Cyfoeth Naturiol Cymru
Natural Resources Wales

Wales Coastal Flooding Review Phase 2 Report

A National Overview by Natural Resources Wales for Alun Davies AM, Minister for Natural Resources and Food

30 April 2014

Cyfoeth Naturiol Cymru
Natural Resources Wales

This page left intentionally blank

Key Findings of this Review

This Review has shown that the overall response to the December 2013 and early January 2014 coastal storms was coordinated and effective, but the national network of defences and the response of professional partners were seriously tested. Similar and worse events are likely in the future, so more needs to be done to ensure our coastal communities are resilient to future flooding.

This Review, which has drawn on the expertise and experience of practitioners across Wales, has identified **47 recommendations** from issues arising from the December 2013 and early January 2014 storms. These are summarised at the end of this Report and are grouped under the themes identified by the Minister in his request for this Review. From these we have drawn **six priority areas** where improvements can be made to deliver a more resilient coastal flood risk and erosion management service. This Review has found there needs to be:

- **Sustained investment in coastal flood and erosion risk management.**
- **Improved information on coastal flood defence and erosion management systems.**
- **Greater clarity on roles and responsibilities.**
- **An assessment of the skills and capacity of Risk Management Authorities.**
- **More support to communities to help them become more self-sufficient and resilient.**
- **Locally developed and delivered plans for coastal communities and infrastructure operators.**

Cyfoeth Naturiol Cymru
Natural Resources Wales

There needs to be sustained investment in coastal flood and erosion risk management.

This includes flood forecasting, warning, awareness, response and recovery, as well as flood defences. Particular focus has to be on the existing defences to ensure they continue to be perform effectively, as well as investment in new defences to reduce the flood risk for more locations.

Increased certainty on budgets over a longer time frame will help maximise efficient and effective delivery.

A more transparent framework of decision making, prioritisation and allocation will ensure available resources are utilised most efficiently and help those impacted by these decisions to better understand them.

There needs to be improved information on coastal flood defence and erosion management systems.

This includes complete and consistent details of all elements, including natural features, their condition, the areas they protect, and how these change over time.

This national set of data must be maintained, monitored and updated regularly.

There needs to be greater clarity on roles and responsibilities.

This includes all organisations and groups that manage coastal flood risks. This will enable more efficient and effective delivery of coastal flood and erosion risk management.

Cyfoeth Naturiol Cymru
Natural Resources Wales

There needs to be an assessment of the skills and capacity of risk management authorities.

To determine what gaps exist, so these can be addressed to ensure continued effective delivery of coastal flood and erosion risk management.

There needs to be more support to communities to help them become more self-sufficient and resilient.

Management of the national coastal flood risk needs a wide range of organisations working together at all levels. It is essential that the communities affected by the flood risk and the decisions made to manage these risks are included in this overall partnership.

Communities have an important role to understand their local flood risk and to prepare and plan for it, so they can contribute to the effective response when flooding occurs. Communities can also provide *'internal'* support to their own population as well as offer support and shared experience to others.

More self-sufficient communities will be: Informed, supported, empowered and motivated to make their local contribution to the national flood risk management service.

There needs to be locally developed and delivered plans for coastal communities and infrastructure operators

To better enable them to adapt to the increased risks due to climate change.

These need to be supported nationally, and set in the strategic framework provided by Shoreline Management Plans.

Cyfoeth Naturiol Cymru
Natural Resources Wales

Contents

Introduction 8
Minister for Natural Resources and Food's Request 10
Approach to Phase 2 of this Review 11
National Flood and Coastal Erosion Risk Management Strategy 13
Current Flood and Coastal Erosion Risks 14
- Coastal Flood Risks 14
- Coastal Erosion Risks 18
- Environmental Impacts and Change 18
- Conclusion 18

Management of Coastal Flood and Erosion Risks 19
- The National Network of Coast Defences and Erosion Protection 19
- Delivery of Coastal Flood and Erosion Risk Management 20
- Continuous Evolution of Coastal Flood and Erosion Risk Management 22
- Conclusion 22

Coastal Flooding and Risks from Other Sources 23
- Characteristics of Coastal Flooding 24
- Conclusion 24

Future Coastal Flood and Erosion Risks and Climate Change 25
Approach to Lessons Learnt and Recommendations 27
Progressing the Recommendations 29
Storm Severity in December 2013 and early January 2014 30
- Issues and Recommendations – Storm Severity 32

Coastal Forecasting, Modelling and Flood Warning 33
- Introduction 33
- General Overview of the Process 33
- The challenge of issuing timely and accurate local warnings 38
- Newport Tidal Gauge – January 2014 40
- Liverpool Tidal Gauge – 5th December 2013 43
- Overview of Flood Forecasting Performance 47
- Issues and Recommendations – Flood Forecasting 49

Overview of Flood Warning Performance 54
Rhyl (East Rhyl, A548 coast road, Garford Road and surrounding areas) 59
Issues and Recommendations – Flood Warning and Community Response 61
Operational Response of Risk Management Authorities 69
Introduction 69
Risk Management Authorities Actions before Flooding Incidents 69
Civil Contingencies Act (2004) 70
Wales Resilience Forum and Local Resilience Forums 70
Overview of Operational Response by Risk Management Authorities 71
Issues and Recommendations – Operational Response 73
Performance of Coastal Defences 79
Introduction 79
National Defence Network 79
Overview of Coastal Defence Performance during these storms 80
Circumstances associated with the flooding of Rhyl on 5th December 2013 81
Circumstances associated with the flooding of Llanbedr in January 2014 84
Overview of Flooded Locations 86
Overview of 'Near Miss' locations 87
Strategic Framework for Decision Making on the Coast 89
Issues and Recommendations – Coastal Defences 95
Infrastructure Resilience 114
Impact of the December 2013 and January 2014 Storms 114
Managing Present Day Coastal Flooding and Erosion Risks 114
Managing Future Coastal Flooding and Erosion Risks 116
The National Overview of Infrastructure Resilience 116
Issues and Recommendations – Infrastructure Resilience 117
Conclusions 122
Summary of Recommendations 123
Introduction 123
Summary of Recommendations 124

Cyfoeth Naturiol Cymru
Natural Resources Wales

Introduction

The coastline and coastal areas of Wales are extremely important to the people, communities, economy and environment of Wales. Many of our important towns and cities are located in coastal areas and these are supported by a wide range of local and national infrastructure. Our coastal areas are an important attraction to visitors from both within and outside of Wales and therefore provide an important contribution to the national economy.

Approximately 60% (1.9million) of the population of Wales live on, or near to, the coast, and 75% of the coastline is designated for its environmental importance. The coastal and marine environment supports an estimated 93,000 jobs, with visits to the coast accounting for over 40% of overnight stays in Wales (*Visit Wales, the Tourism and Marketing Division of the Welsh Assembly Government, 2008).*

The storms and associated coastal conditions on the 5th December 2013 and between the 3rd and 6th January 2014 reached levels and a ferocity we have not seen for many years. The impacts were widespread and diverse in their nature.

We have estimated that in December and January respectively, around 24,000 and 50,000 properties had the potential to flood, but did not. Less than 1% of the properties potentially at risk experienced flooding during these storms. This was as a consequence of investment in the coastal protection and defence networks over many years and the day-to-day maintenance by many organisations.

There were exceptions where things did not function as they should and people, property, infrastructure and farmland were affected. The local distress, suffering to individuals and disruption to communities was significant and not to be under estimated. Some individuals are still to return to their homes. The national costs are also significant, estimated as £8.1m to restore flood and coastal defences alone. The total costs are greater than this.

Overall, from a national perspective, the response of national network of defences and the risk management authorities and others to these storms was effective. However, our defences and our collective capacity to respond were seriously tested. In many locations relatively small increases in water level or timing, and the consequences could have been much worse.

These coastal storms are a reminder of how exposed and vulnerable our coastal areas can be to the elements and how extremely important they are for the people, the environment and economy of Wales. Whilst these recent storms were significant, we will experience similar and worse storms in the future.

Climate change projections indicate we can expect more frequent and serious storms, as well as increasing sea levels in the coming years. Whilst the scientific advice is that sea levels are increasing, the projections for the future have a range of uncertainty for both the rate and size of this change. Coastal managers, decision makers, communities and individuals are all faced with making present day decisions with long term implications in this context of uncertainty.

The challenge to continue to manage the risks to our coast is considerable, and in the future will require difficult national and local choices around acceptable levels of risk, affordability and adaptation.

The '*Future flooding in Wales: flood defences'* report produced by Environment Agency Wales in 2010 considered the impacts on flood risk of different investment scenarios up to 2035. In 2010 this assessment concluded:

'To maintain the numbers of properties at flood risk in 2035 at levels comparable to present day may require around three times the current level of investment in flood defences'.

Everyone in Wales has a stake in our coast and the management of this national flood and erosion risk. This includes people living remote from the coast, as well as those individuals and communities directly affected by the risks and the decisions made to manage these risks. A more flood resilient Wales will require a mature national debate and embedded partnerships across all parts of Welsh society. Collectively we must continue to work to build stronger partnership working between professional partners and with communities. This will take time to deliver but we are on the path of this journey.

It is important that we collectively review our performance during these storms and learn any lessons to help us become better prepared and as a nation, become more resilient to such conditions when they occur in the future.

This review has received many valuable contributions and this Phase 2 Report contains important recommendations which have the potential to deliver a step change in our national resilience to coastal flooding. These recommendations will help deliver the objectives of the Welsh Government's *National Flood and Coastal Erosion Risk Management Strategy (2011).* Delivery of the recommendations in this Report will need the support and cooperation of many people and organisations across Wales.

It is important to remember that whilst this review has focused on the risk of coastal flooding, our nation is also exposed to other sources of flood risk, from our rivers and watercourses, run off from the land, from our urban drainage systems and from reservoirs. Coastal flood risk is, by nature of its extent and potential impact, extremely important to Wales. The management of this risk is also important, but must be considered alongside other sources of flood risk.

Minister for Natural Resources and Food's Request

Following the flooding to the North Wales Coast on 5th December 2013, Alun Davies AM, Minister for Natural Resources and Food (the Minister), asked for an investigation into this coastal flood event to be coordinated by Natural Resources Wales and for the report to involve all of the North Wales authorities affected.

Following the flooding in January 2014, the Minister wrote to Natural Resources Wales to ask that the North Wales review be expanded to include the January flooding across the whole of Wales. The Minister stated that as both are coastal reviews and cover similar issues, one combined review, incorporating all coastal authorities is preferred.

The relevant section of the Minister's written statement of 9th January 2014 is repeated below:

"This review will take a two-phased approach:

- *Phase one will be a swift review of the impacts across the whole of the country from both coastal flooding events and will look at the state of the coastal defences following the storm event. This will be produced by the end of January 2014.*
- *Phase two will look into the wider lessons learnt from both of these coastal flooding incidents and flood risk management in affected areas and include:*
    - *Details of the flood event, its modelling and forecasting*
    - *Operational response from flood risk management authorities*
    - *How defences performed, properties affected and estimates of those protected*
    - *Impacts on infrastructure and resilience to future flood events*
    - *Lessons learnt, so that we can be better prepared for future events.*

The Phase 1 report was submitted to Welsh Government on 31st January 2014 and published on 14th February 2014.

The Ministers statement in response to the Phase 1 Report is available at:

http://wales.gov.uk/about/cabinet/cabinetstatements/2014/flooding/?lang=en

The headline messages from the Phase 1 Report are included in **Annex A**.

Approach to Phase 2 of this Review

Following the flooding in North Wales on 5th December 2013 and the Minister's subsequent request, we developed a series of topic areas and questions to be included in this Review. These were developed from issues arising in the immediate aftermath of this flooding. These topic areas are:

- Forecasting
- Warnings and Communications
- Operational and Community Response
- Defences and Risks
- Infrastructure Resilience
- Summary of Lessons Learnt (drawn from the above)

Following the further and more widespread flooding at the beginning of January 2014 and the Minister's expansion of his request to include these storms and the entire Wales coastline, we reviewed these questions and determined they were of sufficient scope to capture the Minister's requirements for Phase 2.

During this Phase 2 process the Natural Resources Wales team responsible for this report has:

- Written to all coastal Local Authorities (at an officer/coastal practitioner level) and have invited their response and contribution. We have received written responses or have spoken to officers representing all the coastal Local Authorities.
- Held *'face to face'* conversations with experienced coastal practitioners across Wales. This has included officers from coastal Local Authorities and Natural Resources Wales. When considered collectively this has enabled us to draw upon many tens of years of collective coastal practitioner experience.
- Made contact with representatives of principle infrastructure managers and operators to seek their contribution, including rail, water, electricity and telecommunications service providers.
- Received and considered other contributions where we have been contacted and offered information and views.
- Worked with Environment Agency and Met Office colleagues and external consultants on matters of cross border importance.
- Attended a local Flood Warden meeting in Rhyl, North Wales.
- Attended a post incident residents briefing meeting in Rhyl organised by Denbighshire County Council.
- Inspected the location of flooding in Rhyl accompanied by officers of Denbighshire County Council.

This Review has not attempted to specifically consider the performance and operation of the local multi agency response, as this is a matter for each Local Resilience Forum to consider via their local post incident review process. Where such local reviews have been conducted and made available to us we have considered them in this Review.

Where issues concerning incident response have been identified to us as part of this Review, we have captured them in this report for completeness and wider consideration.

This Phase 2 Report builds upon and references the Phase 1 Report.

Within the timescale set by the Minister, it has not been possible to directly engage with every organisation, group or individual who has an interest in coastal management. However, we consider the approach we have adopted as outlined above has been sufficient for us to gather the scope and depth of issues affecting coastal flood and erosion risk management and the particular issues arising from the December 2013 and early January 2014 storms.

Details of the organisations engaged in the Phase 2 Review are included in **Annex B**.

National Flood and Coastal Erosion Risk Management Strategy

The high level strategic direction of travel for **F**lood and **C**oastal **E**rosion **R**isk **M**anagement (FCERM) is set by the Welsh Government National FCERM Strategy, published in November 2011, (*the National Strategy*).

This National Strategy identifies the following four overarching objectives:

- **reducing the consequences** for individuals, communities, businesses and the environment from flooding and coastal erosion.
- **raising awareness of and engaging people** on flood and coastal erosion risk.
- **providing an effective and sustained response** to flood and coastal erosion events, and:
- **prioritising investment** in the most at risk communities.

Details of the National Strategy can be found at:

http://wales.gov.uk/topics/environmentcountryside/epq/flooding/nationalstrategy/strategy/?lang=en

Welsh Government commentary in support of the National Strategy states:

'Implementing these objectives will be the responsibility of everyone involved in or affected by flood and coastal erosion risk management. This includes: the Welsh Government; the Welsh Risk Management Authorities; and the people of Wales.

By working together we can reduce the risks we face and improve the quality of life for communities across Wales.'

There are currently 31 Risk Management Authorities (RMAs) in Wales:

- Natural Resources Wales.
- The 22 Lead Local Flood Authorities.
- Caldicot and Wentlooge Levels Internal Drainage Board.
- Lower Wye Internal Drainage Board.
- Powysland Internal Drainage Board.
- Dŵr Cymru Welsh Water.
- Severn Trent Water.
- Scottish and Southern Water.
- Albion Water.
- Dee Valley Water Plc.

Current Flood and Coastal Erosion Risks

Coastal Flood Risks

The coastline and coastal areas of Wales are extremely important to the people, communities, economy and environment of Wales. Many of our important towns and cities are located in coastal areas and these are supported by a wide range of local and national infrastructure. Our coastal areas are an important attraction to visitors from both within and outside of Wales and therefore provide an important contribution to the national economy.

The findings of the Phase 1 work clearly highlighted the broad range of direct impacts associated with these storms. In addition to the direct financial costs, the Phase 1 Report provided an indication of the range of indirect impacts and costs, including:

- Emergency services response and recovery.
- Repair and restoration of local and national infrastructure.
- Local business losses, for example visitors choosing not to visit the Welsh coastline but go elsewhere either in the UK or overseas. These would not necessarily be economic losses to the UK, but would represent a financial loss to Wales and Welsh communities.

In addition there would be significant social, health and well-being impacts on affected individuals and communities. Whilst these cannot be readily converted to monetary values they can be very important.

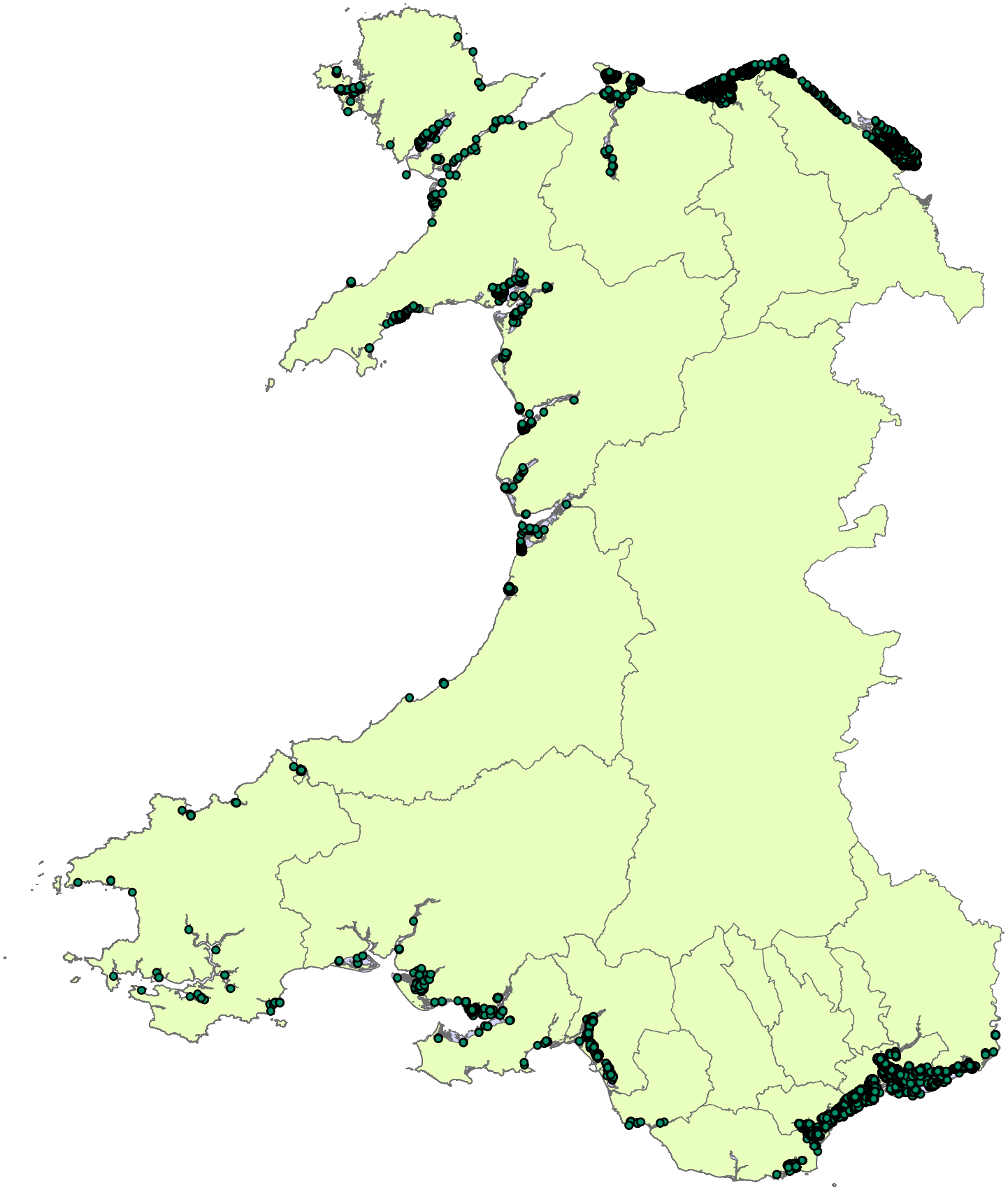
The Phase 1 Report estimated that in excess of 50,000 properties around Wales could potentially have flooded during the January storms. On this occasion these were protected by the national network of coastal defence infrastructure.

We have expanded the work carried out in Phase1 and estimate that of the order of 80,000 properties are potentially at risk around the coast for a 0.1% chance incident. This is a flood incident that has a statistical chance of 0.1% occurring in any given year.

Map 1 below is reproduced from the Phase 1 Report and is included to illustrate the national distribution of coastal flood risks to property.

Cyfoeth Naturiol Cymru
Natural Resources Wales

Map 1 - Damages Avoided - Properties



Legend

- Potentially flooded properties

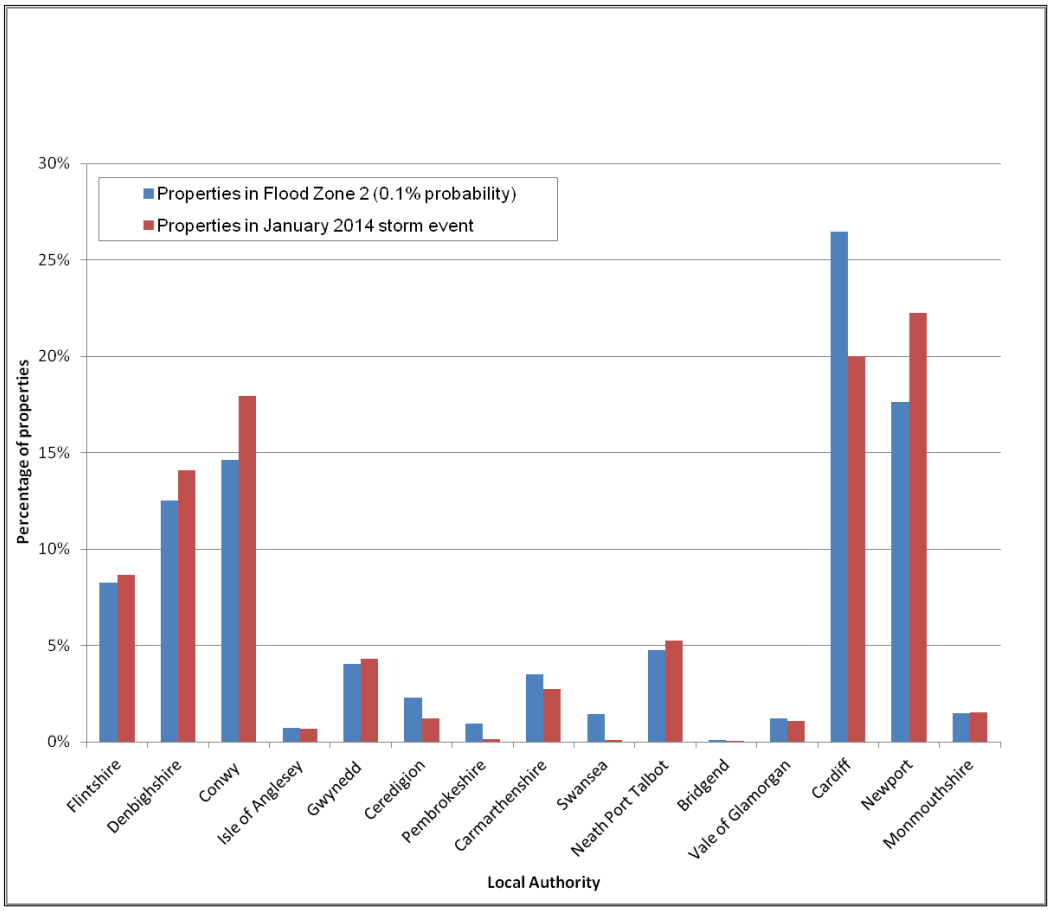
0 5 10 20 30 40 50 Kilometres

N

Figure 1 below supplements the map above and illustrates the broad distribution of properties at risk by Local Authority. This highlights that the majority of properties benefitting from protection/defences are in north east (Deeside), Conwy and south east Wales. The west and south west of Wales is more typically characterised by discrete communities with localised protection. The coastal flood risk is not evenly distributed around Wales.

As a consequence of this risk distribution there are substantial defence structures and embankments protecting areas of north east and south east Wales in particular. For example, the Cardiff Bay Barrage provides coastal flood defence to significant areas of Cardiff.

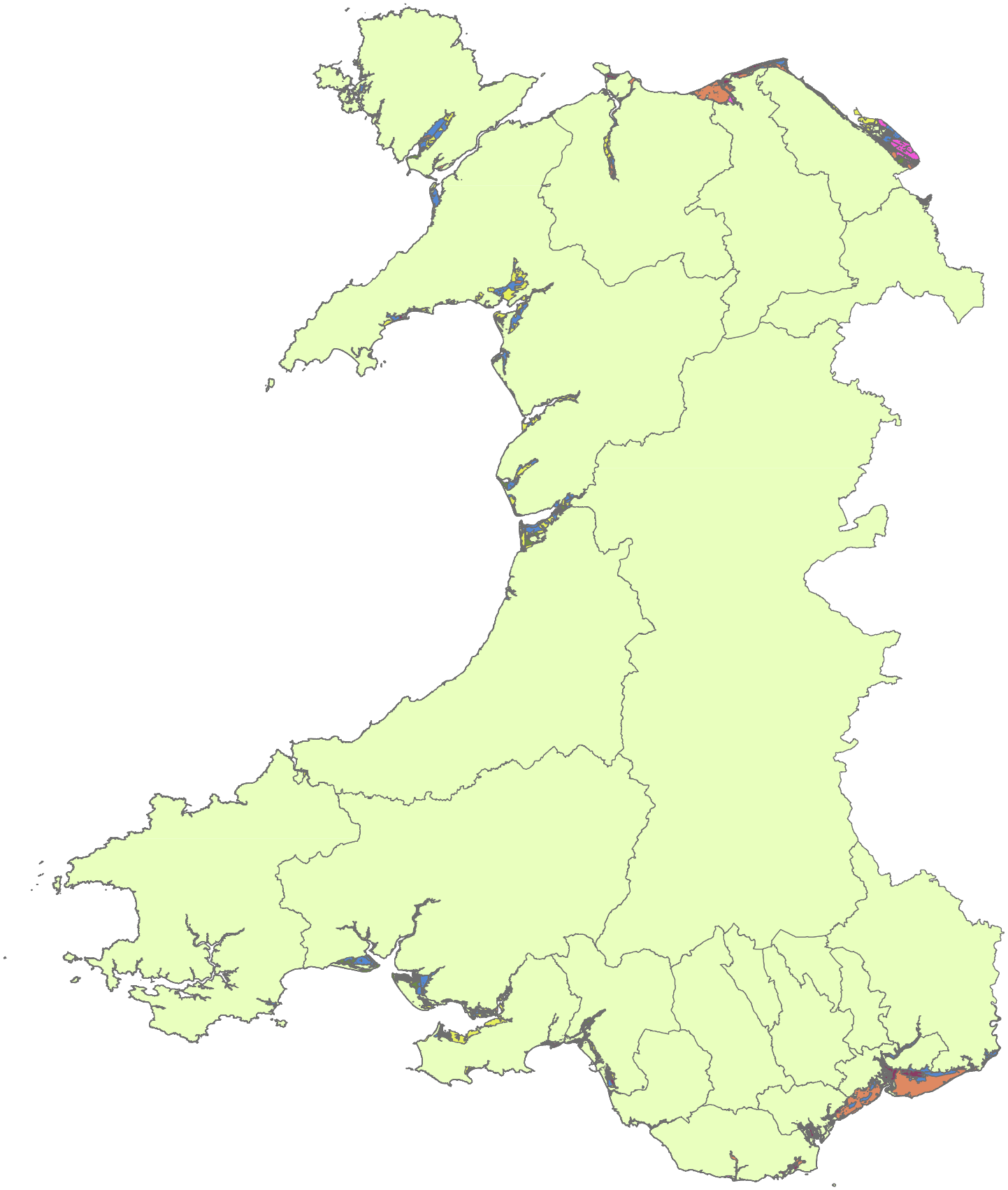
Figure 1: Indicative distribution of properties at coastal flood risk by Local Authority Area



Map 2 below is reproduced from the Phase 1 Report and is included to illustrate the national distribution of coastal flood risks to agricultural land.

