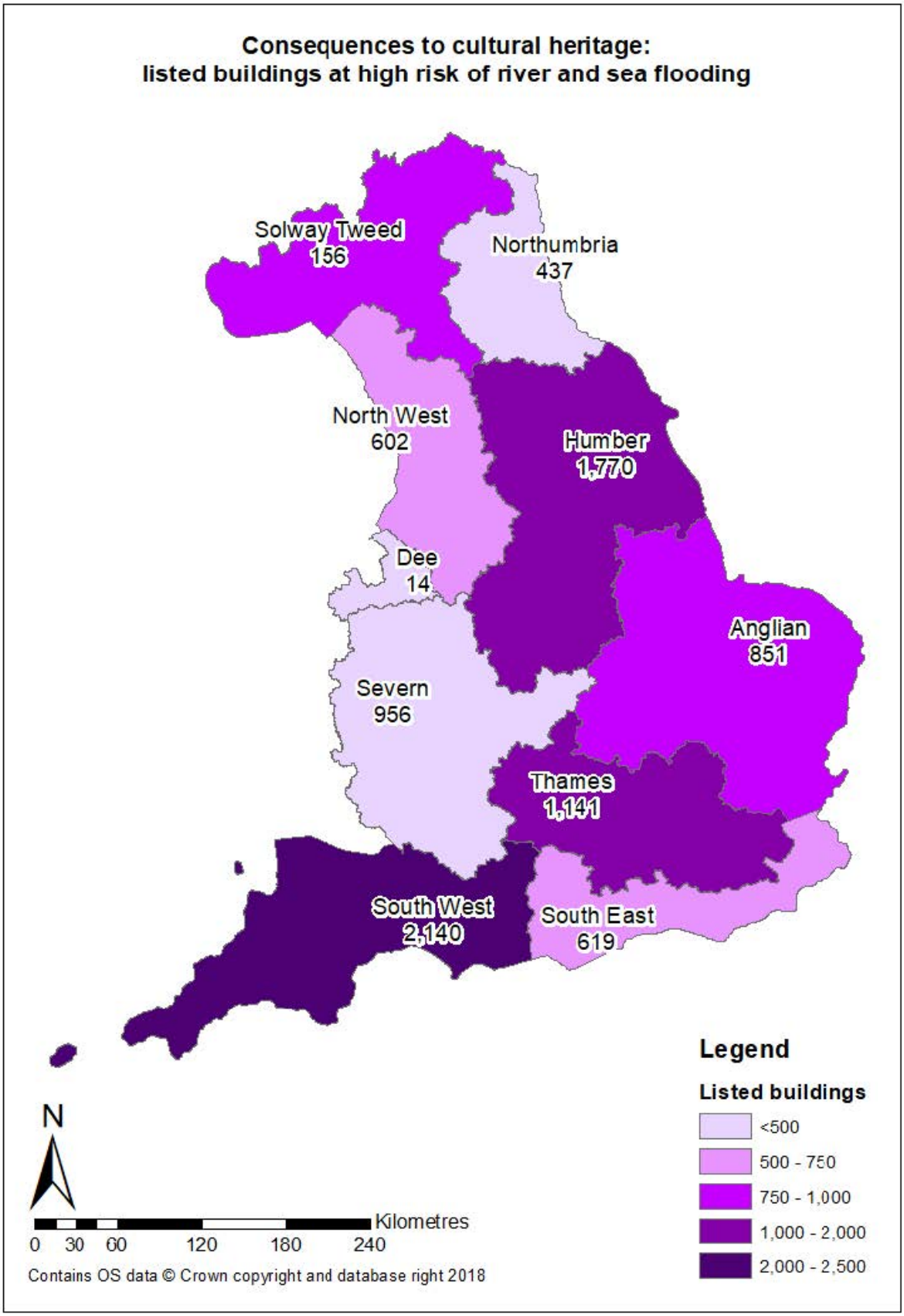



Consequences to the economy:
non-residential properties at high risk of river and sea flooding
Solway Tweed
224
Northumbria
833
North West
3,008
Humber
10,296
Dee
13
Anglian
4,563
Severn
2,031
Thames
5,535
South West
5,330
South East
3,671
Legend
Non-residential properties
<500
500 - 2,500
2,500 - 5,000
5,000 10,000
10,000 - 11,000
N
Kilometres
0 30 60 120 180 240
Contains OS data © Crown copyright and database right 2018


