4. Building the case for resilience – Australian examples

Key Points

There are practical resilience measures which would create net benefits for society:

- A program focussing on building more resilient new houses in high cyclone risk areas of South-East Queensland would reduce the risk of cyclone-related damage for these houses by around two thirds, and generate a BCR of up to 3. Existing houses are particularly challenging to retrofit but the BCR of retrofits approaches one in high risk areas
- Raising the Warragamba Dam wall by 23 metres would reduce annualised average flood costs by around three quarters, and generate a BCR of between 2.2 and 8.5. This would result in a reduction in the present value of flood costs between 2013 and 2050 from $4.1 billion to $1.1 billion, a saving of some $3.0 billion
- Building more resilient housing in high risk bushfire areas generates a BCR of around 1.4; improved vegetation management results in a BCR of around 1.3, and undergrounding electricity wires results in a BCR of around 3.1.

This chapter provides an indicative benefit-cost analysis of three areas in Australia exposed to different natural disaster risks. The areas chosen are South-East Queensland (tropical cyclone, and flood), NSW's Hawkesbury Nepean (riverine flooding) and the outskirts of Melbourne (bushfire).

The selection of the case studies was based on a number of attributes, including:

- **Populous:** areas where a significant number of people and property would be affected
- **Data rich:** readily available data
- **Influence on affordability:** the affordability or availability of insurance is being affected
- **Change is possible:** it is realistically possible to implement resilience measures
- **Weather variability:** future weather variability is likely to increase the risks.

For each case study, a range of options for building resilience is considered. The case studies demonstrate that there are practical approaches to building resilience which, with further research, could be tailored and implemented at a local level in a way which creates net benefits for society. Whilst these case studies demonstrate the potential benefits of pre-disaster resilience, they do not provide the detailed benefit-cost analysis that would be required for decision-making, including, for example, new or targeted engineering information.

The case studies are also heavily focussed on physical or hard approaches to resilience (such as building infrastructure or retrofitting existing buildings). These approaches to resilience are most amenable to quantitative benefit-cost analysis. This should not be taken as an indication that other 'soft' approaches to resilience (such as information and business continuity planning) do not create substantial benefits. Further, in implementing any of the resilience approaches suggested, a comprehensive impact study would need to be carried out.

A detailed description of the methodology used for these case studies is presented in **Appendix E.**

As costs related to natural disasters are highly variable, there are a number of ways to present them. The most basic is to look at the average annual cost. This shows the natural disaster costs that can be expected to occur in any given year and, over the long run, it should be expected that the average costs experienced approach this estimate. This average annual cost can also be summed over a number of years to give a total cost expected over that period.

The total can be considered in present value terms to assess the amount of money that would need to be put aside now to cover costs over the period. However, as the most disastrous events are rare, this approach can work to conceal the true extent of costs that would occur in a bad year. Extreme events are also important to consider as they are more likely to result in mass loss of life and destruction of communities and so are related to high levels of traumatic intangible costs.

To capture these extreme risks, the costs associated with extreme events can be individually estimated. For example, a one-in-100-year event has a 1% chance of occurring in any year while a one-in-1,000-year event has a 0.1% chance of occurring in any year. These events could, however, occur in the near future and could occur within a matter of years.

A final methodological consideration is that the expected natural disaster costs have been estimated separately for cyclone-related events and flood-related events. These results can be combined to form a picture of the total consequences of both events. Table 4.1 provides a summary of the costs of disasters in these areas today and into the future.

Table 4.1: Summary of estimated costs of natural disasters in case study regions

Measure of cost	South East Queensland	NSW	Victoria
		Hawkesbury-Nepean	Melbourne fringe
Average annual cost in 2013	322	102	51
Average annual cost in 2050	1,162	317	165
Total cost to 2050	25,889	7,218	3,727
Present value of total cost to 2050	14,387	4,051	2,087
1% Annual Exceedence Probability (EAP) (≈1 in 100 year event)	3,424#	2,205	1,562
0.1% AEP (≈1 in 1000 year event)	12,899#	10,723	15,862
0.01% AEP (≈1 in 10,000 year event)	40,487#	16,183	68,590

Cyclone only

Source: Deloitte Access Economics (2013)

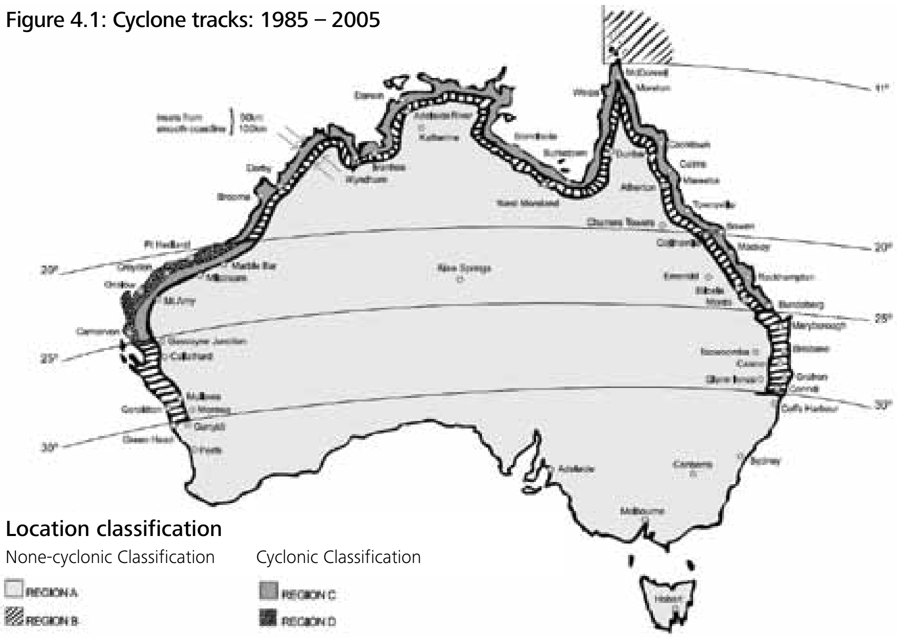
4.1 South-East Queensland – Cyclone and flood

4.1.1 The scenario

South-East Queensland is one of Australia's most disaster prone regions, facing significant risks from tropical cyclones and, in particular, flood. There are around 40,000 houses in the region which are exposed to high or medium flood risk[10].

