Appendix E: Cost benefit analysis methodology

The cost benefit analysis (CBA) undertaken in Section 4 essentially involves the comparison of two cases: a baseline case representing business-as-usual and a policy case where additional resilience measures are put in place. Total economic costs of natural disasters can be estimated under both of these cases. The differential in natural disaster costs can then be compared to the expenditure on resilience to determine the balance of costs of benefits for that particular resilience measure. In short, the process can be summarised as:

1. Estimate baseline natural disaster costs
2. Identify and cost a series of resilience measures
3. Re-estimate natural disaster costs
4. Compare costs of resilience to reduction in natural disaster costs.

The approach there has two data intensive components: estimating natural disaster costs and costing resilience measures.

Estimating natural disaster costs

Our approach for estimating natural disaster costs broadly follows the approach set out by the Bureau of Transport Economics (BTE, 2001) for estimating the total economic costs of a natural disaster. Under BTE's approach, the total economic costs of a natural disaster are broken down into four broad categories based on a combination of whether the costs are directly and indirectly caused by the natural disaster and whether the costs are tangible or intangible.

Considering each of the cost categories in order:

• Damage to buildings

This cost category also encompasses damage to other property such as motor vehicles and home contents. The approach taken to estimate these costs relied on data provided by Insurance Australia Group, MunichRe and Westpac. Insurance Australia Group was able to provide distributions of damage for assets insured with it in each of the case study regions. This allowed us to undertake modelling of both the average annual loss and the distribution of this loss over time. This Insurance Australia Group specific data was then scaled up to market wide insured losses by using MunichRe's data on total insured value in each of the case study regions. Insured value was then converted to total value by drawing on Westpac's data on total housing stock value in each of the case study regions.

• Damage to infrastructure

Damage to infrastructure focuses on damage to public infrastructure such as roads, transport networks, communication systems and the like. Expenditure on rebuilding public infrastructure following a natural disaster is covered by Category B of assistance provided under the NDRRA. A review of previous NDRRA expenditure and natural disasters indicated that:

- In Queensland, category B expenditure made up around 91% of total NDRRA expenditure on average
- In New South Wales, category B expenditure made up around 92% of total NDRRA expenditure on average
- In Victoria, category B expenditure made up around 47% of total NDRRA expenditure on average.

This information was drawn from a review conducted by the Department of Finance and Deregulation (2012). Total NDRRA expenditure was estimated based on an econometric analysis of historical expenditure – explained in more detail under 'emergency response costs'.

Table E.1: Economic costs of a natural disaster

	Direct	Indirect
Tangible	• Damage to buildings • Damage to infrastructure • Damage to crops and livestock.	• Emergency response costs • Household costs • Commercial costs • Loss of production.
Intangible	• Death • Injury • Personal items and memorabilia.	• Psychological • Inconvenience and stress.

Source: Bureau of Transport Economics (2001)

Damage to crops and livestock

In a slight departure from BTE (2001), the value of damage to crops and livestock wasn't estimated from building up individual costs components of agricultural production but, instead, drew on historical information on the value of agricultural production in the region from the ABS. ABS cat number 7503.0 contains detailed information on the value of agricultural production in Australia. This data was transformed to match the case study regions and provided the following estimates of annual agricultural production in each region:

- South East Queensland: $169m
- Melbourne fringe: $31m
- Hawkesbury-Nepean: $242m.

A proportion of this total value was assumed to be destroyed depending on the severity of the natural disaster. For example, if the modelled natural disaster was estimated to result in damages equivalent to half of the value of property, then half of the value of agricultural production was assumed to be lost.

Death and injury

Quantifying the costs of death and injury relied on two pieces of information. First, the value of statistical life was used to estimate the value of each life lost and injury incurred. According to the Office of Best Practice Regulation (OBPR) (2008): 'the value of statistical life is an estimate of the financial value society places on reducing the average number of deaths by one' and 'the value of statistical life (VSL) is most appropriately measured by estimating how much society is willing to pay to reduce the risk of death'. The VSL is a well established economic concept but there is a great deal of variability in estimates. For example:

- Updating the VSL used by BTE (2001) to today's dollars provides an estimate of $1.9m per death avoided
- Guidelines from OBRP based on a literature review recommend a value of $3.5m (OBPR 2008)
- Recent academic research identified a VSL in Australia of around $6m (Hensher et al 2009).

In our analysis, a VSL of $3.5m was used, in line with recommendations from OBPR. Values for serious injury ($853,000) and minor injury ($29,000) were drawn from BTE (2001) and updated to today's dollars using a CPI based adjustment. The adjustment factor was 1.46 based on comparing average CPI in 2011 to CPI in 1999.

The total number of injuries was estimated based on a historical analysis of natural disasters contained in the Emergency Management Australia (EMA) natural disaster database (EMA, 2013). This database contains information on the insured damage caused by natural disasters as well as the total number of deaths and injuries caused. This allows for a relationship to be established between insured costs, death and injury. For example for South East Queensland it was found that a quadratic relationship between insured costs, deaths and injuries was reasonable. This relationship implied, for example, that a $2.5bn insurance loss was associated with around 100 injuries and 17 deaths. Similar relationships were established for NSW and Victoria.

It was assumed that serious injuries made up 33% of total injuries and minor injuries made up 66% of total injuries.

