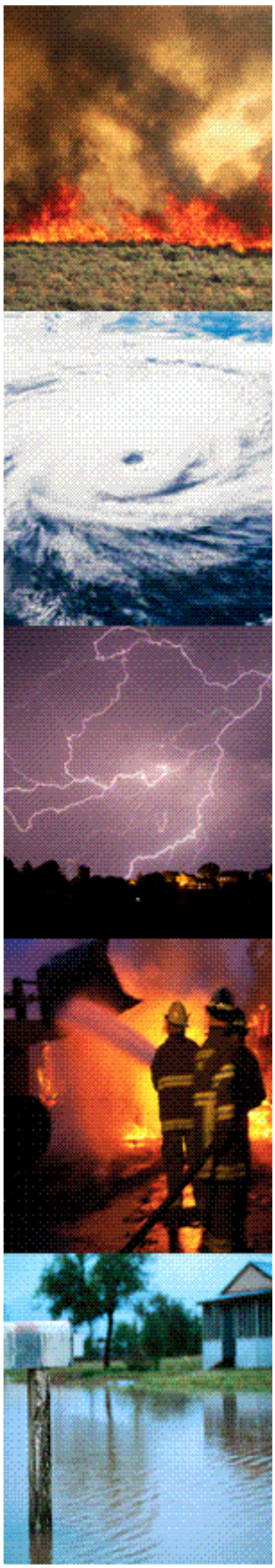

IMPACTS FRAMEWORK FOR NATURAL DISASTERS AND FIRE EMERGENCIES

(Including Project Report)

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RMIT University and Bushfire CRC

Version 10 FINAL May 2010

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ACKNOWLEDGEMENTS

Thank you to Dawn Easton, Nick Nicolopoulos and Vanessa Dickson (NSW Fire Brigades) for providing the Bushfire Cooperative Research Centre (Bushfire CRC) and subsequently myself with the opportunity to propose a framework for national acceptance as part of the Impact of Natural Disasters and Fire Emergencies project.

As well as those from the NSW Fire Brigades, I would also like to thank John Handmer (RMIT University, Bushfire CRC) and Lyndsey Wright (Bushfire CRC) for their guidance and feedback throughout the different stages of preparing this document.

Thank you also to the members of the project's Advisory Group and Steering Committee for their comments and suggestions for improving the framework and other parts of this document.

PROJECT BRIEF

The purpose of the Impacts Project is to *'better understand the economic, social and environmental impacts that natural disasters and fire emergencies have on a community to help inform decision making at the policy level'* (from the Project Plan – Version 0.7 Final, p. 7).

As part of this project, the Bushfire CRC were contracted to undertake Part A of Phase 1 of the project, which is explained below (from the Project Plan – Version 0.7 Final, p. 11). The people involved in achieving this were Catherine Stephenson (RMIT University, Bushfire CRC), John Handmer (RMIT University, Bushfire CRC) and Lyndsey Wright (Bushfire CRC), known from this point on as the Project Team.

This report presents the results of the third requirement of Part A (highlighted in bold on the next page), being the Impact of Natural Disasters and Fire Emergencies Framework, referred to from this point on as the Impacts Framework.

PHASE 1

PART A – Framework Design

1. Environmental Scan

    a. Conduct a literature review and environmental scan to identify and describe current data models and frameworks for collecting and reporting the impacts and costs of natural disasters and fire emergencies, including the National Risk Assessment Framework

    b. Produce a report on the findings of the environmental scan, including commonalities and differences among the frameworks and models reviewed, and the advantages and disadvantages of each

2. Needs Analysis & Requirements Capturing

    a. Consult among the identified Emergency Management Stakeholders (i.e. the Advisory Group and any identified Working Groups) to collect stakeholder requirements for an Impact framework (including the identification of what questions the selected framework must help to answer)

    b. Produce a report that establishes criteria to guide selection and development of the proposed framework

3. Nationally Accepted Australia-wide Impact Framework

Produce a nationally accepted Australia-wide framework for reporting the impacts of natural disasters and fire emergencies based on the work of the first two deliverables above. The framework must:

i. **Identify the data needed for the framework**
ii. **Define core elements such as what is meant by 'impact' and 'cost' and how impact will be represented in the framework (e.g. qualitatively and or quantitatively)**
iii. **Identify key categories or elements of the framework, e.g. social, economic environmental, tangible, intangible**
iv. **Be scalable and capable of being applied to natural disasters and fire emergencies of any type and size**
v. **Be sufficiently detailed and presented to enable the identification of data sources to populate it (i.e. as in the next stage of the project)**

Each of the three deliverables in Part A is revised at three levels before being approved. The first draft is reviewed by the Project Management Team[1], then by the Advisory Group, and finally by the Steering Committee. At each stage, the draft is returned to the Project Team with comments, which are used to amend the draft before it is sent to the next level. This process ensures that the final report or framework is reviewed thoroughly by a number of experts and it is continually improved until the final version.

Future phases of this NSWFB Managed project will take the Framework and identified data sets developed by Bushfire CRC, and use them to build an online pilot portal that will bring the Framework to life by connecting it up with existing Impacts data (where available).

[1] Project Management Team contains the following members of the NSW Fire Brigades: Dawn Easton, Nick Nicolopoulos and Vanessa Dickson.

SUMMARY

Natural disasters and fire emergencies are capable of occurring throughout many parts of Australia and the world, and as a result, various frameworks and models have been developed to measure the impacts and costs of these events. The purpose of this report is to produce for national acceptance a framework for reporting the impacts of natural disasters and fire emergencies that fulfil the criteria set out as part of the project brief (refer to above chapter for details). It was also designed to satisfy as many as possible of the user requirements that were expressed during a workshop held on 9 June 2009 in Sydney with the Impact of Natural Disasters and Emergencies Project Working Group (see Appendix 1 for members).

Three previous reports written for this project served as the background material for the development of the Impacts Framework and subsequently this report. They were the:

- *Summary Report* (of 9 June workshop), which identified the framework requirements, shown in chapter 2 below,
- *Updated Committee-Agreed Framework Selection Criteria*, which consisted of nine criteria by which frameworks and models were scored using a scale of 0–3 for each criterion and
- *Literature Review on Impact and Cost Frameworks and Models for Natural Disasters and Fire Emergencies*. Twenty-four frameworks and models that collect and report the impacts and costs of natural disasters and fire emergencies were reviewed and compared in terms of their advantages and disadvantages and commonalities and differences.

Given that so many existing frameworks and models contain excellent processes, data and/or other information, the aim when developing the Impacts Framework was to incorporate elements of these frameworks and models into one. That is, have a single model that:

- collects and collates information on a disaster's impacts (including losses and benefits),
- can be used for a number of hazard types across any temporal or geographical scale,
- can be used across the prevention, preparedness, response and recovery (PPRR) spectrum, and
- works with existing systems and models.

In order to satisfy these aims, the starting point was to use economic principles. These set what should be included when accounting for a disaster's impacts. An economic loss assessment was proposed to be used as the building block for the Impacts Framework, as it ensures that a number of appropriate steps are followed to enable the true cost to the economy in question to be determined, thereby providing decision-makers with more realistic and accurate information. Several other loss assessment methods exist, such as those that measure insurance and financial losses. These and other types of economic models were all deemed inappropriate

when creating a national framework owing to their complexity, data needs or specificity to a single hazard.

The Impacts Framework is shown in Figure 1 below.

