UK FLOODED AGAIN: WHAT LESSONS CAN NEW ZEALAND LEARN?

Dr David Cobby and Matt Sheppard
Jacobs New Zealand Limited

ABSTRACT (300 WORDS MAXIMUM)

Flooding is the greatest climate risk in the UK and New Zealand, and it is recognized in both countries that the risk is increasing through changing rainfall patterns and rising sea levels. Comparatively, the UK has invested significantly more resources into managing the risk, particularly following the Summer 2007 floods. This investment has occurred at a strategic level (driven by European and central government legislation), at a regional and local level (driven by renewed Environment Agency and local council partnership working) and at a scheme level (driven by government and private partnership investment). It is against this backdrop of renewed organizational focus and funding that the flooding experienced across large areas of northern England and Scotland in December 2015 and January 2016 seems to be particularly concerning. Those who have been flooded through to the Prime Minister are asking whether the UK is on the right track to protect people, infrastructure and the environment from flooding in our current climate, and in a worsening future climate.

New Zealand faces many of the same challenges and adopts many of the global best practices which the UK also adopts. These approaches could range from top down legislation, adaptation and precautionary approaches to managing risk, funding of activities and the use of green infrastructure.

This paper reviews the approaches taken by the UK in key strategic technical areas in the last decade and provides observations from the perspective of a flood risk management professional working in both the UK and New Zealand. These lessons could provide valuable insight to New Zealand policy makers and flood management practitioners as the country decides on the best approach to managing stormwater flooding.

KEYWORDS

Flood, Stormwater, Climate Change, Risk Management, UK, New Zealand

Presenter Profile

David Cobby is a Chartered Water and Environmental Manager and Scientist who has over fourteen years' experience in consultancy and academic research environments. His technical expertise encompasses many areas of water and environmental management, focussing particularly on the sustainable management of flood risk from stormwater and groundwater. David is now based in Christchurch where he is delivering a number of Land Drainage Recovery Projects.

Matt Sheppard is a Chartered Professional Engineer with a specialism in hydraulic analysis and 25 years consulting experience including stormwater capacity assessment, stormwater infrastructure options studies, flood management strategy development as well as detailed design and implementation. He has broad knowledge of stormwater

management challenges in Christchurch, where flood management strategy has been a particular focus since the Christchurch earthquakes.

1 INTRODUCTION

December 2015 was the wettest calendar month for the UK since 1910. Storm Desmond resulted in 342mm falling over 2 days in the Lake District early in the month. Cumbria, Lancashire, Yorkshire and Scotland experienced flooding of ~3,500 homes and businesses, loss of electrical power, major damage to roads and bridges, and disruption to the rail network. Storm Eva resulted in further flooding in Cumbria later in the month with Storm Frank causing flooding in Scotland in late December and early January. Initial estimates are that the flooding has cost the country overall around $11 billion (£5b).

Figure 1: (Left) December 2015 rainfall anomaly map (reproduced from http://www.metoffice.gov.uk/climate/uk/summaries/2015/december) (Right) Recent flood defences in Keswick (reproduced from http://www.cumbriacrack.com/2015/12/05/cumbria-police-issue-updates-on-local-communities)

The UK received record-breaking rainfall in 2012, 2013 and 2014 and suffered extensive flooding every time (e.g. Somerset and Thames River in December 2013 – February 2014). On average in each year between 1998 and 2014, over $460m (£200m) of insured losses was caused by flooding to residential properties in England alone, with the wider average annual costs associated with flooding across the UK being $2.5b (£1.1b). This flooding occurred despite a total central and local government spend on flood risk management in England which has increased from $1.3b (£570m) in 2005/6 to $2b (£870m) in 2014, including unplanned emergency funds of $270m (£120m) following flooding in 2012 and $620m (£270m) following flooding in 2013/14. By the end of January 2016, the total government's investment in recovery from Storm Eva and Storm Desmond amounted to $460m (£200m) which included a Farming Recovery Fund, grants so property owners can install individual property protection measures, providing for affected businesses to get back on their feet and help to repair flood-damaged roads and bridges and damaged flood defences.