Consequences to the economy:
key services at high risk of river and sea flooding
Solway Tweed
43
Northumbria
118
North West
343
Humber
1,197
Dee
9
Severn
306
Anglian
675
Thames
884
South West
553
South East
482
N
Kilometres
0 30 60 120 180 240
Contains OS data © Crown copyright and database right 2018
Legend
Key services
<100
100 - 500
500 - 1,000
1,000 - 1,500

Consequences to the environment:
area of special areas of conservation at high risk of river and sea flooding




Consequences to cultural heritage:
listed buildings at high risk of river and sea flooding
Solway Tweed
156
Northumbria
437
North West
602
Humber
1,770
Dee
14
Anglian
851
Severn
956
Thames
1,141
South West
2,140
South East
619
N
Kilometres
0 30 60 120 180 240
Contains OS data © Crown copyright and database right 2018
Legend
Listed buildings
<500
500 - 750
750 - 1,000
1,000 - 2,000
2,000 - 2,500

Reservoirs

The likelihood of flooding from a reservoir is far lower than for other types of flooding. Legislation ensures reservoirs are regularly inspected by trained civil engineers and owners are legally required to do essential safety works. There are very high safety standards for reservoirs in the UK which makes the likelihood of a failure very low.

We have mapped the maximum flood extent in the event of reservoir breach. Our maps are an absolute worst-case scenario, which assumes reservoirs are full at the time of breach, that there are no emergency reservoir operating measures and that lots of different reservoirs fail at the same time.

We assess risk by counting how many people, properties and cultural sites are within the maximum flood extent and the area of environmental sites affected. We have shown this data by RBD in Table 1. Reservoir flooding is highly unlikely and these numbers are precautionary for the reasons given above. It would take all the reservoirs in any RBD failing at the same time to cause the impact our numbers show. The information for the Severn and Dee RBD includes Wales as we did the work together. You should not directly compare the impacts of reservoir flooding in table 1 with river and coastal flooding in figure 9 as the reservoir flood mapping shows a much less likely flood.

In the extremely unlikely event that reservoirs failed, the highest risk to people would be in the Thames RBD, with the lowest risk in the Dee, South East and Solway Tweed RBDs.

The risk to the economy is highest in the Humber and Thames RBD and lowest in the Dee, South East and Solway Tweed RBDs. The risk to SACs is highest is the Anglian and Severn RBDs and lowest in the Thames, South East and Northumbria RBDs. The risk to cultural heritage is highest in the Humber, Severn and Thames RBDs and lowest in the South East, Solway Tweed and Dee RBDs.

We are currently updating our reservoir mapping to make the most of new data and technical advances. The new mapping will consider different scenarios by considering differences in the condition of a reservoir and the catchment it is in at the time it fails. It will be available at the end of 2019.

The risk of flooding from reservoirs map

The flood risk from reservoirs map on GOV.UK shows the maximum extent of flooding, depth and speed of flow in the unlikely event that a reservoir fails.

Figure 10. Extract from the flood map for reservoirs map

You can view this map at find out if you're at risk of flooding in England (https://www.gov.uk/check-flood-risk).

Table 1. Flood risk from reservoirs

	People at risk	Non-residential properties at risk	Key services at risk	SACs at risk	Listed buildings at risk
Anglian	170,200	32,860	670	6,150	2,180
Dee	12,400	3,600	50	1,250	500
Humber	441,150	68,270	1,430	1,050	3,830
Northumbria	56,850	12,910	250	750	1,030
North West	344,900	33,550	700	3,400	1,340
Severn	261,750	36,620	730	6,050	3,360
Solway Tweed	15,200	2,520	40	3,000	250
South East	16,500	2,600	60	550	220
South West	66,250	14,880	250	3,350	1,790
Thames	940,350	62,000	1,100	400	3,010

5. Flood risk areas

We have used the latest information on flood risk to human health, the economy and environmental and cultural heritage sites to assess which areas nationally are the most significantly affected from river and sea flooding.

What is a flood risk area?

FRAs are areas where the risk of flooding is likely to be significant for people, the economy or the environment (including cultural heritage). By risk we mean not just the chance that flooding will occur (the probability), but also the impact or consequence. In an area with few people or few properties, the consequences of flooding may be relatively low even if the likelihood of flooding is high. In comparison, in areas with high numbers of

people, property, infrastructure or assets the consequences are likely to be higher but the probability of flooding may be much lower because there are flood defences.