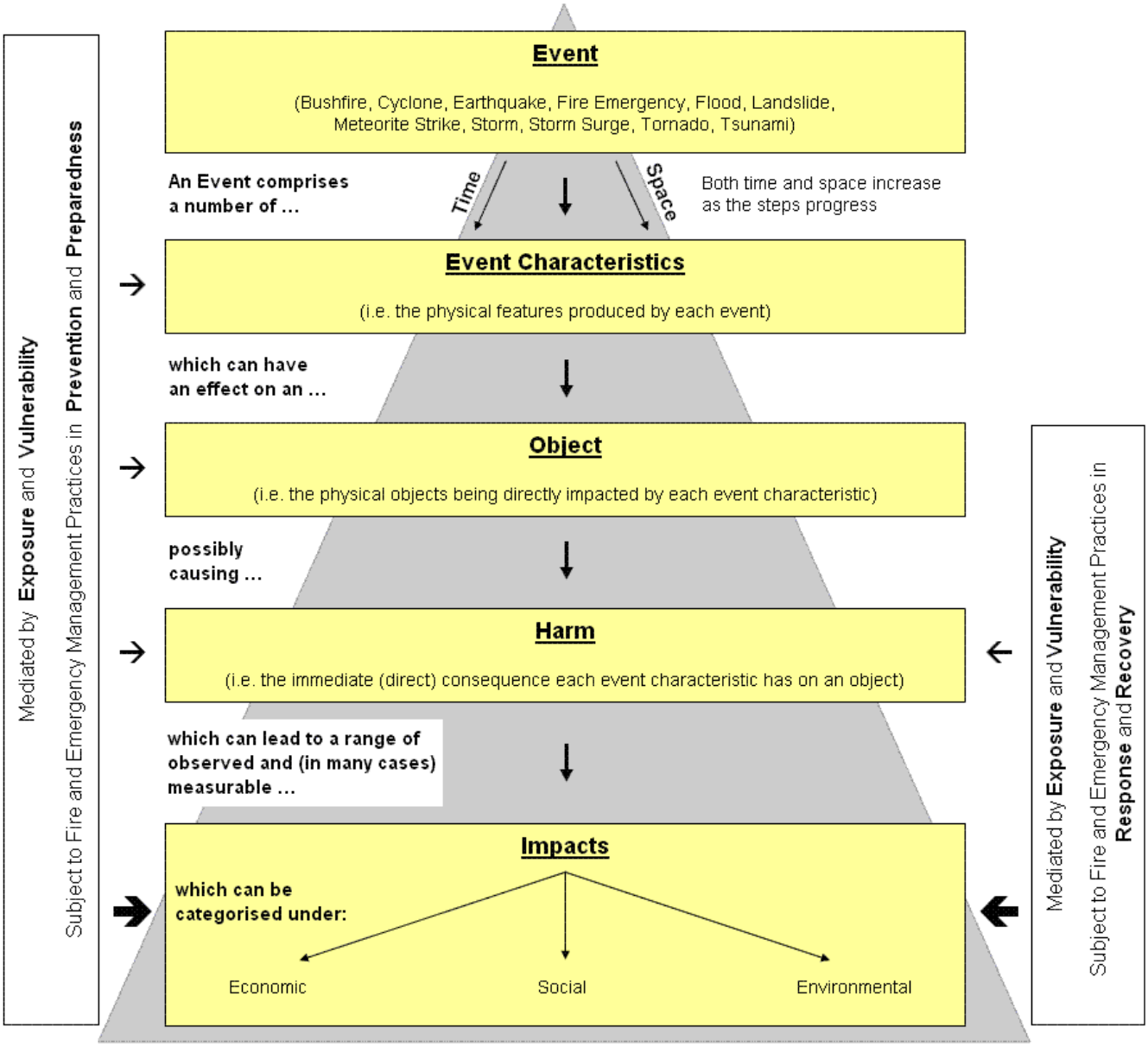

Figure 1 The Impacts Framework

The first element identifies the event. Those events included in this framework are:

- Bushfire
- Cyclone
- Earthquake
- Fire emergency
- Flood
- Landslide
- Meteorite strike
- Storm
- Storm surge
- Tornado
- Tsunami

As per project requirements, this list came from the National Disaster Relief and Recovery Arrangements (Department of Transport and Regional Services 2007), with the addition of 'Fire Emergency'. Definitions of all the events can be found in the glossary.

Following on from this, each event produces from one to several physical features, labelled in the framework as event characteristics, which are responsible for the impacts. Examples include the fire, heat and smoke produced by bushfires and fire emergencies. By separating these out, specific impacts can be attributed to each characteristic, thereby providing emergency management personnel and policy-makers with a much more detailed analysis than simply that the bushfire as a whole caused 'x' impacts. In some cases, however, it may not be possible to identify exactly which characteristic caused each impact. In this circumstance, the step could be bypassed.

Event characteristics directly impact on a range of objects, such as infrastructure, property, agricultural product, people, cultural heritage and the natural environment. A generic list has been created, which can be tailored to suit the specific actual or hypothetic objects required for each study.

The next element in the framework identifies the level of harm caused to an object. Categories have been used to describe these levels: being destroyed, damaged or not harmed for inanimate objects, and fatality, major injury, minor injury and not harmed for people and fauna. The definitions for major and minor injuries were sourced from BTE (2001, p. 106) whereby major injuries account for those admitted to hospital, and minor injuries are those that are treated at hospital, but not admitted. Under each of these categories, the impacts are recorded as economic, social or environmental. Furthermore, these initial impacts typically have flow-on effects that can again be economic, social or environmental. An Impacts Framework Data spreadsheet has been created to identify the actual data items that the online Framework would seek to populate (where the data is available). This spreadsheet also illustrates the complex relationships between impacts and demonstrates the whole framework in action. The spreadsheet accompanies this report.

Lastly, the four elements of prevention, preparedness, response and recovery are divided into two classes in this framework based on when in a disaster or emergency management time-line the element is active. Prevention and preparedness activities are undertaken before the event, and can include altering the event characteristics (e.g. flood mitigation works), reducing the harm or impacts (e.g. compatible building codes), and altering the object to make it less susceptible to harm or to increase its capacity to recover (e.g. community resilience). Response and recovery are activated when an event is imminent or as it occurs, and can be directed at reducing the impacts, either immediate or longer-term, and so focus on the affected objects, generally on infrastructure, people and communities, their livelihoods and ecosystems.

The overall aim of this framework is to be able to assess what the impacts are. As much as possible, this should be done at the quantitative level, i.e. for all economic and some social and

environmental impacts. For impacts unable to be quantified, qualitative information should be sought.

As with any framework or model, the Impacts Framework contains several limitations, including:

- that loss assessments are inherently complex,
- the level of knowledge required and produced. That is, the possible lack of data to produce meaningful results, and vested interests (e.g. major enterprises, land developers, environmental interests) emphasising certain types of data over others,
- the differences in philosophy and differing approaches brought to the loss assessment,
- the variations in funds, expertise, and time available for assessments, and
- the accuracy of monetary estimates given to destroyed or damaged assets.

1. INTRODUCTION

1.1 Background and Objectives

Natural disasters and fire emergencies are an inevitable part of life for many people and numerous frameworks and models have been developed to measure the impacts and costs of these events. These frameworks and models may be generic and applicable to a range of hazards (as typically processed-based ones are), or may be specifically focused on one type of hazard (as is the case with numerous computer-based hazard simulation models). They may only look at the impacts of the event, the losses associated with the event, the financial costs occasioned by the event, or the benefits flowing into an affected area or they may consider a combination of all of these.

To further complicate the range of frameworks and models available, many have been developed to serve one or more different functions, including an assessment of:

- the expected benefits of mitigation strategies,
- the potential impacts if a disaster occurs in the future,
- the actual event while it is occurring or after the immediate threat has passed, or
- the situation long after the disaster, for such purposes as inquiries, preparation for next time, etc.

The functions described in the above four points reflect one way of viewing emergency management, which are its prevention (mitigation), preparedness, response and recovery (PPRR) elements.

As stated in the *Project Brief* chapter, the Impacts Framework is being developed to be used throughout Australia and must satisfy a number of criteria, which are to:

- identify the data needed for the framework,
- define core elements, such as what is meant by ‘impact’ and ‘cost’ and how impact will be represented in the framework (e.g. qualitatively and/or quantitatively),
- identify key categories or elements of the framework, e.g. economic, social, environmental, tangible, intangible,
- be scalable and capable of being applied to natural disasters and fire emergencies of any type and size, and
- be sufficiently detailed and presented so as to enable the identification of data sources to populate it (i.e. as in the next stage of the project).

Other requirements are set out in the following chapter (*User Requirements*).

Given that so many frameworks and models already contain excellent processes, data and other information[2], the aim when developing the Impacts Framework was to incorporate elements of these frameworks and models into one. That is, have a single framework that:

- collects and collates information on a disaster's impacts (including losses and benefits),
- can be used for a number of hazard types across any temporal or geographical scale,
- can be used across the PPRR spectrum, and
- works with existing systems and models.

Even though this was a huge amount of information to be incorporated into one framework, the need to make the method rigorous and the process 'user-friendly' was also a high priority. This was achieved by using an economic loss assessment as the foundation for developing the framework, as it ensured that all impacts and costs could be accounted for and could be easily understood and followed.

1.2 Terminology Used in this Report

To ensure that there is a common understanding of the terminology used throughout this report, the following words have been defined. These words also appear in the glossary.

- **Impact:** Is the broadest term and includes both market-based (i.e. tangible) and non-market (i.e. intangible) effects[3]. Individual impacts can be either negative or positive.

- **Tangible:** Items that are normally bought or sold and that are therefore easy to assess in monetary terms[4]. In the context of the 'triple bottom line' approach used in this study, economic impacts (defined below) are considered to be tangible.
- **Intangible:** Items that are not normally bought or sold and for which therefore no agreement on their monetary value exists[5]. In the context of the 'triple bottom line' approach used in this study, social and environmental impacts (defined below) are considered to be intangible.

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[2] In a report titled 'Literature Review on Impact and Cost Frameworks and Models for Natural Disasters and Fire Emergencies', 24 frameworks, models and other relevant documents were reviewed in the lead up to this report.
[3] National Research Council 1999, p. 5
[4] Handmer, Reed and Percovich 2002, p. 124
[5] Handmer, Reed and Percovich 2002, p. 123

- **Direct:** Impacts that result from direct contact with the event[6].
- **Indirect:** Impacts that arise as a consequence of the impacts of the event[7]. For example, disruption to the flow of goods and services in and out of the affected area.