Indeed, flooding has occurred in areas which have already seen recent and significant investment in defences (e.g. Keswick and Carlisle). Whilst political debates continue about whether funding has increased or decreased, this level of proactive and reactive spend on flood protection is significant. And similarly to the reaction following the

landmark flooding of Summer 2007, floods over Christmas 2015 triggered a media outcry and a government flood defence review. Unusually, the Environment Agency (EA) – the body which overseas the majority of investment in flood management - has itself suggested that a complete rethink is required.

Nonetheless, there is a broad consensus that defences provided valuable time for people and emergency services to prepare and respond, and will have also reduced the depth of flooding which has a direct impact on the cost of flooding. A defence is only designed to provide a certain standard of protection and building higher is not often the answer. However, overtopped defences can have a negative impact in the market value of properties which are supposedly protected. A property with a flood history which is then protected by a scheme can regain its value. However, if the property continues to flood despite the defence, it may be less likely to regain its value as the defence is demonstrated to only have a finite benefit.

The timing of the flooding, following the Paris Climate Conference agreement in December 2015, may be relevant in shaping the debate and review of flood defence. The Paris Agreement reflects the growing global momentum to act on climate change that has increased noticeably since the adoption of the Kyoto Protocol in 1997. Whilst action to cut emissions and reduce the impact of global warming is reinforced as urgent (the poorest on earth stand to suffer most from its impacts), adapting to climate change is now a central issue for global climate action and on par with mitigation. The Paris Agreement establishes a global goal of enhancing adaptive capacity, strengthening resilience and reducing vulnerability. This is welcome news, when the debate on attributing the causes of climate change to human influence or natural cycles can distract from the need to adapt to a climate which is changing. The precautionary and adaptive approaches to flood risk management both have their places, but truly adaptive approaches have taken longer to gain traction.

The Thirty Year New Zealand Infrastructure Plan (New Zealand Government, 2015) underlined that flooding is already the country's most frequent natural disaster, with an average annual cost of approximately $51m. After earthquakes, floods and storms are the country's second-most costly natural hazard (New Zealand Climate Change Centre, 2015). Because of the low earthquake risk in the UK, inland flooding and wind storms are the two dominant natural hazards in terms of insured losses. However, despite the similarity in some risk statistics, the differences between the UK and New Zealand are fully acknowledged. With 75% of New Zealand's population living within 10km of the coast, the coastal hazards of flooding, erosion and high and more saline groundwater which will be exacerbated by sea level rise are clearly of the highest priority (MfE, 2015). So far, sea level in New Zealand has risen in line with the global average but evidence suggests it may rise 10% higher than average in the future. Whilst managing stormwater flooding in New Zealand is devolved to local Councils and may not have been significant enough in the past at a country level to justify a national management strategy, nationally increasing stormwater flood risk due to sea level rise indicates a different philosophy may be required in the future. In 2008, the New Zealand Government published a review of flood risk management led by the Ministry for the Environment (MfE, 2008) and it is understood that the Ministry is working on an update to the guidance for considering sea level rise.

This paper reviews approaches taken in the UK in the last decade to key aspects of flood risk management and suggests, based on the authors experience of working with the EA, central and local government, the benefits and issues of the approaches. These insights are offered in the hope that they are useful for New Zealand policy makers and flood

management practitioners as the country decides on the best approach to managing stormwater flooding in a changing climate.

2 EVOLVING PHILOSOPHY

The priorities which have remained constant through many changes in UK government are firstly to protect lives, secondly to protect people's homes and businesses and thirdly to protect agricultural land. These priorities are embedded in funding arrangements, where agricultural land is purposely valued lower than peoples' homes. However, whilst the goals remain relatively unchanged, the approaches to achieve them have broadly evolved over decades from hard engineering which aims to keep water in watercourses and underground piped networks, to a softer philosophy of making space for water and keeping it separate through more natural approaches, to recognizing the importance of resilience and an acceptance that living with temporary inundation may be necessary. This evolution in philosophy has had a number of drivers but is consistent with recognizing that serious floods continue to happen across the UK despite ongoing investment; including the English Midlands in Easter 1998, southern England in autumn and winter 2000, summer floods across Ireland, Wales and England in 2007, winter floods of south east and west England in 2013/4 and now the flooding in northern England and Scotland in winter 2015.