How we have defined flood risk areas

We identified communities at risk of flooding using datasets on flood risk, properties and communities. The data we used are:

- Flood risk: Risk of flooding from rivers and the sea. This shows the results of NaFRA and the chance of flooding from rivers and the sea, presented in four flood risk likelihood categories.
- Properties: National receptor database. This allows us to assign the level of flood risk to individual properties. We made sure we included schools, hospitals, care homes, infrastructure and other services as well as homes and businesses.
- Communities: Office for National Statistics built-up areas (from the 2011 census). This data provides information on the villages, towns and cities where people live, and allows comparisons between people living in built-up areas and those living elsewhere.

We then analysed the information at a community level to calculate a “community risk score” to each community. The community risk score is based on:

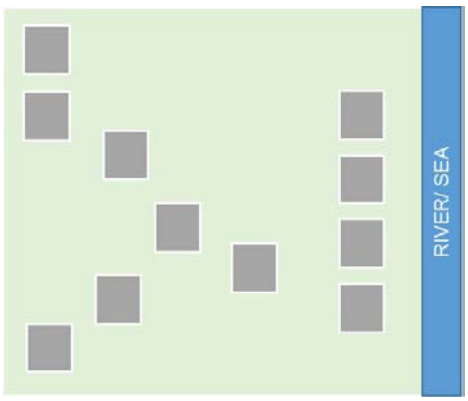
- the number of properties (residential and non-residential) within the community which are at high, medium, low or very low risk of flooding
- the annual likelihood of flooding for each individual property at risk within the community
- the percentage of all properties within the community that are properties at risk of flooding

Calculating the community risk score

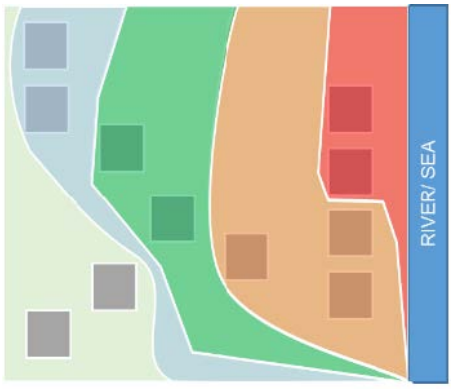
We have shown how we have done this using the worked example below.

Step 1: We defined the community using the built up area data

In this example, there are 11 properties identified within this built-up-area.



Step 2: We used the NaFRA data to identify which properties are at flood risk



Step 3: We used the NaFRA data to identify how likely each property is to flood

Then we added these up to produce the total flood risk within the community (ie in this example 14.9%).

Then we divide the total risk by the number of properties to get the average annual probability of flooding for all the properties within the community (in this example this is 14.9%/11 which gives an average annual probability for this community of 1.35%).

Step 4: We generated the community risk score

We multiplied the total flood risk of the community by the average annual probability of flooding for all properties within the community.

This allows us to distinguish between two communities that share the same average annual probability of flooding for all properties. This means that we have considered both large and small communities on an equal footing.

In this example, the calculation would be 14.9% x 1.35% giving a community risk score of 20.1. We have used this risk score to rank communities.

Using the community risk score

We ranked communities according to their risk score to understand how they contribute to overall national flood risk. We initially selected communities that represented 50% of total risk across the country as a starting point. We then engaged with local experts to check, adapt and refine the selection based on best available knowledge, including:

- sites that are import for the environment or cultural heritage
- roads, rail and other similar infrastructure
- the location of industrial sites that could cause major pollution to happen
- vulnerable local sites, such as caravan parks or camp sites
- future planned development