- **Economic:** Although this is not desirable, the word economic has two meanings in this report. In the field of economics, the word economics refers to the study of the economy as a whole and measures all losses and benefits to that economy[8]. In this sense, all impacts, including environmental and social impacts, are included, regardless of whether they can be valued in monetary terms or not. In the context of the project brief, economic refers to the impacts on tangible assets, both direct and indirect, as shown in Table 1.

  This meaning is not restricted to this project's brief, as the phrase 'economic, social and environmental impacts' is commonplace, with many government policies advocating the use of the 'triple bottom line' approach[9] in the context of this meaning.

  When reading this report, economic means impacts to the whole economy when used in reference to an economic loss assessment, whereas it refers to tangible impacts when used in the Impacts Framework (described in chapter 4).

- **Social:** Impacts relating to people, such as health (e.g. death, injury, mental health)[10] and items or places of personal (e.g. memorabilia) or cultural (e.g. heritage buildings or sacred sites) significance. It also includes impacts to the broader 'social fabric' of the community[11].

- **Environmental:** Impacts on the natural environment, including assets such as the soil, water, air, species, habitat, and flows such as ecosystem services.

[6] Handmer 2003, p. 92
[7] Handmer 2003, p. 92
[8] Handmer, Reed and Percovich 2002, p. 123
[9] Suggett and Goodsir 2002
[10] Middelmann 2007, p. 9
[11] Middelmann 2007, p. 9

- **Loss:** In economic terms, it is a measure of the impact on a specific economy. It is taken as being equal to the resources lost by the specific area as a consequence of the disaster. The resources can be expressed in time, money or intangible loss[12].

- **Benefit:** Any benefits the economy receives as a result of the disaster. These may include financial benefits, such as payments by the government (e.g. recovery packages), donations or insurance payouts[13]. It may also include environmental or social benefits. Enhanced business activity is another potential benefit.

Below are terms used in the Impacts Framework:

- **Event:** An incident or situation that occurs in a particular place during a particular interval of time[14].

  In this case, the incident or situation is the natural hazard, with the following being included in this framework: bushfire, cyclone, earthquake, fire emergency, flood, landslide, meteorite strike, storm, storm surge, tornado and tsunami.

- **Event characteristic:** The physical features produced by an event.

- **Object:** The physical objects being impacted by each event characteristic, which may include people, fauna, flora, buildings and infrastructure.

- **Harm:** The initial impact on an object, categorised as destroyed, damaged or not harmed for inanimate objects, and fatality, major injury, minor injury and not harmed for people and fauna. The definitions for major and minor injuries were sourced from BTE (2001, p. 106). For ease of accessing data it is recommended hospital admissions relating to the event be used as a surrogate for major injuries whilst those treated but not admitted to hospital be used as a surrogate for minor injuries.

Depending on the most appropriate fit, impacts will be represented both quantitatively and qualitatively. Direct (economic) impacts will be represented quantitatively, such as the impact on buildings, infrastructure and fencing. Indirect (economic) impacts will be represented both quantitatively and qualitatively. Intangible impacts will also be in both quantitative and qualitative forms, with fatalities and injuries being given a dollar value. All other social impacts, such as

[12] Handmer, Reed and Percovich 2002, p. 123
[13] Handmer, Reed and Percovich 2002, p. 32
[14] EMA 1998, p. 44

emotional trauma and loss of memorabilia, will be listed, with no dollar value assigned to them. Valuing some environmental impacts as ecosystem services is proposed in this framework.

Cost is another term associated with natural disasters and emergencies, which can be defined as '*direct and indirect, involving any negative impact, including money, time, labour, disruption, goodwill, political and intangible losses*' (Emergency Management Australia (EMA) 1998, p. 26). Since there is some overlap between loss and cost and they could be considered synonyms, loss will be used as the principal word in this report. If cost is used, it should be viewed as a subset of loss to describe the financial losses sustained by the community.

Including the benefits to a community after a natural disaster or emergency may sound strange, since the first thing we envisage is destruction; however, this is a fundamental part of any economic loss assessment. It is especially important when measuring the impacts on a small scale (i.e. regionally or smaller), as the money flowing into an economy partially offsets the losses flowing out of it (Handmer, Reed and Percovich 2002).

1.3 Measuring Natural Disaster and Fire Emergency Impacts Using an Economic Loss Assessment

An assessment of the full range of impacts of natural disasters and fire emergencies is important at all levels of Government. Without a rigorous method to assess the impacts and losses sustained from natural disasters and fire emergencies, decision-makers would not have the objective information they need on which to base mitigation strategies (e.g. policies, programs) for the prevention or reduction of future disaster effects (Handmer, Reed and Percovich 2002). A loss assessment process based on sound economic principles is a very useful tool for providing this information, as it looks at the impacts, losses and benefits of an event and calculates the net economic loss to the affected area (Handmer, Reed and Percovich 2002).

The fundamental attributes of an economic loss assessment are that it (Handmer 2003):

- attempts to capture all economic, social and environmental impacts, which are traditionally measured under the categories of direct, indirect and intangible in a loss assessment,
- attempts to assess the impacts to all members of society or the economy, not just individual firms or businesses,
- defines the spatial (geographic) and temporal boundaries in which the assessment is to be made,
- looks at changes to economic activity within the defined boundaries (i.e. flows in and out of the boundary), not just at components within it,
- counts both negative and positive impacts, and
- looks at market (or depreciated) value, rather than replacement value. This is because the replacement item is typically new, and will generally have a much higher value than the same item that was destroyed or damaged (owing to depreciation over time), which would therefore overestimate the economic loss.

Reports by Handmer (2003) and Handmer, Reed and Percovich (2002) contain thorough descriptions and examples of these attributes.

When conducting loss assessments, impacts are usually broken down into their (tangible) direct, (tangible) indirect and intangible categories (Bureau of Transport Economics (BTE) 2001). Even though the intangible category includes both direct and indirect intangible impacts, these are generally grouped together for the purposes of an assessment. These words are defined as follows, and can also be found in the glossary. Direct losses are comparatively easy to measure and cost, as they are readily bought and sold in existing markets. Indirect losses are slightly harder to value, as they are a consequence of the event and can be more difficult to confirm and measure (Rose and Lim 2002). Intangible impacts, on the other hand, are very difficult to value financially, as generally no market exists to accommodate them (BTE 2001). Several methods have been developed to try and estimate the value of these non-market impacts. They typically use information from related markets to assign a value to non-market goods (revealed preference techniques) or conduct surveys that measure people's willingness to pay for various non-market resources (stated preference techniques) (refer to Morrison 2009 and Thompson and Handmer 1996 for an in depth examination of these techniques).

Table 1 presents several economic, social and environmental impacts, illustrating where they lie within the direct, indirect and intangible categories. In general, economic impacts fit within the (tangible) direct or indirect categories, while social and environmental impacts are traditionally classified as intangibles.

Table 1 Types of loss and measurement (uncertainty in both identification and valuation increase from the top left to the lower right of the table)

Eco – Economic impact Soc – Social impact Env – Environmental impact

Can the loss be bought or sold?	**Direct loss** (Loss from direct contact with the natural event)	**Indirect loss** (No contact – loss as a consequence of the event)
Yes – **Tangible**	Buildings and contents Eco Cars Eco Livestock Eco Crops Eco	Disruption to transport Eco Loss of profit Eco Legal costs associated with lawsuits Eco
No – **Intangible**	Lives and injuries Soc Loss of memorabilia Soc Loss of cultural structures Soc Ecological damage – habitat destruction Env	Stress and anxiety Soc Disruption to living Soc Loss of community Soc Ecological damage – erosion, air pollution Env

Source: Handmer 2003, p. 93

In reality, the impacts associated with any natural disaster or fire emergency do not fit neatly into a box like the one shown in Table 1. They are in fact very complex and can cross over more than one category simultaneously. For example, the disruption to transport with the closure of the main road into a town for prolonged periods leads to a large range of impacts in its own right. It can lead to disruptions in moving commercial products out of the affected area, thereby increasing the cost of transportation when drivers are forced to seek alternative routes, or

possibly the loss of orders being placed with the company in the affected area. Depending on the area in which the study is being carried out, these can be considered economic impacts. In addition, social impacts stemming from the same road closure are just as significant. As a result of losing business, the company may lay off some of its employees, leading to a large strain on the household budget and the associated stress of finding money to pay the bills, causing anxiety and conflict in households, and importantly, affecting other local businesses as people have less to spend and these businesses in turn experience their own stress. If the disruption is longer-term, the local economy may contract permanently, and people may limit health and education expenditure with further negative consequences. Some townspeople may also feel isolated and trapped, causing them to become increasingly anxious.