Cyfoeth Naturiol Cymru
Natural Resources Wales

Map 2 - Damages Avoided - Agriculture



Legend

- Grade 1 - Excellent quality agricultural land
- Grade 2 - Very good quality agricultural land
- Grade 3 - Good to moderate quality agricultural land
- Grade 4 - Poor quality agricultural land
- Grade 5 - Very Poor quality agricultural land
- Urban
- Other

0 5 10 20 30 40 50 Kilometres

N

Coastal Erosion Risks

In addition to flood risk, the Welsh coast is also exposed to erosion risks. The coastal areas are inherently dynamic and subject to change. Some of this erosion can happen over relatively long periods of time, whilst some instance can happen rapidly, such as the significant change reported in the Phase 1 Report.

By way of example:

- A rock fall happened at Porthkerry Leisure Park, Barry, Vale of Glamorgan, in November 2011:

http://www.bbc.co.uk/news/uk-wales-south-east-wales-15540048

- More recently, in April 2014, an estimated 150 tonnes of the cliff face collapsed, near Penarth pier:

http://www.bbc.co.uk/news/uk-wales-south-east-wales-27010225

Environmental Impacts and Change

The Phase 1 Report identified the considerable environmental impacts of the storms of December 2013 and early January 2014.

More information can be found at:

http://naturcymru.blogspot.co.uk/2014/03/after-storm.html

Conclusion

It can therefore be concluded from the above that the scale and distribution of the national coastal flood and erosion risk is considerable and of national significance.

Management of Coastal Flood and Erosion Risks

It was concluded above that the scale of the national coastal flood and erosion risk is considerable and of national significance. Therefore, the management of this risk, both now and into the future is equally of national importance.

The National Network of Coast Defences and Erosion Protection

The national network of coastal defences and erosion protection has developed and evolved over many years. For example, the website of the Caldicot and Wentlooge Internal Drainage Boards states:

'The Romans occupied the area from the 2nd to the 4th Centuries AD and seem to have farmed extensively on the Levels. A boundary stone marking the building of "33 paces" of embankment by soldiers was discovered West of Goldcliffe Head in 1878.'

This national network has typically evolved to meet local needs. At individual locations this can consist of individual structures such as walls and embankments, but in many locations is provided by a complex interaction between the foreshore conditions and the defences. Foreshore conditions can include offshore structures, groynes, salt-marsh and beaches. These can help to manage the movement and loss of sediment, as well as dissipate wave energy before it hits the defence line. The flooding to Aberystwyth in early January 2014 clearly demonstrated the destructive power of high energy waves.

Protection to a particular location or community may be provided by multiple individual assets which act together as a *'system'*. The standard of protection to these areas can be determined by the '*weakest component of the 'system'*. It is often these weak points which can fail or be overwhelmed when placed under the stress of significant storms.

At some locations there may be a primary defence line/structure, which provides the majority of the defence, in particular to still water levels, which is supplemented by secondary defences set back inland, such as walls and embankments. These secondary defences can help to control the volume of water accumulating from wave spills for example. At some locations coastal defence is provided by manual interventions such as closing of tidal doors and installation of barriers or *'stop logs'*.

For example both secondary defences and demountable barriers form part of the defence system at Garford Road area of Rhyl. These are discussed later in this report.

The findings of the Phase 1 Report clearly demonstrate the national benefit provided by this network of assets.

The results from Phase 1 suggest that:

- In excess of 24,000 properties could potentially have flooded across the North Wales coast during the December 2013 incident and;
- In excess of 50,000 properties around Wales could potentially have flooded across Wales, during the January storms.

If we apply an average buildings insurance flood claim figure of £40,000 to these numbers, it suggests the financial costs of the '*damages avoided'* in December 2013 and January 2014 are of the order of £960million and £2billion respectively.

Delivery of Coastal Flood and Erosion Risk Management

Coastal flood and erosion risk management across Wales is delivered by multiple partners, including public and private sector organisations as well as private individuals.

Some of these have direct responsibilities for flood and coastal erosion risk management and are RMAs, such as Natural Resources Wales and Local Authorities. Others have assets which are part of the national network, but where flood defence is a secondary function rather than a primary purpose, e.g. Network Rail embankments and highway retaining walls.

The national coastal flood and erosion risk management service, has changed and progressed rapidly in recent years, from a service historically focused on flood defence, to a more holistic risk management service. This progress and direction of travel is articulated by Welsh Government's National Strategy noted above.

Flood defences will continue to play a very important role in the management of flood risk, particularly around the coast, however a risk management approach places these defences within a wider framework of flood risk management actions.

Flood risk is a combination of likelihood and consequences (or impacts). Flood defences do not stop all flooding they make it less likely to happen. Clearly this is positive, but the loss of connectivity between the community and the direct local risk can result in a false sense of security and a loss of community awareness of the risks.

Some of the areas where flood risk management has developed in recent years are:

- Creation of the Flood Forecasting Centre at Exeter to service Wales and England. The Flood Forecasting Centre went live on 1 April 2009. It is fully operational 24 hours a day, 7 days a week, http://www.ffc-environment-agency.metoffice.gov.uk/

- Improvements in the quality of the daily published UK forecast information and improved distribution of this routine information to professional partners and to the wider public via the national media networks.

- Improvements in the coverage and quality of flood forecasting and flood warning service. We are now better able to identify potentially significant coastal incidents with a longer lead time. This is discussed later in this Report.

- Improvements in quantity and quality of discussion between professional partners in advance of flood incidents.

- Improvements in the understanding of coastal flood risk and its representation to partners and communities, through improvements in coastal modelling and mapping.

- Improvements in the understanding of coastal erosion risk and mapping.

- Flood Awareness Wales, being the work to expand local understanding and community preparedness for flooding.

- Investment in the construction of new coastal defences, such as Borth, Riverside at Newport and Fairbourne.

- Investment in the maintenance and reconstruction of existing coastal defences. This can range from routine inspections and minimal works through to full reconstruction or major improvements: such as Tidal Clwyd Embankments.

- Incident management, testing and exercising and response, built upon the improved forecast information and the development of strong local and national partnerships.

Continuous Evolution of Coastal Flood and Erosion Risk Management

The coastal flood and erosion risk management service of Wales is a continually learning and improving service. Its history of development is characterised by '*day to day'* learning and improvement, interjected with '*step changes',* typically as a result of significant incidents which test defences, systems and the risk management processes.

By way of example: Significant progress in recent years was accelerated following the summer floods of 2007 and the subsequent investigation and report by Sir Michael Pitt. Although the summer floods of 2007 primarily impacted areas of England and were surface water and river floods, the *'Pitt Report'* did initiate significant change to coastal flood risk management in Wales, for example by the establishment of the Flood Forecasting Centre.

A copy of the *'Pitt Report'* report can be found at:

http://webarchive.nationalarchives.gov.uk/20100807034701/http:/archive.cabinetoffice.gov.uk/pittreview/thepittreview/final_report.html

In recent years considerable progress has been made in improving the management of the overall coastal flood risk.

We reported in our Phase 1 Report that:

Officers of Natural Resources Wales of many years' experience are of the opinion that 10 or 20 years ago, the impacts of these recent storms would have been worse on our coastal communities, with an increased risk of lives being lost.

Conclusion

It can therefore be concluded that:

- The national coastal flood and coastal erosion risk management service is multi-faceted and complex and;

- It is important we use the experience and lessons from these recent coastal incidents to review the current management activities and change where needed, how we do them in future, or re-focus priorities.

Coastal Flooding and Risks from Other Sources

It has been concluded above that coastal flood risk is significant to Wales and so therefore is the management of this risk.

However it must be considered within a decision making and investment framework which includes consideration of other sources of flood risk.

These include:

- Risks from main rivers.
- Risks from smaller watercourse and run off from the land.
- Risks from surface water flooding.
- Risks from reservoirs.
- Risks of coastal erosion.

Characteristics of Coastal Flooding

There are many common issues that span all sources of flood risk and their management; however, there are some characteristics of coastal flood risk and its management that are particularly important, these being:

- Flood defences do not stop all flooding; they are designed to make it less likely to happen. Clearly this is positive, but the loss of '*connectivity'* between the community and the local risk can result in a false sense of security and a loss of community awareness of the risks.

- This is a particular issue along our coastline, as generally the likelihood of flooding is relatively low, however the consequences have the potential to be very high. The relatively low likelihood means it can be challenging to raise and then sustain local awareness of risks and the effectiveness of the local response.

- In some respects coastal flooding is more predictable than other sources of flooding and should be more foreseeable, due to the regular tidal cycles. However, normal high tides and even significant astronomical tides are typically not a cause of significant impacts.

- The significant coastal flooding incidents typically come from the combination and interaction of high tides, induced tidal surges, wind strength and direction, as well as local impacts such as performance of defences. It is the dynamic interaction of these mechanisms and the sensitivities to different parts of our coast that add complexity and difficulty to local forecasting, warning and incident management.

- Coastal flooding can be determined by locally significant factors, as was experienced in north east Wales in December 2013.

- Coastal flooding can have the potential for widespread impacts, as was experienced in early January 2014.

Conclusion

- Some of the recommendations identified by this Phase 2 Review are transferable to the management of other sources of flooding.

Cyfoeth Naturiol Cymru
Natural Resources Wales

Future Coastal Flood and Erosion Risks and Climate Change

Projections for the future of our coastal areas are of increasing risk, as a consequence of climate change and in particular sea level rise.

The Intergovernmental Panel on Climate Change (IPCC), Fifth Assessment Report estimates that global temperatures have risen 0.85°C from 1880-2012 (1). There has been an associated rise in global sea level which is now increasing at approximately 3.2 mm per year (2).

The IPCC state that it is very likely that the 21st Century sea level rise rate will exceed the 1971-2000 rate, for all modelled emissions scenarios. A central estimate of 0.47m increase is projected by 2081-2100, relative to the 1986-2005 baseline. An increase of 0.5m is estimated to result in 10-fold to 100-fold increase in the frequency of sea level extremes (relative to present day) in northern Europe by the end of the century (2). This would mean a coastal flooding event that has a return period of 100 years at present will potentially occur on average between every year and every ten years by 2100.

Storminess and precipitation extremes are also important factors that will be exacerbated by climate change and contribute to the increased flood and erosion risk. Already, the Met Office have recorded an increase in days of heavy rain in the UK, such that a rain event with an average return period of 125 days in the 1970s now has a return period of 85 days (3). In terms of storminess the Met Office suggests that while there have been no significant changes in storm frequency in mid latitudes in the north Atlantic, the intensity of individual storms has increased (3). Future projections of storminess are still highly uncertain due in part to resolution limitations of climate models while there is no evidence to counter the basic premise that a warmer world will lead to more intense daily and hourly heavy rainfall events (4).

While the question of attribution of a weather event or a series of weather events to anthropogenic climate change will always be couched in terms of probability, it is possible to discern significant trends in climate data that are consistent with recent extreme events in Wales and the UK. At a global scale, the IPCC suggest that it is likely that there has been an anthropogenic influence on increasing extreme coastal high water due to an increase in mean sea level. (5).

Taken collectively and with a view to enhancing our resilience for the future, the question of attributing the events of last winter to climate change is really a technical aside: given the considerable confidence around the projected increase in frequency of coastal flooding due to climate change during this century, the experience of winter 2013/2014 should serve as invaluable insight for policy makers, planners and practitioners into what in the future may become commonplace for the coastal environment of Wales.

It is important to recognise that the fundamental physics of global warming provides certainty that continuing (and historical) emissions will lead to further warming of both the atmosphere and consequently the oceans, making further significant sea level rise due to thermal expansion inevitable. Moreover in south and mid-Wales isostatic land subsidence will inevitably exacerbate sea level rise too.

References

1. http://www.climatechange2013.org/images/report/WG1AR5_SPM_FINAL.pdf

2. http://www.climatechange2013.org/images/report/WG1AR5_Chapter13_FINAL.pdf

3. http://www.metoffice.gov.uk/media/pdf/1/2/Recent_Storms_Briefing_Final_SLR_20140211.pdf

4. http://www.metoffice.gov.uk/media/pdf/4/8/Drivers_and_impacts_of_seasonal_weather_in_the_UK.pdf

Approach to Lessons Learnt and Recommendations

The Minister has rightly identified the importance of learning lessons, to enable us as a nation to be better prepared for future coastal flooding incidents when they happen, which they will.

We have considered the phrase *'lessons learnt'* in the context of this Review and have concluded that lessons learnt only become lessons learnt when:

- Incidents occur and issues, areas of concern or opportunities are identified and prioritised in terms of their significance.
- Recommendations for improvement are made and endorsed.
- Recommendations are implemented into business as usual arrangements and then;
- The new systems, tools and ways or working are tested by exercises or real incidents.

Only then can we be confident that the lessons have been learnt. This is a continual process which has happened in the past and will happen in the future.

Therefore it is important to initially identify issues which have impacted on effective delivery, or offer opportunity to improve flood risk management and then translate these into recommendations. An *'issue'* or an *'opportunity'* can include a wide range of things, across the full spectrum of activities that contribute to efficient and effective coastal flood risk management.

Significant flooding incidents, such as resulted from these recent storms, test our defences, our systems and processes and our operational response, as they tend to be *'exceptional to a degree*' and '*out of the ordinary'* events. For example the early January 2014 storms resulted in the issue of widespread and multiple Severe Flood Warnings, our highest level of warning. This was unprecedented in recent years.

Issues arising from these recent storms are identified over different timescales. Some are relatively easily identified, corrective actions agreed and then implemented almost immediately during the incident itself. Other issues and areas of concern can emerge days and weeks after the incident itself and can be more challenging to address.

Some examples are:

- Some issues across Wales were identified and acted upon between tides. The experience of the '*first'* high tide on 3rd January informed the operational response for the '*second tide'* for example at Crindau in Newport.
- The change in the beach profile at Aberystwyth caused by the storms informed and influenced subsequent operational decision making.
- Some issues have arisen locally during the incidents and subsequent investigations and have highlighted the need for a wider assessment across Wales, for example the need for more understanding of secondary defence systems and the performance of temporary and demountable defence assets.
- Other issues have arisen in the days, weeks and months since the storms, but are as a consequence of these coastal incidents raising awareness of wider coastal management issues, for example Fairbourne where the storms and their aftermath have highlighted issues around the long term strategic direction of travel.

This Phase 2 Review has sought to draw out from the collective experience of the storms in December 2013 and early January 2014, the issues identified during and after these events and translate these into a series of recommendations. These are presented throughout the report in the following general style.

Issue/area of concern or opportunity - headline statement:

<Text to describe and explain the issue of area of concern>

Rec.	***Brief explanation of the recommendation***

Rec. = Recommendation
For reasons of simplicity, within the following text the term 'issue' has generally been used to cover issues, areas of concern and opportunities giving rise to a recommendation

---

Progressing the Recommendations

Delivery of the recommendations in this Report will need the support and cooperation of many people and organisations across Wales.

Managing and improving the flood resilience of coastal areas of Wales will require more partnership working across all levels of society, including Government, public sector bodies, private sector organisations and individuals and communities affected by the flood risks and impacted by risk management decisions.

This Report contains a large number of individual recommendations, which cover a wide range of coastal flood and erosion risk management activity.

Delivering progress on these recommendations will require the support, cooperation and input from a wide range of partners. This will need to be coordinated across Wales

We therefore recommend:

Rec.1	**The recommendations included in this report are compiled into a Delivery Plan.** **This Delivery Plan will identify how the recommendations will be progressed. It will consider matters such as: the parties to be involved, lead responsibility, priorities, governance and resources and capacity to deliver.**

Rec. 2	**The Delivery Plan should consider opportunities to expand the recommendations beyond just coastal flooding and erosion risks and to consider the link to risks from other sources of flooding.**

Storm Severity in December 2013 and early January 2014

The Phase 1 Report included the following overview of the December 2013 and January 2014 storms.

On 5th December 2013 a deep low pressure system off the west coast of Scotland brought severe gale force winds to north Wales, specifically the Liverpool Bay area. These created a significant storm surge and large onshore waves that coincided with high tide and caused considerable disruption along the north Wales coastline.

During January 2014 a succession of low pressure systems, tracking from the Atlantic, generated significant storm surges and very large offshore waves which, combined with high astronomic tides, caused considerable disruption to the south and west coasts of Wales. Although the highest tide was on 3rd January, this event continued until the 6th January, as successive low pressure systems continued to bring gale force winds and very large waves, a considerable number of which were high energy swell waves.

The Phase 1 Report also identified that the peak sea level experienced in December 2013 was the highest recorded in Liverpool Bay in over 20 years since the tidal gauge was established. The level exceeded the previous highest value by a considerable amount of 300mm (1 ft).

In January, the peak recorded level at:

- Milford Haven was 4.51mAOD. This was the highest level since at least February 1997 and exceeded the March 2008 tide (another notable event) by 0.14m.
- Newport was 8.03mAOD. This was the highest level since at least February 1997 and exceeded the February 1997 level by 200mm.
- Barmouth was 3.92mAOD. This is marginally higher than the February 1997 level.
- Liverpool was 5.86mAOD. Some 0.36m lower than the peak level on 5th December 2013.

Note: Metres Above Ordnance Datum, (mAOD) is based on the mean sea level at Newlyn in Cornwall and is used as the reference point to calculate height above sea level in the UK.

Both of these storm incidents affected not only Wales, but also other parts of the UK, most notably the east coast of England in December and the south and south west coast of England in January.

Given the complexity of these conditions and their impacts across the UK, we have, since completion of the Phase 1 Report worked with colleagues in the Flood Forecasting Centre, Met Office and Environment Agency to assess the severity of these storm incidents. External specialist consultants have also been engaged to assist with this assessment.

The results of the work so far have continued to highlight the complexity of the assigning statistical estimates of frequency (and storm severity) to individual situations and locations, when this involves the complex and dynamic interaction of a number of individual factors, including:

- Wind speed and direct.
- Wave heights and period.
- Tidal surge.
- Astronomical tides.

The assessment of these individual elements in combination, or the '*joint probability'* of occurrence is complex.

The recommendations of the analysis undertaken so far include the following statement:

'Return periods for the coincident sea levels and wave heights seen in December 2013 and January 2014 have been calculated using the DEFRA 'desk study' approach (FD2308). These are very large and extremely sensitive to the level of dependence assumed. Such extreme values mean that we have little confidence in the reported numbers and can only conclude, qualitatively, that the combination of wave and sea level seen in December 2013 and January 2014 made them significantly rarer than their still water level return period alone.'

Further analytical work is required and this is included in the recommendations below.

The December 2013 and early January 2014 sea levels were also significant in terms of the available dataset of information. This in itself may have an impact of the evaluation of this dataset and work to review this is recommended below.

The analysis of the December 2013 and early January 2014 storms has also reaffirmed a previously identified strategic gap in the offshore wave buoy network in the Irish Sea. This is the subject of a recommendation later in this report.

(DEFRA – Department for Environment, Food and Rural Affairs, http://www.defra.gov.uk/)

Cyfoeth Naturiol Cymru
Natural Resources Wales

Issues and Recommendations – Storm Severity

There is a need to undertake further work to assess joint probability:

Rec.3	**Further work is required to assess the joint probability of wind, waves and tides for these recent winter storms. This may take the form of an initial assessment coupled with consideration of more thorough analysis. The scope of this work will require further technical discussion.**

There is a need to review the extreme sea level dataset and determine impacts on this of the recent storms:

There is an existing dataset of '*extreme sea levels'*. The recent tidal conditions are amongst the highest for many years. This dataset may need to be amended.

Rec.4	**Review and update if required, the extreme sea level dataset around the Welsh coast. The recent tidal conditions are amongst the highest for many years. This dataset may need to be amended.** **This is to include methods for assessment of joint probability for storm severity.**

There is a need to review how the assessment of coastal standards of protection against flooding deals with assessment of complex joint probability issues:

This likelihood of coastal flooding can involve the complex interaction of *'normal'* high tides, elevated levels created by tidal surges, wave heights, wave period and wave/wind directions. Local factors such as beach and foreshore conditions may have an impact.

Rec.5	**Review and update if required, the guidance used for the assessment and design of coastal standard of service against flooding. The review should consider whether more clarification is needed, in particular on the issues of the treatment of joint probabilities, in combination effects and appropriate national consistency.**

Coastal Forecasting, Modelling and Flood Warning

Introduction

Flood forecasting and warning is not an exact science. It seeks to forecast complex dynamic natural systems and translate information from global models, regional models and local models into timely specific local warnings. The purpose of flood forecasting and warning is to inform professional partners and the public, so they can take action to protect themselves and others.

The purpose of this section of the Report is:

- **To provide a general overview of how coastal Flood Forecasting and Flood Warning is delivered in Wales and their purpose;**
- **To discuss the challenge of issuing timely and accurate local warnings;**
- **To use examples at Newport in January 2014 and Liverpool in December 2013 to illustrate the variability of forecast information over periods of days and hours;**
- **To provide an overview of the performance during the winter storm events in terms of, Flood Forecasting, Flood Warning and Community response.**
- **To identify issues and associated recommendations for improvement.**

General Overview of the Process

Flood forecasting and warning is not an automated process; it is based on detailed science and data, but requires the day to day interpretation and judgement by professional, skilled and experienced staff. Given the complexities highlighted above and discussed below this is a very challenging task.

Coastal flood forecasting and warning in Wales is carried out by '*duty officers'* within Natural Resources Wales. These duty officers monitor and respond to weather conditions 365 days a year, 7 days a week and 24 hours a day. During significant incidents such as early January 2014, standby duty rotas are established to support the lead officers. Many of these officers were on duty or stand by over the 2013 Christmas and New Year periods.

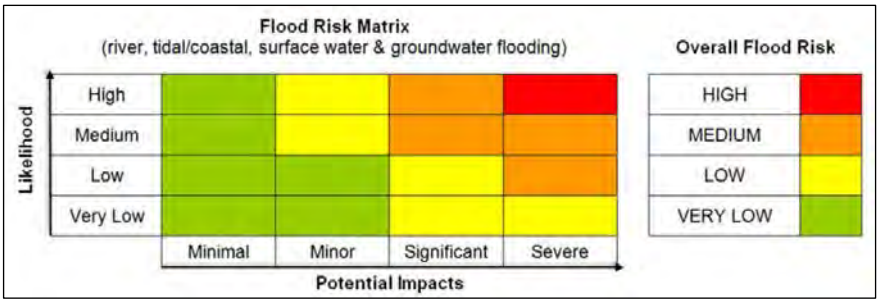
Coastal forecasting is carried out on an all-Wales basis with local officers responsible for issuing flood warnings. Coastal forecasting and warning are intrinsically linked and not independent activities. Uncertainties inherent in the forecasting process can influence local decisions concerning flood warnings. Equally, local information such as wave over - topping can help to improve the forecasting models.

Both coastal forecasting and flood warning evolve and develop over time as additional information, experience and data is gathered and can be used to validate the analysis and decision making process.

Duty officers at the local level lead on communications with their local professional partners and provide advice during incident management.

Duty officers receive routine daily information from Flood Forecasting Centre. This includes 5 day rainfall forecasts and the Flood Guidance Statements (FGS). The FGS provides guidance on the nature of flood risk for the coming 5 days and considers all sources of flooding. Natural Resources Wales are consulted and determine the local coastal risk assessment represented on the FGS. A 3 day version of the FGS is also publically available via the internet.

The FGS includes an assessment of overall food risk based on the following Flood Risk Matrix. This matrix considers the 'likelihood' of flooding and the 'potential impacts'.