It is important to recognize this change in philosophy because it is resulting in:

- A move from different organisations being responsible for different elements of water infrastructure and thus different sources of flooding, to a more coordinated response which is slowly putting the victim of flooding – who doesn't care what sort of water they have been flooded by – first.

- A recognition that larger schemes protecting whole communities are only suitable in some situations (e.g. stormwater flooding is more disparate than fluvial flooding) and can be overtopped; therefore the cumulative impact of smaller schemes may offer better overall protection, be more easily integrated into dense urban environments but ultimately protection at a property level may also be required.

- An appreciation that green infrastructure, as part of a well-planned living environment, offers benefits that extend beyond flood protection and into social, environmental and economic improvements.

- The maintenance burden of flood infrastructure – and particularly underground infrastructure – remaining a major financial challenge and continuing to be overlooked in favour of investing in new assets.

- Flood risk management now being based on a partnership of national and local funding, which has evolved from a system of local choice and funding prior to 2004 and national priorities and funding until 2012.

It is also worth highlighting that government aims to reduce flood risk over time rather than maintain current levels of risk. This is a significant challenge in the context of increasing risk with climate change and development and it remains to be seen whether funding to achieve this aim - estimated at up to $2b (£900m) per year - can be secured.

3 INTERNATIONAL AND NATIONAL LEGISLATION

The UK Government is under no legal duty to provide protection from flooding to a certain standard. However, the social and economic costs of flooding have driven a response and a significant legislative framework has grown up to assign certain duties and powers to a variety of organisations. The powers remain permissive, however, and a person has no right to any protection from flooding or coastal erosion and no right to any particular standard of protection; responsibility for protecting land and property lies with the owner. Some notable benefits of existing legislation are:

- It has resulted in a flow of funding from central government to public bodies to cover their new duties; to recruit and upskill staff, to undertake studies and to plan and implement schemes.

- It has driven a wide recognition of sources of flooding which, until recently, no organization had responsibility for managing. Principally, these were stormwater and groundwater. This recognition has resulted in an improved understanding of risk through recording of flood events and predictive modeling and mapping, and therefore better preparedness to deal with an emergency.

- It has required organisations which are principally the EA, local councils and private water companies to cooperate, share information and even funding, to improve protection in a given geographical location where flooding may be a hybrid of different sources.

- In strategic terms, the focus of flood risk management is consistent across the country, whilst being flexible to enable local characteristics and priorities to be accommodated.

However, with the introduction of the European Floods Directive in 2009 and the Flood & Water Management Act in 2010, these improvements are taking time to embed:

- The victim of flooding is still faced with having to contact one or more of the EA, local councils and private water companies to get help. Therefore is still no centralized flood helpline and a person at risk of flooding must choose between waiting for an uncertain emergency response and taking action to protect their own land and property.

- Responsibility for integrating flood risk management into local planning is still split between district councils, county councils, the EA and private water companies and the strengthening of rules around integrating sustainable drainage systems into new development has been severely curtailed after years of indecision by government. Inappropriate building in flood risk areas is more likely to continue as a result.

- Although there is now a significant volume of information available on flooding, the number of maps, plans, strategies, guides etc can be overwhelming and actually make a coordinated approach in a given location challenging.

The European legislation has made relatively little impact in the UK where managing, reporting and modeling/mapping were largely underway. However, it is proving beneficial in other countries, and particularly in driving cooperation where flooding crosses political boundaries (e.g. the River Danube) and where little information was previously available.

4 SUDS AND NATURAL FLOOD MANAGEMENT

Despite continued efforts to divert development away from flood prone areas, the UK continues to permit building on floodplains. According to the Committee on Climate Change (2015), housing within the 1 in 30 year floodplain has grown annually at a rate of 1.2% since 2011, compared with average annual growth of 0.7% in areas with a risk of less than 1 in 1000 years. Similarly to climate change, every effort must be made to limit the causes of risk as well as adapting to the unfolding situation.

Sustainable drainage systems (SuDS) mimic natural drainage processes in urban areas and natural flood management schemes (e.g. woody dams, tree planting) can attenuate flood water higher in a catchment. Both approaches have a growing body of evidence to support their cost-beneficial impact on reducing flood risk, as well as the often clearer benefits to the natural and social environment. For example, the village of Pickering in north England was reported (Independent, 2016) to have been protected during the December floods from an upland natural flood risk management scheme to attenuate flow. This scheme cost a tenth of the alternative conventional flood wall scheme which was too expensive to attract funding, despite the village flooding four times in eight years. This is one example of the benefits of flood schemes that work with the natural environment.