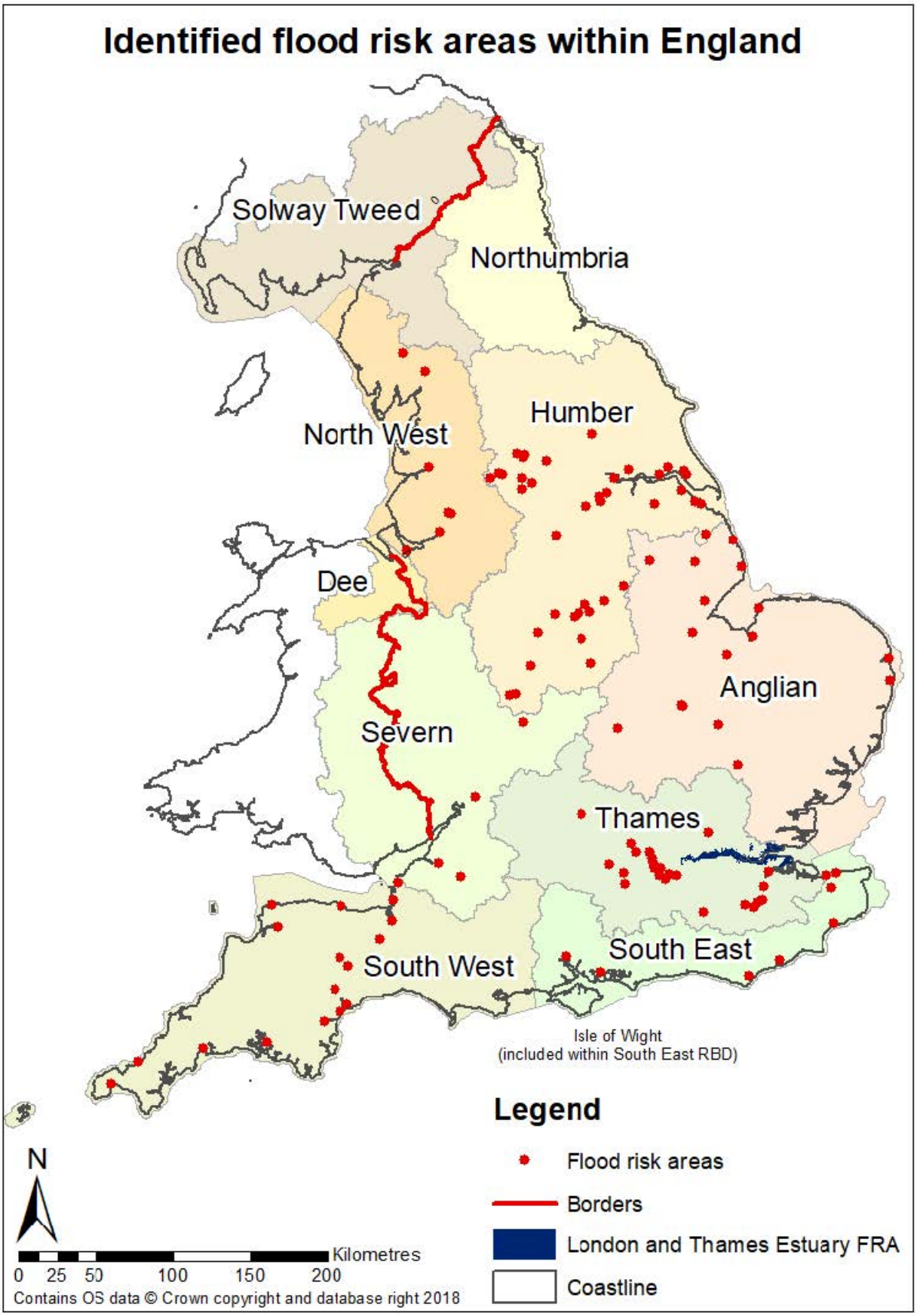
Identified flood risk areas

We have identified 116 communities that are at significant risk of flooding in England and you can see these on the map below. We have also provided a more detailed map of these separately to accompany the report. You can also download this as data from data.gov.uk

The number FRAs varies around the country:

- The highest number are in Humber RBD (40) followed by Thames RBD (25)
- There are a similar number in Anglian RBD (18) and South West RBD (17)
- There are also a similar number in South East RBD (8), North West RBD (8) and Severn RBD (5)
- There are no FRAs in Dee RBD, Northumbria RBD or the Solway Tweed RBD
- There are two FRAs that overlap RBD boundaries one between South East and Thames (Whitstable) and one between Severn and South West (Weston-Super-Mare)

Figure 11. Identified flood risk areas



6. Summary and next steps

This report meets our requirements under the Regulations to produce a preliminary flood risk assessment for river, sea and reservoir flooding. We have also used the information to identify nationally significant FRAs.

We will continue to plan for and manage the risk of flooding to all communities, whether they are in a FRA or not, but the FRAs will be our priority. There are many local reasons why we would pursue a flood risk management intervention for a particular community. Being in a FRA or not will not affect the amount of funding for flood defences and the way we comment on local plans and planning applications.