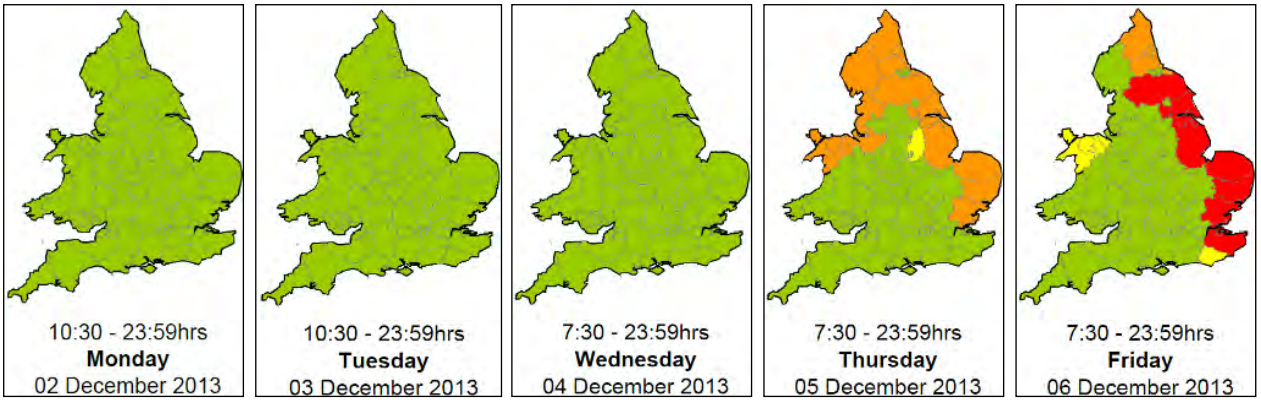


Included below are extracts of the FGS for the period around the December 2013 and early January 2014 storms.

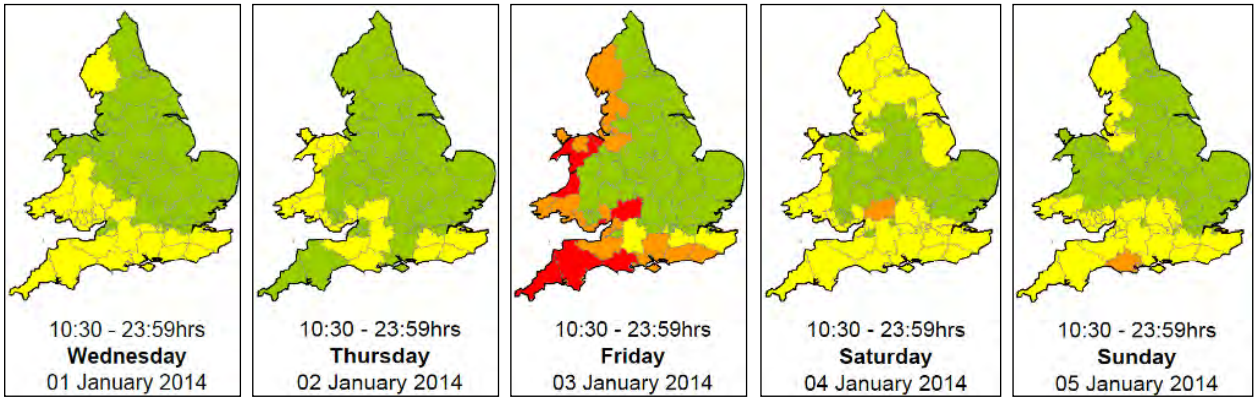
The December FGS illustrates the overall Medium assessment of risk to north Wales on 5th December. It also illustrates how the prevailing weather conditions initiated the storm surge conditions on the east coast of England on Friday 6th December.

The January 2014 FGS illustrates the more widespread distribution of forecast impacts around the entire Welsh coast, most notable on 3rd January where localised High risk areas are highlighted.

Flood Guidance Statement Extracts - December 2013



Flood Guidance Statement Extracts - January 2014



The FGS helps to inform communications between Natural Resources Wales duty officers and professional partners. Formal professional partner discussions take place when the FGS is amber. However, local conversations with professional partners often begin (subject to local agreements) as soon as duty officers receive a signal that there may be forecast flooding issues, albeit this may contain significant uncertainty a few days in advance of the forecast conditions.

The communication with and between professional partners escalates with increasing risk and increasing confidence in the scale of the flood incident expected. This confidence typically increases closer to the potential flood incident itself. Whilst proximity to the potential flood event brings increased confidence (or less uncertainty) it also reduces the time available for professional partners and communities to respond to a warning.

This balance between confidence (and uncertainty) and lead time, to enable partners and communities to respond, is at the heart of the challenge of issuing timely and accurate local warnings. This is discussed more fully in later sections.

The FGS also serves to inform media activity in advance of potential flooding incidents. This seeks to raise the general level of public awareness, either nationally or more locally, where this is possible. This will typically take the form of media releases with subsequent interviews. Awareness raising activity and messages are also issued via social media channels. This real time interaction can escalate rapidly as flood incidents develop.

The volume of activity on social media and also via website visits is also a useful indicator of the severity of a flooding incident.

In the Phase 1 Report we identified that, during the January storms the Natural Resources Wales media relations and communications team recorded the following activity:

- A 25% increase in Twitter followers.
- A reach of over 2 million accounts on Twitter.
- Over 700 re-tweets.
- Almost 30,000 visitors to the Natural Resources Wales website

Natural Resources Wales works closely to align messages and escalation of potential incidents with the Met Office to ensure the general public receive consistent messages from professional partners.

The December 2013 storm and especially the January 2014 storms were heavily covered by both the national UK and Welsh media outlets. This helped significantly to raise the general level of public awareness. There was a period of days during the January storms where the UK media were almost permanently established at Aberystwyth and featured on nightly news broadcasts.

The flood warning codes used in Wales are:

Severe Flood Warning
Severe Flooding. Danger to Life

Flood Warning
Flooding is expected. Immediate action is required

Flood Alert
Flooding Possible. Be Prepared.

Flood warnings are issued by local Natural Resources Wales duty officers using decision making processes that have been developed and refined over time and as a consequence of practical experience and local validation. Where new flood forecasting and warning locations are introduced to improve coverage, these can initially be based on limited validation data, that will improve over time.

Flood warning areas are identified by local Natural Resources Wales officers and threshold or trigger levels are set at which the different levels of flood warning will be issued. These thresholds may be based on still water levels or wave over topping criteria.

An example of a flood warning area (for Aberystwyth – Tidal) is included in **Annex C**. This illustrates how a location can be sub divided to reflect the different risks and enable different warnings to be issued.

Duty officers also exercise their professional judgement and local knowledge, during incidents.

For example the storm impacts at Aberystwyth in early January re-profiled the beach and therefore altered the conditions upon which the original warning thresholds had been set.

In addition, observations of the impact of the first high tide at Newport on 3rd January influenced the subsequent decisions.

During these storms, most notably the sustained storms of January, duty officers across Wales made similar decisions to reflect the dynamic changes happening to the coast.

The challenge of issuing timely and accurate local warnings

Issuing locally timely and accurate warnings is the objective of the flood forecasting and warning duty officers, but this is a very considerable challenge. The officers who are required to make these decisions continually balance the risks of issuing warnings and nothing happening, in terms actual flooding at the location warned (false warnings) with the risk of not issuing the warnings and people and property being flooded.

These officers fully understand the disturbance and distress caused by warnings which are issued and subsequently no flooding occurs.

These officers are also fully aware that every time a flood warning is issued and nothing happens this erodes public and community confidence in these messages.

The criteria behind the decisions to issue flood warnings are continually reviewed and revised in response to experience and incidents. Therefore a specific Flood Warning issued today may well be based on different and better criteria than the same Flood Warning issued in December or January. But the public and community perception (understandably) is this is the same warning and if nothing happened last time then nothing will happen this time and no action is required.

Work is continually undertaken to improve the accuracy and timeliness of flood warnings.

However as these decisions concern the potential risks to people and property they will always be taken on a precautionary basis. It is therefore the nature of this service that there will be local flood warning messages issued, which hindsight will show were unnecessary.

There will also be locations which do experience flooding and where flood warnings were not issued. This would typically be due to very specific local circumstance or characteristics. The national forecasting and warning service strives to minimise locations which receive no warnings at all.

It is one of the particular challenges of this service that the introduction of new flood forecasting and warning areas is a positive improvement to flood risk management, but any subsequent *'false warnings*' are potentially negatively received. Prior to the introduction of these 'new' warning areas there would have been no local warning at all.

Initially warnings for such areas may be based on limited information which will be refined and improved over time and as local information is gathered in response to actual coastal events.

The continual challenge for this service is to balance the technical improvements associated with the decisions to issue warnings with the communications elements which inform professional partners, individuals and communities who receive these message.

The following pages contain two examples:

- The first example considers the tidal forecasts for Newport tidal gauge in January 2014. This illustrates the forecast variability in the days before a forecast high tide. It highlights the advantages of technological advancement in longer range tidal forecasting as well as the additional challenges this presents.

- The second example considers the evolution of the tidal surge at Liverpool tidal gauge on 5th December 2013. This illustrates the forecast variability in the 1 to 2 hours before the forecast high tide. It also highlights the advantages of the duty officers working relationship with the Flood Forecasting Centre.

Both Newport and Liverpool tidal gauges are part of the UK National Tide Gauge Network. This was formed in 1953 following violent North Sea storms, which caused extensive flooding along the east coast of Britain, killing 307 people.

Newport Tidal Gauge – January 2014

This first graph shows the period containing the most severe tides of the January 2014 incident. This snapshot was taken during the afternoon of the 31st December 2013.

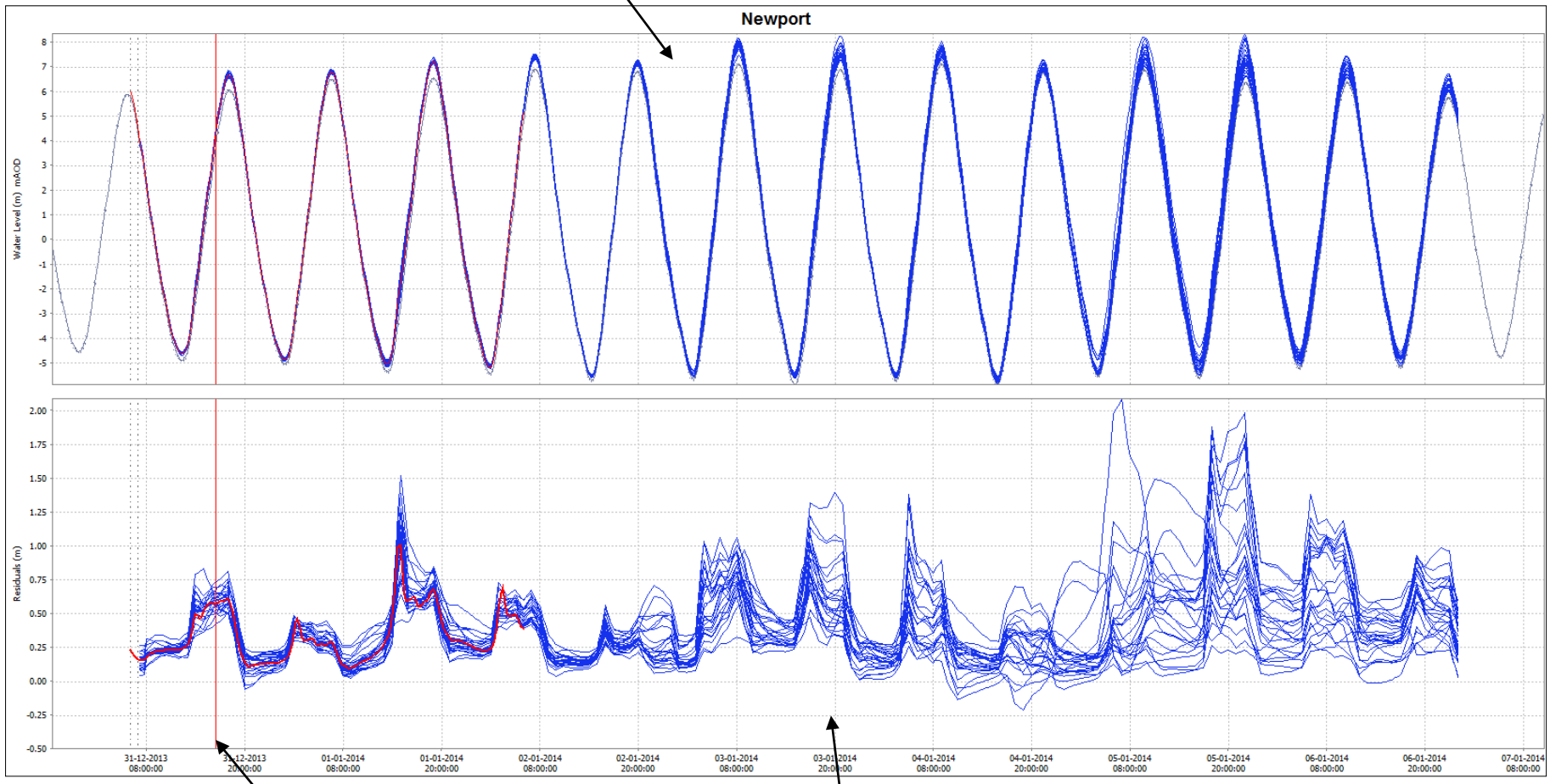
It shows the surge ensemble [see below*], and the scatter or spread of the ensembles reflects the uncertainty over the forecast confidence. We had a strong signal that there was likely to be a significant storm surge and that it could coincide with high tide, but by day 3 of the forecast (i.e. looking 3 days ahead), the uncertainty was over 1 metre and by day 5 the uncertainty was a difference of 2 metres in places.

Without these technical advances and the ability for the surge ensembles to capture the relative uncertainty, we would have not had early sight of this event when we did. This is a relatively recent development (within the last couple of years).

(surge ensemble – Multiple computer model runs with different starting conditions, designed to capture uncertainty in the weather forecasts. The results provide an indication of the confidence in a given forecast)*

Cyfoeth Naturiol Cymru
Natural Resources Wales

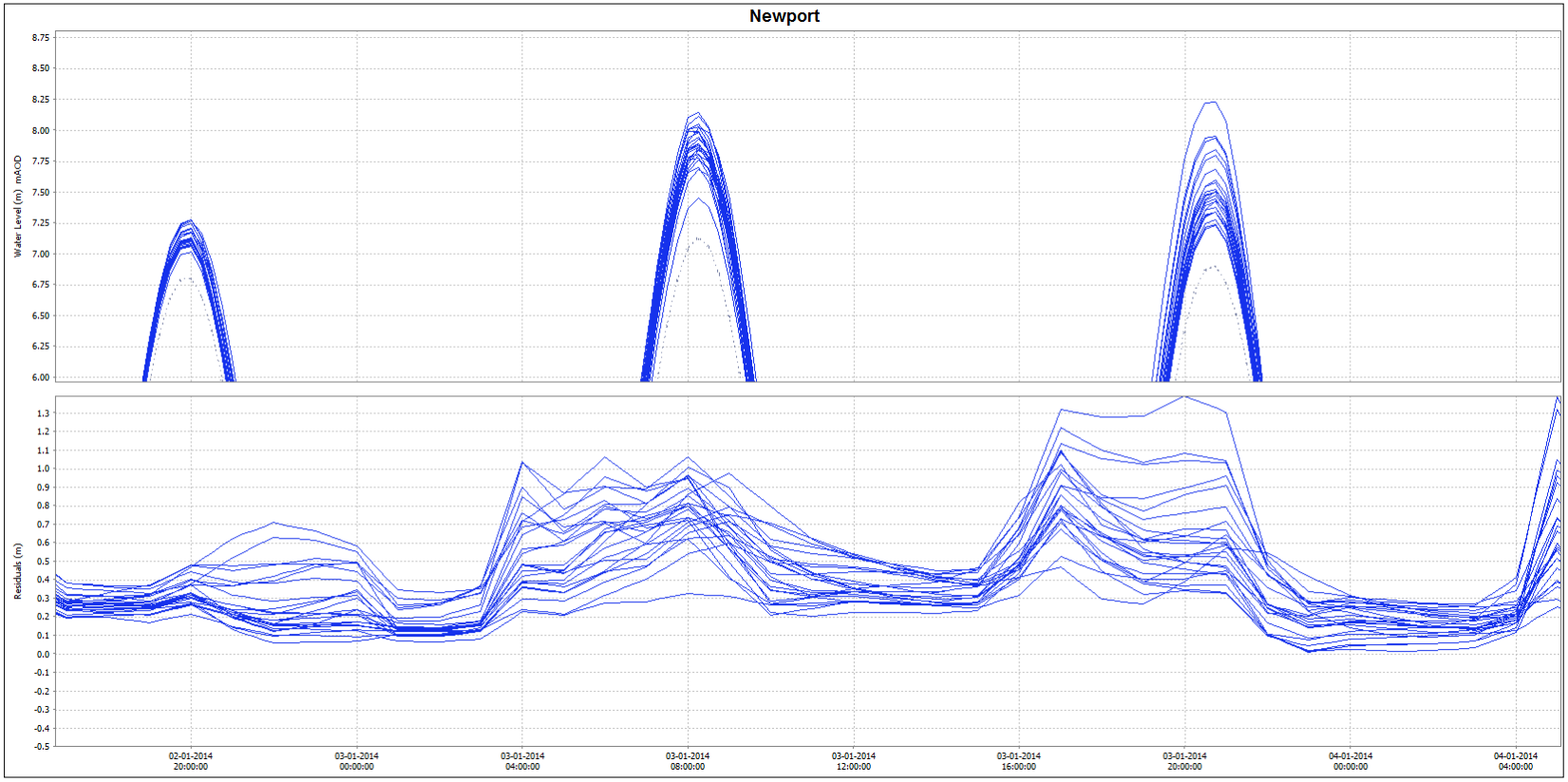
Sea level forecast with ensemble data



Current time

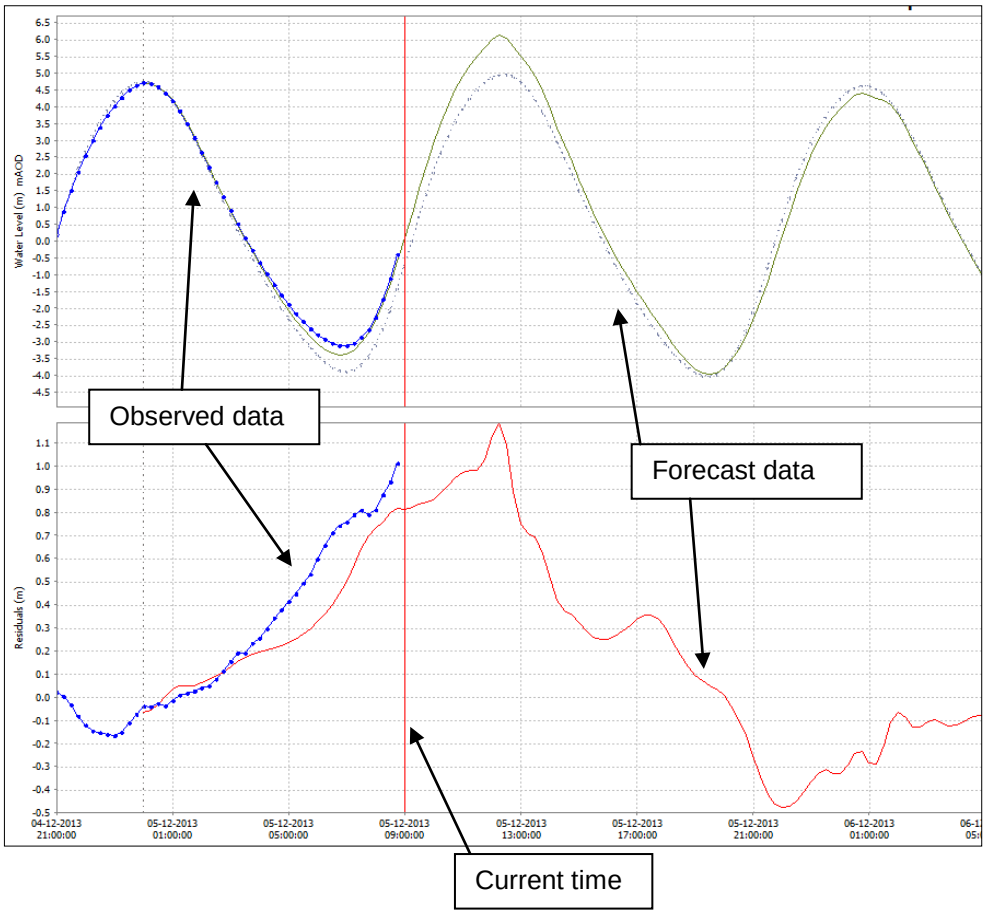
Surge ensemble forecast

This is an expanded section from the graph above showing in more detail the spread of the ensemble for the critical morning and evening tides of the 3rd January. For the early high tide on the 3rd January, the ensemble forecasts are clustered around 7.60 to 8.10mAOD. The peak level actually reached on the morning of the 3rd January was 8.03m AOD. The flood impacts associated with forecasts at Newport gauge have the potential to increase significantly for relatively small increase in water level.



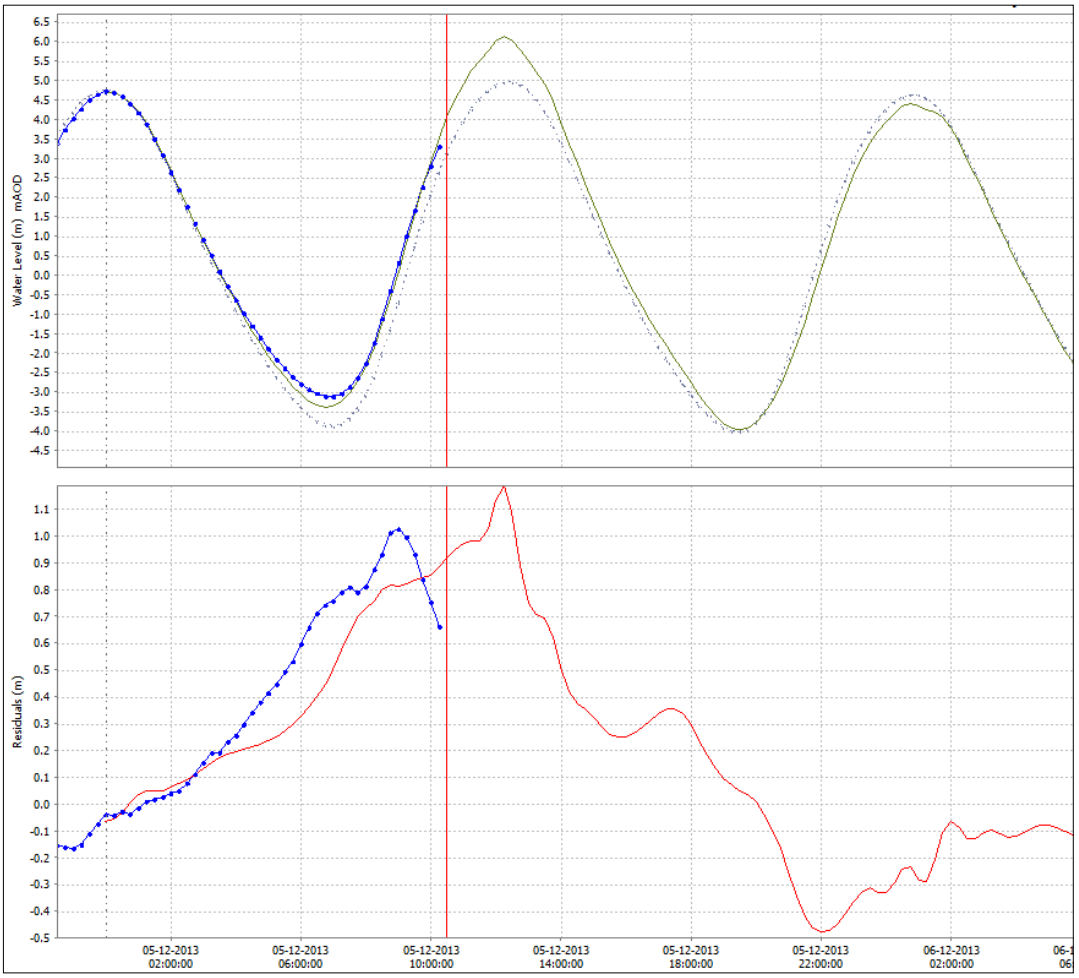
Liverpool Tidal Gauge – 5th December 2013

The following screenshots show the forecasts as the duty officer would have seen them as the December storm developed.



This screenshot is from 3 hours before high tide and it shows a forecast surge of 1.2 metres coinciding with high tide.

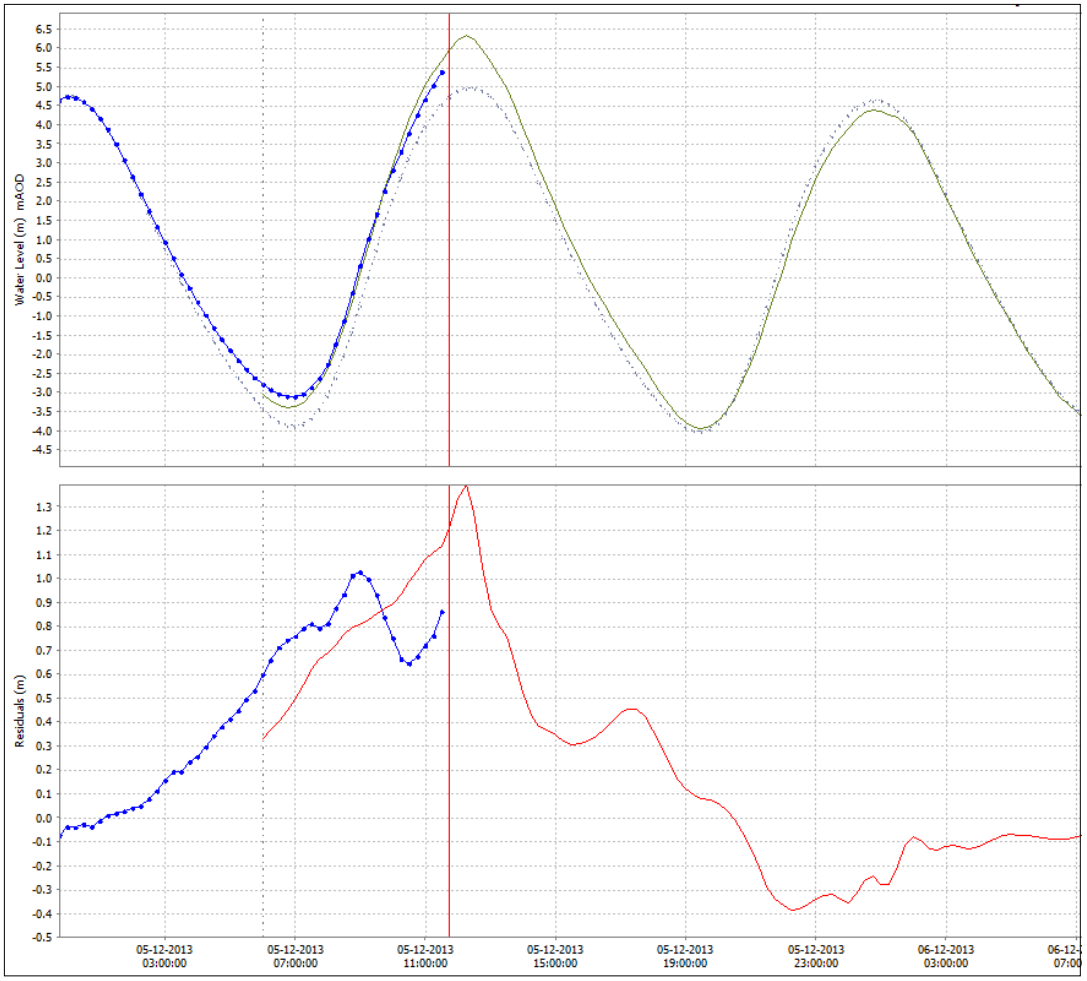
The duty officer's concern for this tide is the potential for the peak estimate of the tidal surge to coincide with the high tide itself. The lower graph above suggests the potential for the tidal surge to peak before high tide, giving a lower than expected total water level.