Emergency response costs

Following the approach in BTE (2001), emergency response costs were estimated based on NDRRA payments. Expenditure under category A of the NDRRA covers emergency response costs. A review of historical NDRRA expenditures indicated that expenditure under Category C and D are insignificant when compared to Category A and B (Department of Finance and Deregulation, 2012). As a result, NDRRA expenditure on Category A was assumed to be the remainder of expenditure once category B expenditure was removed (this is described above under 'Damage to infrastructure').

However, it should be noted that NDRRA expenditure does not account for total government expenditure. Rather, NDRRA expenditure reflects the Australian Government's contribution to costs incurred by state governments. This contribution depends on the scale of expenditure made by the state government – higher levels of expenditure receive greater contributions from the Australian Government reaching a maximum of almost 75% of total costs for very large natural disasters. The rules set out in the NDRRA Determination can be used to convert Australian Government expenditure to total government expenditure (Attorney General's Department, 2012).

For example:

- For natural disasters occurring in Queensland, Australian Government expenditure was estimated to be around 89% of total government expenditure
- For natural disasters occurring in NSW, Australian Government expenditure was estimated to be around 45% of total Government expenditure
- For natural disasters occurring in Victoria, Australian Government expenditure was estimated to be around 48% of total Government expenditure.

Overall, Australian Government expenditure was estimated to be around 80% of total government expenditure.

A relationship was then established between this total government expenditure and the insured natural disaster costs in the Insurance Council of Australia database. Essentially, it was found that a $1 increase in the insured natural disaster costs leads to 60c of expenditure by all levels of government over the following four years.

This information allows for total government expenditure to be estimated for any level of insured natural disaster costs in each of the case study regions and for this total government expenditure to be attributed between Australian and state governments and between Category A and Category B of the NDRRA.

• Commercial and household costs

The commercial and household costs to be estimated encompassed costs of clean-up for commercial premises and costs of clean-up and evacuation for household costs. The values for these costs were drawn directly from BTE (2001) and updated to 2011 dollars using the change in CPI. In particular the costs used were:

- Residential clean-up: $5,900 per house
- Commercial clean-up: $3,800 per premises
- Public Building clean-up: $15,000 per premises
- Evacuation: $77 for the first night and $38 for each subsequent night per person.

For evacuation it was assumed that there were 2.6 people per household (on average) based on the 2011 census results and that these people were evacuated for two days each, on average.

While reliable information on the distribution of evacuation time and how this relates to the nature and severity of a natural disaster was not available, the sensitivity of results were tested and changes in evacuation time did not significantly affect our findings.

To estimate the number of buildings affected, a similar approach was taken as for that used to estimate the extent of death and injury: historical data on insured losses and the number of properties affected were compared to identify average statistical relationships. This relationship was then used to estimate the number of buildings affected for any sized natural disaster.

• Loss of production

In general, loss of production was not included in the CBA. Whether to include or exclude production largely comes down to a decision on the scope of the CBA. As the CBAs are essentially conducted at a national level, it is likely that production is able to shift from one location to another. That is: losses in production for a business in the disaster area are offset by gains in production for another business elsewhere in Australia. For example, a light manufacturer located in Brisbane may have to close their business for a week following a flood and so cannot supply their products to market. Users of their products would then seek out the next best alternative and purchase from its manufacturer– transferring their expenditure within the economy.

From a national perspective, it is only in rare cases where loss of production from natural disasters should be accounted for. This involves cases where imports or exports are affected or where unique production abilities are affected. For example, in the Hawkesbury-Nepean case study there is the potential that exports of Grain and Coal from NSW might be affected and the loss of these exports could be included in the CBA. We did not, however, include these costs in the CBA figures as diversion of exports of both coal and grain to other ports is possible. These potential costs were covered separately in a qualitative manner.

• Personal items and memorabilia

Treated qualitatively and so did not enter the CBA.

• Psychological, inconvenience and stress

Treated qualitatively and so did not enter the CBA.

Estimating resilience benefits and costs

The resilience benefits and costs are outlined in some detail in Section 4 but the inputs used are gathered below for convenience of reference

Table E.2: Resilience options – benefits and costs

Case study	Resilience measure	Data	Source
South East Queensland	**Housing**		
	Benefit:	66% reduction in damage.	Risk Frontiers (n.d.)
	Cost – retrofit	$13,000–52,000	Stewart and Wang (2011)
	Cost – new	$2,600–6,500 a house	Stewart and Wang (2011)
NSW	**Dam wall**		
	Benefit:	73% reduction in damage	Molino Stewart (2012)
	Cost	$337m	Molino Stewart (2012)
Victoria	**Housing**		
	Benefit:	87% of houses burnt are located within 100m of bushland No reliable information on effectiveness of ember proofing, assumed 80% rate of effectiveness	Risk Frontiers (2010)
	Cost	Average $14,931 a house	ABCB (2009)
	Vegetation management		
	Benefit:	5m clearance reduces total risk by 30%	Risk Frontiers (2010)
	Cost	$198 a year a house in vegetation management cost $17 in enforcement cost a year a house	Vegetation management costs estimated from data on expenditure on vegetation management by electricity distribution and transmission businesses. Data indicated average costs of 11c per m3 of management area. Enforcement cost based on half an hour of time at current AWE levels.
	Underground power lines		
	Benefit:	14% reduction in damage	Weber (n.d.)
	Cost	$9,685 a property	ERAWA (2011)