While it is important to understand that the impacts associated with disasters are more complex than shown in the table above, using simple tables and diagrams captures the basic impacts, thereby making the assessment of them relatively straightforward and the results easy to interpret. It must be kept in mind, however, that this does not give the full picture, which is effectively impossible to capture without an extensive case study over an extended period (i.e. up to many years).

1.4 Why not Measure Impacts on Natural Disasters and Fire Emergencies Using a Different Loss Assessment Method?

Four common forms of loss assessments were excluded in the selection process for choosing suitable frameworks and models to review as part of the literature review completed at an earlier stage of this project. The first relates to insurance losses. Insurance losses are typically seen as indicative of disaster losses, but insurance is in the hands of part of the private sector and is generally not interested in the impact of the disaster on the local economy. It is interested in the claims against insurers. Insurance is usually only partial; not everyone is covered, underinsurance is widespread and many assets (such as those held by government) and activities are normally uninsured. Furthermore, household insurance usually replaces lost items with new ones, resulting in a much higher value for such items. In contrast, economic loss assessments, a depreciated (or market) value is used to reflect the actual value of the lost asset.

Another approach excluded from selection is general equilibrium modelling, which attempts to estimate the impact of an event on a specified economy. It does this by modelling the impact on the total economic flows of goods and services. This approach would appear to make sense in disaster loss assessment when it is concerned with the impact of an event on an economy. However, there are a number of reasons why this approach is not widely used in disaster loss assessment. A good model of the economy is needed, which in turn requires very detailed data on all sectors and how they respond to different impacts. Such models exist at national and state levels but most Australian disasters have barely discernable small impacts at these levels. At local levels, the impacts may be large but the models at this level tend to be much more basic. The models require specialist expertise to develop and run, and for all these reasons were considered inapplicable in this study with its emphasis on robust approaches that can be applied with limited expertise and data at a wide range of scales.

There is another model called the Cost plus Net Value Change (C+NVC) model (Donovan and Rideout 2003), which focuses on the best use of suppression resources, although it can be applied to other fire risk management strategies. It does not put benefits against costs, but

seeks to find the smallest total of costs plus loss. The standard measure of mitigation, that of losses avoided, is not used and there is no attempt to calculate the losses avoided by the suppression measure under assessment. The advantage of the approach is that data on losses avoided are not needed, and it can be seen as a measure of the sensitivity of losses to changes in the amount spent on suppression. In addition to being limited to the economics of fire management, another major disadvantage from an economic point of view is that it does not directly examine the return on investment – other than in a comparative sense with alternative suppression measures.

In some circumstances, however, an economic assessment may not be appropriate, as people may want to undertake a financial assessment instead. This type of assessment focuses on losses from the perspective of a business or businesses, or that of a local area, ignoring the benefits the economy receives, transfer effects and depreciated values of assets (Handmer 2003). An example of this may be when a town is separated by a river and a bushfire burns through the businesses on one side of the river. In this case, there will be large financial losses to the affected businesses that can be assessed and used by decision-makers. When conducting an economic assessment on the whole town, however, there maybe no net loss (or gain) as a result of transfer effects. That is, people will now buy goods and services from businesses on the side of the river that was not burnt, keeping the money within the community and local economy, resulting in no net loss of local trade. There may, however, be significant loss of assets and indirect (or consequential) loss to the economy as a result of wages lost and therefore not spent. Analysing losses through a financial assessment may be appropriate for specific cases, but when considering the impacts of natural disasters and fire emergencies on a local, regional or state scale, an economic assessment will generally reveal the true impact on society and provide decision-makers with more realistic and accurate information. Sometimes, however, an economic assessment will not take account of significant social disruption.

1.5 Report Structure

The user requirements are reviewed in chapter 2. The methodology in chapter 3 then explains the process used to create the Impacts Framework. Following on from this, chapter 4 presents the Impacts Framework, providing an example of the framework in use. Chapter 5 is the conclusion for the report. The glossary makes up chapter 6, where the definitions of the economic and natural disasters and fire emergency terms used in this report are found. A list of appendices follows in chapter 7, which includes a worked example of the framework using an earthquake scenario, with chapter 8 containing the full list of references.

2. USER REQUIREMENTS

A workshop was held on 9 June 2009 at the Botanical Gardens in Sydney, in which the Impact of Natural Disasters and Emergencies Project Working Group (see Appendix 1) discussed what the framework should be able to do and incorporate. The following information has been extracted from the workshop's *Summary Report*.

Please note that the issues raised under the '*Data Considerations*' section will not be addressed in this report, as they will be tackled by those completing Part B of the Impacts Project. In addition, the first two questions under '*Difficult Questions*' could also be tackled by those completing Part B of this project, or be issues for the decision-makers to address.

What a Framework Must be Able to Do

General Considerations

- Be usable at different levels of government, with local or regional government levels being most advantageous.
- Be scalable to different types and sizes of disasters.
- Be flexible as a tool across the PPRR spectrum.
- Work with existing systems.
- Show the cost of a natural disaster to assist with decision-making (e.g. for allocation of resources or policy-making). Figures might be actual or hypothetical.
- Be able to be used for tactical and response operations as well as mitigation planning.
- Contextualize the particular impact assessment being done with some parameters around it so the user can understand issues around pre-planning, planning during the event (i.e. rapid impact assessment) or long-term recovery.
- Be user-friendly, but still have a robust methodology or theoretical framework that sits behind it.
- A process-based framework or model may be useful.

Comparability considerations

- Have clear definitions, terminology and counting rules for comparability.
- Allow comparability between types of hazards and hazards across geographic areas.
- The boundaries drawn around local or regional government areas will determine the cost methods that are included or excluded and therefore affect comparability. Guidance needs to be given around this to limit this type of comparability[15].

Data considerations

- Be supported by good quality data that are also reliable.
- Work broadly with data management systems already in place.
- Consider standards in relation to understanding how the costs are arrived at, e.g. formulas used, metadata.
- Deliver guidance to set out boundaries on how to collect data during natural disasters and emergencies.
- Address the protection and custodianship of data, as the project is using existing data.
- Quantify and measure inputs and outputs that are also able to relate to each other.
- Be able to give the user the data or information to take to their superiors and present a case for showing the return on investing money in a particular activity (for example, Treasury work in dollars).
- Understand what the framework will deliver in terms of helping to identify the data that will be slotted in underneath it.
- Resist imposing a new regime of data collection and reporting.
- Be forward-looking, so it is still compatible and relevant in the years to come. Also look at what data fields may become available in the future.

[15] For example, a locaql government area (LGA) with a small assessment area may be able to gather more detailed information through the creation and use of household surveys, which it can use to determine the costs, whereas within a LGA with a large assessment area, the only viable option may be to source data from government and other industry bodies, thereby providing basic statistics from which to calculate the costs.

Difficult Questions

How does the framework cope with normal variability, e.g. seasonal variability?

How does the framework capture compound effects, e.g. multiple floods over 2 months, or a town in severe drought that is then burnt by fire?

Is a single model the optimal outcome or is a choice of models with a single suite of outcomes the best method?

It was noted that the workshop should help to decide what is desirable, useful, feasible and affordable. The ideal result would be to have one framework and a common set of data elements.

3. METHODOLOGY

Three previous reports written for this project served as the background material for the development of the Impacts Framework and subsequently this report. They were the:

- *Summary Report* (of 9 June Workshop), which identified the framework requirements, shown in the chapter above (*User Requirements)*,

- *Updated Committee-Agreed Framework Selection Criteria*, which consisted of nine criteria by which frameworks and models were scored using a scale of 0–3 for each criterion, and

- *Literature Review on Impact and Cost Frameworks and Models for Natural Disasters and Fire Emergencies*. Twenty-four frameworks and models that collect and report the impacts and costs of natural disasters and fire emergencies were reviewed and compared in terms of their advantages and disadvantages and commonalities and differences.

  Each framework and model was scored against the Framework Selection Criteria in the Literature Review, with the Disaster Loss Assessment Guidelines (Handmer, Reed and Percovich 2002) and The Development of a Socio-Economic Impact Assessment Model (SEIA-Model) (Office of the Emergency Services Commissioner (OESC) 2008) both receiving perfect scores (27 out of 27).

Given the wealth of knowledge contained within the above documents, a generic framework was created by drawing on information from the reviewed frameworks and models that follow economic principles and those that list examples of possible impacts, losses and benefits. In particular, the frameworks and models which this type of information was drawn from were the California Fire Plan (California Department of Forestry and Fire Protection and the Board of Forestry and Fire Protection 1996), Rapid Appraisal Method (RAM) for Floodplain Management (Reed Sturgess and Associates 2000), Economic Costs of Natural Disasters in Australia (BTE 2001), Disaster Loss Assessment Guidelines (Handmer, Reed and Percovich 2002), The Cost of Fire Now and in 2020 (Handmer et al. 2008) and the SEIA-Model (OESC 2008).