This screenshot is from 2 hours before high tide. The shape of the observed surge seems to mimic the shape of the peak of the forecast surge but occurs earlier and slightly lower than forecast. The duty officer was faced with the question of whether the worst of the surge has passed before peak high tide. If the observed surge continued to fall at the same rate, the actual high water level would be little higher than the astronomic alone, i.e. negligible surge and a high water level that would be expected several times a year.

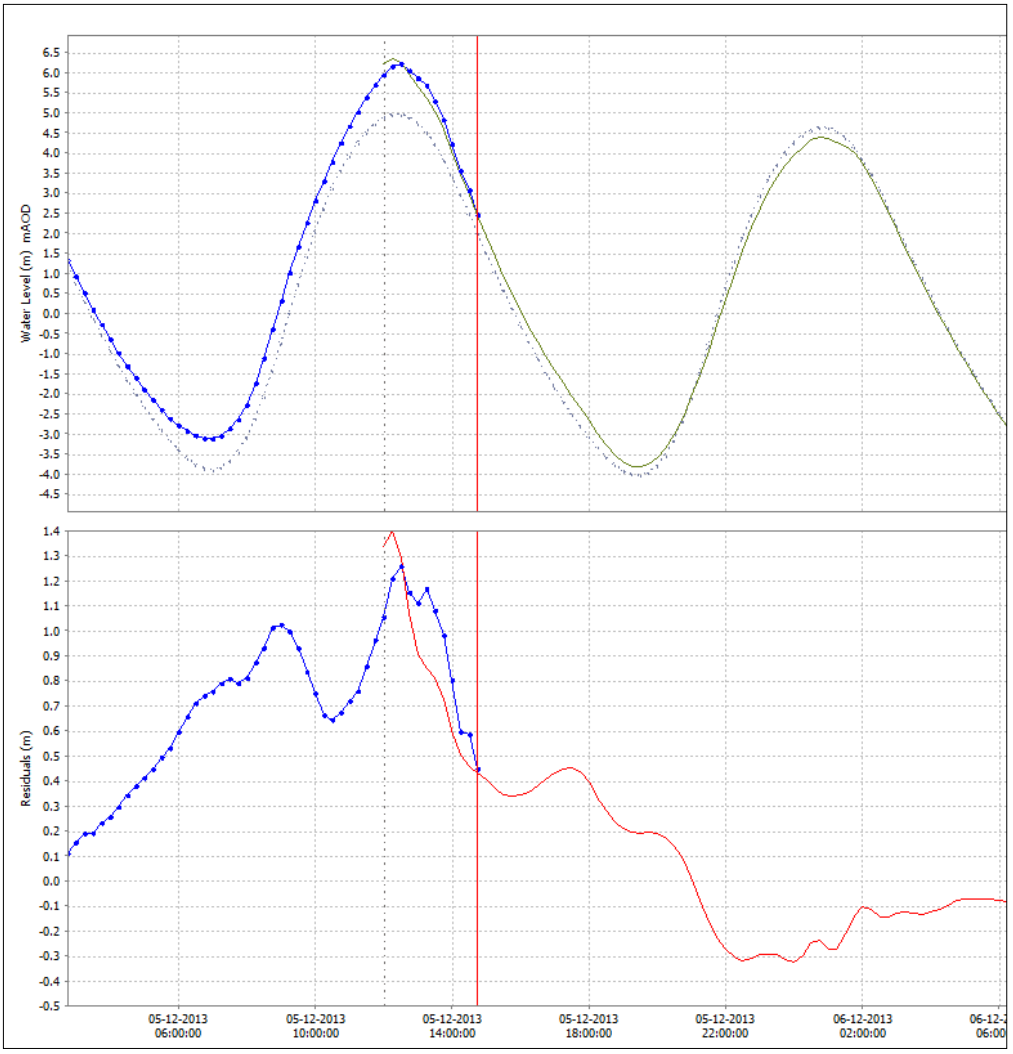
At this stage there was a phone call involving Natural Resources Wales duty officers and duty managers to the Flood Forecasting Centre to discuss and to assess validity of the forecast.

The duty Hydro-Meteorologist at the Flood Forecasting Centre spoke to the Chief Meteorologist at the Met Office and the advice was that their best information showed the atmospheric forcing conditions were still in existence and they believed that we would see the surge turn and continue to rise.



Within half an hour the observed surge had turned and started to increase. Within an hour it was back to nearly 1 metre.

This screenshot from an hour before high tide shows the new forecast data that had been received. Here the peak of the surge is even greater at 1.4 metres.



This screenshot, from after high tide, displays a newer forecast surge output, It shows the rapid increase in observed surge immediately prior to high tide. The peak of the observed surge reached over over 1.2 metres and coincided with the high tide point. Resulting in the highest water level recorded at this gauge, 300mm higher than any other tide in over 20 years of record.

Overview of Flood Forecasting Performance

Overall the coastal flood forecasting service performed well during the flood events in December 2013 and January 2014. Developments in improved lead time and a greater ability to understand risk at set locations enabled us to communicate to partners general locations of concern several days ahead, and more specific areas at risk the day before the onset of flooding.

Where the forecasts differed from the local experience these will be evaluated by Natural Resources Wales officers as part of the '*business as usual'* post incident assessment and where appropriate local information used to help validate and improve the forecasting models.

Since 2006 there has been significant investment in new coastal forecasting models for the west and north Wales coastlines. These provide improved predictions of near shore wave heights and wave overtopping at locations vulnerable to this flood risk. As a result flood warnings were issued during the December and January events which would not have been issued several years ago when the forecasting capability was more limited.

However, it remains a continued challenge to translate the coastal forecasting information into timely and local warnings, as is discussed later in this report.

The December 2013 incident, the Liverpool tidal gauge example above, illustrates the benefit of duty officers having access to the expertise at the Flood Forecasting Centre in general, and in this case to the Chief Meteorologist at the Met Office in particular.

The development in longer term forecast information enabled advance testing of *'what if scenarios?'* to gauge the potential scale of impacts. For example the following assessment was carried out on 31st December for the morning tide of 3rd January.

Scenario (a): a '*most likely'* assessment

- Severe Flood Warnings – 1
- Flood Warnings – 39
- Flood Alerts - 20

Scenario (b) a '*worst case* 'assessment

- Severe Flood Warnings – 12
- Flood Warnings – 49
- Flood Alerts – 20

This identified the potential range of forecast impacts, in terms of warnings issued, for the morning of the 3rd January, based on the data provided in surge ensemble and long range wave forecasts. This analysis would not have been possible several years ago.

Whilst this longer term information cannot be used directly for operational decisions, given the uncertainty ranges identified above in the Newport January 2014 example, it can provide an early '*heads up*' to potential significant incidents.

This in itself can help professional partners consider early decisions around deployment of staff and equipment, checking on critical assets and establishment of standby rotas. This can be important when the incident coincides with holiday periods, such as Christmas.

This type of analysis will become more important for the larger and more significant future tidal incidents which may require large scale evacuations. This is discussed below.

Issues and Recommendations – Flood Forecasting

There needs to be continued improvement in longer range forecasts:

The discussion above has highlighted the scenario testing and early '*heads up*' benefits of longer range forecasts.

For more extreme tidal events it may be necessary to make significant operational decisions on the basis of this information.

Earlier in this report it was illustrated that the most concentrated locations of property at risk from coastal flooding are in south east and north east Wales. In these locations there is the potential for relatively modest increases in tidal levels to significantly increase the number and extent of properties at risk.

In this situation it may be necessary to initiate and implement a complex and large scale evacuation. This could take significant time, potentially days, to deliver effectively. In such a scenario this decision would be informed by the longer term forecast and would need to consider the inherent uncertainties associated with such a forecast a number of days in advance.

This would not be a simple decision. Continued improvements to longer term forecasts can help inform this decision. This work needs to be carried out in cooperation and partnership with the Flood Forecasting Centre, Met Office and Environment Agency.

The issue of preparedness for tidal incidents which may require large scale evacuations is the subject of a separate recommendation later in this report.

Rec. 6	**Continue to identify and implement risk based opportunities to deliver further improvements to longer range forecasts.**

The national forecasting advice needs to contain more supplementary information to better inform local decisions:

The experience from these storms has highlighted the importance of incident management decisions being taken locally, but informed by advice and guidance provided by national service providers, such as the flood forecasting service.

In some locations, as experienced in Rhyl in December 2013, factors such as wind and wave information can have an important impact on local flood risk and therefore the local operational decisions.

The issue therefore is to consider what supplementary information could be provided by the flood forecasting service to aid local decision makers as part of the flood warning service. During incidents local officers will have an understanding of how local risk may be changing as a consequence of damage to defences and changes to beach and foreshore conditions.

Supplementary information on wind and wave conditions may provide local added value. Only information or data that provides added value to the local decision makers should be considered.

There is an associated feedback loop for local information to be captured and fed back into the flood forecasting and warning process, in order to provide validation and continuous improvement. This is subject of a separate recommendation later in this report.

Rec. 7	**Review with partners what additional forecast information could be provided to support local incident management decisions. Identify options and recommendations.**

There needs to be continued risk based improvements to the coastal forecasting service:

There are several work themes which are ongoing with partners at the Wales and England level, for example:

- Probabilistic forecasting to capture uncertainty.
- Improvements to the Bristol Channel forecasts to improve sea level predictions. The Severn estuary has the second highest tidal range in the world and one of the most challenging locations for forecasting extreme tide levels. This is coupled with a high proportion of properties potentially at risk.
- Re-engineering of the astronomic data to improve forecasts at UK Tide Gauge Network sites.
- Better understanding of wave transformation to better resolve near shore wave conditions.
- Improved overtopping techniques and verification of overtopping impacts to improve site specific wave overtopping forecasts.

All of which will improve the accuracy of the forecasting service and therefore the warning service.

Rec. 8	**Continue to progress risk based opportunities to deliver improvements to the accuracy of the coastal forecasting service. Develop and deliver a programme of improvement works.**

There needs to be a review of the wave buoy network around the Welsh coast:

There needs to be a review of the whole wave buoy network around the Welsh coast, including working with UKCMF to address a strategic gap in the offshore wave buoy network in the Irish Sea. This has previously been identified as a UKCMF WaveNet recommendation and work to analyse these recent storms has further highlighted this gap.

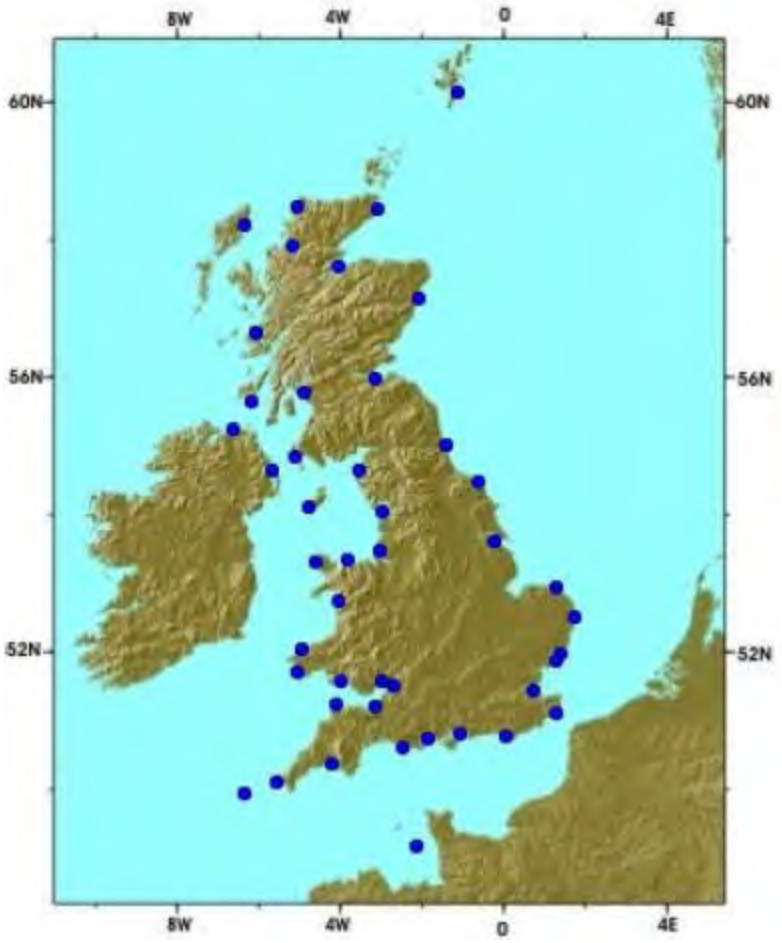
This is required to better validate offshore wave forecasts, leading to improvements to the Wales forecasting service.

UKCMF- UK Coastal Monitoring and Forecasting Service

Rec. 9	**Review the whole wave buoy network around the Welsh coast, including working with UKCMF to address a strategic gap in the offshore wave buoy network in the Irish Sea. This is required to better validate offshore wave forecasts, leading to improvements to the Wales forecasting service.** ***(UKCMF- UK Coastal Monitoring and Forecasting Service)***

UK National Tide Gauge Network

The UK National Tide Gauge Network, run by the Tide Gauge Inspectorate, records tidal elevations at 44 locations around the UK coast. The UK national network of sea level gauges was established after violent storms in the North Sea in 1953 resulted in serious flooding along the east coast.



The Tide Gauge Inspectorate at The National Oceanography Centre, Liverpool, formerly the Proudman Oceanographic Laboratory, (http://www.pol.ac.uk/) is responsible for modernising and maintaining this network, with the aim of obtaining high quality tidal information through telemetry at coastal locations around the British Isles.

Overview of Flood Warning Performance

Given the significant size of these storms they tested the robustness of the flood warning service, which by its nature needs such significant storms to help validate its accuracy. When considered overall, in many places the flood warning service performed well during the flood events in December 2013 and January 2014. Many thousands of properties received timely and accurate warnings. This enabled professional partners, communities and individuals to prepare and respond to these incidents. There were a few locations where flood warnings were issued and no flooding occurred and where properties flooded and no Flood Warning was issued.

The table below illustrates the total number of warnings issued across both storm incidents. These numbers are unprecedented in recent years, in particular the number and distribution of Severe Flood Warnings in January 2014.

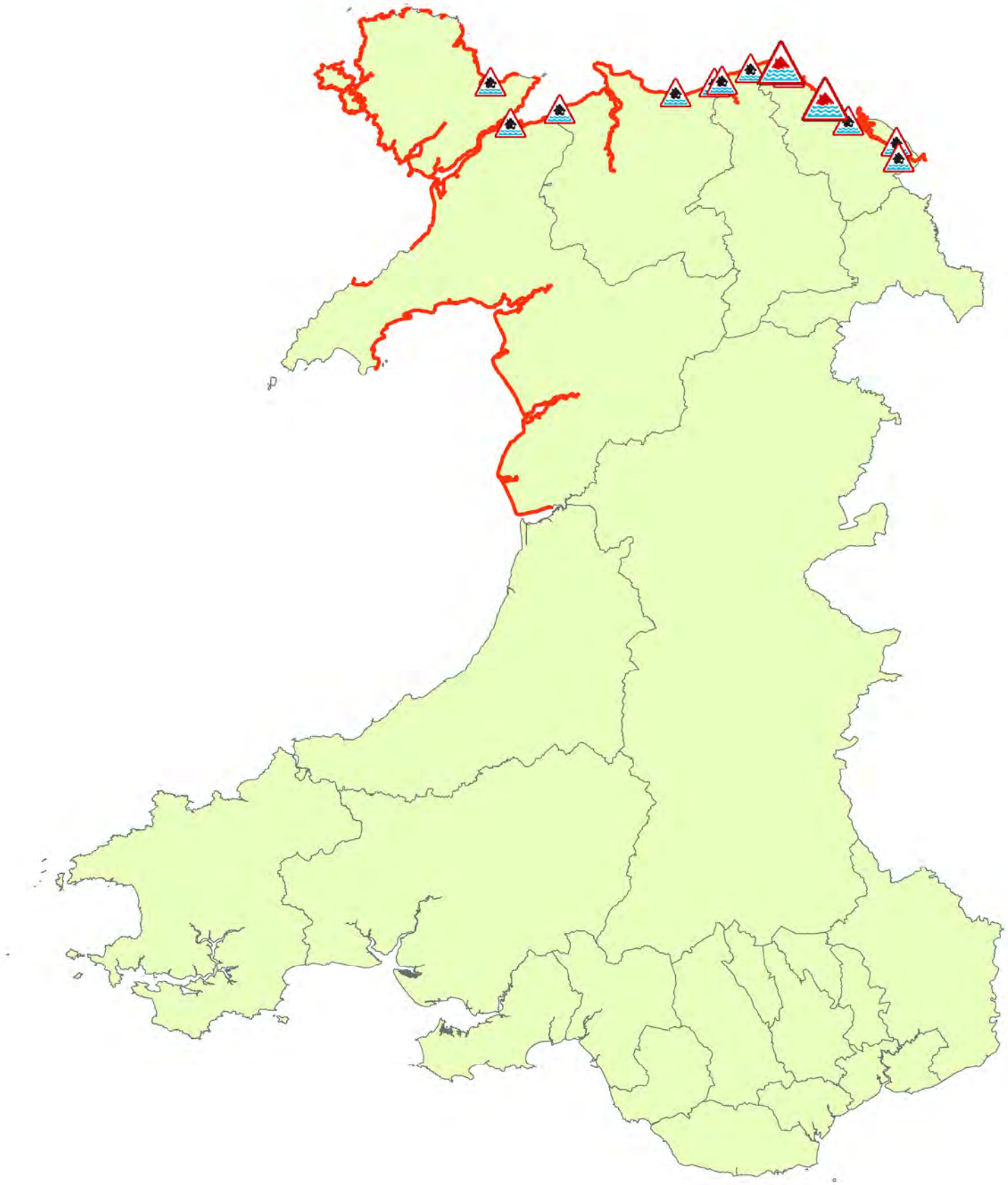
Table 1: Summary of flood warnings

Summary for period 4th - 5th December 2013				
Day		Cumulative warnings		
		Alerts	Warnings	Severe
Wednesday 4th December 2013		3	9	0
Thursday 5th December		0	6	2
	TOTAL	**3**	**15**	**2**
Summary for period 2nd - 6th January 2014				
Day		Cumulative warnings		
		Alerts	Warnings	Severe
Thursday 2nd January 2014		4	55	4
Friday 3rd January		4	29	2
Saturday 4th January		1	2	0
Sunday 5th January		10	3	0
Monday 6th January		2	14	0
	TOTAL	**21**	**103**	**6**

The distribution of flood warnings is illustrated on the following **Map3** and **Map 4.**

Cyfoeth Naturiol Cymru
Natural Resources Wales

Map 3 - Flood Warnings Issued - December



Legend

Flood Warnings issued

Coastal Flood Alert Issued

Flood Warning

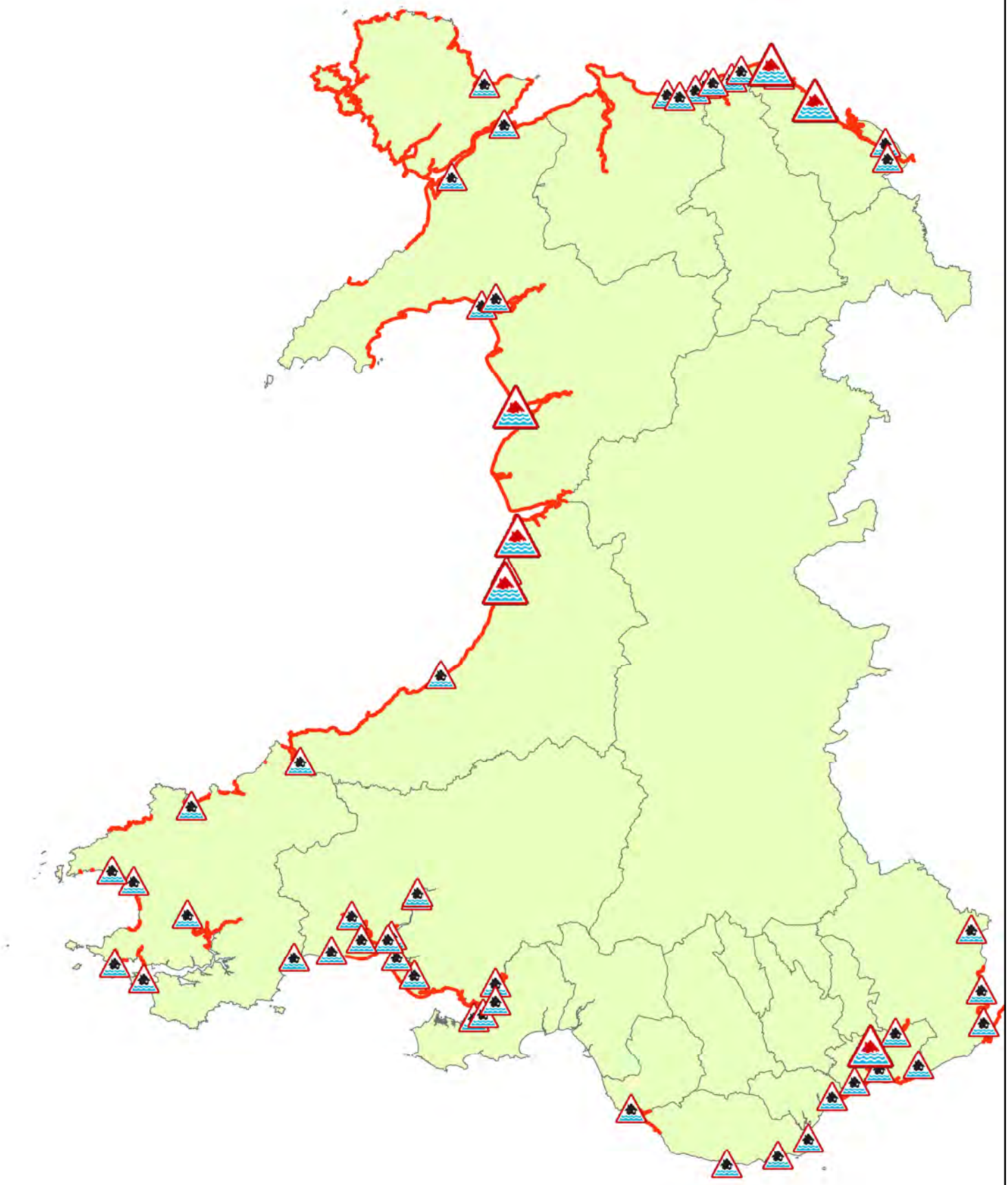
Severe Flood Warning

0 5 10 20 30 40 50 Kilometres

N

Cyfoeth Naturiol Cymru
Natural Resources Wales

Map 4 - Flood Warnings Issued - January



Legend

Flood Warnings issued

Coastal Flood Alert Issued

Flood Warning

Severe Flood Warning

0 5 10 20 30 40 50 Kilometres

N

Table 2: Summary of Severe Flood Warnings
December 2013

Warning Area	Timing of issue
Point of Ayr Area A	Thursday 5th at 10:49
Greenfield to Bagillt Area A	Thursday 5th at 10:56

On this occasion significant flooding was not experienced at these locations but flooding was experienced further west along the coast at Rhyl. This is discussed below.

Table 3: Summary of Severe Flood Warnings
January 2014

Warning Area	Timing of issue
Barmouth	Thursday 2nd Jan at 18:04
Greenfield to Bagillt Area A	Thursday 2nd Jan at 21:46
Point of Ayr Area A	Thursday 2nd Jan at 22:11
Usk Estuary and Crindau and Malpas Road Area	Thursday 2nd Jan at 21:35
Tidal Area of Borth	Friday 3rd Jan at 15:36
Tidal Area at Aberystwyth Seafront	Friday 3rd Jan at 16:26

On this occasion flooding was experienced in Barmouth, the Crindau area of Newport, Borth and Aberystwyth seafront.

The following comments have also been received from local officers who suggest that the impacts at both Talacre (in the vicinity of Point of Ayr) and the Crindau area of Newport could potentially have been worse with relatively small changes in local tide and/or weather conditions.

Regarding Talacre:

“Had wind conditions in January 2014 been similar to December 2013 then an overtopping/breach here would have been highly likely, giving severe impacts due to number and setting of properties.”

Regarding Crindau area of Newport:

I can only reiterate that we had what I would describe as an “extremely near miss”.

I do think it’s important to say again that this was an extremely near miss and that slightly higher levels would have resulted in considerable flooding of properties in this area.

Whilst we were pleased to avoid significant flooding it is important that lessons are learnt for the future.

Rhyl (East Rhyl, A548 coast road, Garford Road and surrounding areas)

Flood warnings for the coast are delivered by Natural Resources Wales and are triggered by the forecast exceedence of either a tidal level or an overtopping volume.