South-East Queensland's population and economy have been growing strongly over the past few decades. This has led to a growth in both the quantity and value of assets located in the area. Much of this new population had, until recently, little experience of the cyclone and flood losses that have impacted the region historically.

Figure 4.1: Cyclone tracks: 1985 – 2005



Location classification

None-cyclonic Classification

Cyclonic Classification

Source: Stegbar, 2009, 'AS4055 wind loads for housing'. The above figure represents the broad wind risk regions in Australia; note refinements have been made in subsequent updates

10 High flood risk is here defined as being located below the 5% AEP level. Medium risk is defined as being located within the 1% flood level.

In the last few years, there has been some experience of extreme flooding events such as the events in Toowoomba, the Lockyer Valley, Ipswich and Brisbane. In addition, in early 2013, residents felt the effects of ex-Tropical Cyclone Oswald. However, South-East Queensland has not recently experienced a severe event that combines cyclonic winds with major floods.

Based upon historical tropical cyclone impacts near Brisbane, including the 1893 tropical cyclone that produced extreme river flooding of the Brisbane Rivers and the destructive 1954 Gold Coast tropical cyclone, it is apparent that this region could experience a Category 3 cyclone impact in the future with a combination of extreme river and flash flooding, a major storm surge and destructive winds.

Illustrating this potential, in 1967, Tropical Cyclone Dinah, a Category 3 cyclone, passed just east of the Brisbane coast but did not make landfall. A repeat of Tropical Cyclone Dinah which did cross the coast and pass directly over Brisbane and the Gold Coast would be something of a worse-case scenario – bringing extreme wind speeds, major flooding and material storm surge damage. With the majority of recent development in South-East Queensland having occurred on or near rivers and coastlines, the impact of this disaster would be catastrophic. Wind damage in Brisbane and the Gold Coast is estimated to be in the region of $8–14 billion in insured costs (Munich Re 2006). Insured flood costs would have to be added to this figure and could reach into the billions of dollars based on the $2.4bn of the 2011 floods and the $2.6bn of costs generated by the Brisbane River flooding of 1974. This level of insured losses could result in total economic costs of at least $27–42 billion.

For South-East Queensland, the average annual cost of cyclone and flood is currently estimated to be around $322 million in total economic value and is estimated to rise to around $1.2bn by 2050. Population growth together with increases in the value of property and assets in the region are the primary drivers of this inflation.

The total economic costs from cyclone and flood in the region are expected to be around $25.9 billion in the period to 2050, which has a present value of around $14.4 billion.

These figures take into account a range of costs including insured assets (such as houses, contents, cars and business continuity losses) as well as a number of direct disaster costs such as disaster response, public infrastructure reconstruction, private clean-up costs and loss of agricultural production. Estimates for a number of intangible costs such as loss of life, injury and evacuation are also included.

Beyond the impacts quantified in the measurement of risks, there are also a wide range of social, psychological and community effects of natural disasters which are difficult to quantify but no less important. For example, while the statistical value of life has been used a basis for assessing costs related to death and injury, this does not take into account longer term psychological consequences for survivors from the loss of property and memorabilia but more significantly the loss of family and friends.

Table 4.2: Estimated costs in South-East Queensland Case Study ($m 2011)

Measure of cost	Cyclone	Flood	Total
Average annual cost in 2013	160	164	322
Average annual cost in 2050	570	593	1,162
Total cost to 2050	12,685	13,204	25,889
Present value of total cost to 2050	7,050	7,338	14,387
1% AEP	3,424		
0.1% AEP	12,899		
0.01% AEP	40,487		

Source: Deloitte Access Economic analysis (2013)

Case study: The human side of natural disasters

As an auxiliary to government in humanitarian endeavours, Red Cross has a key role in supporting governments to respond to humanitarian crises. Through its work providing aid to those affected by natural disasters, it is able to bring a unique perspective to the personal side of natural disaster costs. In the case of the 2013 floods in South-East Queensland, the stories gathered by the Red Cross are particularly insightful as many individuals had been flooded out of their homes only a few years prior.

For example, the Red Cross interviewed residents of Ipswich in South-East Queensland following the floods. Like many others in Queensland, Ipswich residents had been similarly evacuated in 2011. Some of the natural disaster risks and costs of greatest concern to affected individuals included the:

- Speed at which flood waters can rise
- Destruction of a bridge connecting a victim's town to Ipswich
- Lack of basic supplies such as bread, milk and fuel
- Permanent damage done to carpets and flooring
- Loss of personal items with sentimental meaning.

Other more on-the-ground effects which will create economic costs have not been explicitly accounted for in the above estimates. These include:

• Disruption to road, air, sea and rail services

In a minor event this may last only a few days while, in a major event, disruption could last for a number of months and destroy key transport infrastructure. This would affect local and international trade from industries including agriculture, consumer products, industrial manufactures and coal.

• Utilities

For larger events (beyond the one-in-100 level), there is the potential for widespread loss of telecommunications and electricity services.

• Water flow

For extreme events, there are risks associated with water flow such as the release of industrial chemicals into the water system; the backflow of stormwater drains into residential and commercial buildings; and damage to sewerage systems. Damage to sewerage can have serious longer term health effects as well as complicating the post-disaster recovery process.

• Community cohesion

There are risks associated with disruption to communities and businesses. The time taken to rebuild what could amount to thousands of homes following the disaster could lead to communities dissolving or relocating. For businesses even a minor disaster increases the risks of closure while, in an extreme event, there is the possibility for a longer term decline in the riverside portion of the Brisbane CBD, particularly if businesses rebuild in a less disaster-prone location.

4.1.2 Pre-disaster resilience options

The pre-disaster resilience options focus on improving structures so that they are more resilient to wind and on changing planning regulations to reduce the number of houses in high flood risk areas.