A criticism often leveled at the EA is that of protecting the environment at the expense of people, and that requirements to mitigate flood scheme impacts to the ecology of an area prohibitively increase costs and time. Indeed, it can seem that with no legal duty for authorities to protect the human environment from flooding whereas there are legal duties to protect the natural environment, the sense of proportionality has been lost. It is true that significant efforts are made to minimize the impacts of any flood schemes on the environment but the success stories demonstrate that with appropriate strategic planning, schemes can benefit both the human and social environment in a cost-effective manner.

However, SuDS in urban areas can require a relatively large area which developers find difficult to justify in preference to traditional underground drainage. Uptake of SuDS in the UK is being promoted jointly through strengthening the evidence base for their effectiveness (e.g. through monitoring performance and costs) and legislation to make them the preferred approach. Promotion within the industry is proceeding well (recent updated CIRIA SuDS Manual has been well received) whilst legislation is widely viewed as having failed.

The Flood and Water Management Act drafted in 2010 required developers to set out sustainable drainage plans giving preference to SuDS, which had to be approved by local authorities working through a legal process with the planning authority. In many cases, the SuDS Approval Body and the planning authority were the same which would have strengthened implementation and, once satisfied the systems had been correctly constructed, the authorities would have become responsible for their maintenance and successful operation. However, after years of failed attempts to enact this legislation, SuDS are not a legal requirement but must only be considered as part of the planning process, depending on the requirements of individual planning authorities. Non-statutory standards have been published to guide Councils, but these are only enforceable for major new development and not to highways. There is no clear arrangement for maintaining the drainage systems and no specific requirements to improve water quality.

5 FUNDING FLOOD MANAGEMENT

Funding for flood risk management in England mainly comes from central government, with additional funding derived from local government levies and private partner contributions to flood schemes. In FY2014/15, total funding was around $2b (£870m; Defra, 2015). For the six years from 2016 to 2021, approximately $870m (£380m) per year is expected to be spent on schemes.

Experts agree that the flooding experienced in December 2015 and previous events would be considerably higher without the decades of investment in flood risk management. Economic appraisal of schemes is fundamental to the process in the UK to ensure that the benefits of investing in flood and coastal erosion risk management outweigh the costs. Planned investment seeks returns of at least 8:1 otherwise works are unlikely to be undertaken. Reactive funds for repair and improvements following a major event are unlikely to be subject to these same criteria and therefore, whilst important, do not offer the same economic benefits.

With the recognition of stormwater and groundwater flooding alongside fluvial and coastal flooding since the Flood & Water Management Act in 2010, all schemes are now subject to the same appraisal process. This has opened up improved opportunities for managing these previously neglected risks. However, schemes for stormwater (being typically shallower and more geographically dispersed) and groundwater (being typically more infrequent) struggle to demonstrate the same minimum 8:1 economic return and, in the overall prioritization for funding, these schemes typically underperform.

However, it is true that the partnership funding model which has operated since 2012 has allowed these, and other locally important schemes to go ahead, because a shortfall in central government funding is met by locally-sourced contributions. However, whilst government wish these contributions to come largely from the private sector, to date they have largely come from levies collected by local government and so smaller schemes remain mostly publicly funded. For example, for the UK government to achieve its promised spend of $5b (£2.3b) over the next six years, $1.3b (£600m) of external contributions is required, of which only $140m (£61m) has to date been secured from the private sector.

Support for the Partnership Funding model is provided in a report by CDP (2015) which emphasizes that cooperation between cities and businesses leads to better resilience and benefits to both parties. Resilience to climate change is a growing factor in cities' economic competitiveness. It should, however, be recognized that attracting investment from business to protect an area then requires councils to play a part in maintaining and improving this protection to retain business and attract more and so on. Whilst this so called 'escalator effect' may not be desirable in currently undeveloped areas, in those which are already developed, and where retreat is prohibitively costly, it is a mechanism which may be necessary, as long as the residual risk of overtopping of defences is managed. There is evidence from the UK, however, that this model of public/private funding does not result in any shift in investment towards deprived communities.