Rhyl is serviced by two flood warning areas, Rhyl A and Prestatyn Area B as outlined in the table 4. During the incident in December 2013, Rhyl Area A was issued with a flood warning as was Prestatyn Area A to the east.

- Rhyl Area A: flood warning was issued at 20:35hrs on 4 December 2013.
- Prestatyn Area A: flood warning was issued at 20:46hrs on 4 December 2013.
- Prestatyn Area B: flood warning was not issued.

The map below illustrates the resulting flooded area, the flood warning area extents and the Extreme Flood Outline (EFO). Table 4 shows the warning area names and descriptions, the numbers of properties contained within each warning area and the thresholds that are used to issue the warnings.

The areas around Garford Road, Molineaux Road and Rhyl Coast Road were affected by flood water during December 2013. This area sits within the Prestatyn Area B flood warning area extent. This part of the EFO begins behind the defences at Prestatyn and ends to the East of Rhyl. The flood plain then breaks and starts again nearer to the tidal reaches of the Clwyd. This is why the flooded area is contained within the Prestatyn Area B flood warning extent.

The flood warning for Prestatyn Area B was not issued because the flood warning threshold level was not met in the Wales Coastal Model. The maximum value forecast was 5.49mAOD against a threshold of 6.41mAOD.

The analysis presented later in this report includes the following relevant levels:

5.65mAOD: Peak water level recorded at Rhyl Harbour tidal gauge.
6.30mAOD: Typical level of the Promenade adjacent to the flooded area of Rhyl.
7.20mAOD: Typical sea defence level adjacent to the flooded area of Rhyl.

This suggests the peak recorded water level local to the flooded area of Rhyl was approximately 0.16m above the forecast level but some 0.7m and 1.6m below the level of the Promenade and sea defence respectively. This illustrates the local impacts of the wave and wind direction at Rhyl. These are discussed later in this report.

Location of Rhyl and Prestatyn Flood Warning Areas, including the extreme flood outline and the flooded area In December 2013

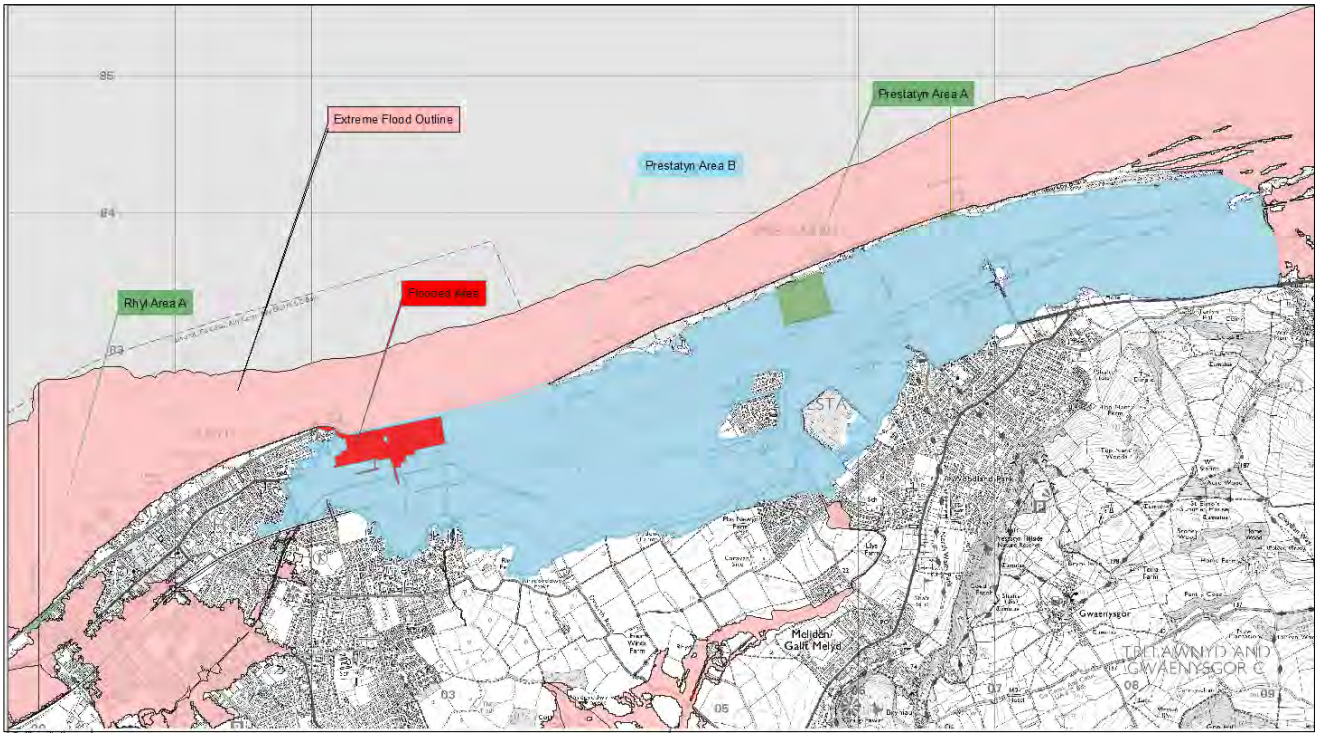


Table 4: Rhyl and Prestatyn Flood Warning Areas

Flood Warning Area Name	*Flood Warning Area Description*	*Number of Properties in Flood Warning Area*	*Flood Warning Threshold Level (m)*
Rhyl Area A	West Parade from Butterton Road to Sydenham Avenue	72	6.0 (5.42)
Prestatyn Area A	The frontage near the Grand Hotel and also Lido Beach Caravan Park	1	6.18 (5.49)
Prestatyn Area B	Extensive areas along the coast road from the outskirts of Rhyl to Prestatyn Golf Course	6455	6.41 (5.49)

The values shown in red are the maximum forecast values for this event.

Issues and Recommendations – Flood Warning and Community Response

There is a need to clearly identify Natural Resources Wales as the provider of the flood warning service in Wales:

Natural Resources Wales issue flood warnings in Wales using systems managed by the Environment Agency. Natural Resources Wales are working to update these systems as the warnings appear to be issued by Environment Agency Wales.

This led to mixed messages during the December 2013 and January 2014 incidents where the media often reported the Environment Agency as the provider of the flood warnings.

Rec. 10	**Complete the ongoing work by summer 2014 to 'rebrand' the flood warning service in Wales so that the provider is clearly identified as Natural Resources Wales.**

There is a need to review and where necessary amend the extent and naming of flood warning areas and accuracy of flood warning thresholds:

Given the significant size of these storms they tested the robustness of the flood warning service, which by its nature needs such significant storms to help validate its accuracy.

Accuracy of the flood warning service is subject to continual review and is improved through on-going validation of the flood warnings issued. Validation of warnings is event reliant and is an iterative process.

The validation can be time consuming and labour intensive. Validation consists of the following activities:

- Natural Resources Wales staff must be on-site to observe and record the storm conditions or information is gathered from other sources.
- The data captured must then be collated, interpreted and quality assured by technically competent officers.
- Flood warning thresholds, flood warning area maps or forecasting parameter updates are then made to systems and procedures.
- Natural Resources Wales duty officers and professional partners must then be informed.
- The community must also be made aware of what changes have been made and how they should respond to the warning.

Rec. 11	**Develop and implement a prioritised programme of improvement works to flood warning areas and thresholds, using the experience and data gathered from these storms. This should include engagement with professional partners and communities as appropriate.**

Rec. 12	**Review and consider additional sources of validation information for future incidents. This has potential to improve confidence in both forecasting and warning. This may involve seeking feedback from professional partners and others.**

There needs to be more done to sustain an effective community (local) response to flood warnings:

This is a general aspiration across all locations.

In coastal areas the risk in many locations can be of relatively low likelihood but potentially with high impacts. This low likelihood can make raising and sustaining awareness and ability to respond effectively, particularly challenging.

Effective community response originates in an awareness of local risk and the community, either collectively or individually, understanding the actions to take in advance of and during flooding incidents. It then needs the community or individuals to take the pre-determined action when the warnings are issued.

Sustaining an effective response can be a particular challenge where awareness has been raised, but community and individual confidence and trust has been eroded by *'false warnings'*, i.e. where warnings have been issued and flooding has not occurred.

This lack of confidence and therefore lack of, or reluctant, response to warnings can also be a factor for professional partners to address.

We have highlighted in earlier sections of this report:

- The complexity of translating natural events into timely and accurate local warnings, which is what individuals, communities and professional partners want and expect.

- The fact that forecasting and warning decisions by Natural Resources Wales duty officers will always adopt a precautionary approach, as flooding impacts on people and property.

- The fact that forecasting and warning are continuously reviewed and improved as a result of technical developments and experience from real incidents, such as the December 2013 and January 2014 storms.

Individuals and communities can generally accept the broad uncertainties associated with weather forecasting, as this is something that affects day to day life and decisions. We are all familiar with how unpredictable the weather can be. However, despite this, there can still be an unrealistic expectation as to the certainty and accuracy of local flood warnings when these are based on forecast weather conditions. This may be in part due to a lack of understanding of the process associated with the flood warnings and its inherent link to weather forecast.

Unless individuals and communities are advised of the changes and improvements carried out to the flood warning process then it is understandable that they will consider a flood warning issued today, is the same as the flood warning issued last time, when perhaps it did not flood. The validation process explained above identifies the importance of this step.

Within flood warnings themselves there is also as range of *'seriousness'* which it can be difficult to communicate and of which communities may be unsighted. For example, there will be Flood Warnings which are only just above the lesser Flood Alert level. There will also be Flood Warnings which are a precursor to issuing the more serious Severe Flood Warning.

In addition, and as noted earlier, the criteria which influence decisions to issue warnings may also rapidly change during incidents themselves. Such as the dynamic change which occurred in the recent storms, particularly those of early January 2014 that included:

- Re profiling of beaches, most notably at Aberystwyth.
- Loss of significant volumes of beach material at numerous locations.
- Physical damage to defences at numerous locations.

All of the above add further layers of complexity onto an already challenging issue.

Progress on how to sustain effective response, will require consideration of matters of:

- Shared understanding and awareness of process, procedures and uncertainty.

- Trust and confidence, both at an individual and organisational level.

Trust and confidence is determined by personal experience and the development of relationships. These relationships can be built by closer day to day communication and cooperation between duty officers and communities. These *'foundations of trust and understanding'* can then help to increase resilience during incidents.

However, to establish and sustain the required level of understanding and trust/confidence can be resource intensive. There is a link between this and the discussion below which seeks to explore how communities can become more self-sufficient and resilient.

Rec. 13	**Work with sample communities to identify options to help sustain an effective local response to flood warnings. This should consider communities where effective response and or confidence in the warning system is low.**

There is a need for more support to communities to help them become more self-sufficient and resilient:

Management of the national coastal flood risk needs a wide range of organisations working together at all levels. It is essential that the communities affected by the flood risk and the decisions made to manage these risks are included in this overall partnership.

Communities have an important role to understand their local flood risk and to prepare and plan for it, so they can contribute to the effective response when flooding occurs. Communities can also provide *'internal'* support to their own population as well as offer support and shared experience to others.

Public service flood risk providers need communities to become more self-sufficient and resilient to their flood risks, as all the needs of these communities cannot be met or sustained over a long period by public service providers alone. Experience from these recent coastal storms has significantly tested the public service response.

More self-sufficient communities will be:

- Informed, supported, empowered and motivated to make their local contribution to the national flood risk management service.

To progress towards this objective, communities will need:

- Advice and support from professional partners.
- To be advised and supported at all times but particularly during recovery. After flooding incidents the affected individuals need practical and emotional support. This can require skilled staff and specialist expertise.
- Easy access to simple public facing messages and advice regarding flooding and who can help them. This may include professional partners developing generic products that are suitable for a wide range of customer groups. It will require consideration of where this information is held and how it is maintained.
- A broad support network to communicate with each other locally and nationally as well as to seek advice and support.
- Clear information about how to access opportunities to increase their resilience. For example opportunities to introduce individual property level protection. See separate recommendation (15) below.
- Clear information on the duties of public service providers. This must include what public service providers are under a duty and are resourced to deliver. Communities must be informed so they can have realist expectations.

Rec. 14	**Identify and evaluate options to help communities to become more self-sufficient and resilient and identify a recommended option.**

There is a need for more clear and consistent information to communities about the things they can do to protect themselves and their properties from flooding:

The role of sandbags to manage and mitigate flooding is deeply embedded in the community consciousness and can be reinforced by media coverage.

Sandbags are popular but they have disadvantages:

- During an emergency sufficient quantities may be difficult to obtain.
- They are time consuming and require two people to fill each one.
- They can be difficult to handle, particularly for the elderly or infirm.
- When they come into contact with floodwater they tend to retain contaminants, such as sewage.
- The outer sacking material is biodegradable, and will disintegrate if left in place for long periods of time.

Sandbags can have a role in managing flood risks, in particular when they are used strategically to protect groups of properties. During the recent storms *'strategic sandbagging*' in north Wales worked well to protect 70 plus properties from flooding.

- Communities and individuals can have unrealistic expectations as to their effectiveness and availability during incidents. This will take a time and require concerted effort to shift the public perception.

- The demand and expectation for sandbags during incidents can place significant pressure on limited public service resources and direct focus away from higher risk management activities.

- The inability for communities to access sandbags from public service authorities can cause significant local anger and frustration.

This will require clear and consistent publicly focused messages, as well as support and guidance as to alternative options for individuals and communities to protect themselves.

This will include information on property level measures to improve resilience (to minimise damage if flooding does happen) and resistance (to prevent flooding to properties) as well as how to access these measures.

Rec.15	**Produce and communicate nationally consistent, public focused information on the types and availability of property level protection measures and the support available.**

There is a need to improve the effectiveness of local Flood Plans in coastal communities:

Effective local or community Flood Plans are an important component of community resilience. It has been noted previously that in many locations, coastal flooding is a low likelihood but potentially high impact risk. The low likelihood can mean it is a challenge to maintain these Flood Plans so they are effective when needed.

Rec.16	**Using the experience from these recent storms, identify and evaluate options for the future development of local Flood Plans in coastal areas and identify a recommended option to help these be more effective at improving community resilience.**

There is a need to improve the effectiveness of the role of local Flood Plan Leads / Warden Volunteers in coastal communities:

As above Local Flood Plan Leads / Warden Volunteers are also important components of community resilience.

In many locations the low likelihood of coastal risks can present particular challenges to sustaining recruitment and support to local Flood Plan Leads / Warden Volunteers. Effective management and support for volunteers is a specialist activity. This can be resource intensive and requires specialist skills and expertise.

Rec. 17	**Using the experience from these recent storms, identify and evaluate options for the future development of local Flood Plan Leads / Warden Volunteers in coastal areas and identify a recommended option.**

Operational Response of Risk Management Authorities

Introduction

Risk Management Authorities (RMAs) in Wales have been identified earlier in this report and includes Natural Resources Wales and all 22 Local Authorities in Wales. In addition it includes the Water Companies operating in Wales.

The purpose of this section of the Report is to:

- **Provide an overview of the framework within which RMAs operate during flooding incidents.**
- **Provide an overview of the operational response of RMAs.**
- **Highlight issues identified and associated recommendations.**

Risk Management Authorities Actions before Flooding Incidents

In the period of time before notable coastal flooding incidents the forecasting tools, Flood Forecasting Centre daily weather outlook and the Flood Guidance Statements will be used to inform local discussions with professional partners.

These discussions provide a forum for professional partners to share and discuss information about the potential local impacts. This can enable professional partners to consider and take action as required. This may include inspection of significant assets, deployment of materials and establishment of staff rotas, if a sustained period of flooding is forecast.

Once a flooding incident commences the formal civil protection framework arrangements outlined below are instigated.

Civil Contingencies Act (2004)

The Civil Contingencies Act (the Act) delivers a single framework for civil protection in the UK capable of meeting a full range of challenges, such as flooding. The Act is separated into two substantive parts:

Part 1: focuses on local arrangements for civil protection, establishing a statutory framework of roles and responsibilities for local responders.

Part 2: focuses on emergency powers, establishing a modern framework for the use of special legislative measures that might be necessary to deal with the effects of the most serious emergencies.

More information can be found at:

http://www.legislation.gov.uk/ukpga/2004/36/contents

Wales Resilience Forum and Local Resilience Forums

The introduction of the Act required a restructure of joint-agency planning in Wales. This resulted in the creation of Local Resilience Forums (supported by various co-ordinating groups) in Wales based on the four police force areas in Wales.

The Local Resilience Forums are:

- South Wales
- Gwent
- North Wales
- Dyfed-Powys

At the all-Wales level, the Wales Resilience Forum has been established to endorse good communication and enhance emergency planning across agencies and services in Wales.

The Welsh Government, emergency services, local authorities, health authorities and other emergency planning organisations work together to strengthen the resilience of services in Wales.

More information can be found at the website, Wales Resilience

http://walesresilience.gov.uk/splash?orig=/

Overview of Operational Response by Risk Management Authorities

Information gathered for this review has indicated that overall the response by RMAs and other partners to both incidents was coordinated, effective and proportionate.

This view is in part reflected by the numbers of properties that were protected from flooding, feedback to this review and wider comments on the '*collective experience'* of these incidents.

Given the severity of the December 2013 and January 2014 storms, it is expected that there will be areas of learning (as well as good practice) arising from this recent experience and at the local level these are for the LRFs to identify and address.

We have not attempted in this Phase 2 Review to replicate these local reviews. Where issues concerning incident response have been identified to us as part of this all Wales Review, we have captured them in this Report for completeness and wider consideration.

Firstly this Review has concluded and reaffirmed the essential role during flooding incidents, of local decision making being made by local partners with detailed local knowledge. This needs to be supported by national advice and guidance as required, for example the flood forecasting information discussed earlier.

It is apparent to this Phase 2 Review that there are some key characteristics of effective local decision making associated with flooding incidents. These are well known to the local partners and we would urge them to continue to review their performance and ways of working against these characteristics:

- Training and testing in advance of incidents is essential.
- Commitment to continual learning and improvement.
- The importance of collective decision making based on best available information and advice.
- Shared understanding and ownership of the decisions and their associated risks and consequences. These may include risks to people and property, financial and resource risks as well as risks of false warnings and evacuation.
- Clarity of roles, responsibilities and expectations at incident control centres.
- Appropriate representation at incident control centres to both provide the degree of technical advice as well as seniority and authority to deliver the collective ownership of decisions and risks.
- Difficult decisions made under the pressure of significant incidents require, not only good information and advice, robust and tested process and procedures, but also confidence and trust between individuals This can take time and experience to develop. It needs continuity of staff.
- Early and regular communications, based on trust and relationships and not only process and procedures.

From this Phase 2 Review we have identified the following six areas to be considered for the future.

- There is a need to improve involvement of infrastructure operators and managers in the incident management process (where appropriate).
- There needs to be improved and accessible information on possible impacts in advance of incidents.
- There is a need to identify issues and learn from the decision making process associated with evacuation and Severe Flood Warnings issued in December 2013 and early January 2014.
- There is a need to assess our collective capacity to effectively respond to a sustained period of flooding.
- There is a need to assess our collective capacity to effectively respond to a coastal incident which would require large scale evacuation.
- This is an opportunity to review if any changes need to be made to the Wales resilience structures and ways of working.

These are discussed in more detail below.

Issues and Recommendations – Operational Response

There is a need to improve involvement of infrastructure operators and managers in the incident management process (where appropriate):

Infrastructure and utility operators do already, to varying degrees contribute to the incident management process. However, some operators and other responses to this Review have highlighted the need to improve engagement and communications during incident response.

Rec. 18	**Review and identify how to improve involvement of infrastructure operators and managers in the coastal flood risk incident management process.**

There needs to be improved and accessible information on possible impacts in advance of incidents:

During incident response there is a need for professional partners to have readily accessible information on potential impacts and '*what if scenarios'*.

This work is best carried out in advance of the incident, in order that information is readily available and the incident response discussion can be more focussed on the likelihood, timing and confidence (level of uncertainty) in the forecast of the impact occurring.

This work is already underway and must be continued on a risk basis.

Rec.19	**Continue to develop potential 'impact scenario' assessments, maps and/or statements. This work must be developed in close discussion with professional partners to ensure it meets all parties requirements.**

There is a need to identify issues and learn from the decision making process associated with evacuation and the Severe Flood Warnings issued in December 2013 and early January 2014:

The issuing of Severe Flood Warnings is an unusual occurrence. The number of Severe Flood Warnings issued across the December 2013 and early January 2014 storms is unprecedented in recent years.

This presented local challenges for decision makers around deployment of people and resources, communication, and implementation of evacuation procedures.

Rec. 20	**Review the local decision making process associated with the issue of Severe Flood Warnings and evacuation procedures in December 2013 and early January 2014. Identify improvements and share at an all Wales level.**

There is a need to assess our collective capacity to effectively respond to a sustained period of coastal flooding:

Whilst the overall performance of RMAs on this occasion was good, these two storm incidents (especially early January) seriously tested our collective capacity to respond.

In many locations relatively small increases in water level or changes in timing, and the consequences could have been much worse.

For example, a relatively small increase in the tidal level at Newport gauge could have significantly increased the seriousness of the impacts of the January event in south east Wales. In particular the Crindau area of Newport.

Rec.21	**Assess our national capacity to respond to a widespread and sustained period of coastal flooding. This should include consideration of when the current national resource pool will no longer function effectively. This should also consider post incident recovery issues.** **Provide a report with recommendations for improvement.**

There is a need to assess our collective capacity to effectively respond to a coastal incident which would require large scale evacuation:

It has been highlighted earlier in this Report that the densely populated coastal areas of south east and north east Wales have the potential for relatively small variance in the tidal levels to substantially increase the numbers of properties at risk during an incident.

This would introduce the need for potential *'large scale evacuation'*. Such a process could take significant time to implement. This will necessitate a longer lead in time and an earlier decision to evacuate, which in itself will be based on a forecast projection containing a significant uncertainty.

The longer the period of time between when the decision to evacuate is required to be made and the event causing the evacuation, the larger the forecast uncertainty.

A forecast projection made 3 days before a high tide has substantially greater uncertainty associated with it than a forecast made 12 hours before the high tide.

Rec.22	**Assess the collective ability to provide an effective response to a potential large scale evacuation scenario in either north east or south east Wales. This should also consider post incident recovery issues.** **Provide a report with recommendations for improvement.**

This is an opportunity to review if any changes need to be made to the Wales resilience structures and ways of working:

The storms which affected Wales on 5th December 2013 and early January 2014 are amongst some of the most significant in recent years.

They seriously tested the national network of coastal defences and our collective operational response.

Projections are for coastal flood risks to increase in the future.

In addition, this review has identified concerns around:

- Skills and capacity in the coastal flood risk management community.
- Our collective capacity to effectively respond to a sustained period of coastal flooding.
- Our collective capacity to effectively respond to a coastal incident which would require large scale evacuation.

Given all of these factors this is a timely opportunity to consider if changes are required to improve the Wales resilience structure and its ways of working.

Rec.23	**Review the Wales resilience structures and ways of working to identify what changes may be needed to enable us to collectively be better prepared and resilient to future coastal flooding.**

Performance of Coastal Defences

Introduction

The purpose of this section of the Report is to:

- **Provide an overview of the national network of coast defence infrastructure and how it is managed.**
- **Provide an indication of the scale of areas and properties benefitting.**
- **Provide an overview of performance during these storms.**
- **Consider the circumstances of the flooding at Rhyl and Llanbedr.**
- **Consider the importance of coastal adaptation and the strategic framework set by Shoreline Management Plans.**
- **Highlight issues identified and associated recommendations.**

National Defence Network

An estimated 415km of man-made sea defence structures exist to protect over £8billion of assets from coastal erosion and tidal flooding and replacing these structures would cost about £750million (*Wales Audit Office, 2009*). The national network of coastal protection and defence infrastructure has evolved and developed over many years, in order to protect and manage the risks to our important and sensitive coastal areas and communities.

This national infrastructure network is managed and maintained by a wide range of public and private sector organisations, as well as private owners. Some of the structures within this network have been specifically constructed for coastal flood and/or erosion protection. Others have been constructed for another primary purpose, such as railway embankments and highway retaining walls, but provide a degree of coastal defence as a secondary function.

Coastal defence and protection at individual locations can consist of individual structures such as walls and embankments, but in many locations is provided by a complex interaction between the foreshore conditions and the defences. Foreshore conditions can include offshore structures, groynes, salt-marsh and beaches. These can help to manage the movement and loss of sediment, as well as dissipate wave energy before it hits the defence line. The flooding to Aberystwyth in January clearly demonstrated the destructive power of high energy waves.

At some locations there may be a primary defence line/structure, which provides the majority of the protection, in particular to still water levels, which is supplemented by secondary defences set back inland, such as walls and embankments. These secondary defences can help to control the volume of water accumulating from wave spills for

example. At some locations coastal protection is provided by manual interventions such as closing of tidal doors and installation of barriers or '*stop logs*'.

Overview of Coastal Defence Performance during these storms

The Phase 1 Report identified that overall performance of the national defence network was good, with many thousands of properties and thousands of hectares of agricultural land protected.

There was however a very significant impact on coastal features and the coastal environment.

The Minister's statement in response to the Phase 1 Report is available at:

http://wales.gov.uk/about/cabinet/cabinetstatements/2014/flooding/?lang=en

The headline messages from the Phase 1 Report are included in **Annex A.**

There were exceptions where defences did not function as they should and people, property, infrastructure and farmland were affected. The local distress, suffering to individuals and disruption to communities was significant and not to be under estimated. Some individuals are still to return to their homes.

The two most notable locations where raised defences were overwhelmed are:

- Rhyl – Garford Road and surrounding area in December 2013 and.
- Llanbedr in January 2014.

These are discussed below.