Next steps

We will produce flood risk and hazard mapping by the end of 2019 and FRMPs by the end of 2021 for FRAs to meet our requirements under the Regulations. FRMPs must include objectives and measures to address the risks within FRAs. Our FRMPs will help us prioritise our flood risk management interventions for people, the economy and the environment (including cultural heritage) by focussing our efforts on those communities with the greatest risk from flooding.

We will do this work together with LLFAs. They will also need to do this for FRAs from surface water, smaller watercourse and groundwater flooding.

There is ongoing work that will inform the future work we need to do. This could mean that the results look different to ones we have presented in this PFRA. The content of the PFRA will not change, but work to complete the flood risk and hazard mapping as well as the FRMPs will take account of the most up-to-date and relevant data and information.

This work will include:

- updated UK climate projections, that are due in late 2018
- updating our reservoir flood mapping, which should be available by the end of 2019
- flood investigations into any major flood events that change our national understanding of river, sea and reservoir flooding
- local updates to floodplain models, that will inform updates to the NaFRA
- a major revision to the way we undertake our NaFRA, although the results of this work will not be available until 2021

Information collected for the PFRA and identifying FRAs will be also be useful for informing other plans and strategies. For example, it could be used by local planning authorities to inform strategic flood risk assessment for local plans or by RFCCs to help build a pipeline of future locations for flood schemes.

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8. Glossary

Floods Directive

This is European legislation that sets out how we need to identify, map and plan for flood risk management work. This was put together after the major and devastating floods that affected central Europe in the early 2000s.

Flood Risk Area (FRA)

Areas where the risk of flooding is significant nationally for people, the economy or the environment (including cultural heritage). We report these to the European Commission and need to do further work in these areas under the Flood Risk Regulations.

Flood Risk and Hazard Mapping

We need to produce maps showing the distribution of flood risk and hazard (how deep water is and how fast it flows) for Flood Risk Areas by the end of 2019.

Flood Risk Management Plan (FRMP)

We need to produce a plan for each Flood Risk Area that sets out what we want to achieve when we manage flood risk and how we will do that by the end of 2021.

Flood Risk Regulations

This is legislation that sets out how we need to meet the European Floods Directive in England and Wales.

Listed Building (LB)

These are buildings, objects or structures that are considered to be nationally important for their architectural or historic interest. They are included in a special register called the 'List of Buildings of Special Architectural or Historic Interest'.

Lead Local Flood Authority (LLFA)

There are County, Unitary or Metropolitan Boroughs that are responsible for managing flooding from surface water, smaller watercourses and groundwater such as Staffordshire County Council, Birmingham City Council and Walsall Metropolitan Borough Council. There are 152 in England.

National Flood Risk Assessment (NaFRA)

We undertake a national assessment of flood risk from rivers and the sea that takes into account flood defences and the condition they are in. We publish a summary of this on the government website called the Risk of Flooding from Rivers and the Sea map.

Natural Resources Wales (NRW)

Natural Resources Wales oversee flood risk management in Wales and we are working with them to produce shared reports for the River Severn and Dee River Basin Districts.

Preliminary Flood Risk Assessment (PFRA)

These consider past and potential future floods that have had significant consequences to human health, the economy, the environment and cultural heritage.

River Basin District (RBD)

These are large river catchments in England, Wales and Scotland and we report at this scale to the European Commission. They cover an entire river system, including river, lake, groundwater, estuarine and coastal water bodies.

River Basin Management Plan (RBMP)

River Basin Management Plans set out how organisations, stakeholders and communities will work together to achieve an improved water environment for each River Basin District.

Regional Flood and Coastal Committee (RFCC)

These are regional committees made up of a government appointed Chairperson, local Councillors and people with special and relevant skills that make decisions about regional funding for flood defences.

Special Areas of Conservation (SAC)

Special Areas of Conservation are protected by the European Habitats Directive because they have habitats that are important internationally.

Scottish Environmental Protection Agency (SEPA)

The Scottish Environmental Protection Agency oversees flood risk management in Scotland and we are working with them on our assessment for the Solway and Tweed River Basin District.

Strategic Flood Risk Assessment (SFRA)

Strategic Flood Risk Assessments are done by Local Planning Authorities to inform local planning policies and allocate sites through Local Plans.

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