The framework was developed by the Project Team in close communication with the NSW Fire Brigades members managing this project (Appendix 1). In addition to regular emails and phone conversations, a small workshop was held on Monday 9 November 2009 at the NSW Fire Brigades' Sydney office between the Project Team and those managing the project, in which the structure of the Impacts Framework was improved.

4. THE IMPACTS FRAMEWORK

4.1 The Impacts Framework

The Impacts Framework is based on economic principles, and steps through the process one would take to determine the economic, social and environmental impacts, losses and benefits in the event of a natural disaster or fire emergency (Figure 2).

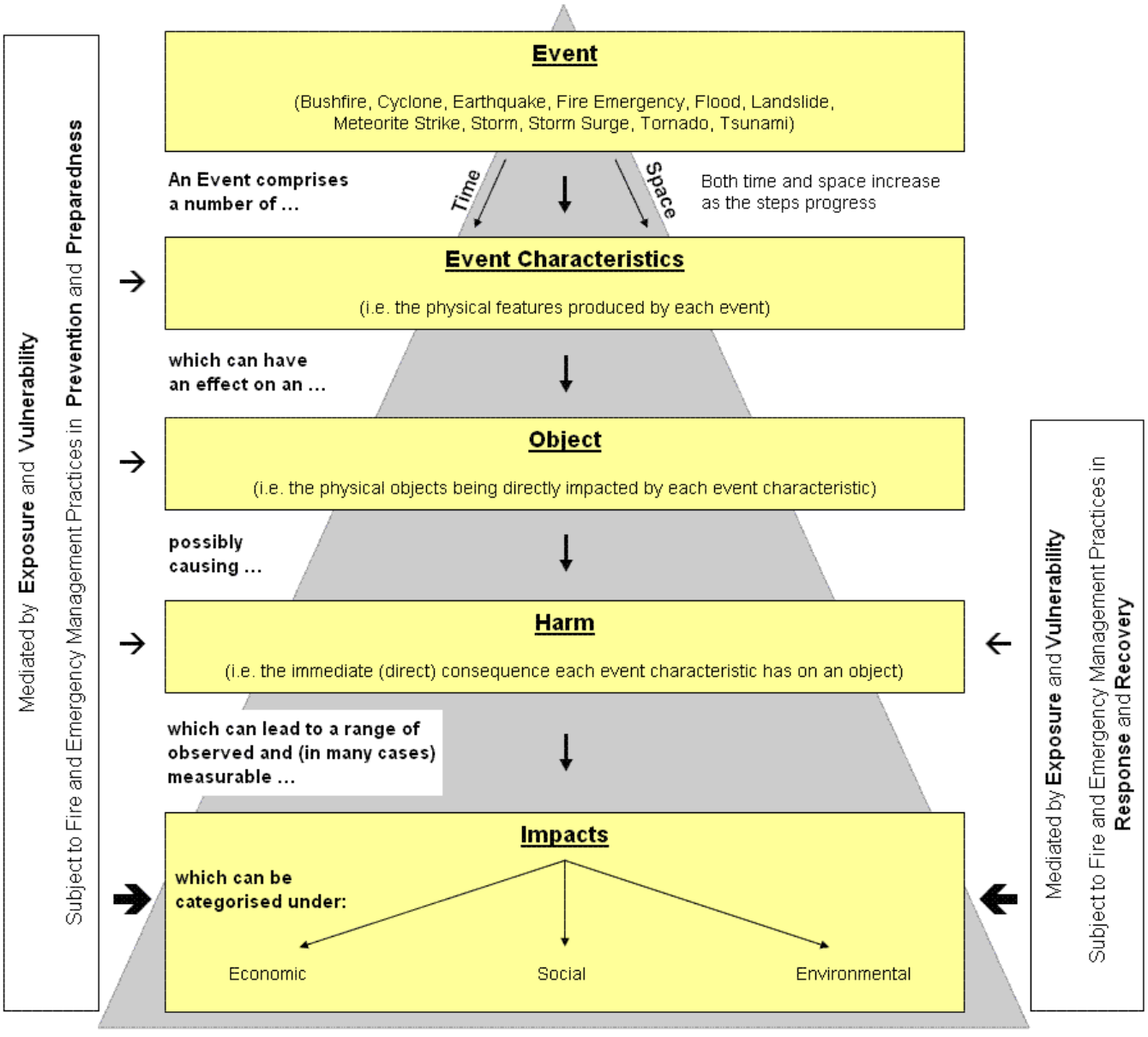

Figure 2 The Impacts Framework

The framework starts with an **event**, which is based on the hazard agent, with those included in this framework being:

- Bushfire
- Cyclone
- Earthquake
- Fire emergency
- Flood
- Landslide
- Meteorite strike
- Storm
- Storm surge
- Tornado
- Tsunami

As per project requirements, this list came from the National Disaster Relief and Recovery Arrangements (Department of Transport and Regional Services 2007), with the addition of 'Fire Emergency'. Definitions of all the events can be found in the glossary.

Each event produces from one to several physical features that are responsible for the impacts, known in this framework as **event characteristics** (Table 2). By separating out each event into their characteristics, those using this framework will be able to attribute individual impacts to specific characteristics, thereby providing decision- and policy-makers with a more detailed and informative account, which can be used when planning for future events. In some cases, however, it may not be possible to identify exactly which characteristic caused each impact. In this circumstance, the step could be bypassed.

As well as listing these event characteristics, Table 2 also lists the secondary events that may occur as a result of the initial event. This is an important feature for all phases of emergency management, as being aware that a secondary event may occur will allow for more holistic prevention, preparedness, response and recovery strategies and a better understanding of how to minimise the impacts. For example, although cyclones can produce large wind speeds, it is the resultant storm surges (if produced) that are responsible for the greatest number of fatalities (Geoscience Australia 2009). In other cases, floods can release sewage and industrial contaminants, and fires release carbon compounds and may expose toxic substances such as asbestos.

Table 2 The event characteristics and possible secondary events

Event	Characteristic	Secondary Event	
Bushfire	Flame	→	Erosion or landslide (from removal of vegetation, leaving soil exposed)
	Heat		
	Smoke		
		→	Spot fires can be created when embers ignite fuel ahead of the fire front
		→	If a bushfire is large enough, it can create its own weather patterns (e.g. lightning), leading to more fires

Event	Characteristic	Secondary Event
Cyclone	Rain	→ Flood
	Wind	→ Storm surge
Earthquake	Ground collapse	→ Landslide
	Ground tremors	→ Landslide
	Particles become airborne (e.g. dust, fungal spores)	
Fire emergency	Flame	
	Heat	
	Smoke	
Flood	Flowing water	
	Inundation	
Landslide	Movement of soil, rock or debris down a slope	
Meteorite strike	Impact with the Earth (i.e. soil or water)	→ (Onshore) Flood (if it strikes close to shore)
Storm	Hail	
	Lightning	→ Bushfire → Fire emergency
	Rain	→ (Flash) Flood
	Wind	→ Storm surge → Tornado or cyclone (depending on whether the storm occurs on land or over the sea)
Storm surge	Flowing water	
	Inundation	
Tornado	Wind	
Tsunami	Flowing water	
	Inundation	

Each event characteristic will directly impact on a number of **objects**. These are based around people, assets, activities and the environment, as shown in Table 3. The listed objects constitute a generic list, which may or may not be impacted by the specific natural disaster or fire emergency in question. In order to know what has been lost, a database or map overlays of what objects are within the geographic area of the event zone would be beneficial, thereby giving the emergency services baseline data with which to compare the impact with and without the event.

A full list of the objects with related sub-categories (loss of value to these sub-categories constitutes examples of impacts) is shown in Appendix 2. In addition, Appendix 2 also provides suggested ways of measuring the degree of impact on the object (e.g. hectares of agricultural land lost, km of fencing damaged) and ways of assessing the associated costs.

Table 3 List of objects and examples of what is included

Objects	**Examples of direct impacts (Loss of value to these objects)**
People and Community	Lives and injuries
Cultural Heritage	Structures and artefacts
Memorabilia	Medals, photos, jewellery
Infrastructure – Private	Fencing, sheds
Infrastructure – Parks and Reserves	Huts, office buildings, walking trails
Infrastructure – Public (excluding Parks and Reserves)	Bridges, roads, utilities
Property – Commercial	Retail buildings and contents
Property – Industrial	Factory buildings and contents
Property – Public[16]	Government buildings and contents
Property – Residential	Home buildings and contents
Vehicles	Cars, trucks
Agricultural Products and Equipment	Animal feed, field crops, livestock
Horticultural Products and Equipment	Cut flowers, fruit crops, nurseries
Natural Resources and Equipment	Fish, mining, timber
Trade	Flow-on impacts to businesses
Natural Environment and Ecosystem Services	Air, fauna[17], flora[18], habitat, soil, waterways

Harm is the next element of the framework, and categorises the initial impact on an object as destroyed, damaged or not harmed for inanimate objects, and fatality, major injury, minor injury and not harmed for people and other animals. 'Damaged' is further separated into Major Damage (i.e. uninhabitable) and Minor Damage (i.e. habitable) for Property – Residential, as the degree to which a house is damaged is important when applying for the Australian Government

[16] Public buildings, such as schools and town halls, have significant community impacts.
[17] Includes both native and introduced fauna living in the natural environment.
[18] Includes both native and introduced flora.