• Building more resilient houses

Analysis by the Cyclone Testing Station suggests that the most common risk to houses during a cyclone occurs once the building envelope (the physical separator between the interior and the exterior environments) has been penetrated. Once this occurs, the pressure differential between the house and its environment often results in the destruction of the house's roof structure. As a result, the Cyclone Testing Station has found that some of the most common sources of cyclone damage to houses consist of:

- Failure of fasteners
- Failure of rotten timbers
- Garage doors being blown in or out
- Roofs being blown away in whole or in part
- Doors and windows blown open
- Water ingress through the roof, doors, windows, vents, etc.
- Failure of attachments such as guttering, fascias and eaves
- Damage caused by falling trees.

This suggests that cyclone-related costs could be reduced by first increasing the resilience of the building's envelope by strengthening doors, roller-doors and windows. In high risk locations, resilience could be further developed by adding roof ties to a structure. Roof ties connect the roof structure to the core of the building, essentially linking the roof to the building's foundation.

Past experience from northern Queensland suggests that application of a more resilient building code in South-East Queensland could reduce the physical damage of a cyclone by around 55–66% (Risk Frontiers n.d.). This figure relies heavily on data gathered by the Cyclone Testing Station from actual loss experience in other parts of Queensland. It is, therefore, a good example of how improved research is able to help guide the development of resilience.

Improving planning

Land use planning, as outlined in Chapter 3, is generally the responsibility of local government. The ability of local governments to assess the safety of a particular development is limited by the quality and availability of information. For example, the national rainfall map, as published in Australian Rainfall and Runoff underpins most of the nation's flood studies. It provides detailed information on design rainfalls of a wide range of frequencies, durations and intensities and is due to be updated in 2013, the first time since the late 1980s. More timely information could help eliminate high risk housing while, for existing structures, it may enable changes in zoning which encourage development of buildings (such as high-rises) which are less prone to cyclone and flood. This is a prime example of how better risk information is related to building resilience.

4.1.3 Benefits of pre-disaster resilience

Building more resilient houses

Analysis of the benefits of building more resilient houses needs to take into account the mix of old and new houses. It is generally less costly to change standards for new houses than to retrofit existing houses. For example, research by Stewart and Wang (2011) suggests that, in South-East Queensland, building new houses to a more resilient cyclone standard could cost around $2,600–$6,500 per house while upgrades to existing housing could cost from $13,000–$52,000.

While retrofitting is more costly, it can generate significant, immediate reductions to natural disaster costs whereas changes to new houses can take a long time to result in large-scale savings.

The differential in costs between new and existing houses also highlights the fact that, in constructing new houses, it may be valuable to prepare the building for later additions that add resilience.

A further factor to take into consideration is the difference in cyclone risk within South-East Queensland. Exposure to cyclone risk is affected by factors such as the topography of the local neighbourhood and the design and location of nearby buildings. A straightforward approach to capture these local differences is to differentiate between foreshore property and inland property. Data in Stewart and Wang (2011) suggest that foreshore properties make up around 10% of houses in South-East Queensland but account for around 26% of insured damage during high wind events. This suggests that an intervention targeted closely on these high risk houses may be more beneficial than a broader program.

Taking into consideration the variability in both costs of more resilient housing and risks, the benefits of this type of mitigation are best expressed as a range of values, as shown in the following tables.

Table 4.4: More resilient housing: Benefits ($m NPV to 2050)

House type	Existing	New
Foreshore only (Benefits)	794.4	340.3
Inland only (Benefits)	2,302.9	986.7
All houses (Benefits)	3,097.3	1,327

Source: Deloitte Access Economics analysis (2013)

Table 4.3: More resilient housing: Costs ($m NPV to 2050)

House type	Existing			New		
Assumes:	Low	Med	High	Low	Med	High
Cost per house ($)	13,000	32,500	52,000	2,600	4,550	6,500
Foreshore only (Costs)	1,062.7	2,656.8	4,250.9	110.1	192.6	275.2
Inland only (Costs)	9,932.5	24,831.2	39,729.9	1,028.9	1,800.5	2,572.2
All houses (Costs)	10,995.2	27,488.0	43,980.8	1,139.0	1,993.2	2,847.4

Source: Deloitte Access Economics analysis (2013)

Table 4.5: More resilient housing: Benefit-Cost Ratio

House type	Existing			New		
Assumes:	Low	Med	High	Low	Med	High
Cost per house ($)	13,000	32,500	52,000	2,600	4,550	6,500
Foreshore only (BCR)	0.75	0.3	0.19	3.09	1.77	1.24
Inland only (BCR)	0.23	0.09	0.06	0.96	0.55	0.38
All houses (BCR)	0.28	0.11	0.07	1.17	0.67	0.47
All houses (Costs)	10,995.2	27,488	43,980.8	1,139	1,993.2	2,847.4

Source: Deloitte Access Economics analysis (2013)

Given past experience that more resilient buildings experience around 66% less wind-related damage following a cyclone, an intervention program focussed on new housing in foreshore areas could generate significant benefits over the full range of potential costs (with a BCR of 3.09–1.24).

There are a number of other interventions with BCRs close to one, including targeting of new houses in inland areas (when costs are low) and, if retrofitting could be achieved for slightly less than the range of costs reported in Stewart and Wang (2011), then a program targeting existing houses in foreshore areas could also be cost beneficial.

Improving planning

Assessment of the precise cost and benefits of improved planning is made difficult by the complexity of the process. That is, improved planning decisions can be made by simply implementing better procedures; a very low cost process. However, this requires better information for decision-makers, and this comes at a cost. Some indication of the scale of expenditure on improved information gathering can be seen in other recent government programs aimed at improving information related to natural disaster:

- Geoscience Australia Flood information enhancements has been allocated a budget of $12m for the period to 2016 which equates to $3m a year
- The Bushfire and Natural Hazards CRC has been granted a budget of $47m over eight years, equating to $5.9m a year
- The Bushfire Hazard Map project in Victoria received $13.8m.

The budget for these programs suggests that information gathering and dissemination can be achieved for a relatively low initial outlay. This can then be compared to the expected benefits of improved planning.