Whilst total funding is one issue, appropriate channeling of the available funds is another. Firstly, central government funding to local authorities is not ring-fenced and can often be used by the authority to provide other services seen as a higher priority. This raises the need to demonstrate the impacts of flood risk and the need to be comfortable making investment decisions based on probabilities. Secondly, although public bodies are currently upskilling, the majority of flood risk management services in the UK are

delivered by engineering consultants working for the responsible organisations. Procurement of services based on a lowest cost model which aims to meet often unnecessarily tight deadlines to align with financial year boundaries does not always deliver the best value as measured by those at risk of flooding. Whilst rapidly delivered projects may meet short term funding deadlines and political drivers can lead to good headlines, they do not necessarily achieve the best long-term outcomes. Thirdly, whilst funding is based on the whole life cost of schemes, the proportion for maintenance is not secured for future use in that scheme and maintenance funding becomes a continual battle.

6 MODELLING AND MAPPING OF FLOOD RISK

For decades, the EA has funded a rolling programme of modeling and mapping flood risk from rivers and the sea, largely to inform property development and latterly to inform flood forecasting and warning services. There was no similar structured consideration of stormwater and groundwater. Following the Summer 2007 floods, the EA started to develop a map of stormwater flood risk covering England and Wales (and the Scottish Environment Protection Agency began a similar programme in Scotland). The English stormwater maps are now on their third generation, with each generation having improved upon the previous. The events represented are standardized with those used for other sources of flooding, and are more realistic in the areas and depth of flooding predicted. The EA has sufficient confidence to display these maps online alongside those for fluvial and coastal flooding. The improvements have occurred partly as a result of better input data (e.g. consistent LiDAR topography and observations of flooding for calibration) and partly through improved hydraulic model representation of the flood mechanisms (e.g. artificially lowering road networks to better define key flow paths).

Despite its faults, the early mapping was sufficient to get a strategic appreciation of the risk. This was used to inform a series of local studies (termed Surface Water Management Plans) in highest risk areas which then developed more detailed modelling and a more robust appreciation of the risk. In turn, these more detailed studies are used to improve the strategic mapping, as well as informing planning decisions and schemes. This same evolution of mapping is now underway for groundwater flooding, with an early flood map produced for England (Defra, 2004) now being improved through observations of flooding and innovative application of technology (Morris et al., 2015).

7 LIVING WITH UNCERTAINTY

The 2004 Foresight report concluded that "Hard choices need to be taken – we must either invest more in sustainable approaches to flood and coastal management or learn to live with increased flooding." Whilst warming of the climate system is unequivocal and the impacts of a changing climate are already being seen, these hard choices must be made in the face of continuing uncertainty about the magnitude and timing of the impacts. Reddish (2014) cites a useful example from the UK planning system whereby greenbelt planning restrictions are enforced because the greenbelt is tangible; development in flood risk zones are not enforced with the same vigour because the consequences of flooding are infrequent, temporary and uncertain. The high level of uncertainty has been cited by the New Zealand Minister for the Environment as a reason not to set rigid standards for the country's response to sea level rise (Local Government and Environment Select Committee, 2015). Whilst centrally-prescribed and rigid design

standards may not be the most sensible approach, uncertainty must not be a reason for inaction.

Similarly to a shift in philosophy from hard engineering to resilience, there is an ongoing move recognizing the limits of a precautionary approach and the benefits of an adaptive approach. A precautionary approach considers what an acceptable level of risk is and 'overdesigns' accordingly, e.g. adding freeboard to stopbank heights. For example, the MfE (2008) guidance recommends a precautionary approach. An adaptive approach defers major interventions until defined decision points and then reassesses the options at these points based on the latest information, favouring a number of smaller interventions to single large interventions.