Recovery Payment (Centrelink 2010), for example. 'Major injuries' are defined as those who are admitted to hospital, while 'minor injuries' refers to those who are treated in hospital, but not admitted (BTE 2001, p. 106)[19]. While major and minor injuries focus on the physical impacts sustained by natural disasters and fire emergencies, psychological impacts are just as important. Psychological impacts have not been included as a harm category, however, because they are considered to be indirect. That is, they are not a direct result of being caught in a flood or cyclone (for example), but are a consequence of them. The spreadsheet accounts for these impacts under the object titled 'People and Community'. For a fatality, the psychological harm caused to loved ones is included, for major and minor injury, the psychological impacts of the patient are included, and in the case that a person is not harmed, the psychological impacts of that person are still considered.

The first pieces of information will be sourced at the harm stage in the framework, as basic information (indicators) can be gained quickly, being particularly important at the response phase. For example, an indicator for destruction of agricultural products would be the number of hectares destroyed by the event. In another example, the number of people potentially impacted may be derived from the number of houses within the event zone. This would provide rapid information that the emergency services personnel would use initially.

The final element in the framework provides the **impacts** of the event, which are shown as economic, social or environmental[20]. Conventionally, impacts are categorised as direct or indirect depending on whether there is direct contact with the damaging characteristic of the event[21], and tangible or intangible depending on whether the affected object is generally traded or not. These terms are explained in chapter 1.2 (*Terminology Used in this Report*) and in the glossary and are not repeated here. Instead, the range of impacts that can eventuate is shown in the Impacts Framework Data spreadsheet (Appendix 3) (provided electronically as an Excel spreadsheet accompanying this report).

Impacts can be positive and are described in the spreadsheet under the Impacts columns. Examples of positive impacts include government aid, donations and maintaining environmental bio-diversity.

In chapter 1.4 (*Why not Measure Impacts on Natural Disasters and Fire Emergencies Using a Different Loss Assessment Method?*), it was stated that conducting a loss assessment using insurance losses was not appropriate. The information derived from the proportion of people with insurance is, however, very useful. For example, knowing which residents or general areas are underinsured or uninsured can indicate that their level of resilience will be lower that those with full insurance. The spreadsheet has entered data fields that allow the user to enter the number of people that are fully insured, underinsured and uninsured for each property type (listed under objects in Table 3).

[19] If data is not available for major and minor injuries as defined in this report, other hospital data, such as the severity of the injuries, is recommended as a surrogate.

[20] For the purposes of a risk assessment, the National Emergency Risk Assessment Guidelines (Australian Emergency Management Committee 2009) separate these categories further into economy, infrastructure (which corresponds to economic), people, social setting, public administration (which corresponds to social) and environment (which corresponds to environmental).

[21] Although many of the event characteristics listed in Table 2 make direct contact and therefore directly impact on an object, there are some that are considered to cause indirect impacts, which are smoke (for bushfires and fire emergencies) and particles becoming airborne (for earthquakes).

When viewing the framework, there are several points to consider (in order to better explain the points, an earthquake event has been used as an example):

- Firstly, the list of objects shown in Table 3 is a generic list, and will not be applicable to every event characteristic that is produced by an event. In the earthquake example, for instance, the three characteristics are ground collapse, ground tremors and particles becoming airborne. It is reasonable to assume that ground collapse and ground tremors have the potential to impact on all the objects listed in Table 3; however, particles becoming airborne will initially impact on people and animals, who may also be impacted in the event the particles become part of the ecosystem cycle (e.g. particles land on soil and are washed into waterways, possibly killing marine life). Conversely, particles that come into contact with inanimate objects will not destroy or damage them. Therefore, under 'particles become airborne' in the example, only impacts on people, other animals and the natural environment have been shown.

- There will be occasions where, although the event characteristics and/or the indicators of harm differ, the outcomes – in terms of the impacts – are the same. For example, regardless of whether railway infrastructure was destroyed or damaged owing to ground collapse or ground tremors, the fact remains that these objects cannot be used safely, leading to disruption for commuters who intended to travel on the train, with additional flow-on effects being illustrated in the example. Furthermore, some impacts will be the same across different events, that is, bushfires and floods may also destroy or damage railway infrastructure, leading to the same flow of impacts.

- The third point to make is that the impacts shown are not what will happen, but what might happen, and the impacts should be incorporated into each study on a case by case basis. For example, an earthquake may occur within a large town, and not impact in any way on agricultural land or national or state parks or reserves. In another scenario, the earthquake may only be felt within a national park, but may release harmful fungal spores that are blown towards a rural town. The earthquake example provides the full extent of impacts and should be used as a planning tool as to what may eventuate.

- Lastly, the framework does not provide every impact that could eventuate from an event. As well as making the process of creating the example a very long task, accounting for every possible impact would dilute the strength of the framework, making it too long to complete at any stage of PPRR. This is especially true in the response phase, where information is required as soon as possible. Therefore, the example provides a maximum of five flow-on impacts, but in a large majority of cases two or three are used.

The dynamics of time and space are important factors to consider when managing an actual or hypothetical natural disaster or fire emergency. This is represented in the framework by a large triangle in the background with two arrows pointing downwards. Coupled with the increasing width of the triangle for each step, these arrows represent the lengthening of time and broadening of space, as the event and its characteristics cause harm on objects, leading to impacts. Impacts in particular may occur across large scales of time and space.

At a very general level, direct impacts are clearly defined and limited in both time and space – although water damage and structural faults resulting from floods, for example, may not be obvious until well after the event. Indirect impacts, which flow as a consequence of the direct impact, will almost by definition be spatially more extensive, as commerce and individual lives far from the impact area may be affected as supplies, access and transport are disrupted. Intangible impacts (e.g. on people, stress, cultural heritage, memorabilia and the environment) will often present a mixed picture depending on the severity of the impacts. Some intangibles may appear well bound in space. Loss of lives, for example, resulting from a direct impact will be clearly defined as within the impact area, but, as they are irreplaceable, the impact of this will extend over a long time. An otherwise apparently well-defined event, such as a major bushfire, may have impacts in terms of fear and policy change that are almost global. The temporal and spatial boundaries applied will be different for each individual assessment, with factors such as the chosen event, specific purpose of the assessment, end-user of the information and required level of detail all contributing to the final boundaries.

Lastly, the four elements of prevention, preparedness, response and recovery are divided into two classes in this framework based on when in a disaster or emergency management time-line the element is active. However, it is important to keep in mind that there can be considerable overlap between the four elements.

Prevention and preparedness are used before the event and can be directed at altering the event characteristics (e.g. by flood mitigation works, stabilising a hill slope or reducing bushfire fuel), reducing the harm or the impacts (e.g. by building to be compatible with flood water, bushfires or earthquakes, duplicating critical habitats or endangered species breeding programs, ensuring infrastructure resilience), or altering the object to make it less susceptible to harm or to increase its capacity to recover (e.g. by supporting resilient communities and organisations).

Response and recovery will be activated when an event is imminent or as it occurs. They can be directed at reducing the impacts, either immediate or longer-term, and so focus on the affected objects: generally on infrastructure, people and communities, people's livelihoods, and ecosystems. Recovery can be part of response planning in a number of ways. Response can be organised to limit its own impacts on livelihoods and to minimise disruption, thereby helping to speed recovery. Recovery can also involve psychological support, the salvage of memorabilia, re-establishment of local commerce and action to prevent the degradation of waterways. Appropriately tailored response can support this.

The timeframe in which to use the framework will depend on the availability of the data, and therefore means that it may not be able to be used immediately after a disaster or fire emergency has occurred. As with any framework however, the usefulness of the Impacts Framework depends on the information being put in it. Therefore critical data, such as the number of people, homes and infrastructure impacted, will be a major priority when first responding to a disaster. As this information becomes known within the first few hours, it can be entered into the framework and the relevant agency can begin preparing assistance packages, including financial assistance and alternative accommodation. If however, the purpose of the assessment is to collect longer term data and understand the indirect and intangible impacts of a disaster as well as the immediate direct impacts, then the loss assessment should be conducted six months to a year after the event (Handmer, Reed and Percovich 2002). For example, a business may lose all of its trade immediately after the initial impact, but make up this lost business within six months following impact. This type of data is important in

understanding the resilience of a community and helps plan the long term recovery in similar situations in the future.