For example, if better planning resulted in 10% of high risk housing being redeveloped into more resilient forms the benefits over the period to 2050 are estimated to be around $52.4m in present value terms.

The above analysis demonstrates that there is an overall benefit from improving the resilience of houses. Further research is required into the most cost-effective methods of improving resilience, as well as an education and incentive program to encourage households to action these modifications. An example of the approach that could be taken is provided below.

Example

Minor modifications to improve the cyclone resilience of a new house in South-East Queensland could cost around $5000. There will be benefits for both the individual and government from undertaking this home improvement and so costs should be allocated accordingly.

A hypothetical cost sharing arrangement could include a combination of government grants (funded jointly by the Australian and Queensland Governments and upfront expenditure by the home owner).

Over time, insurance premiums would be expected to fall as the resilience measure reduces the risks of damage to the house and its contents. This means that, over time, the home owner may be able to recoup some of their upfront cost through reduced insurance premiums.

Local government's role could be the collection and dissemination of risk information and compliance monitoring, working in close collaboration with the relevant state government.

4.2 New South Wales – Flood

4.2.1 The scenario

The Hawkesbury-Nepean has been recognised as a major flood risk for the greater Sydney area since colonial times. This can be evidenced by flood peaks of 11.1m in 1992, 15m in 1961 (one-in-100-year flood levels), 19m in 1867 and 20m in 1788 (one-in-200-year flood levels).

In a repeat of historic large floods, heavy rainfall west of Sydney over a number of days would result in water flowing down the spillway and out of Warragamba Dam. The floodwaters would likely spread over large parts of Western Sydney and take days to drain away (due to the small pathways through which water can escape the basin – particularly around Wiseman's Ferry).

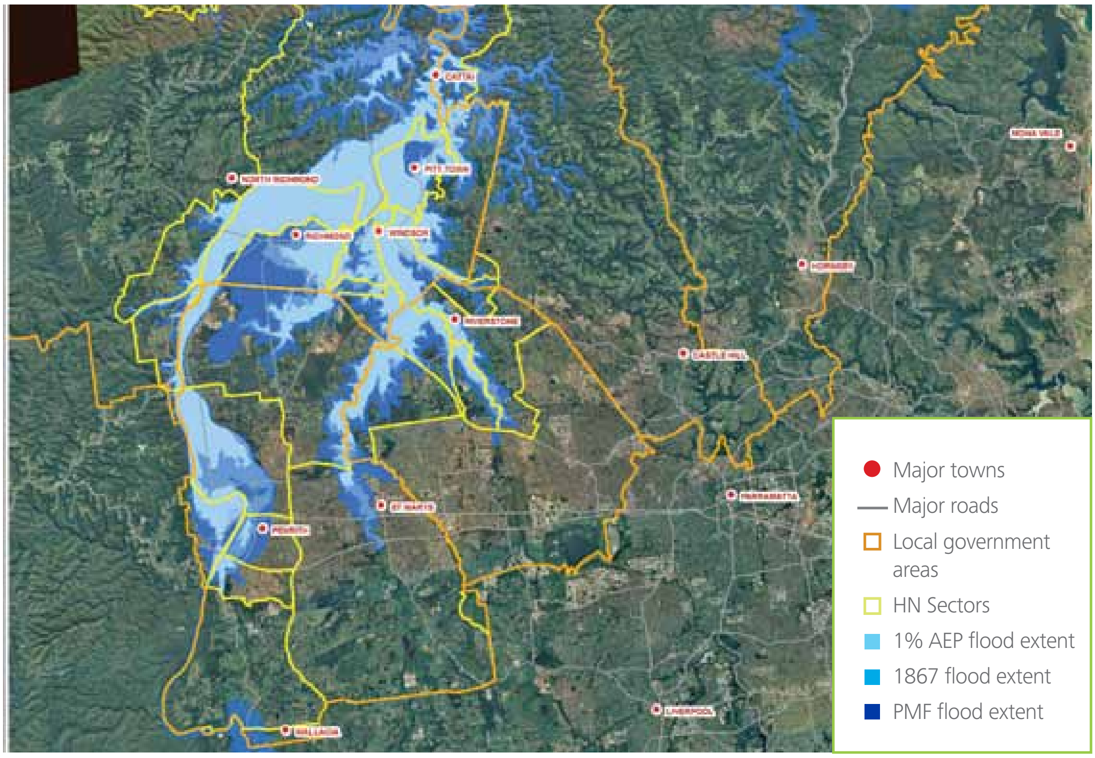
The scale of such an event today would result in the evacuation of around 60,000–90,000 people with an additional 20,000 people stranded for a number of days (as evacuation routes are cut off).

Those stranded would be stuck on ever-diminishing islands as flood waters continue to rise and cut off evacuation routes. In addition, around 1,000–3,000 businesses would be directly affected.

Intermittent steps have been taken to manage these risks with the earliest commands from Governor Lachlan Macquarie in 1817 regarding suitable locations for construction in the Hawkesbury-Nepean area. Building requirements have been an ongoing feature of resilience in the area – for example, since the mid–1990s, houses in Windsor must be built with a floor level high enough to survive a 17.3 metre flood, still insufficient for a one-in-200-year event.

Mitigation activity culminated in the construction of Warragamba Dam between 1948 and 1960, with the addition of a spillway in the 1990s to ensure the Dam's structural integrity during an extreme flood event. While the presence of Warragamba Dam can work to reduce natural disaster risks, it cannot eliminate them.

Figure 4.2: Extent of the probable maximum flood in the Hawkesbury-Nepean



Source: Ministry for Police and Emergency Services (2005)

4.2.2 Natural disaster risks

Noting the different ways to present natural disaster costs discussed at the beginning of this chapter, the Hawkesbury-Nepean area is currently estimated to be exposed to average annual flood costs of around $102 million in total economic value, increasing to around $317 million by 2050. This increase is primarily driven by growth in the value of property and assets in the area as well as increases in population. The total economic costs over the period to 2050 are expected to be around $7.2 billion in the period to 2050, which has a present value of around $4.1 billion (Table 4.6).