Circumstances associated with the flooding of Rhyl on 5th December 2013

Natural Resources Wales has reviewed the information provided by Denbighshire County Council in the following report:

Flooding to properties in Rhyl
(A548 Coast Road, Garford Road and surrounding areas) 5th December 2013
Report by Head of Highways and Environmental Services
Denbighshire County Council

A copy of this report can be obtained from Denbighshire County Council.
https://www.denbighshire.gov.uk/en/resident/home.aspx

We have also inspected the site and have carried out our own analysis. From this we agree with the general mechanism of flooding on 5th December 2013 as identified by the Denbighshire Report, in that:

- Large volumes of water flowed into the storage lagoon between the properties and the sea wall promenade. This was a combination of waves spilling over the sea wall and water flowing through the openings created by the stairwells and potentially Garford Road slipway.

- The outflow from the storage lagoon area to the east and onto the golf course was impeded by the chain link fence and accumulation of debris.

- Water levels in the storage lagoon were sufficient to flow over the secondary defence, in particular via access paths over this defence.

- The wall at the end of Garford Road collapsed.

The flows into the storage lagoon were from a combination of wave over topping and water flowing through the two openings created by stairwells opposite Garford Road and Hilton Drive, plus potentially from the Garford Road slipway.

The two stair wells had stop boards installed on two sides but not the third. We understand that this was left open, partly to provide a route for some *'wave splash'* to return back to the sea. It is reported that the slip way had stop boards installed but these are understood to have been '*blown out'* at some time during the storm.

There is considerable uncertainty as to the contribution of flows to the storage lagoon from the slipway. This had the potential to contribute the largest proportion of flow from the three openings due to its breadth. However, this is complicated by the unknown timing of the 'blow out' of the stop boards and the impacts of its location downstream of the chain

link fence and the prevailing west to east wind direction. The two latter factors would have tended to direct flows into the golf course itself, rather than directly into the storage lagoon.

We have concluded that the amount of inflow from these three openings would not have substantially altered the mechanism of the flooding; it would have had some impacts on the timings but we do not think these would have significantly impacted the resultant flooding or response. The impact of flows through these openings should be considered as part of a detailed hydraulic assessment of the storage system as a whole.

It is clear from site inspection that the storage lagoon has been deliberately '*engineered*' to collect spilled water and convey it to the east onto the golf course. This is confirmed by the Denbighshire Report which includes the following statement:

The houses are also protected by a secondary sea defence system that was constructed by Rhuddlan borough council in response to the 1990 flood event. Its stated purpose was "to divert overtopping flows from the Splash Point Inn Car Park on to the Rhyl Golf Links"

Details of the design of the storage lagoon and the associated assumptions have not been available for this review.

From inspection on site and by consideration of aerial photographs and plans, it is clear that the storage lagoon area is relatively small. At the time of its construction its size was probably constrained by the adjacent properties.

The overall hydraulic effectiveness of this storage lagoon system is, in part, dependent on the flow path into and across the golf course. We do not know what ground levels and flow paths into and across the golf course were included in the original design of this storage lagoon system. We do not know what standard of protection or capacity the storage lagoon system was designed to achieve.

.

Rec.24	**Options to seek improvements to the standard of protection at the Garford Road area of Rhyl should be identified and evaluated. This should include detailed hydraulic analysis of the capacity and performance of the storage lagoon. This should include an assessment of the stairwell and slipway openings and the interaction with the adjacent golf course area.**

The December flooding at this location has also highlighted two further issues for consideration here and elsewhere in Wales

There needs to be a national review of potential 'weakness' in defence systems posed by demountable stop boards, stop logs or moveable gates.

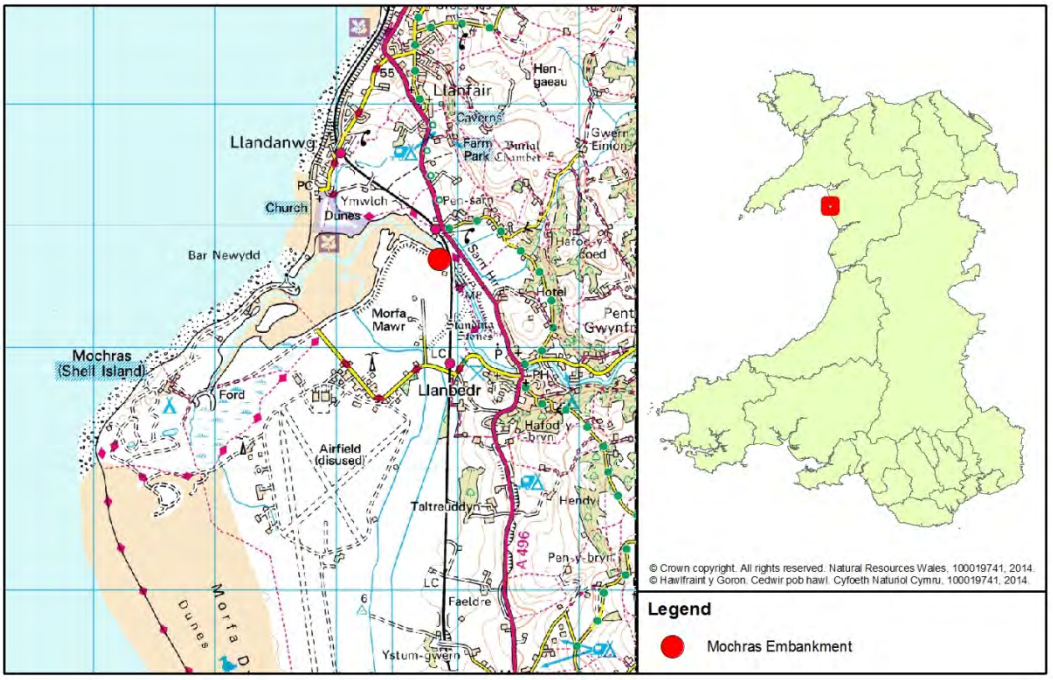
Rec.25	**All Risk Management Authorities (RMAs) around Wales should review their local use of stop boards, stop logs, temporary barriers or moveable gates. The purpose of this review is for RMAs to satisfy themselves that existing arrangements are appropriate and robust. Consideration should be given to replacing existing arrangements with more permanent or more robust temporary solutions. This review should be 'risk based' and focused on the locations with highest local risk.**

There needs to be a national review of local awareness and understanding of 'secondary defence systems' such as the local storage lagoon at Rhyl and the ability for them to perform as designed when needed.

Rec.26	**All Risk Management Authorities (RMAs) around Wales should review locations where they have secondary defence systems in place. The purpose of this review is for RMAs to satisfy themselves that the secondary systems will operate as designed when required. This review should be 'risk based' and focused on the locations with highest local risk.**

Circumstances associated with the flooding of Llanbedr in January 2014

In January 2014 the Mochras flood bank at Llanbedr in north west Wales was breached over a length of approximately 50m, as a consequence four properties were flooded, along with significant areas of agricultural land twice daily under high tide conditions.



This section of embankment has been in place for many years. It is believed it was originally constructed using locally sourced material (i.e. river gravel silts and clays etc.). with the design height defined from previous flood event levels. The flood bank as a whole is a grass earth embankment with reasonably wide crest widths and, although slender in places the front and back slopes are acceptable.

The majority of the seaward face is reinforced by a stone berm and stone *'rip rap'* that extends two thirds up the height of the embankment. The purpose of this is to reduce wave impact and bank erosion. The stone rip rap does not extend along the whole length of the embankment and the more sheltered section does not include this stone rip rap

In the immediate aftermath of the storm, a helicopter was used to position giant, industrial-sized sandbags to fill the gap ahead of further predicted high tides.

In early April work to repair the breach was completed. This was a challenging project due to the difficult access conditions and the hostile tidal environment. The works required around 12 weeks to complete and involved construction of an access road to the breach and 15,000 tonnes of boulders, clay and soil.

The new section of the bank has been reinforced with a solid clay core, strengthened with boulders and covered with topsoil to bring it back to the required level of flood protection.

Over coming months engineers will monitor its performance.

Overview of Flooded Locations

The table below provides an overview of the locations that experienced the higher numbers of property flooding in December 2013 and January 2014.

This table is not intended to be fully inclusive of all property flooding.

Options to improve local flood risk management will be evaluated as appropriate by the relevant lead risk management authority.

Table 5: Overview of locations that experienced the higher numbers of property flooding in December 2013 and January 2014.

Community name	No properties flooded	Local Authority	Which event
Rhyl (Splash Point)	138 homes	Denbighshire	Dec'13
Kinmel Bay	8 homes, 1 supermarket	Conwy	Dec'13
East of Pwllheli	Caravan park	Gwynedd	Jan'14
Llanbedr	4 homes plus farms	Gwynedd	Jan'14
Barmouth	15 homes, 2 commercial	Gwynedd	Jan'14
Borth	12 homes, 2 non-residential	Ceredigion	Jan'14
Aberystwyth	23 properties (typically basement flats)	Ceredigion	Jan'14
Aberaeron	7 properties	Ceredigion	Jan'14
Cardigan	30 properties	Ceredigion	Jan'14
Lower Town Fishguard	13 homes, 2 non-residential	Pembrokeshire	Jan'14
Little Haven	4 homes, 3 non-residential	Pembrokeshire	Jan'14
Amroth	4 homes, 1 caravan park, 1 non-residential	Pembrokeshire	Jan'14
Carmarthen Bay Holiday Park nr Kidwelly	70 chalets, 6 static caravans flooded.	Carmarthenshire	Jan'14

Overview of ‘Near Miss’ locations

The table below provides an overview of the locations which responses to this review have identified as coming close to more significant flooding in either December 2013 or January, i.e. ‘near miss’ locations.

Cyfoeth Naturiol Cymru Natural Resources Wales

Table 6: Overview of 'near miss' identified in December 2013 and January 2014.

Community name	Local Authority	Which event
Talacre	Flintshire	Jan'14
Prestatyn (Tower Gardens, Central Beach)	Denbighshire	Dec'13
Llanfairfechan	Conwy	Dec'13
Hen Wrych	Conwy	Dec'13
Pensarn Shingle Bank	Conwy	Dec'13
Abererch and Traeth Crugan	Gwynedd	Jan'14
Borth-y-Gest	Gwynedd	Jan'14
Morfa Bychan	Gwynedd	Jan'14
Ceredigion - all	Ceredigion	Jan'14
Saundersfoot	Pembrokeshire	Jan'14
Loughor, Machynys, Llanelli Beach, Burry Port, Llansteffan and Pendine.	Carmarthenshire	Jan'14
Mumbles	Swansea	Jan'14
Swanbridge	Vale of Glamorgan	Jan'14
Sandy Bay, Porthcawl (Coney Beach fairground)	Bridgend	Jan'14
Shaftesbury and Crindau	Newport	Jan'14
Talacre embankment	Flintshire	Dec'13
Dock Rd at Connah's Quay	Flintshire	Dec'13
Northern and Hawarden Embankments along Dee from Connah's Quay to Chester	Flintshire	Dec'13
Abererch	Gwynedd	Jan'14
Carreg Y Defaid (west of Pwllheli)	Gwynedd	Jan'14
Porthcawl	Bridgend	Jan'14
Newton (nr Porthcawl)	Bridgend	Jan'14
Clarach	Ceredigion	Jan'14
Penparcau, Aberystwyth	Ceredigion	Jan'14
Llanstephen South	Carmarthenshire	Jan'14
St Clears	Carmarthenshire	Jan'14
Pembrey and Loughor	Carmarthenshire/ Swansea	Jan'14
Caerleon	Newport	Jan'14
Chepstow	Monmouthshire	Jan'14

Strategic Framework for Decision Making on the Coast

Shoreline Management Plans (SMPs) are non-statutory policy documents for coastal defence management planning. They provide a large-scale assessment of the risks associated with coastal evolution and present a policy framework to address these risks to people and the developed, historic and natural environment in a sustainable manner.
The first edition SMPs were created in the late 1990s/early 2000's.

The second edition plans (SMP2s) were produced by consultants for Coastal Groups in Wales from typically 2005 onwards and largely funded by Welsh Government. There are five Coastal Groups in Wales and these are illustrated on **Map 5** below.

For the exercise of SMP2 development the Ynys Enlli to Great Orme Coastal Group collaborated with the Cardigan Bay Coastal Group, resulting in four SMP2s for Wales namely:

- SMP no 19: Anchor Hard to Lavernock Point, being the 'Severn Estuary' SMP2

- SMP no 20: Lavernock Point to St Ann's Head, being the 'South Wales' SMP2 available at: http://www.southwalescoast.org/content.asp?id=58
- SMP no 21: St Ann's Head to the Great Orme, being the 'West of Wales' SMP2 available at: http://www.westofwalessmp.org/content.asp?nav=23&parent_directory_id=10
- SMP no 22: The Great Orme to the Scottish Border, being the 'North Wales and North West England' SMP2 available through contacting coastal Local Authorities within this geographic area.

These four SMP2s for Wales have been adopted locally by respective Local Authorities. but none have been formally signed off by Welsh Government as yet.

SMP2s consider a 100 year timeframe across 3 epochs for proposed management of our coastline. These epochs are:

- Epoch 1 (short-term) = years **0 to 20**.
- Epoch 2 (medium term) = years **20 to 50** and;
- Epoch 3 (long term) = **50 to 100**.

One of four policies can be applied per epoch to each coastal management unit (i.e. defined length of coastline) and these policies are:

- **No Active Intervention (NAI)**: where there is no planned investment in coastal defences or operations, regardless of whether or not an artificial defence has existed previously.
- **Hold the Line (HTL)**: an aspiration to build or maintain artificial defences so that the current position of the shoreline remains.
- **Managed Realignment (MR):** by allowing the shoreline to move backwards or forwards naturally, but managing the process to direct it in certain areas.
- **Advance the Line (ATL)**: by building new defences on the seaward side of the original defences.

The SMP2 policies for the three epochs are illustrated **on Maps 6, 7 and 8** below.

The pace at which change occurs around the coast will be very dependent upon the future rate of climate change impacts, such as increased sea levels and storm effects. The epochs provide an indication of this '*pace*' in terms of short, medium and long term timescales.

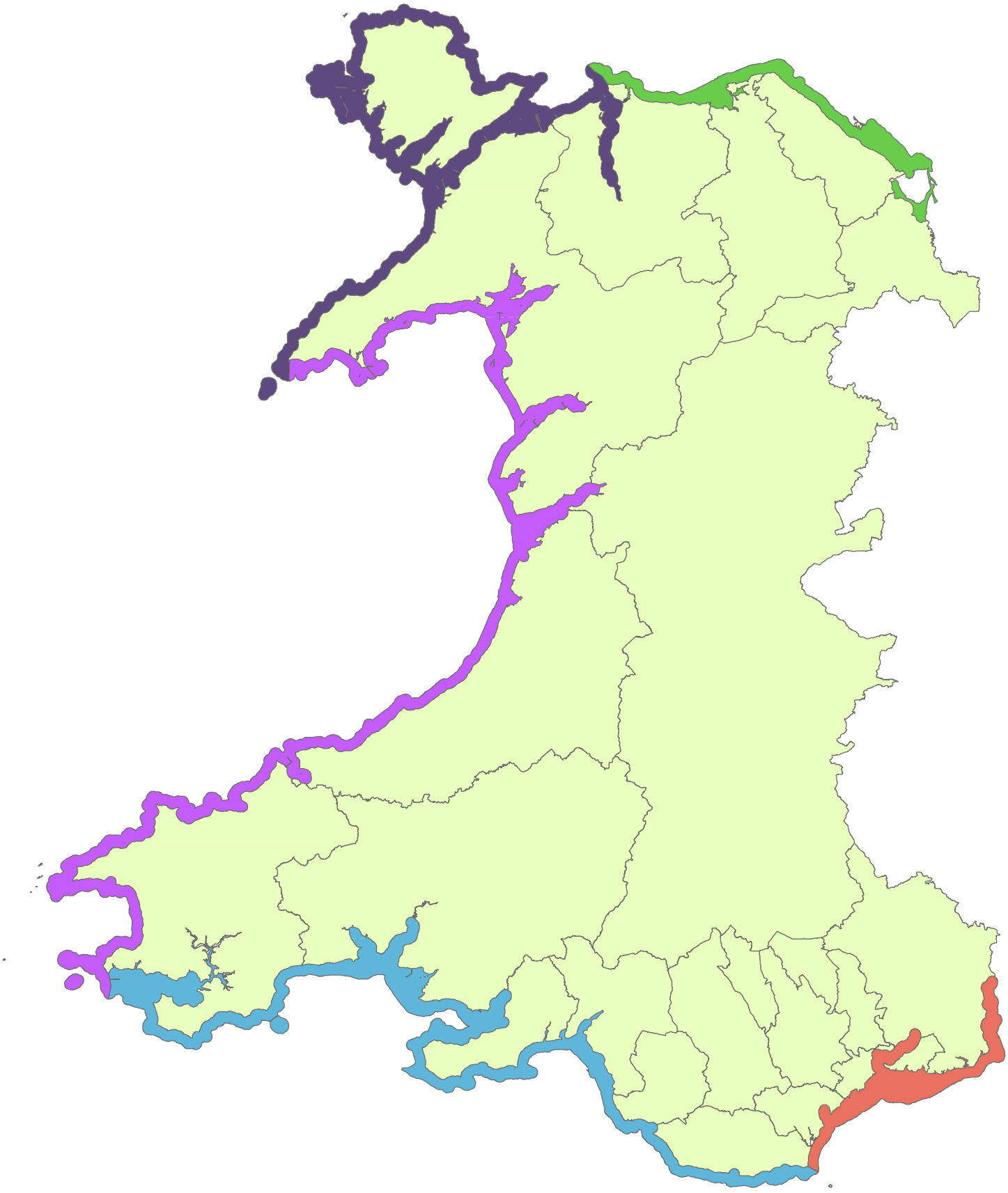
Some of the changes around the coast may require significant timescales to prepare, plan and deliver effectively.

All of the above policies will incur costs (NAI), or require significant national investment to deliver. These policies do not include any commitment to future funding. Future investment will continue to be subject to tests of value for money, affordability and prioritisation.

When considered together, the *'epochs'* and the *'policies'* represent the important strategic framework for flood and coastal erosion risk management decision making around the coast.

Cyfoeth Naturiol Cymru
Natural Resources Wales

Map 5 - Wales Coastal Groups



Legend

Wales Coastal Groups

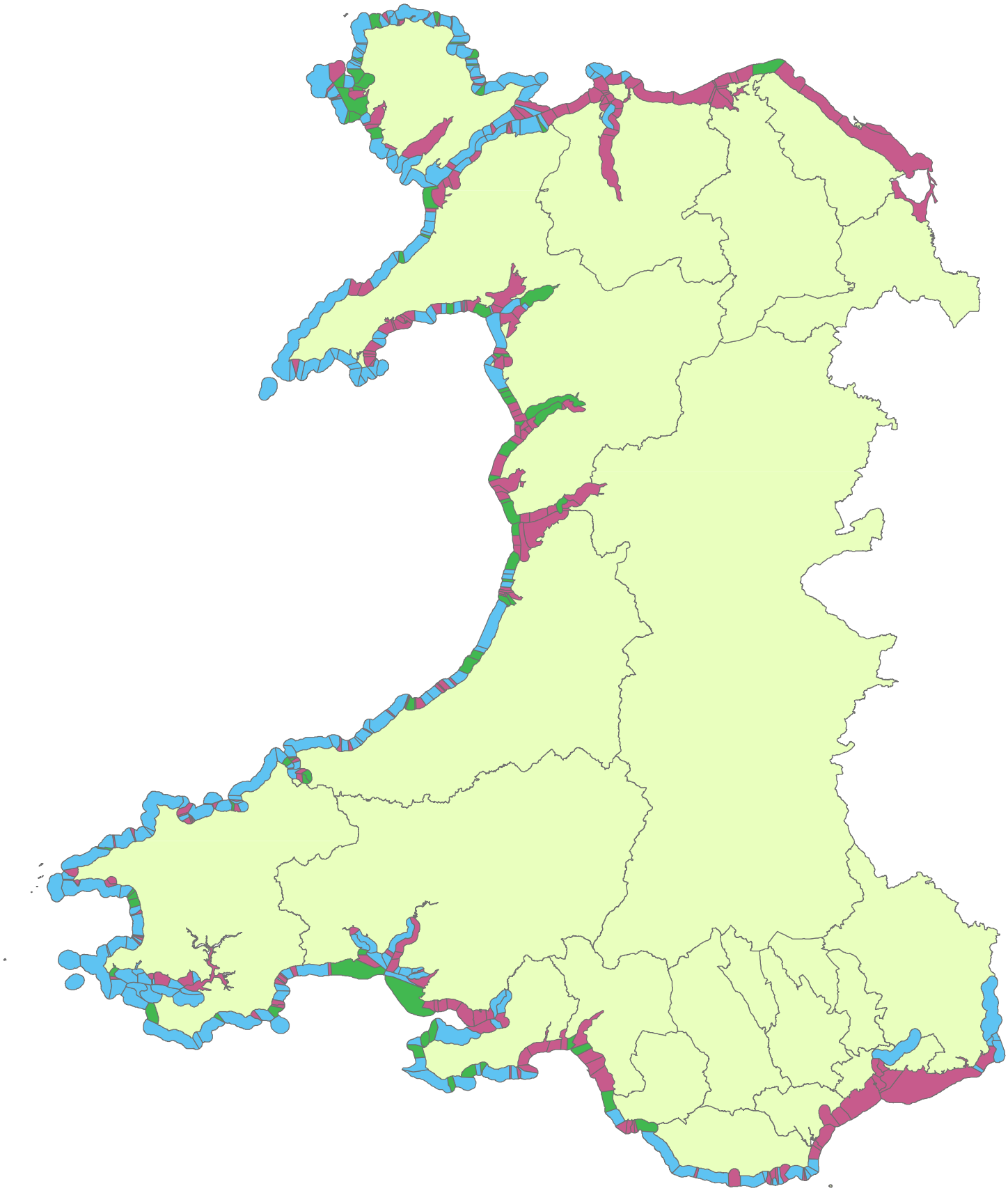
- Liverpool Bay Coastal Sub-Group
- Ynys Enlli to Great Orme Coastal Group
- Cardigan Bay Coastal Group
- Swansea and Carmarthen Bay Coastal Engineering Group
- Severn Estuary Coastal Group

0 5 10 20 30 40 50 Kilometres

N

Cyfoeth Naturiol Cymru
Natural Resources Wales

Map 6 - Shoreline Management Plans - First Epoch



Legend

Shoreline Management Plans

0-20 year policy

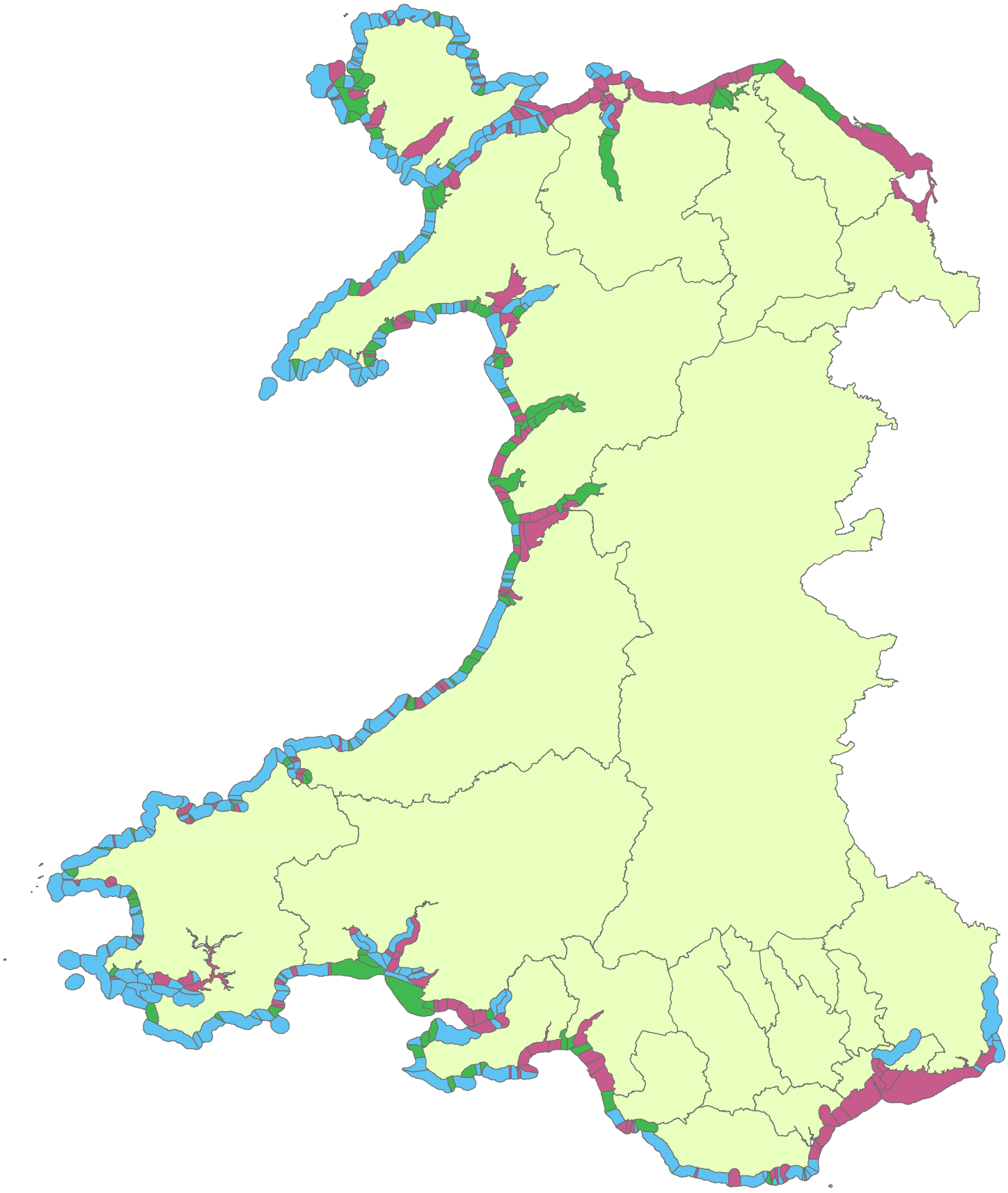
- Hold the Line
- Managed Realignment
- No Active Intervention