The data entered will be useful long after a disaster or fire emergency has occurred, or a hypothetical disaster produced. In the short to medium term, i.e. one to two years after the event, the data can be used in the recovery phase. However after this time, the data is stored while new events are added. By continually adding to the pool of data, detailed analysis can be undertaken, which can then be used by those in all areas of government, particularly the emergency management or policy fields. In this sense, there is no 'expiry' date for the data collected from a natural disaster or fire emergency.

The overall aim of this framework is to be able to assess what the impacts are. As much as possible, this should be done at the quantitative level, i.e. for all economic and some social and environmental impacts. For impacts unable to be quantified, qualitative information should be sought.

4.2 Benchmark Data

Knowing the basic demographic details of a population within the impacted area and the measurements associated with the event (e.g. wind speed, flame intensity, flood height) provide important background data for interpreting the impacts of a natural disaster or fire emergency. As part of the framework process, this information should be collected and referred to when assessing the impacts of an event, either real or hypothetical, at any stage of the PPRR spectrum.

While it is not sure how this type of information will be incorporated into the framework process at present (to be considered in a later phase) data will most likely be sourced from census data (i.e. for population demographics) and agencies that provide event information (e.g. Bureau of Meteorology).

4.3 Limitations

As with any framework or model, the Impacts Framework contains a number of limitations (the first four extracted from Handmer 2003), which are:

- the inherent complexity of loss assessments
- the level of knowledge. This includes lack of data for a specific event as well as vested interests (e.g. major enterprises, land developers, environmental interests) emphasising certain types of data over others. In addition, it is often uncertain what data are being used and appropriate metadata are often unavailable
- differences in the philosophy and approach brought to the loss assessment – for example, is the need for a rapid assessment for political purposes or to inform response and recovery actions, a thorough economic analysis to persuade Treasury officials, something to guide recovery planning, or deciding between competing mitigation proposals in the same area? Each approach and accompanying mindset will have its own gaps and limitations

- variations in the funds, expertise, and time available for assessments

- the accuracy of monetary estimates given to destroyed or damaged assets (more applicable to the next phase of the project). Estimates may be taken from previous loss assessments and either not be updated to align with present-day values (e.g. value per km of fence line may be from a study conducted in 2000 that is not updated) or not be applied correctly (e.g. value given per km of fence line may be for a basic wire fence, whereas the only type of fence destroyed in the disaster being studied was electric fences, which would cost more to replace).

5. CONCLUSION

The Impacts Framework is to:

- collect and collate information on a disaster's impacts (including losses and benefits),
- be used for a number of hazard types across any temporal or geographical scale,
- be used across the PPRR spectrum, and
- work with existing systems and models.

The framework achieves this by identifying the elements contributing to impacts and the relationship between them and by informing the collection of information on a wide range of natural disasters and fire emergencies. It can also be used across any temporal or geographic scale, limited or broad, as the framework demonstrates (i.e. shown in the Excel spreadsheet). The importance of considering time and space when assessing impacts is illustrated in the framework diagram, with the triangle behind the framework demonstrating that the amount of time since the event increases, and the physical area over which impacts occur (including direct and indirect) expands.

The framework provides an extensive list of possible impacts that the user can select depending on their area of interest and requirements. The framework is not limited to any one phase of the PPRR spectrum, and can be used for emergency management, policy-making or other purposes. Furthermore, the framework can be used with existing systems and models to identify and assess the impacts of a broad range of natural disasters and fire emergencies.

6. GLOSSARY

Benefit: Any benefits the economy receives as a result of the disaster. These may include financial benefits, such as payments by the government (e.g. recovery packages), donations or insurance payouts[22]. It may also include environmental or social benefits. Enhanced business activity is another potential benefit.

Bushfire: A general term to describe a fire in vegetation[23].

Cyclone: An intense low-pressure system that forms over warm ocean waters at low latitudes[24] and is sufficiently intense to produce sustained gale-force winds of at least 63 km/h. If the sustained wind reaches hurricane force of at least 118 km/h, the system is defined as a severe tropical cyclone. In other parts of the world, they are called hurricanes or typhoons[25].

Direct: Impacts that result from direct contact with the event[26].

Earthquake: The shaking and vibration at the surface of the earth caused by underground movement along a fault plane or by volcanic activity[27].

Economic: Although this is not desirable, the word economic has two meanings in this report. In the field of economics, the word economics refers to the study of the economy as a whole and measures all losses and benefits to that economy[28]. In this sense, all impacts, including environmental and social impacts, are included, regardless of whether they can be valued in monetary terms or not. In the context of the project brief, economic refers to the impacts on tangible assets, both direct and indirect, as shown in Table 1.

This meaning is not restricted to this project's brief, as the phrase 'economic, social and environmental impacts' is commonplace, with many government policies advocating the use of the 'triple bottom line' approach[29] in the context of this meaning.

When reading this report, economic means impacts to the whole economy when used in reference to an economic loss assessment, whereas it refers to tangible impacts when used in the Impacts Framework (described in chapter 4).

[22] Handmer, Reed and Percovich 2002, p. 32
[23] Australasian Fire and Emergency Service Authorities Council
[24] Bureau of Meteorology
[25] Geoscience Australia 2009
[26] Handmer 2003, p. 92
[27] Geoscience Australia 2009
[28] Handmer, Reed and Percovich 2002, p. 123
[29] Suggett and Goodsir 2002

Economy: Pertaining to the production, distribution and use of income and wealth[30].

Environmental: Impacts on the natural environment, including assets such as the soil, water, air, species, habitat, and flows such as ecosystem services.

Event: An incident or situation that occurs in a particular place during a particular interval of time[31].

In this case, the incident or situation is the natural hazard or fire emergency, with the following being included in this framework: bushfire and other fire emergencies, cyclone, earthquake, flood, landslide, meteorite strike, storm, storm surge, tornado and tsunami.

Event characteristic: The physical features produced by an event.

Fire emergency: Relates to fires other than bushfires, such as structural and non-structural fires.

Flood: A general and temporary condition of partial or complete inundation of normally dry land areas from overflow of inland or tidal waters from the unusual and rapid accumulation or runoff of surface waters from any source[32].

Harm: The initial impact on an object, categorised as destroyed, damaged or not harmed for inanimate objects, and fatality, major injury, minor injury and not harmed for people and fauna. For ease of accessing data it is recommended hospital admissions relating to the event be used as a surrogate for major injuries whilst those treated but not admitted to hospital be used as a surrogate for minor injuries,

Impact: Is the broadest term and includes both market-based (i.e. tangible) and non-market (i.e. intangible) effects[33]. Individual impacts can be either negative or positive.

Indirect: Impacts that arise as a consequence of the impacts of the event[34]. For example, disruption to the flow of goods and services in and out of the affected area.

Intangible: Items that are not normally bought or sold and for which therefore no agreement on their monetary value exists[35]. In the context of the 'triple bottom line' approach used in this study, social and environmental impacts are considered to be intangible.

[30] Macquarie University 1982, p. 387
[31] EMA 1998, p. 44
[32] Geoscience Australia 2009
[33] National Research Council 1999, p. 5
[34] Handmer 2003, p. 92
[35] Handmer, Reed and Percovich 2002, p. 123

Landslide: A landslide is the movement of rock, debris or earth down a slope. Landslides result from the failure of the materials that make up the hill slope and are driven by the force of gravity. Landslides are known also as landslips, slumps or slope failure[36].

Loss: In economic terms, it is a measure of the impact on a specific economy. It is taken as being equal to the resources lost by the specific area as a consequence of the disaster. The resources can be expressed in time, money or intangible loss[37].

Meteorite strike: A meteorite (strike) is a meteoroid that has survived entry through the atmosphere and reached the Earth's surface[38].

Other related definitions:

Meteoroid – a small piece of dust, rock, ice or metal moving through space. Meteoroids are at least the size of a speck of dust but smaller than an asteroid[39].

Asteroid – small planet like bodies that orbit the sun lying mostly in the region between the orbits of Mars and Jupiter. Their diameters range from a few meters to hundreds of kilometres[40].

Natural disaster: The impact of abnormal or infrequent natural hazards on communities or geographic areas that are vulnerable to such hazards, causing substantial damage, disruption and possible casualties and leaving the affected communities unable to function normally. Thus, natural disasters concern the interaction of natural hazards and socio-economic systems, rather than natural hazards *per se*[41].

Natural hazard: Is simply the event, such as a bushfire, cyclone etc..

Object: The physical objects being impacted by each event characteristic, which may include people, fauna, flora, buildings and infrastructure.

Social: Impacts relating to people, such as health (e.g. death, injury, mental health)[42] and items or places of personal (e.g. memorabilia) or cultural (e.g. heritage buildings or sacred sites) significance. It also includes impacts to the broader 'social fabric' of the community[43].