Table 4.6: Estimated costs in Hawkesbury-Nepean Case Study ($m 2011)

Measure of cost	Total economic cost
Average annual cost in 2013	102
Average annual cost in 2050	317
Total cost to 2050	7,218
Present value of total cost to 2050	4,051
1% AEP	2,205
0.1% AEP	10,723
Probable maximum flood	16,183

Source: Deloitte Access Economics analysis (2013)

These estimates bear comparison to those made in Molino Stewart (2012). For current natural disaster costs the estimates are quite similar; Molino Stewart estimate current average annual costs at $70.3m while we estimate costs at $95.6m. This difference can be attributed to different data sourced from Roundtable members on the number of houses in the area, flood levels and the effect of flood levels of house contents. Over time, however, the two estimates diverge. Although the annual costs are not reported in the Molino Stewart report, we estimate that their annual costs are around $80m by 2050 while our estimated annual cost is $317m. This represents different assumptions on the increase in house numbers, house value and population[11].

11 Molino Stewart make a conservative assumption that natural disaster costs are likely to remain fairly stable over time while we predict an increase in costs in line with growth in the value of assets and population.

These figures take into account a range of costs including insured assets (such as houses, contents, cars and business continuity losses) as well as a number of direct disaster costs such as disaster response, public infrastructure reconstruction, private clean-up costs and loss of agricultural production. Estimates for a number of intangible costs are also included such as costs related to loss of life, injury and evacuation.

Beyond the impacts quantified in the measurement of risks, there are also a wide range of social, psychological and community effects of natural disasters which are difficult to quantify but no less important.

Other more on-the-ground effects which will create economic costs have not been explicitly accounted for in the estimates. These include:

- **Disruption to road and rail services**

Once flood levels exceed the one-in-100-year level, significant damage and closure of the Victoria Bridge and Great Western Highway at Penrith is expected to have widespread consequences. Primarily this will affect the movement of people and goods by both road and rail from west of Penrith into Sydney. Many of Sydney's exports pass over this bridge, including coal from the western coalfields and agricultural products from west of the Great Dividing Range. In an extreme event, these services would be affected for around six months.

- **Utilities**

Many critical electricity and telecommunications connections also pass over the Nepean bridges. These include telecommunications and electricity, both of which would be affected in a similar way to road and rail services.

- **Water flow**

At the one-in-100-year level, there is likely to be discharge of sewerage into water systems around Richmond and at the one-in-1,000-year level, this is expected to extend to sewerage treatment plants around Penrith. Inundation of industrial areas would also likely be accompanied by chemical contamination of water.

- **Community cohesion**

There are also risks associated with disruption to communities and businesses. In extreme events, there would be a need to evacuate 60,000–90,000 people, with an additional 20,000 people left stranded for a number of days as evacuation routes are cut off. In this extreme event, resettlement of evacuees may take a number of months with rebuilding continuing for a number of years. There are also estimated to be around 1,000–3,000 businesses affected in the area.

4.2.3 Pre-disaster resilience options

Approaches for building resilience to flooding in the Hawkesbury-Nepean have been a focus for the NSW government since the late 1980s. This concern led to the development of a thorough Economic Impact Statement (EIS) in the mid-90s. This EIS considered a broad range of resilience options including flood insurance, flood emergency planning, town planning, house raising, wall raising, flood resistant buildings, levees, deflection walls, dredging and river straightening.

The EIS found that the option with the highest BCR was raising the level of the dam wall by 23 metres. This EIS was updated in 1997 and was further reconsidered and updated by Infrastructure NSW in 2012. As part of the Infrastructure NSW process, Molino Stewart undertook a thorough review of the costs and benefits of raising the dam wall but did not attempt to re-assess the ranking of resilience options. This ongoing process is a good example of how risk information can be combined with adaptation research to provide insight into the benefits of pre-disaster resilience infrastructure.

More recently, government has also raised the possibility of increasing the height of the Warragamba Dam wall. On 28 February 2013, the Australian Government announced $50 million in federal funding to be used for flood protection in Western Sydney – funded as part of the National Insurance Affordability Council. This included a plan to raise the Dam wall by the identified 23 metres.

Our analysis builds from that undertaken over the past 20 years and primarily relies on the analysis of pre-disaster resilience options made in the Molino Stewart report (2012) focussing on raising the dam wall height by 23m. While this has traditionally been identified as the most cost-beneficial approach to building resilience in the Hawkesbury-Nepean, a number of factors should be kept in mind.

Importantly, before investing in construction of the Dam, it would be beneficial to re-do the EIS conducted in the mid-90s to ensure that the engineering and cost data are as accurate as possible and to factor in the construction of the desalination plant in Sydney. Having a reliable source of water in addition to Warragamba Dam should work to reduce costs as it takes pressure off the water volumes needed to be maintained in the dam. There are also a number of non-quantifiable costs associated with raising the Dam wall including potential consequences upriver such as increased flooding and inundation of bushland areas. A comprehensive impact assessment should therefore be prepared to assess the full extent of these environmental effects.

4.2.4 Benefits of pre-disaster resilience

Implementing the pre-disaster resilience measures outlined above would involve total construction costs of around $411m spread over five years. This has a present value of around $349m.

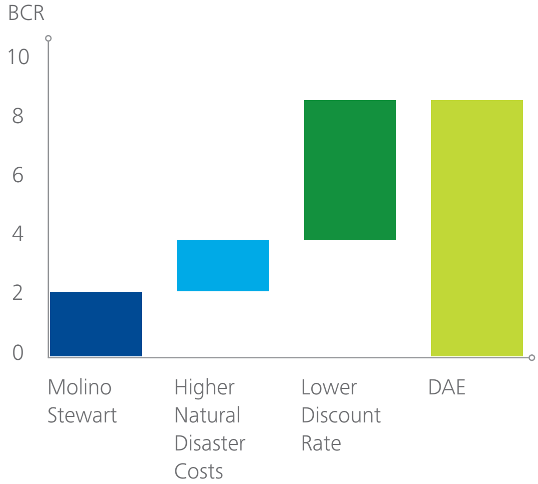
Raising the Dam wall reduces average flood costs by around 73%. This results in a reduction in the present value of flood costs between 2013 and 2050 from $4.1 billion to $1.1 billion, a saving of some $3.0 billion. This gives a benefit-cost ratio of 8.5 for raising the dam wall.