In some situations, precaution has been embedded in decision making to an extent that has had negative consequences. The Thames Estuary 2100 project to plan protection of London to the end of the century was the first major UK project to put adaptation at its center (EA, 2012). A precautionary approach was considered but analysis showed that it would have been expensive, environmentally damaging and would have risked creating an expensive 'white elephant' if flood risk developed at a slower level than predicted. Instead, an adaptation strategy was developed which provided benefits including the following and is widely regarded as an exemplar approach:

- Adaptability to changes in timing: interventions can be brought forward or delayed if change occurs faster or slower than predicted
- Ability to change between options: if change occurs much differently to that predicted, alternative options can be implemented
- Adaptable engineering actions: structures are designed to be modified (e.g. built higher on existing foundations) in the future
- Safeguarding of land: allocating land now which may be required for future interventions

Without proper planning, responses to risk which has either occurred or is predicted can accumulate fixed assets which are costly to adapt and/or protect as the climate changes. This planning should recognize that incremental adaptation may be possible to extend the useful life of existing infrastructure to a degree, but that there will come a point (e.g. governed by rising sea level) when incremental changes will no longer be sufficient and a wider transformation of the system will be required. An adaptive strategy will likely be a combination of incremental and transformational change.

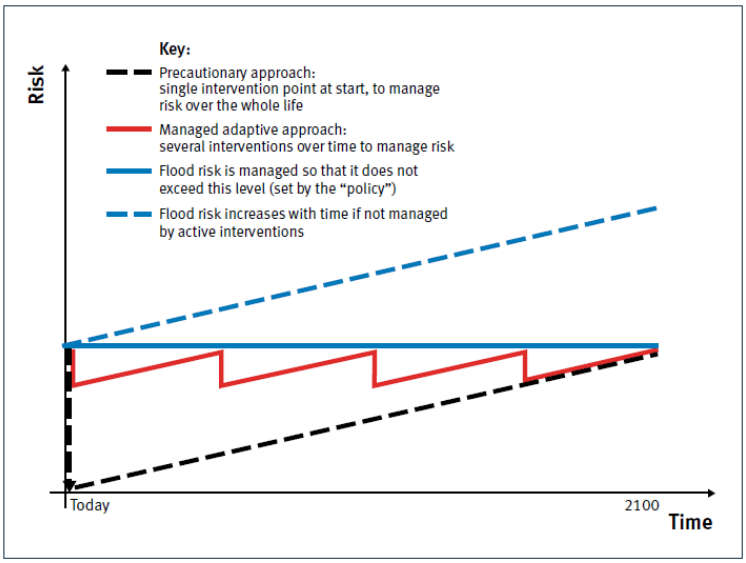

Figure 2: Contrasting precautionary and adaptive approaches to achieving a standard of flood risk protection. From EA (2012).

8 DISCUSSION AND APPLICATION TO NEW ZEALAND

The significant UK flooding of December 2015 and January 2016 follows from previously significant flood events in 2014, 2013, 2012 and almost every year since 2000. The flooding has occurred in some of the same locations which have seen recent substantial investment in flood protection schemes. This has triggered a Government review into whether the UK is on the right track to a more resilient future. Previous reviews have been undertaken following the Easter 1998 floods (Bye, 1998) and the Summer 2007 floods (Pitt, 2008) This latest review will focus on the nation's resilience to flood risk, the resilience of key infrastructure, temporary defences and the future investment strategy. It is also worth noting that the UKCP18 project will update the UKCP09 projections over UK land areas and projections of sea-level rise, giving greater regional detail, further analysis of the national and global risks and giving more information on potential extremes and impacts of climate change.

This paper has highlighted a number of topic areas where learning from the UK would be usefully reviewed and considered for application as New Zealand continues to develop its approach to flood risk management. But as well as important similarities with the UK, there are important parallels between New Zealand and the Netherlands (Flikweert, 2015), for example:

- four of the largest cities in the Netherlands are at risk of flooding, similar to the largest cities in New Zealand being at risk of coastal/inland flooding
- both the Netherlands and significant areas of New Zealand's most at risk cities have shallow topography which makes retreating either impossible or incurring vast economic, social and environmental implications
- Netherlands Government is committed by law to achieving standards of protection against flooding in a similar way to New Zealand's commitment to no floor level flooding in a 1 in 50 year event.

However, the Netherlands has a much greater sense of urgency with regards managing flood risk than either the UK or New Zealand, which translates to the country spending twice as much per annum than the UK and being more receptive to developing innovative solutions.

The philosophy underpinning flood management across New Zealand is not clear, and appears to have elements of the various philosophies outlined from the UK. For example, in Christchurch, there remains an emphasis on defending against flooding through pipes, pumped and raised infrastructure although there is a desire for naturalized flood management approaches (Waterways, Wetlands and Drainage Guide; CCC, 2003) and even a formal recognition of the role of overland exceedance routes in the Infrastructure Design Standard (CCC, 2013).