0 5 10 20 30 40 50 Kilometres

N

Cyfoeth Naturiol Cymru
Natural Resources Wales

Map 7 - Shoreline Management Plans - Second Epoch



Legend

Shoreline Management Plans

20-50 year policy

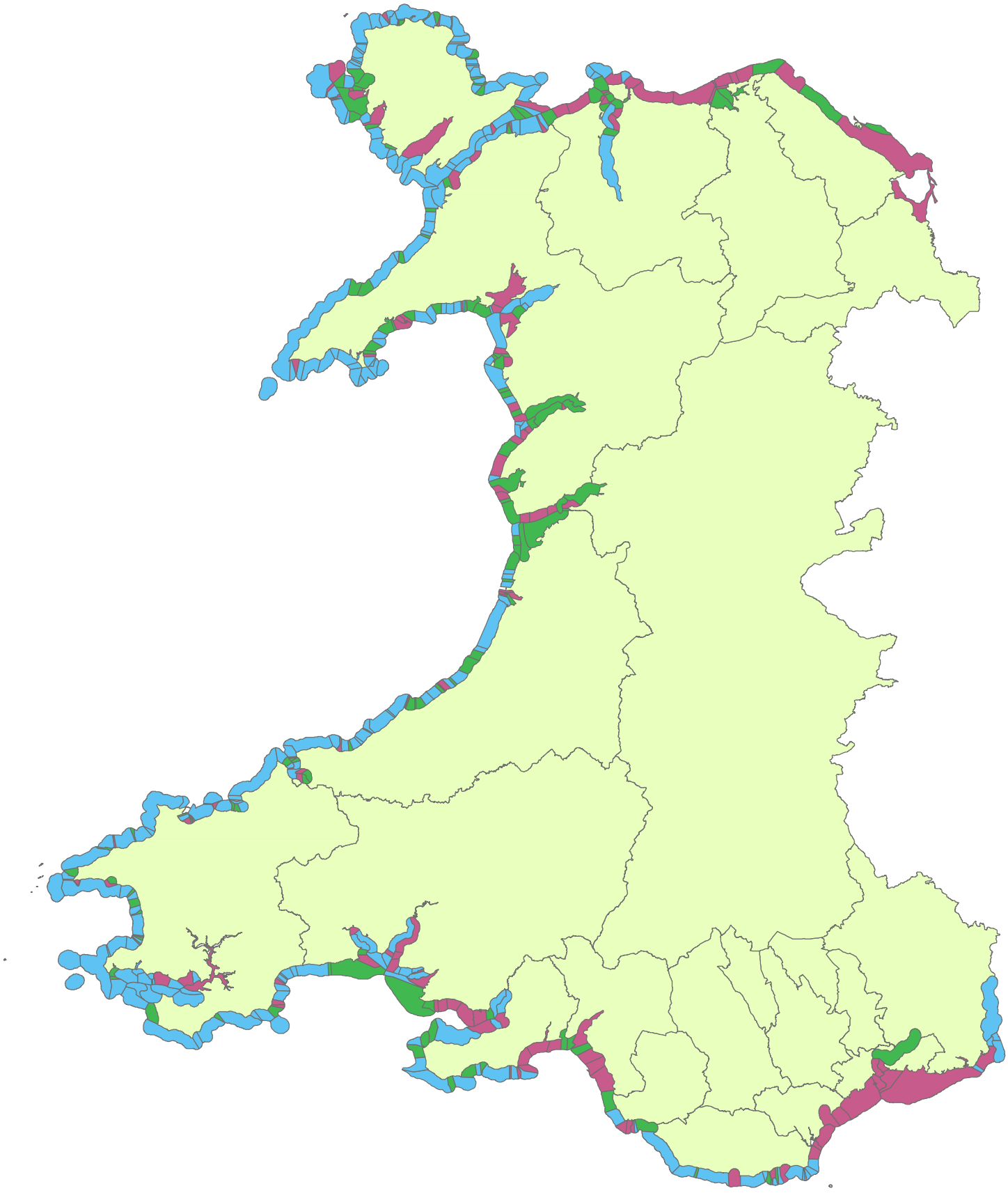
- Hold the Line
- Managed Realignment
- No Active Intervention

0 5 10 20 30 40 50 Kilometres

N

Cyfoeth Naturiol Cymru
Natural Resources Wales

Map 8 - Shoreline Management Plans - Third Epoch



Legend

Shoreline Management Plans

50-100 year policy

- Hold the Line
- Managed Realignment
- No Active Intervention

0 5 10 20 30 40 50 Kilometres

N

Issues and Recommendations – Coastal Defences

Sustained investment in coastal flood and erosion risk management:

Experience from these recent storms has illustrated the considerable national benefit provided by the network of flood and coastal erosion defences. It has also identified the benefits of the full range of flood and coastal risk management activities around the coastline of Wales.

Coastal incidents such as these recent storms in December 2013 and early January 2014 and worse, will happen again in the future. Climate change projections suggest more frequent coastal flooding.

Therefore, there needs to be continued sustained investment to manage these national coastal risks to acceptable levels. This must include flood forecasting, warning, awareness, response and recovery, as well as flood defences. Particular focus has to be on the existing defences to ensure they continue to be fit for purpose, as well as investment in new defences to reduce the flood risk for more locations.

Rec.27	**There needs to be continued sustained investment to manage the national coastal risks to acceptable levels.** **This must include flood forecasting, warning, awareness, response and recovery, as well as flood defences. Particular focus has to be on the existing defences to ensure they continue to be fit for purpose, as well as investment in new defences to reduce the flood risk for more locations.**

In addition the following needed to be considered in relation to future investment:

- Increased certainty in budgets over a longer time frame and increased flexibility between capital and revenue expenditure.
- Increased clarity and transparency of all Flood and Coastal Erosion Risk Management (FCERM) investment allocation, decision making and prioritisation.
- There is a need for additional funding to supplement core national FCERM investment.

These aspects are discussed below.

Increased certainty in funding over a longer time frame and increased flexibility between capital and revenue expenditure:

Many of the investments required around the coast already require significant time to prepare, plan and complete. In the future this is likely to become more complex, as we collectively seek to manage and deliver the adaptation of the coast.

Any uncertainty and constraint on the availability and use of funding does impact on efficient and effective delivery of FCERM outcomes.

Increased confidence and certainty in the availability of future funding and increased flexibility in the use of this funding would significantly help to maximise efficient and effective delivery.

This would need to be set within a framework which ensures public funds are invested appropriately.

Rec.28	**Review and identify options to maximise certainty in flood and coastal erosion risk management funding over a longer timeframe and to maximise flexibility in the use of this funding. This would mean less focus on annual and in year budgets and more focus on delivery and budget management of 3-5 years.**

There is a need for increased clarity and transparency of FCERM investment allocation, decision making and prioritisation:

FCERM investment in Wales is primarily allocated nationally to meet national objectives.

As identified earlier in this report, the national objectives are set out in the Welsh Government's National FCERM Strategy published in November 2011, (the National Strategy)

This National Strategy identifies the following four overarching objectives:

- **reducing the consequences** for individuals, communities, businesses and the environment from flooding and coastal erosion.
- **raising awareness of and engaging people** on flood and coastal erosion risk.
- **providing an effective and sustained response** to flood and coastal erosion events; and
- **prioritising investment** in the most at risk communities.

Broadly the national funds are allocated by Welsh Government to Natural Resources Wales and the Local Authorities. In recent years investment levels have been sustained and included successful bids for European funding and allocations from the Wales Infrastructure Investment Programme.

However, the **decision making process** for investment in flood and coastal erosion risk management activities needs to be:

- **more fully risk based** to meet the national objectives. With appropriate consideration given to all sources of flood risk, including coastal, main rivers and smaller watercourse, surface water, reservoirs as well as coastal erosion.

- **more efficient and effective** – making the more of the funds we have available.

- **more clear and transparent** to communities affected by flooding and the associated management decisions. Lack of clarity and transparency of decision making does lead to frustration and anger in communities who do not receive the flood risk solution they want and expect public service to provide for them.

These issues are already recognised by Welsh Government and the mechanism for addressing these issues is the National Strategy Objective four, '**prioritising investment in most at risk communities'** and sub-objective 10, '**Develop a National Programme of investment for flood and coastal erosion risk management**'.

This Review supports this approach.

We recommend that the development of the National Programme of Investment should be progressed as a matter of importance and its development should seek a wide range of ways of working and technical improvements to the FCERM investment allocation, decision making and prioritisation process.

Some of these aspects are identified below:

- Coastal flood risk must be placed in its appropriate position alongside other sources of flooding. This must be risk based but address the challenge of typically low likelihood but high consequence flooding alongside more high likelihood but low consequence type incidents.
- The national investment programme should drive behaviours and *'ways of working'* which require partners to work together and deliver multiple benefits.
- The national investment programme should drive behaviours and decisions which are consistent with the long term strategic direction of travel and adaptive to uncertainty. In particular the range of uncertainty associated with sea level rise around the coast.
- Consider how additional sources of funding to supplement the core FCERM investment will be incorporated (see next recommendation).
- The approach to be adopted for additional local and national funding contributions
- Governance structure which is proportionate and representative.
- Deliver maximum transparency to the people of Wales. Ensuring communications back to affected and impacted communities are clear.
- Grant rates are currently complex and variable; these should be reviewed and simplified.
- Consistent investment Appraisal Guidance to be used by all Welsh RMAs seeking funding.
- Address what support and advice will be available to communities which do experience flooding but are not among the most at risk communities.
- Consider opportunities to improve efficacy and effectiveness in how projects and programmes of investment are managed and delivered.

Rec.29	**The development of the National Programme of Investment should be progressed as a matter of importance and its development should seek a wide range of ways of working and technical improvements to the flood and coastal erosion risk management investment allocation, decision making and prioritisation process.**

There is a need for additional funding to supplement core national FCERM investment:

In recent years investment levels in FCERM nationally have been sustained and have included successful bids for European funding and allocations from the Wales Infrastructure Investment Programme.

However there is a substantial network of coastal defences which requires investment under increasing demands as future projections are for increasing risk and the need for managed adaptation of the coast.

The '*Future flooding in Wales: flood defences"* report produced by Environment Agency Wales in 2010 considered the impacts on flood risk of different investment scenarios up to 2035. In 2010 this assessment concluded:

"To maintain the numbers of properties at flood risk in 2035 at levels comparable to present day may require around three times the current level of investment in flood defences'.

Both the Phase 1 Report and this Phase 2 Report have identified the scale and extents of the coastal risks to Wales are of national importance and that these risks are projected to increase. The national management of these risks by the network of defence infrastructure and the associated risk management activities are all essential to sustaining community health and well-being, jobs and economic growth and tourism in our coastal areas.

The important multi-faceted benefits provided by the national FCERM service around the coast were recognised by the funding package announced by the Minister following the Phase 1 Report. This included contributions from tourism and economic regeneration.

There is a need for additional funding to supplement core national FCERM investment. This may came from both private and public sources as well as from local, national and European opportunities.

Rec.30	**Review and identify options to gain additional funding to supplement core FCERM investment. This must be closely aligned with the development of the National Programme for Investment.**

There is a need for a more consistent and complete all Wales dataset which contains the essential management information for our entire national network of coast protection and defence assets:

The national network of coastal defences consists of a complex interaction of many man-made and natural components. In many locations coastal defence is provided by a *'system'* of inter-connected and/or inter related individual components. The standard of protection to the inland areas is primarily dependent on the weakest point in the coastal system.

Some of the coastal defences have been specifically designed for flood and erosion protection purposes. Others contribute to this as a secondary function to their primary purpose e.g. railway embankments and highway retaining walls. Some of the coastal defences are fixed, i.e. walls and embankments, whilst others contain movable structures such as gates, doors and *'stop logs'*. Some sections of the coast have *'primary'* defences such as a sea wall supplemented by *'secondary'* defences set back further inland, e.g. to help to manage localised wave overspill, such as at Rhyl.

In some locations the natural foreshore, beach and dune systems can provide or support local coast protection and defence. These systems can by their very nature be dynamic and subject to changes. This was clearly demonstrated by the substantial quantities of beach and dune movement identified during the Phase 1 Review.

There is a need for a more consistent and complete all Wales dataset which contains the essential management information for our entire national network of coast protection and defence assets. This dataset should also include information on the areas benefitting from these defences.

This improved dataset is essential for delivery of a more efficient and effective risk based coastal risk management service.

Rec.31	**Produce a complete national dataset of coastal protection and defence assets including details of areas benefitting.** **It is essential that this dataset becomes a 'live management tool' and not merely a representative picture of a snapshot in time. This dataset must therefore be associated with a process for ensuring the information is maintained.**

There is a need for a more consistent approach to the inspection of the national network of coastal defences:

The national network of coastal defences is managed and operated by multiple partners.

These partners are a diverse mix of public bodies, private organisations and individuals. As a consequence there is an inconsistent approach to coastal asset condition assessment across all the responsible partners.

A more consistent approach to asset inspection has the potential to offer efficiency savings, with asset systems in multiple ownership being inspected once for all, rather than on multiple occasions.

A more consistent approach to asset inspection is essential for delivery of a more efficient and effective risk based coastal risk management service.

Rec.32	**Review and identify options to achieve a more consistent approach to the inspection of the network of coastal defence systems. This must include recommendations to improve the efficiency and effectiveness of the asset inspection process.**

There is a need to continue to improve the quality of coastal flood risk mapping to better understand and therefore manage the risk:

Effective and efficient flood risk management decisions require accurate understanding of the risks. The technology of coastal modelling and mapping continually develops.

Risk is a combination of the likelihood of an occurrence, in this case flooding and its consequence. The mechanisms of coastal flooding can be complex including elements of wave overtopping and the risk of localised breach of defences, as occurred at Llanbedr in January 2014.

Coastal modelling and mapping is in place for all Wales. However some of this is based on simplified modelling approaches which may under or overestimate the true risk.

Inappropriate information about risk can result in inappropriate risk management decisions.

This work is essential to support national coastal asset dataset described above.

Rec.33	**Continue to develop a nationally prioritised programme of coastal modelling and mapping improvements. This must be nationally risk based and consistent.**

There is a need to review the standard of coastal flood defence protection in locations that flooded in December 2013 and early January 2014:

The storm events of December 5th 2013 and early January 2014 resulted in property and community flooding as well as locations with substantial change to the foreshore and beach areas in particular.

The risks of coastal flooding following these storms have now changed from the pre-storm condition. In some locations the risks may now be greater than before these storms

Consequently it may be appropriate to invest in further flood risk management activity.

Rec.34	**Locations and communities which experienced flooding in December 2013 and early January 2014 should be subjected to a risk based assessment to determine if further risk management activity/intervention is needed and can be justified.**

There is a need to review the standard of coastal flood defence protection at 'near miss' locations that flooded in December 2013 and early January 2014:

The storm events of December 5th 2013 and early January 2014 resulted in some 'near miss' locations as well as locations with substantial change to the foreshore and beach areas in particular.

The risks of coastal flooding following these storms have now changed from the pre-storm condition. In many locations the risks may now be greater.

Consequently it may be appropriate to invest in further flood risk management activity.

Rec.35	**Near miss locations and locations subjected to substantial foreshore change should be identified and subjected to a risk based assessment to determine if further risk management activity/intervention is needed and can be justified.**

There is a need to capture a more complete assessment of the environmental changes due to the December 2013 and early January 2014 storms:

The Phase 1 Report identified the scale and extent of the storm impacts and change on the coastal environment, although some impacts, such as impacts on seabirds were not apparent at that time.

This Phase 1 assessment was carried out in a limited time and should be updated to capture a more complete picture of the environmental change experienced during the December 2013 and January 2014 storms.

A follow up Natural Resources Wales Evidence Report describing the environmental change in more detail, and setting out a series of recommendations is in preparation and will be completed by June 2014. It is expected this evidence report will include recommendations, for example on matters such as ongoing monitoring of change, impacts and recovery.

Rec.36	**Complete the ongoing update to the Phase 1 'rapid' assessment of environmental changes experienced during the December 2013 and January 2014 storms.**

There is a need to improve the understanding of the national skills and capacity in coastal flood and erosion risk management:

This Phase 2 review has identified concerns within the risk management '*community'* about the breadth and depth of skills and capacity in the coastal risk management authorities.

The national *'pool of resource'* was significantly tested by these recent storms.

In some cases these specialist areas of skill and expertise are vested in a small number of individuals. This area of concern also includes matters of succession planning and training.

The skills and capacity of the national resource will impact on delivery of the present day service and the future challenges.

Rec.37	**Carry out a national skills and capacity audit for all Risk Management Authorities to assess and quantify the scale of the issue – to assess the size of the skills and capacity gap** **Produce an options document for how the skills and capacity gap could be addressed to meet present day flood risk management needs and future challenges.**

There is a need to improve the clarity of roles and responsibilities around the coast:

It has been noted above that the national network of coastal defences and the flood risk management service as a whole is complex and multi-faceted. In some locations and aspects of work this has contributed to a lack of clarity about roles and responsibilities.

This lack of clarity can in part contribute to community confusion and frustration.

Improved clarity of roles and responsibilities will also improve the efficient and effective delivery of flood and coastal risk management outcomes.

Rec.38	**Clarify roles and responsibilities amongst risk management authorities at both the local and national level as required.** **Develop consistent and common communication messages and tools to convey roles and responsibilities to communities.**

There is a need to review established professional partner groups around the coast:

There a number of groups established with a role in managing flood and coastal erosion risks. In particular, these include:

- Five Coastal Groups
- The Wales Coastal Group Forum

There is a need for professional partners to work together.

However, the December 2013 and January 2014 coastal incidents are amongst the most significant in recent years and this Phase 2 Review has identified the scale of the present day and future coastal risk management challenges.

It is therefore appropriate that the membership and terms of reference of these groups should be reviewed to ensure they contribute most effectively to management of the national and local coastal risks.

This review should also consider, as appropriate, links and relationships with other similar groups who have a role in management of flood and coastal erosion risks.

Rec.39	**Undertake a review of Welsh Coastal Groups and the Wales Coastal Group Forum. This review should include, as appropriate, links and relationships with other similar groups who have a role in the management of flood and coastal erosion risks.** **This review should identify improvement options to maximise efficient and effective delivery of flood and coastal risk management.**

There is a need to evaluate options and make recommendations to better meet the coastal monitoring needs of Wales. This should include consideration of an enhanced Wales Coastal Monitoring Centre in its present form and other alternative options:

The Wales Coastal Monitoring Centre (WCMC) is funded by Welsh Government and was established following recognition by the Wales Coastal Groups Forum of the need to improve the co-ordination of coastal monitoring data collection, storage and analysis in Wales. Its aim is to establish a framework necessary to provide good quality information on coastal change that will help inform flood and coastal risk management decisions.

WCMC is hosted by Gwynedd Council and became operational in January 2010.

Since its establishment WCMC has actively engaged with a wide range of coastal practitioners, both within Wales and across the UK. The WCMC has received support from Welsh coastal practitioners as to its aims and purpose.

However it has proven to be challenging for the WCMC as it is currently structured and resourced to meet the hopes, aspirations and expectations of partners across Wales.

Coastal monitoring will become increasingly important as our coastline seeks to adapt to climate change.

It is important therefore, that the future role and responsibility of the WCMC is clearly defined to meet the needs of Wales; that this is communicated to all partners and it is structured and resourced to meet these needs.

Rec.40	**The Wales Coastal Monitoring Centre submitted a business case for the future of the centre to Welsh Government in December 2013. This business case should be determined by Welsh Government.**

There needs to be more locally developed and delivered plans for coastal communities, to better enable them to adapt to the increased risks due to climate change. These need to be supported locally and nationally, and set in the strategic framework provided by Shoreline Management Plans.

Future flood risks around our coast will increase, primarily as a result of the climate change projections of sea level rise. Climate change is also expected to increase the volatility of our weather and the energy in coastal storms. This will increase the risk to our coastal assets and the costs to maintain them to acceptable standards.

These increasing risks mean it will not be affordable or acceptable in terms of risks to defend the entire coast at all locations into the future. We must adapt our coastline in response to these increasing risks. It will be necessary to deliver this local adaptation in the context of significant uncertainty in the pace and magnitude of these future increases in risk. There is no simple pre-determined timeline for the changes.

Messages around climate change, increasing risk and adaptation of the coast, involving no active intervention or managed realignment policies are extremely difficult for communities and individuals affected. This is understandable, as these policy positions directly impact on communities, individuals lives, property and business and their view of their future and the future of their families.

The Shoreline Management Plan review process (SMP2) investigated the factors impacting on our coast in considerable technical detail and provide a compelling evidence base for the future risks to the coastline of Wales.

Considerable effort was also put into local consultation and engagement during the production of these Plans. However, despite this, more work is needed to engage and work with communities affected to help them understand the drivers for change and to support them in the local adaptation process.

In the term '*Managed Realignment'* the word managed is extremely important. It means there must be a Plan to deliver the realignment/adaptation (*a local adaptation plan*) and this must be fully supported by a community inclusive communication and engagement strategy.

The word '*managed*' also means this is a process overtime and not an instantaneous event. There is no single moment in time when this adaptation will happen. The SMP2s use three timescales, effectively short, medium and long to indicate the likely urgency of the change needed.

It is important that these local adaptation plans include consideration of the local drivers for change and set appropriate trigger or decision points. It is important these are established and widely discussed in advance of the decisions themselves.

For example, such trigger or decision points could be around sea level rise increasing local groundwater levels. These would be monitored to establish the pace and rate of the local change and appropriate, pre-determined actions set for implementation according to projected increased levels.

Alternatively, decision points could be set around the frequency of operation of demountable defences or movable gates. The frequency of operation being indicative of increasing risks and pre-determined actions identified for implementation when the frequency of operation reaches a pre-determined value.

- More needs to be done to provide national and local support to better help communities in coastal areas adapt over time to increasing risk and change.

- It is essential that the community are involved in the development of local adaptation options. This work could identify positive benefits and opportunities as well as negatives associated with adaptation over time.

- It is essential that local adaptation plans are set in the context of the strategic framework established by SMP2.

All of the coastal communities around Wales will need to consider the local impacts of their increasing risks and the implications of the local challenges as set out within the SMP2.

Local discussions need to begin now, involving professional partners and the community on a risk basis. These discussions will need to explore and develop local plans to adapt and increase resilience over time.

The timescale over which communities will need to adapt will vary and will depend on local factors and impacts. Some coastal communities will need to adapt and become more resilient sooner than others, however, all of the coastal communities will need to address their local adaptation needs.

These recent storms have highlighted these issues at Fairbourne. However, as noted above Fairbourne is not alone in facing the challenge of adaptation. For Fairbourne a multi-agency group has been established locally and this includes community representation. The community have formed a Fairbourne Facing Change Group. The title of this group is very positive.

This multi-agency group is already facing up to the challenge of developing a local adaptation plan as a *'real life'* issue to be worked though. The work of this group should be supported, to both help this group address these issues and this will better inform this process in other communities facing the challenge to adapt around the coast.

Rec.41	**Welsh Government should endorse the strategic framework established by the Shoreline Management Plans (SMP2). This should be accompanied by more national and local support to communities and community involvement in the development of local adaptation options and plans.** **Develop a 'local adaptation toolkit' to better support communities. This may include technical guidance, templates, and engagement and communication tools and policy positions.** **Local discussions in all coastal communities need to begin now, involving professional partners and the community. These discussions should consider communities on a risk basis. These discussions need to explore and develop local plans to adapt and increase resilience over time.** **Support and draw upon the experience of the Fairbourne multi-agency group to help inform adaptation and community resilience discussions at other locations.**

There is a need to ensure coastal adaptation will require support from Local Development Plans and the wider Planning and Development Control process:

Local adaptation to coastal change will be impeded if inappropriate decisions are made concerning new development.

It is essential that communities are not *'blighted'* in the present by the adaptation process and that new development decisions are themselves consistent with the strategic framework and the local adaptation options and plans.

It is also essential that the planning process provides the opportunities for local adaptation.

It is also important that the climate change guidance used by all parties around the coast is appropriate for purpose.

Rec.42	**Review and evaluate existing barriers and gaps to supporting coastal adaptation and make recommendations for improvement.** **Review, where necessary, existing climate change guidance to ensure the most appropriate approach is being used by all parties involved in all aspects of flood and coastal erosion risk management (i.e. all Government departments, RMAs infrastructure and utility operators).**

Infrastructure Resilience

Impact of the December 2013 and January 2014 Storms

From discussions and contributions to this Review, it is concluded that:

- The coastal storms of December 2013 and early January 2014 did significantly test the resilience of important national infrastructure such as rail, water, electricity and telecommunications. The severity of this test was variable across the infrastructure and utility operators.

- Some of the impacts were direct, such as damage and flooding to assets, most easily highlighted by the damage to Network Rail assets identified in the Phase 1 Report. Other impacts were associated with the wider impacts of the storms, such as damage due to strong winds.

- In many cases the storms and their impacts placed a considerable strain on operational staff and resources. Some infrastructure and utility operators have responsibilities across both Wales and England and this provided increased flexibility to utilise operational staff across the two countries, where necessary. This helped to increase local resilience.

Managing Present Day Coastal Flooding and Erosion Risks

- Generally infrastructure/utility operators are aware of present day flood risks and are to differing degrees managing their networks and systems to address their present day risks.

- This activity is generally '*risk driven'* and primarily determined by their own individual business needs and regulatory drivers.

- There is a continued need for infrastructure and utility operators to actively prepare plan and manage their present day risks.

- There is a continued need for RMAs to offer advice and guidance to help and encourage infrastructure and utility operators to understand and manage their present day risk.

- It has been identified earlier in this Phase 2 Report that some infrastructure operators assets contribute to the national network of coastal defence, albeit as a secondary function and not their primary purpose for example, Network Rail assets and some highway assets. Other, assets can contribute to local flood management or flood risk such as pumping stations and drainage networks. Other infrastructure assets do not directly contribute to flood risk management, but are impacted by flooding and this can have consequential impacts on the local community and elsewhere.

- There is also a continued need for RMAs and infrastructure and utility operators to work together and interact operationally on a '*day to day'* basis. These working relationships will need to be risk based and informed by the factors identified above. Some are more relevant on a day to day basis than others.

- There is a continued need for infrastructure and utility operators to work together and interact on issues of mutual interest. There is a Wales Utility Group which meets primarily to share best practice. It is a Group which can consider matters referred to it by the Local Resilience Forums and can provide a basis for maintaining critical networks between companies.