This ratio is far higher than that estimated in Molino Stewart (2012), which indicated a BCR of around 2.2. The reconciliation of the two results is illustrated in Chart 4.1.

The first cause of this deviation is the difference in natural disaster costs discussed above. In addition, Molino Stewart use a discount rate of 7% a year while this analysis uses a discount rate of 2.7% a year. This means that the benefits that are experienced far into the future are given more value in our analysis than in Molino Stewart's. A discount rate of 7% is the normal value required by the NSW government in assessing infrastructure projects while the discount rate of 2.7% a year is based on the long-term real Commonwealth bond rate and aligns with recommendations from the Australian Government Department of Finance. This lower rate is appropriate when assessing costs and benefits from a societal point of view (which is the aim of this paper).

If the discount rate in our analysis is adjusted to 7%, then the estimated benefit-cost ratio for raising the dam wall at Warragamba falls to 4.1. This suggests that around 70% of the difference in BCRs is attributable to the difference in discount rates while 30% is related to differences in the estimated natural disaster costs.

Chart 4.1: Reconciliation of BCR estimated by Molino Stewart and DAE



Source: Deloitte Access Economics analysis (2013)

The above analysis demonstrates that pre-disaster resilience action is cost beneficial for Australia. The process needs to be extended by a coordinated approach to consideration of pre-disaster resilience investment. Some key steps are set out below:

- The most effective measures for mitigating the identified risks need to be ascertained. For example, this may involve specific flood modelling to assess the effectiveness of raising levees or relocating electrical grid assets
- A strategy for implementing the measures in the previous step needs to be developed. Ideally, this should be done by an entity closer to the ground. For example, local government could develop a business case describing the benefits of a particular public asset project. A comprehensive impact assessment should also be prepared
- The strategies developed need to be assessed by an independent entity. For example, the Australian Government could assess submitted strategies in a process similar to that currently used by Infrastructure Australia. This results in a competitive prioritisation process to drive best practice pre-disaster resilience and also serves as a method for collecting and collating information and data to promote and communicate 'best practice' pre-disaster resilience options across the nation
- The costs for such projects need to be apportioned between different levels of government. The intention here is to preserve incentives for all parties by ensuring that they all have a financial commitment. An example of this would be the Australian, state and local governments funding a project at a ratio of 1:1:1.

Along the lines of Infrastructure Australia's competitive prioritisation of projects, the Australian Government announced on 28 February 2013 that it is setting up a new agency, the National Insurance Affordability Council, to approve investments in priority areas for flood pre-disaster resilience. At least $100 million over two years is expected to be injected into the Council, which will fund pre-disaster resilience works jointly with state and local governments by redirecting funds currently used to buy terrorism reinsurance.

This is a positive step forward but needs to be extended in funding and in focus from just flood pre-disaster resilience to an 'all hazards' approach. Greater incentivisation of state governments and local councils would align efforts and generate a greater flow of information and dissemination of best practice, and support local councils' capability development.

Moreover, business can play a role by sharing risk data and their analysis with local councils to demonstrate the value of pre-disaster resilience. Businesses can also work with communities to help in understanding the financial benefits of reduced risk to their properties resulting from the pre-disaster resilience infrastructure and in developing social and community based resilience (such as disaster management plans).

4.3 Victoria – Bushfires

4.3.1 The scenario

Victoria is heavily exposed to bushfire risk and has experienced a number of very large bushfire events.

Some of the largest bushfire events in Victoria's history include:

- Black Saturday in 2009 which burnt 4,500km^2 of land, killed 173 people, injured an additional 414 and destroyed 2029 homes
- Ash Wednesday in 1983 where 2,300 homes were destroyed and 75 people were killed
- Black Friday in 1939 which burnt 20,000km^2 and resulted in 71 fatalities
- Black Thursday in 1851 which burnt around 50,000km^2 and killed 12.

The largest potential loss caused by a bushfire in Victoria would be one that affects the populous greater Melbourne Metropolitan fringe area. This area is the focus of this scenario. In the worst case scenario considered in this case study, a wet spring encourages the growth of grass and is followed by a severe drought throughout summer.

This drought dries out the bushland surrounding Melbourne. A heatwave then hits Melbourne with a string of days registering maxima in the 40–45°C range. The heatwave is itself associated with a range of economic costs including disruptions to electricity supply, potential closure of buildings in the CBD and an increase in heat-related deaths.

On one of the hottest and windiest days a number of fires spring up around the outskirts of Melbourne. This could involve a fire starting somewhere within the north-west to north-east of the city. This fire could then be fanned by strong north-westerly or north-easterly flames and driven south towards the outskirts of Melbourne. The fires may then spread to housing near bushland and further into urban areas. This scenario would be similar to the Duffy fires in Canberra, which resulted in the loss of 200 houses, only on a much larger scale. In this scenario, the most heavily affected Local Government Areas (LGAs), on a risk weighted basis, are likely to be Nillumbik and Whittlesea. Both of these LGAs are located in Melbourne's far north.

Figure 4.3: Example of housing intermingled with Bushland in Nillumbik, Victoria

Source: Google Earth

4.3.2 Natural disaster risks

Noting the different ways to present natural disaster costs discussed at the beginning of this chapter, average annual bushfire risks in the Melbourne area are currently estimated to be around $51 million in total economic value, increasing to around $165 million by 2050. This increase is primarily driven by increases in the value of property and assets in the area as well as increases in population. The total economic costs over the period to 2050 are expected to be around $3.7 billion which has a present value of around $2.1 billion.