Furthermore, at a fundamental level, New Zealand government should decide whether all the authorities should aim to maintain some existing level of risk (i.e. standard of protection) over time, or whether the level of risk should be reduced. Proactive investment has been shown in the UK to be more cost beneficial than reactive investment, although both will be significantly expensive and the total response will be a combination of both. A cursory examination of the UK figures indicates that spending following significant flood events can be expected to be in the same order as planned spend. Whilst funding will always be required to react to events which occur, planned expenditure alone may underestimate the total funding required to manage flood risk.

Economic appraisal of schemes must become as fundamental to the appraisal of management responses in New Zealand as it is in the UK, to ensure that the benefits of investing in flood and coastal erosion risk management outweigh the costs. Hughes et al. (2015), based on analysis in Christchurch, highlight the need for locally tailored cost-benefit analyses of climate adaptation options.

There is a good opportunity here to include other aspects of the costs and benefits of flood management than the number of households at risk, which remains the focus of appraisals in the UK. The system for funding flood management in the UK has a high level of disconnection between public rates and the use of this money to support schemes. This can make protection works to individual properties easier than in New Zealand where the rates-based environment means that the use of rate payers money is more clearly visible. Councils in New Zealand may be reluctant to use community rates to fund works to individual properties, even though this may be a more cost-beneficial solution than a community scheme to protect a limited number of properties at risk. For example, in the UK, a community scheme aims for a benefit:cost ratio of greater than 8:1 whereas individual property protection works commonly achieve a return far in excess of 10:1. Conversely, purchasing a flood-prone property may only achieve a return of 1:1 since damages are capped at its market value.

Under New Zealand law, planning for sea level rise, along with most environmental management, is the responsibility of local government. Although consideration of sea level rise is becoming more common, effective strategic planning would benefit from clearer unifying policies and better coordination between central and local government. This longer-term direction will also stablise local responses which may otherwise be upset by local elections and shorter-term decision making. Whilst a similar devolution arrangement has existed in the UK since 2009, all local Councils are working towards implementing the nationally consistent requirements of the international and national legislation. This legislation followed a recognition of the need (ongoing flooding), the prioritization of a response (economic, social and environmental costs experienced now

and anticipated to increase), the drafting of the policies and then the provision of funding to facilitate its implementation. The necessity of this final step should be fully recognized.

It is worth noting that SuDS legislation in the UK has failed, and the reasons for this may be beneficial for authorities in New Zealand to understand. However, the cost-effective benefits of SuDS and natural flood management to the social and natural environment are being demonstrated in UK projects. What is required is *time* to plan schemes properly, *cooperative working* between the different organisations with relevant responsibilities, *land* or suitable open space (e.g. green roofs do not require additional land but suitable building design) but, perhaps most importantly at the moment, *robust evidence* that SuDS and natural flood schemes will be cost-effective. As New Zealand faces higher temperatures, higher intensity rainfall and also time spend in drought (in the east and north), SuDS and natural flood management could provide multiple environmental and social benefits as part of an adaptation strategy. The growing body of evidence and design standards (e.g. CIRIA, 2015) could prove useful to adapt for New Zealand.

Undertaking wider-scale modeling in key areas of New Zealand studies in New Zealand would be beneficial to gain a strategic understanding of how more detailed local studies could fit together, rather than with a view to it being the final answer. Strategic mapping can also inform strategic economic appraisal of high level management responses (e.g. upstream storage verses retreat from downstream areas, tidal barrier verses raising of stopbanks etc). Wider-scale mapping is already underway for coastal inundation (e.g. MfE, 2015) but should be undertaken for inland flooding in key population centres. It is also worth considering feedback which the EA has recently received following a consultation on communicating flood risk. Although maps and plans are crucial to the work of professionals in the field, communities in the UK expressed that they wanted specific information about whether flooding will affect their community and not necessarily any information about what is happening across the country. Maps should be generated and used appropriately and a 'one size fits all' approach is unlikely to be achievable. Development of flood maps in the UK been undertaken over a number of years and information disseminated in carefully considered ways. As part of the same EA consultation, there was general agreement that whilst providing maps, information and talking about the real impact of flooding is more likely to lead to action, the devastating effect of flooding should only be discussed alongside practical advice to people on what they can do about it.