- Infrastructure and utility operators do already, to varying degrees, contribute to the incident management process. However, some operators have highlighted the need to improve engagement and communications during incident response. This has been identified as a recommendation by this Review above.

Managing Future Coastal Flooding and Erosion Risks

This picture concerning the planning and preparation for future risks is more mixed.

- Where it exists, regulatory pressure and expectations are significant factors influencing long term infrastructure planning and investment.

- As discussed above for local community adaptation, there is also a need here for infrastructure and utility operators to develop their own *'local adaptation plans or resilience plans'*. These need to be set within the context of a longer term strategic framework and where necessary aligned with the broader community based adaptation plans.

- In many locations rail and highway assets play an important part of the coastal defence infrastructure. Long term plans for local sections of the coast will have significant impacts on the Network Rail infrastructure and potentially highways infrastructure. These impacts need to be discussed and considered at a national scale as they cannot solely be addressed locally.

The National Overview of Infrastructure Resilience

- Whilst it is clear that infrastructure operators are, to varying degrees, managing their own risks and working together to discuss matters of mutual interest, there does not appear to be any process to provide the Minister (responsible for flood risk matters) with a national overview as to the resilience of the national networks of infrastructure and utilities to flooding or coastal erosion.

- The apparent absence of this national overview means it is difficult to provide to the Minister, and therefore the communities of Wales, a clear *'picture*' of how infrastructure resilience is being collectively managed both now and for the future and of the progress being made towards increased resilience.

- Such a picture would need to distinguish between locally important and nationally important assets and services. It would also need to be periodically reviewed to provide national assurance of progress towards increased national and local resilience.

Issues and Recommendations – Infrastructure Resilience

There is a need to do more to enable RMAs and infrastructure and utility operators to work together and interact operationally more efficiently and effectively:

This will include consideration of advice and guidance from RMAs on present day and future risks.

It will reflect the different role the various infrastructure and utility operators have in terms of directly contributing to coastal flood risk management or being impacted by flooding and consequentially affecting broader community resilience, in terms of power and telecommunication services, as examples.

Infrastructure operators whose assets play a role in coastal defence, most notably (but not only) Network Rail must be included in the assessment of the national coastal asset dataset and inspection recommendations identified above.

Where appropriate this may consider Memorandum of Understandings or other agreements to help ensure clarity of roles and responsibilities between the professional partners and with communities.

Rec.43	**Review and make recommendations for how Risk Management Authorities and infrastructure and utility operators can work together operationally more efficiently and effectively. This should consider a range of working agreements to ensure clarity of roles and responsibilities between professional partners and for communities.**

There is a need to review if more needs to be done to enable infrastructure and utility operators to effectively work together and interact on issues of mutual interest:

This may include reviewing the role and remit of the exiting Wales Utility Group to determine whether these should be revised. It should also consider alternative and additional options.

Rec.44	**Review and make recommendations if more needs to be done to enable infrastructure and utility operators to effectively work together and interact on issues of mutual interest. This may include a review of the role and remit of the Wales Utility Group and other options.**

There is a need for infrastructure and utility operators to do more to prepare and plan for the longer term adaptation of their assets and to increase their resilience:

This needs to be set within the context of a longer term strategic framework and where necessary, aligned with the broader community based adaptation plans.

Water companies (who are RMAs) are required to implement a programme of making their assets flood resilient through the periodic business planning process.

Where there are regulatory *'barriers*' or *'improvements*' which either currently obstruct this process of adaptation, or could potentially help it should be identified.

Rec.45	**Encourage and support the development of programmes of works to increase resilience of infrastructure and utility assets. These must be aligned with local community adaptation planning.** **Review where appropriate if there are regulatory barriers to obstruct this process of adaptation and identify regulatory improvements which could help adaptation.**

There is a need for more national discussion and evaluation of the impacts of climate change scenarios on Network Rail and highways infrastructure around the Welsh coastline and long term adaptation options:

In many locations Network Rail and highway assets play an important part of the coastal defence infrastructure. Long term plans for local sections of the coast will have significant impacts on the Network Rail infrastructure and potentially highways infrastructure. These impacts need to be discussed and considered at a national scale as they cannot solely be addressed locally.

Network Rails and highway longer term adaptation plans must be set within the overall strategic framework and aligned with local community adaptation plans as necessary.

Rec.46	**Review and evaluate at the national Wales level, the impacts of climate change scenarios on Network Rail infrastructure and highways infrastructure around the Welsh coastline and the long term adaptation options.**

There is a need for a periodic national overview (or assessment) of infrastructure and utility resilience across Wales:

This should consider locally important and nationally important assets and services.

It should also consider infrastructure that contributes directly to coastal flood and erosion risk management or has a potential to contribute to flood risk. It should also consider other assets and services which are impacted by flood and erosion risks and the consequential impacts on communities locally and elsewhere.

This should be periodically reviewed to help provide public assurance of progress towards increased resilience.

Rec.47	**Undertake a periodic national assessment of infrastructure and utility resilience across Wales, in order to provide assurance of national progress towards increased resilience to coastal flood and erosion risks.**

Conclusions

- Coastal flood risk is an important national issue for Wales. The coastal areas are of national importance to the people, economy and environment of Wales.

- Typically, large scale coastal flood risk, is characterised by its relatively low likelihood but with the potential for widespread and serious consequences of flooding. This is illustrated by Towyn in 1990 and the flooding around the Welsh and English coast last winter.

- Risks of this nature, i.e. low likelihood but with high consequences present particular challenges in terms of their management. For example, it is difficult to raise and sustain community and professional partner awareness and ability to respond effectively to these relatively infrequent events.

- Current arrangements for managing the national coastal flood risk have evolved over many years and are complex, in part due to the dynamic interaction of natural and manmade assets and structures. These are managed by many organisations and individuals, some for the primary purpose of managing flood risk and others that fulfil this role as a secondary function.

- Management of our coastal flood risks can work effectively, and this was demonstrated by the national response to these recent storms. From a national perspective the properties impacted by flooding was very small compared to the total potentially at risk.

- Overall from a national perspective the response of risk management authorities and others to these storms was good. However, our collective capacity to respond was seriously tested. In many locations, given relatively small increases in water level or timing, the consequences could have been much worse.

- However, whilst these storms were significant, we will experience similar and worse in the future. This Phase 2 Review has identified numerous and wide ranging issues and recommendations.

- Coastal flood and erosion risk will increase. The challenge to continue to manage the risks to our coast is considerable and in the future will require difficult national and local choices around acceptable levels of risk, affordability and adaptation.

Summary of Recommendations

Introduction

- Listed below are a total of **47 recommendations**. These draw upon issues highlighted by these recent winter storm incidents affecting the Welsh coast. These are summarised at the end of this Report and are grouped under the themes identified by the Minister in his request for this Review. Many of these recommendations are interdependent and linked.

- These recommendations will help deliver the objectives of the Welsh Government's, *National Flood and Coastal Erosion Risk Management Strategy (2011).*

- Delivery of the recommendations in this Report will need the support and cooperation of many people and organisations across Wales. Recommendation 1 proposes compilation of a Delivery Plan; to define how to take these recommendations forward.

- Some of the recommendations encompass existing ongoing activities or initiatives. These should be reviewed in terms of their scope, progress to date and priority as part of development of the Delivery Plan.

- Progression of the recommendations should be on a risk based approach.

- All of the recommendations are important and have the potential to improve delivery of the national flood and coastal erosion risk management service in Wales and therefore our national resilience.

- This review and the recommendations below have focused on coastal flood risk, however many of these recommendations are transferable to other sources of flooding. It is important that coastal flood and erosion risk is considered appropriately on the basis of risk, but alongside other sources of flood risk. This is included in the recommendations (Rec.2)

Summary of Recommendations

	Progressing the Recommendations
1.	**The recommendations included in this report are compiled into a Delivery Plan.** **This Delivery Plan will identify how the recommendations will be progressed. It will consider matters such as; the parties to be involved lead responsibility, priorities, governance and resources and capacity to deliver.**
2.	**The Delivery Plan should consider opportunities to expand the recommendations beyond just coastal flooding and erosion risks and to consider the link to risks from other sources of flooding.**
	Recommendations – Storm Severity
3.	**Further work is required to assess the joint probability of wind, waves and tides for these recent winter storms. This may take the form of an initial assessment coupled with consideration of more thorough analysis. The scope of this work will require further technical discussion.**
4.	**Review and update if required, the extreme sea level dataset around the Welsh coast. The recent tidal conditions are amongst the highest for many years. This dataset may need to be amended.** **This is to include methods for assessment of joint probability for storm severity.**
5.	**Review and update if required, the guidance used for the assessment and design of coastal standard of service against flooding. The review should consider whether more clarification is needed, in particular on the issues of the treatment of joint probabilities, in combination effects and appropriate national consistency.**
	Recommendations – Flood Forecasting
6.	**Continue to identify and implement risk based opportunities to deliver further improvements to longer range forecasts.**
7.	**Review with partners what additional forecast information could be provided to support local incident management decisions. Identify options and recommendations.**

8.	**Continue to progress risk based opportunities to deliver improvements to the accuracy of the coastal forecasting service. Develop and deliver a programme of improvement works.**
9.	**Review the whole wave buoy network around the Welsh coast, including working with UKCMF to address a strategic gap in the offshore wave buoy network in the Irish Sea. This is required to better validate offshore wave forecasts, leading to improvements to the Wales forecasting service.** ***(UKCMF- UK Coastal Monitoring and Forecasting Service)***
	Recommendations – Flood Warning and Community Response
10	**Complete the ongoing work by summer 2014 to *'rebrand'* the flood warning service in Wales so that the provider is clearly identified as Natural Resources Wales.**
11.	**Develop and implement a prioritised programme of improvement works to flood warning areas and thresholds, using the experience and data gathered from these storms. This should include engagement with professional partners and communities as appropriate.**
12.	**Review and consider additional sources of validation information for future incidents. This has potential to improve confidence in both forecasting and warning. This may involve seeking feedback from professional partners and others.**
13.	**Work with sample communities to identify options to help sustain an effective local response to flood warnings. This should consider communities where effective response and or confidence in the warning system is low.**
14.	**Identify and evaluate options to help communities to become more self-sufficient and resilient and identify a recommended option**
15.	**Produce and communicate nationally consistent, public focused information on the types and availability of property level protection measures and the support available.**
16.	**Using the experience from these recent storms, identify and evaluate options for the future development of local Flood Plans in coastal areas and identify a recommended option to help these be more effective at improving community resilience.**
17.	**Using the experience from these recent storms, identify and evaluate options for the future development of local Flood Plan Leads / Warden Volunteers in coastal areas and identify a recommended option.**

	Recommendations – Operational Response
18.	**Review and identify how to improve involvement of infrastructure operators and managers in the coastal flood risk incident management process.**
19.	**Continue to develop potential *'impact scenario'* assessments, maps and/or statements. This work must be developed in close discussion with professional partners to ensure it meets all parties' requirements.**
20.	**Review the local decision making process associated with the issue of Severe Flood Warnings and evacuation procedures in December 2013 and early January 2014. Identify improvements and share at an all Wales level.**
21.	**Assess our national capacity to respond to a widespread and sustained period of coastal flooding. This should include consideration of when the current national resource pool will no longer function effectively. This should also consider post incident recovery issues.** **Provide a report with recommendations for improvement.**
22.	**Assess the collective ability to provide an effective response to a potential large scale evacuation scenario in either north east or south east Wales. This should also consider post incident recovery issues.** **Provide a report with recommendations for improvement.**
23.	**Review the Wales resilience structures and ways of working to identify what changes may be needed to enable us to collectively be better prepared and resilient to future coastal flooding.**
24.	**Options to seek improvements to the standard of protection at the Garford Road area of Rhyl should be identified and evaluated. This should include detailed hydraulic analysis of the capacity and performance of the storage lagoon. This should include an assessment of the stairwell and slipway openings and the interaction with the adjacent golf course area.**
25.	**All Risk Management Authorities (RMAs) around Wales should review their local use of stop boards, stop logs, temporary barriers or moveable gates. The purpose of this review is for RMAs to satisfy themselves that existing arrangements are appropriate and robust. Consideration should be given to replacing existing arrangements with more permanent or more robust temporary solutions. This review should be 'risk based' and focused on the locations with highest local risk.**
26.	**All Risk Management Authorities (RMAs) around Wales should review locations where they have secondary defence systems in place. The purpose of this review is for RMAs to satisfy themselves that the secondary systems will operate as designed when required. This review should be *'risk based*' and focused on the locations with highest local risk.**

	Recommendations – Coastal Defences
27.	**There needs to be continued sustained investment to manage the national coastal risks to acceptable levels.** **This must include flood forecasting, warning, awareness, response and recovery, as well as flood defences. Particular focus has to be on the existing defences to ensure they continue to be fit for purpose, as well as investment in new defences to reduce the flood risk for more locations.**
28.	**Review and identify options to maximise certainty in flood and coastal erosion risk management funding over a longer timeframe and to maximise flexibility in the use of this funding. This would mean less focus on annual and in year budgets and more focus on delivery and budget management of 3-5 years.**
29.	**The development of the National Programme of Investment should be progressed as a matter of importance and its development should seek a wide range of ways of working and technical improvements to the flood and coastal erosion risk management investment allocation, decision making and prioritisation process.**
30.	**Review and identify options to gain additional funding to supplement core flood and coastal erosion risk management investment. This must be closely aligned with the development of the National Programme for Investment.**
31.	**Produce a complete national dataset of coastal protection and defence assets including details of areas benefitting.** **It is essential that this dataset becomes a '*live management tool*' and not merely a representative picture of a snapshot in time. This dataset must therefore be associated with a process for ensuring the information is maintained.**
32.	**Review and identify options to achieve a more consistent approach to the inspection of the network of coastal defence systems. This must include recommendations to improve the efficiency and effectiveness of the asset inspection process.**
33.	**Continue to develop a nationally prioritised programme of coastal modelling and mapping improvements. This must be nationally risk based and consistent.**
34.	**Locations and communities which experienced flooding in December 2013 and early January 2014 should be subjected to a risk based assessment to determine if further risk management activity/intervention is needed and can be justified.**

35.	**Near miss locations and locations subjected to substantial foreshore change should be identified and subjected to a risk based assessment to determine if further risk management activity/intervention is needed and can be justified.**
36.	**Complete the ongoing update to the Phase 1 '*rapid*' assessment of environmental changes experienced during the December 2013 and January 2014 storms.**
37.	**Carry out a national skills and capacity audit for all Risk Management Authorities to assess and quantify the scale of the issue – to assess the size of the skills and capacity gap** **Produce an options document for how the skills and capacity gap could be addressed to meet present day flood risk management needs and future challenges.**
38.	**Clarify roles and responsibilities amongst risk management authorities at both the local and national level as required.** **Develop consistent and common communication messages and tools to convey roles and responsibilities to communities.**
39.	**Undertake a review of Welsh Coastal Groups and the Wales Coastal Group Forum. This review should include, as appropriate, links and relationships with other similar groups who have a role in the management of flood and coastal erosion risks.** **This review should identify improvement options to maximise efficient and effective delivery of flood and coastal risk management.**
40.	**The Wales Coastal Monitoring Centre submitted a business case for the future of the centre to Welsh Government in December 2013. This business case should be determined by Welsh Government.**

41.	**Welsh Government should endorse the strategic framework established by the Shoreline Management Plans (SMP2). This should be accompanied by more national and local support to communities and community involvement in the development of local adaptation options and plans.** **Develop a 'local adaptation toolkit' to better support communities. This may include technical guidance, templates, and engagement and communication tools and policy positions.** **Local discussions in all coastal communities need to begin now, involving professional partners and the community. These discussions should consider communities on a risk basis. These discussions need to explore and develop local plans to adapt and increase resilience over time.** **Support and draw upon the experience of the Fairbourne multi-agency group to help inform adaptation and community resilience discussions at other locations.**
42.	**Review and evaluate existing barriers and gaps to supporting coastal adaptation and make recommendations for improvement.** **Review, where necessary, existing climate change guidance to ensure the most appropriate approach is being used by all parties involved in all aspects of flood and coastal erosion risk management (i.e. all Government departments, RMAs infrastructure and utility operators).**
	Recommendations – Infrastructure Resilience
43.	**Review and make recommendations for how Risk Management Authorities and infrastructure and utility operators can work together operationally more efficiently and effectively. This should consider a range of working agreements to ensure clarity of roles and responsibilities between professional partners and for communities.**
44.	**Review and make recommendations if more needs to be done to enable infrastructure and utility operators to effectively work together and interact on issues of mutual interest. This may include a review of the role and remit of the Wales Utility Group and other options.**
45.	**Encourage and support the development of programmes of works to increase resilience of infrastructure and utility assets. These must be aligned with local community adaptation planning.** **Review where appropriate if there are regulatory barriers to obstruct this process of adaptation and identify regulatory improvements which could help adaptation.**
46.	**Review and evaluate at the national Wales level, the impacts of climate change scenarios on Network Rail infrastructure and highways infrastructure around the Welsh coastline and the long term adaptation options.**

47.	**Undertake a periodic national assessment of infrastructure and utility resilience across Wales, in order to provide assurance of national progress towards increased resilience to coastal flood and erosion risks.**

Annex A: Headlines from the Phase 1 Report

At the request of Welsh Government, Natural Resources Wales has carried out an assessment of the information received to determine the potential costs which may be eligible for the Welsh Government's flood and coastal risk management grant funding. These are estimated costs for works necessary to restore the national network of Local Authority and Natural Resources Wales managed coastal defences which were damaged specifically during the recent storm events.

This assessment has estimated that around **£8.1million** may be eligible for flood and coastal risk management grant funding

December 2013 event – *Impacts upon North Wales only*

- Peak sea level was the highest recorded in Liverpool Bay for at least 21 years.
- Natural Resources Wales issued 2 Severe Flood Warnings and 15 Flood Warnings.
- Over 400 properties were advised to evacuate in Rhyl.
- 155 properties flooded internally and 160 properties were indirectly affected.
- Approximately 65 coastal defences were damaged.
- Costs to both temporarily and permanently restore damaged defences to their pre-storm
- condition are estimated at £5.3million.
- Defences protected over 24,000 properties in North Wales during this event and over
- £960 million of damages were avoided.

January 2014 event – *Widespread impacts upon the West and South Wales coast*

- Peak sea levels on January 3rd 2014 were the highest on the south and west coast of Wales for at least 16 years.
- Natural Resources Wales issued 6 Severe Flood Warnings and over 100 Flood Warnings.
- Over 1050 properties were advised to evacuate in Borth, Aberystwyth, Cardigan and Newport combined.
- 150 properties flooded internally and 415 properties were indirectly affected.
- • Approximately 110 coastal defences were damaged.
- Costs to both temporarily and permanently restore damaged defences to their pre-storm condition are estimated at £2.8million.
- Defences protected over 50,000 properties around the coast of Wales during this event and over £2billion damages avoided.

Combined storm impacts:

- Network Rail assets were significantly damaged during the storms, with the Barmouth to Pwllheli line remaining closed for several months due to damage at Llanaber.
- Widespread damage occurred to the Wales Coastal Path with repair costs estimated at £340,000.
- Over 360ha of agricultural land was flooded, most significantly in January 2014 at Llanbedr with flooding to four properties, over 200ha of farmland and loss of over 120 sheep.
- New palaeo-environmental and archaeological discoveries have been uncovered, such as ancient submerged forest and peat cuttings at numerous locations.
- Environmental change has been identified at 37 Sites of Special Scientific Interest and10 Special Areas of Conservation.

Annex B: Organisations Consulted During this Phase 2 Review

Bridgend County Borough Council
British Telecommunications
Caldicot & Wentlooge Levels IDB
Cardiff Council
Carmarthenshire County Council
Ceredigion County Council
City and County of Swansea
Conwy County Borough Council
Denbighshire County Council
Dwr Cymru – Welsh Water
Flintshire County Council
Gwynedd Council
Isle of Anglesey County Council
Monmouthshire County Council
National Grid
Natural Resources Wales - flood risk management and communications teams
Neath Port Talbot County Borough Council
Network Rail
Newport City Council
Pembrokeshire County Council
Scottish Power Energy Networks
The Crown Estate
Vale of Glamorgan Council
Vodafone
Wales and West Utilities Ltd
Wales Utilities Group
Western Power

Annex C: Extract from Flood Warning Plan for Ceredigion

102FWB456 - Aberystwyth Tidal

Tidal area at Aberystwyth

The location of the Flood Warning Area is shown on Map numbers 102FWB456_1, 102FSC456A_1, 102FSB456B_2 and 102FST456C_3.

Area Affected

The localities affected and the impact of these messages within this particular Flood Warning Area are described in the table below.

Flood Warning Area	Flood Warning Area Reference Code*	Locations affected	Messages Issued
Tidal area at Aberystwyth	102FSC456A	Property along Victoria Terrace, Marine Terrace and South Marine Terrace. In particular the road along the sea frontage and cellars of property bordering the road	Flood Warning Severe Flood Warning
	102FSB456B	The Caravan Site at Aberystwyth Holiday Village	Flood Warning Sub Area (Update Flood Warning) Severe Flood Warning
	102FST456C	Property in the vicinity of Trefechan extending as far north as Portland Street and east as far as the Ambulance Station, includingYr Ysgol Gymraeg	Flood Warning Sub Area (Update Flood Warning) Severe Flood Warning

**The Flood Warning Area Reference Code is the unique code that is given to all Flood Warning Areas. This appears on all faxes and emails that partners receive when a warning is issued.*

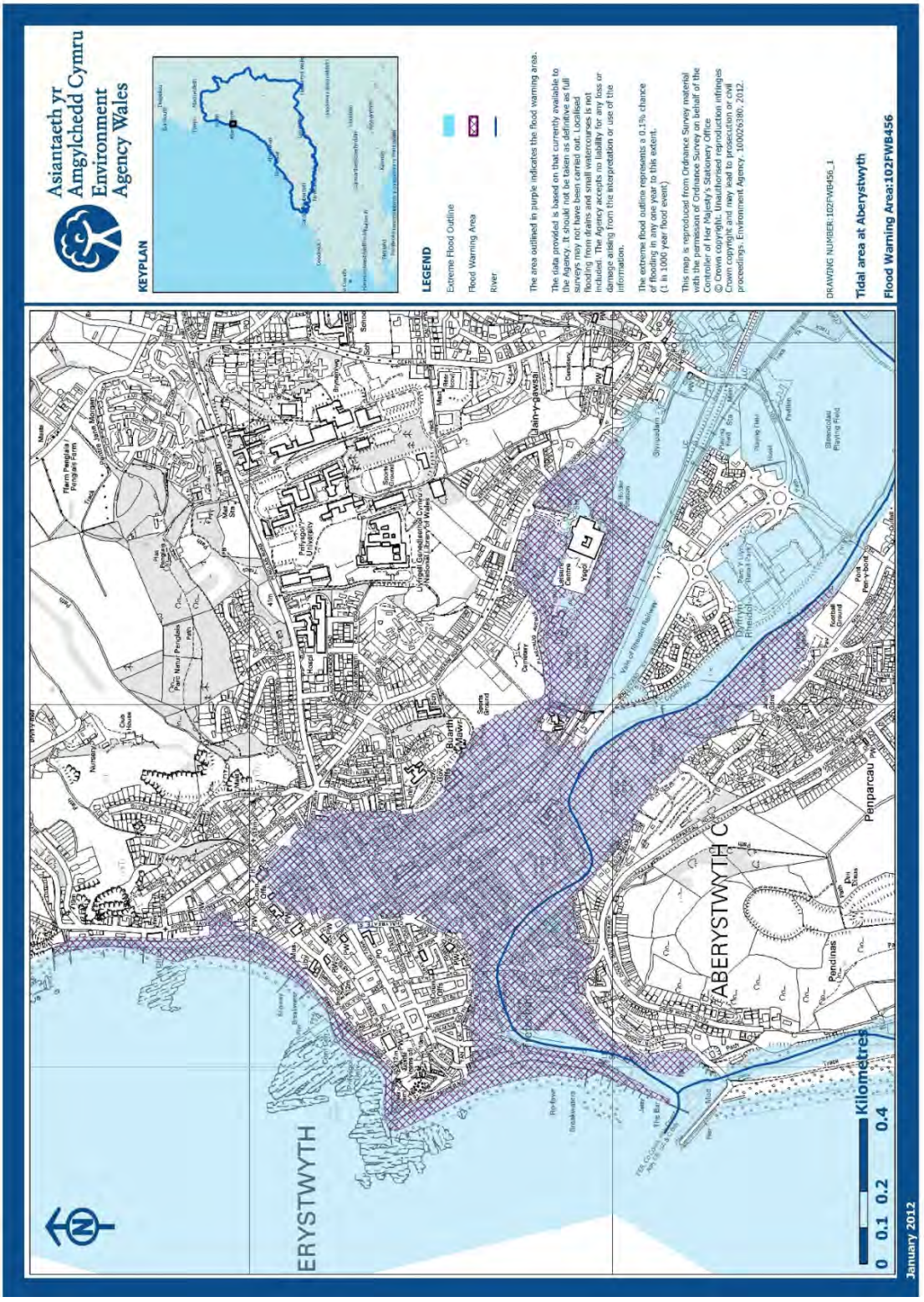
Property Numbers and Probability of Flooding

The number of properties we expect to be affected by flooding in the Flood Warning Area will be reported to partners in the messages received from FWD.

Flood Warning Area Reference Code*	Frequency of flooding	Probability of flooding	Number of properties
102FSC456A	1:10	10%	206
102FSB456B	1:200	0.5%	26
102FST456C	1:200	0.5%	986

*The Flood Warning Area Reference Code is the unique code that is given to all Flood Warning Areas. This appears on all faxes and emails that partners receive when a warning is issued.

Flood Warning Area for 102FWB456 - Aberystwyth Tidal



Published by:
Natural Resources Wales
Cambria House
29 Newport Road
Cardiff
CF24 0TP

0300 065 3000 (Mon-Fri, 8am - 6pm)

enquiries@naturalresourceswales.gov.uk
www.naturalresourceswales.gov.uk