Table 4.7: Estimated costs in Victoria Case Study ($m 2011)

Measure of cost	Total economic cost
Average annual cost in 2013	51
Average annual cost in 2050	165
Total cost to 2050	3,727
Present value of total cost to 2050	2,087
1% AEP	1,562
0.1% AEP	15,862
0.01% AEP	68,590

Source: Deloitte Access Economics (2013)

These figures take into account a range of costs including insured assets (such as houses, contents, cars and business continuity losses) as well as a number of direct disaster costs such as disaster response, public infrastructure reconstruction, private clean-up costs and loss of agricultural production. Estimates for a number of intangible costs are also included such as costs related to loss of life, injury and evacuation.

Beyond the impacts quantified in the measurement of risks, there are also a wide range of social, psychological and community effects of natural disasters which are difficult to quantify but no less important.

Other more on-the-ground effects which will create economic costs have not been explicitly accounted for in the above estimates. These include:

- **Utilities**

Depending on the precise path of the fire, above-ground services in the affected areas may be lost. In the case of electricity, this has the potential to affect broad areas of Melbourne in the rare event that critical transmission lines are destroyed. This would have flow-on effects for public transport networks and other infrastructure including schools and other public buildings.

Case study: The human side of natural disasters

Firefoxes Australia was consulted as part of the research undertaken for this paper. This organisation is a grassroots support group that formed in the Kinglake region of Victoria following the 2009 Black Saturday bushfires. The formation of Firefoxes Australia was a response to the unmet need of affected communities for a framework, forum and practical approach to rebuilding communities following a natural disaster.

Some of the critical experiences of those involved in the Black Saturday bushfires were that:

- The initial trauma of the event can last up to 10 years as the community recovers. Within this, the longer term psychological effects of natural disasters are poorly understood, with support focussed too strongly on those who have directly suffered loss rather than more broadly on those affected by the disaster
- There is a tension between the feeling of being lucky to survive and feeling loss over smaller things such as possessions, gardens and sentimental items
- At the moment, around four years after the fires, the community continues to feel effects of mental health issues, divisions between those who have been able to rebuild and those who have not, the consequences of insurance battles and the breakdown of families and friendships
- Rebuilding of housing and resettlement can take many years. Rebuilding is still an ongoing process in the Kinglake region, with only around 30% of houses rebuilt after two years. A particular cause of slow rebuilding that was noted is the difficulty in deciding whether to move on to another location or attempt to rebuild. Renters were particularly at risk of social dislocation from having to move out of the region, as landlords decide whether to rebuild the property or not.

- **Water**

Again depending on the path of the fire, there is the possibility of contamination of drinking water supplies. This would occur if fires were to heavily affect the catchment area of dams in Melbourne. For example, the Cardinia Reservoir, Silvan Reservoir, Sugarloaf Reservoir and Yan Yean Reservoir all lie within areas of risk. Together, these reservoirs account for around 25% of Melbourne's water storage capacity. Widespread fire within a catchment results in the destruction of ground cover, allowing high levels of dirt to run into the dam, as well as the creation of large amounts of ash which flows into the dam.

4.3.3 Pre-disaster resilience options

Pre-disaster resilience options focus on improving processes, structures and infrastructure to reduce the creation and effect of flying embers, which are primarily responsible for the ignition of houses during bushfires.

- **Building more resilient houses**

Past experience has shown that the 6% of houses located within 100m of bushland (71,000 properties in Melbourne) are responsible for around 87% of total housing losses during a bushfire. This has led to the development of specific housing standards for these bushfire-prone areas of Victoria. Depending on the specific risks of the location, the measures covered by these standards encompass:

- Sealing gaps in the building
- Sealing vents with mesh
- Installing a bushfire sprinkler system
- Replacing doors.

All of these changes in construction aim to reduce the chance of ember attack.

While these building codes are mandatory for new construction in bushfire-prone areas, they are only voluntary for existing properties. This is an area where community education about the benefits of retrofitting for disaster resilience could generate real benefits.

- **Vegetation management**

While properties at serious risk from bushfires are normally located within 100m of a large area of bushland, 50% of all properties destroyed by bushfires are within 15m of bushland (Risk Frontiers 2010). This implies that frequent management of vegetation within a property could generate significant benefits, not only for that property but for its neighbours.

Strategic alliances between local communities, organisations such as the Country Fire Authority and local government, are best placed to implement such granular pre-disaster resilience options and monitor compliance.

- **Reducing ignition sources**

Faults in either electricity transmission or distribution networks are a frequent cause of bushfires. Over the past 20 years they have been responsible for around 14% of the total area of land burnt by bushfires in Victoria (Weber n.d.) and the Victorian Bushfire Royal Commission found that five of the 15 fires it investigated were caused by electrical faults (Victorian Bushfires Royal Commission 2010). Burying wires underground would remove electricity transmission and distribution networks as a bushfire risk and is an example of an infrastructure-based response to developing resilience.

4.3.4 Benefits of pre-disaster resilience

- **Building more resilient houses**

The upgrades required for houses in bushfire-prone areas were thoroughly costed for a range of fire hazards and house types by the Australian Building Codes Board (ABCB 2009). A weighted average of these cost estimates suggests an average cost of compliance of $14,931 per house (the weights take into account the distribution of risks within the 100m zone covered). This cost estimate is a total cost of compliance with fire standards and not an incremental cost of the new standards. This means that it can be interpreted as the cost of upgrades for both new and existing houses.

It does not, however, appear that there is any thorough analysis of the benefits of compliance with these standards in terms of reducing fire risk. The analysis undertaken by the ABCB concedes that, due to a lack of evidence, it 'is not possible to accurately assess the effectiveness of enhanced bushfire protection measures in reducing estimated annual damage costs'. We have therefore assumed a reduction in fire risk of 80% for houses complying with the new building code. Although this is an assumption it is in line with some evidence from bushfire losses in America which suggested that there was an 82% increase in the proportion of buildings surviving a bushfire when certain ember resilience measures were in place (Foote 1994).

Building more resilient houses in high risk areas of the Melbourne fringe would therefore cost around $1.04bn in net present value terms but would generate benefits of around $1.45bn in net present value terms over the period to 2050. This gives a benefit cost ratio of 1.4.