REFERENCES

Bye, P. (1998) 1998 Easter Floods: Final assessment by the Independent Review Team. 30 September 1998. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/292915/geho0807bnay-e-e.pdf

CCC (2003) Waterways, Wetlands and Drainage Guide. Available at: http://www.ccc.govt.nz/consents-and-licences/construction-requirements/infrastructure-design-standards/

CCC (2013) Infrastructure Design Standard. Available at: http://www.ccc.govt.nz/consents-and-licences/construction-requirements/infrastructure-design-standards/

CDP (2015) Protecting Our Capital. How climate adaptation in cities creates a resilient place for business. Based on the CDP responses from 207 global cities.

CIRIA (2015) The SuDS Manual (C753). London 2015. Available at: http://www.ciria.org/Resources/Free_publications/SuDS_manual_C753.aspx

Committee on Climate Change (2015) Progress in preparing for climate change. 2015 Report to Parliament. June 2015

Defra (2004) Strategy for flood and coastal erosion risk management: Groundwater Flooding Scoping Study (LDS 23). Final Report for Defra. May 2004, 2004.

Defra (2015) Central Government Funding for Flood and Coastal Erosion Risk Management in England. December 2015. Available at https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/480527/Funding_for_Flood_and_Coastal_Erosion_in_England_Dec_2015.pdf

Environment Agency (2015) No Regrets. Planning for Sea Level Rise and Climate Change and Investing in Adaptation August 2015

Environment Agency (2012) Thames Estuary 2100. Managing flood risk through London and the Thames estuary. TE2100 Plan. November 2012

Flikweert, J. (2015) Flood Management in the UK – an Informed Dutch Perspective. Flooding in focus: Recommendations for more effective flood management in England. Available at: http://www.nationalfloodforum.org.uk/wp-content/uploads/Flood-report-Flooding-in-Focus-RSPB.pdf

Foresight Future Flooding (2004). Available at: https://www.gov.uk/government/publications/future-flooding

Hughes, M. W., Quigley, M. C., Ballegooy, S., Deam, B. L., Bradley, B. A., Hart, D. E. and Measures, R. (2015) The Sinking City: Earthquakes Increase Flood hazard in Christchurch, New Zealand. GSA Today. March/April 2015.

Independent (2016) UK flooding: How a Yorkshire town worked with nature to stay dry. Available at: http://www.independent.co.uk/news/uk/home-news/uk-flooding-how-a-yorkshire-flood-blackspot-worked-with-nature-to-stay-dry-a6794286.html?utm_source=UKCIP+enews&utm_campaign=492eebd49a-01UKCIP_news_January_20161_7_2016&utm_medium=email&utm_term=0_a7d6f30eab-492eebd49a-3609173

Local Government and Environment Select Committee (2015) 2015/16 Estimates for Vote Environment. July 2015

MfE (2008) Meeting the challenges of future flooding in New Zealand. ME 900. August 2008. Available at: http://www.mfe.govt.nz/publications/land/meeting-challenges-future-flooding-new-zealand

MfE (2015) Preparing New Zealand for Rising Seas: Certainty and Uncertainty. November 2015. Available at: http://www.pce.parliament.nz/media/1380/preparing-nz-for-rising-seas-web-small.pdf

Morris, S. E., Cobby, D., Zaidman, M. and Fisher, K. (2015) Modelling and mapping groundwater flooding at the ground surface in Chalk catchments. Journal of Flood Risk management.

New Zealand Climate Change Centre (2015) Climate Change: IPCC Fifth Assessment Report New Zealand Findings.

New Zealand Government (2015) The Thirty Year New Zealand Infrastructure Plan 2015. Available at: http://www.infrastructure.govt.nz/plan/2015

Pitt, M. (2008) Learning from the 2007 Floods. June 2008. Available at: http://webarchive.nationalarchives.gov.uk/20100807034701/http:/archive.cabinetoffice.gov.uk/pittreview/thepittreview/final_report.html

Reddish, J. (2014) FLOOD RISK AND SPATIAL PLANNING REGULATIONS – LESSONS FROM THE UK