• Vegetation management

Based on costs of vegetation management experienced in the electricity industry, we have estimated that clearing a 5m area around a house could be achieved at a cost of $200 a year. We have also incorporated an hour and a half of monitoring and compliance costs per house. For the 71,000 houses in Melbourne, in the high risk area, this translates to a total cost of $15.3m a year, which equates to $467m in present value terms over the period to 2050.

As a 5m clearance around a house reduces total bushfire risks by 30%, this is expected to result in a reduction in average annual disaster costs of around $14.7m in 2013 (increasing to around $47.6m by 2050). This translates to a reduction in the present value of disaster costs by $603m in the period to 2050.

Overall this suggests that improved vegetation management has a benefit-cost ratio of around 1.3.

• Reducing ignition sources

The cost of burying electricity wires has been estimated at around $9,700 per house in an in-depth analysis undertaken by the Economic Regulation Authority of Western Australia (ERA). This suggests that the overall cost for the 71,000 high risk homes in Melbourne would be around $690m.

Burying these electricity wires would reduce the chances of ignition by around 14%, giving a present value of reduced disaster costs of around $292m in the period to 2050. This implies that burying electricity wires has a benefit-cost ratio of around 0.4.

However, our analysis only takes into account the benefits of burying electricity wires for natural disasters. The analysis undertaken by the ERA focussed on benefits for electricity companies (such as reduced maintenance) and society in general (such as less visual clutter and less severe vehicle accidents). ERA's analysis found that burying electricity wires had a benefit-cost ratio of around 2.7.

If natural disaster costs are added to this calculation, the estimated benefit-cost ratio increases to around 3.1, with the program generating around $2.1bn of benefits in the period to 2050.

This case study again illustrates the benefit of undertaking pre-disaster resilience activity. It highlights the need for greater coordination to ensure that the most effective activities are targeted.

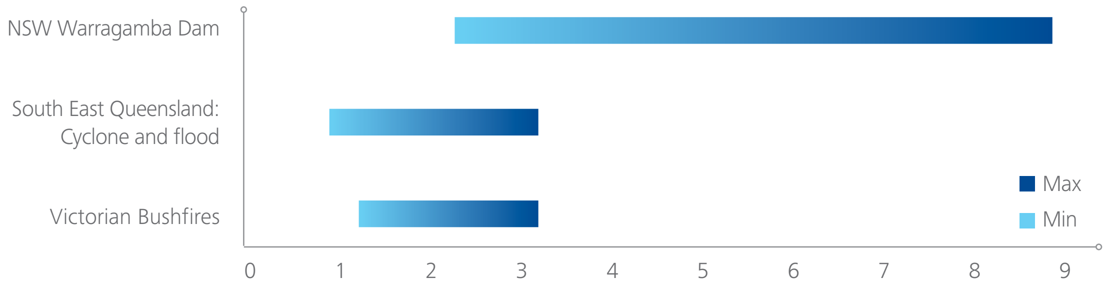
- Natural disaster risk needs to be mapped by location. For example, in the case of bushfires, the extent of the bush and fire load needs to be mapped in a manner that allows the determination of risk level in each house
- The most effective measures of mitigating the identified risks need to be ascertained. As an example, vegetation clearance may be determined to be the most appropriate solution to mitigating disaster risk
- Action on this front can be either compulsory or market-based. An on-the-ground compliance officer will be required to ensure that the property remains compliant, in this case potentially the rural fire service. Incentives can be either market-based (insurance discount) or mandated (legal requirement)
- Payment needs to be apportioned between the parties involved. In the example used, there is an immediate burden being placed on the compliance officer. To share the burden, it could be possible for governments to fully cover or subsidise the costs of the compliance officer.

Burying electricity wires generates around $2.1 billion of benefits to 2050

4.4 Summary

The case studies outlined above provide evidence of the economic benefits of building resilience[12]. While there is a large range of BCRs estimated (see Chart 4.2 below), it is important to note that investments in resilience which target high risk locations using appropriate combinations of infrastructure, policy and procedure have the potential to generate economic benefits.

Chart 4.2: Case Studies – Ranges – Benefit-Cost Ratio of specific resilience measures



Source: Deloitte Access Economics analysis (2013)

Whilst demonstrating that cost effective action can be taken, these case studies also highlight and point to some core elements of a reinvigorated agenda to build resilience:

- The estimated net benefits from upgrading the Warragamba Dam differ from those found in earlier studies in part because they have utilised detailed and current data provided by Roundtable members on the risks and costs of the Nepean River flooding. A national strategy to improve resilience needs to find ways to better coordinate relevant data held by all parts of government and business so that decisions can be made on the best available information
- The other two case studies point to the desirability of finding mechanisms that allows key investment decisions to be taken at a localised level, often property by property. The ranges shown for the BCRs for both cyclones and floods in SE Queensland and bushfires in high risk locations in Victoria reflect differences in whether the buildings are new or existing, and how risks and costs vary according to the precise location and type of building. For new buildings, the BCRs will tend to be towards the top of the ranges depicted in the chart and there will often be a clear case for requiring preventative action through building codes or planning for all new houses being considered in a region.
- In contrast, the BCRs for existing properties may be towards the lower end of the ranges shown. It will only be cost effective to invest in prevention in a subset of cases. Decisions taken by individual property owners will need to reflect the particular circumstances involved. Those decisions can be supported by government providing information and incentives and by the private sector providing price signals that reflect the risks involved. A coordinated approach across all parties will be needed for this to be effective.

These measures involve broader application of existing building codes, gathering better risk information, making better planning decisions and individuals taking responsibility for reducing risks around their own homes.

The case studies clearly point to the need for coordination across many parties, effective identification of both the risks and the resilience options as well as clear alignment of incentives to act.

The following chapter outlines recommendations for future actions in the area of pre-disaster resilience.

12 In each case, the estimated BCRs have been based on data and information drawn from existing studies as well as data provided by IAG and Munich Re. As with all government investment decisions, detailed analysis utilising the latest engineering and technical data should be conducted.

Estimated annual cost 2013

$

bn

FORECASTED TO GROW
BY 3.5% ANNUALLY