[36] Geoscience Australia 2009
[37] Handmer, Reed and Percovich 2002, p. 123
[38] Meteorites Australia
[39] Meteorites Australia
[40] Meteorites Australia
[41] Centre for Research on the Epidemiology of Disasters 1997, p. 7
[42] Middelmann 2007, p. 9
[43] Middelmann 2007, p. 9

Storm: A general term for relatively small-scale convective processes that develop when warm, humid air near the ground receives an initial upward push from converging surface winds and rises quickly in an unstable atmosphere. Under these conditions, cumulonimbus clouds develop rapidly to potentially reach heights of up to 20 km with associated lightning, thunder, severe wind gusts from downdraughts, heavy rain and hail.[44].

Storm surge: Storm surge is a raised dome of water about 60 to 80 km across and typically about 2 to 5 metres higher than the normal tide level. It is caused by a combination of strong winds driving water onshore and the lower atmospheric pressure in a tropical cyclone. In the southern hemisphere, the onshore winds occur to the left of the tropical cyclone's path. In Australia, this is the east side on the north-west and north coasts, and the south side on the east coast[45].

Tangible: Items that are normally bought or sold and that are therefore easy to assess in monetary terms[46]. In the context of the 'triple bottom line' approach used in this study, economic impacts are considered to be tangible.

Tornado: A small mass of air that whirls rapidly about an almost vertical axis; made visible by clouds and by dust and debris sucked into the system[47].

Tsunami: A sudden movement of the water column resulting from earthquakes, landslides or volcanic eruptions in or adjacent to oceans.

A tsunami is different from wind-generated surface waves on the ocean, such as storm surges. The passage of a tsunami involves the movement of water from the surface to the sea floor, which means its spread is controlled by water depth. Consequently, as the wave approaches land and reaches increasingly shallow water, it slows. However, the water column still in deeper water is moving slightly faster and catches up, resulting in the wave bunching up and becoming much higher. A tsunami often is a series of waves and the first may not necessarily be the largest[48].

[44] Geoscience Australia 2009
[45] Geoscience Australia 2009
[46] Handmer, Reed and Percovich 2002, p. 124
[47] American Meteorological Society
[48] Geoscience Australia 2009

7. APPENDICES

Appendix 1 Working Group Members

Linda Anderson-Berry	Bureau of Meteorology
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Glen Benson	NSW Rural Fire Service
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David Prestipino	Attorney General's Department (Federal)
Suzanne Robinson	Department of Primary Industries (NSW)
Daminda Solangaarachchi	Australian Defense Force Academy (University of NSW)
Jill Tomlinson	Australian Bureau of Statistics

The following people also participated as part of the Working Group for the workshop held on 9 June 2009; however, they are also managing this project (i.e. the Project Management Team):

Dawn Easton	NSW Fire Brigades
Nick Nicolopoulos	NSW Fire Brigades
Vanessa Dickson	NSW Fire Brigades

Appendix 2 Full List of Objects Used in the Framework

The table below is an expansion of Table 3. As well as listing the generic set of objects that can be drawn on for any natural disaster or fire emergency, it also provides information on the typical measurement unit used to measure the impact on objects, possible calculation bases and sources of the calculation base. As already made obvious in the table, the measurement units and calculation bases shown are indicative, and are not the only means of assessing impacts. Many of them are, however, the standard approach used in economic loss assessments. This table provides simplified information, with the framework (Excel spreadsheet) providing more measurement units for indirect impacts.

The text in the measurement unit column refers to the standard unit used to measure the object. When two or more are separated by a comma, there are multiple units that can be used.

The text in the calculation base column is a suggested means of quantifying the cost of the impact using economic principles, that is, valuing objects using their actual market value or depreciated value (Handmer 2003).

When the cell starts with a percentage value, then, following economic principles, an estimate of the average age and condition of an asset at the time of impact is taken into consideration when it comes to replacing it with a new one, and the cost is depreciated using the percentage value to reflect what it would have cost to replace the asset like for like (on average).

For example: two wool sheds were destroyed in a fire. If a new building costs $15,000 and the calculation base uses 85% of new market value, then the economic cost of losing two wool sheds is 2 x $15,000 x 0.85 = $25,500.

When the cells start with 'market price' or 'market value', then the number of units impacted (from measurement unit column) can simply be multiplied by the cost per unit.

For example: 4 tonnes of grain were destroyed in a flood. If grain costs $300 per tonne, then the cost of losing the grain is 4 x $300 = $1200.

The information in the source column provides the reference for the corresponding possible calculation base column. When there is no source for the calculation base, the calculation bases have been entered by the author based on the calculation bases for other similar objects. For example, the value given for shelters in the table below on the next page was also given for shower blocks. These may not be the only sources of data, however, as there are many publications that provide their own calculation bases for valuing the impacts resulting from natural disasters and fire emergencies.

Object	Examples of direct impacts			Typical Measurement Unit	Possible Calculation Base	Source
People and Community				no.	Human capital approach, willingness to pay	Bureau of Transport Economics (BTE) 2001
Cultural Heritage	Indigenous	Structures		no.	Continent Valuation Method	Office of the Emergency Services Commissioner (OESC) 2008
		Artefacts		no.	Continent Valuation Method	OESC 2008
	Non-indigenous	Structures		no.	Continent Valuation Method	OESC 2008
		Artefacts		no.	Continent Valuation Method	OESC 2008
Memorabilia				no.	Qualitative only	OESC 2008
Infrastructure – Private	Agriculture	Fencing	Boundary fencing	km	66% of new market value or cost of repairs if damaged	OESC 2008
			Crown boundary fencing	km	66% of new market value or cost of repairs if damaged	OESC 2008
			Internal fencing	km	66% of new market value or cost of repairs if damaged	OESC 2008
		Structures	Dairy sheds	no., m²	85% of new market value or cost of repairs if damaged	OESC 2008

Object	Examples of direct impacts			Typical Measurement Unit	Possible Calculation Base	Source
		(excluding residence)	Wool sheds	no., m²	85% of new market value or cost of repairs if damaged	OESC 2008
			Other structures	no., m²	85% of new market value or cost of repairs if damaged	OESC 2008
	Residential	Fencing		km	66% of new market value or cost of repairs if damaged	OESC 2008
Infrastructure – Parks and Reserves	Buildings	Roofed accommodation (including huts and staff accommodation)	Structure	no., m²	85% of replacement cost or cost of repairs if damaged	OESC 2008
			Contents	% of total contents	50% of new market value or cost of repairs if damaged	OESC 2008
		Offices	Structure	no., m²	85% of new market value or cost of repairs if damaged	OESC 2008
			Contents	% of total contents	50% of new market value or cost of repairs if damaged	OESC 2008
	Facilities	BBQs		no.	50% of replacement cost or cost of repairs if damaged	OESC 2008
		Shower blocks		no.	50% of replacement cost or cost of repairs if damaged	
		Shelters		no.	50% of replacement cost or cost of repairs if damaged	OESC 2008
		Table, seats		no.	50% of replacement cost or cost of repairs if damaged	OESC 2008
		Toilets		no.	50% of replacement cost or cost of repairs if damaged	OESC 2008
	Other infrastructure	Bridges		no.	85% of replacement cost or cost of repairs if damaged	OESC 2008
		Fencing	Boundary fencing	km	66% of replacement cost or cost of repairs if damaged	OESC 2008
			Internal fencing	km	66% of replacement cost or cost of repairs if damaged	OESC 2008
		Fire towers		no.	66% of replacement cost or cost of repairs if damaged	OESC 2008
		Lookouts		no.	50% of replacement cost or cost of repairs if damaged	OESC 2008
		Park signage		no.	50% of replacement cost or cost of repairs if damaged	OESC 2008
		Roads	Dirt road	km	73% of replacement cost or cost of repairs if damaged	OESC 2008
			Tarred road	km	73% of replacement cost or cost of repairs if damaged	OESC 2008
		Walking trails		km	73% of replacement cost or cost of repairs if damaged	OESC 2008
		Other structures		no.	% of replacement cost or cost of repairs if damaged	
Infrastructure – Public (excluding parks and reserves)	Bridges	on a Dirt road		no.	73% of replacement cost or cost of repairs if damaged	OESC 2008
		on a Local (tarred) road		no.	73% of replacement cost or cost of repairs if damaged	OESC 2008

Object	Examples of direct impacts			Typical Measurement Unit	Possible Calculation Base	Source
		on a Major arterial road (freeway, highway)		no.	73% of replacement cost or cost of repairs if damaged	OESC 2008
		on a Minor arterial (main road through city, town)		no.	73% of replacement cost or cost of repairs if damaged	OESC 2008
	Railways	Overhead cables		km	85% of replacement cost or cost of repairs if damaged	OESC 2008
		Signals		no.	85% of replacement cost or cost of repairs if damaged	OESC 2008
		Track work		km	85% of replacement cost or cost of repairs if damaged	OESC 2008
	Roads	Dirt road		km	73% of replacement cost or cost of repairs if damaged	OESC 2008
		Local (tarred) road		km	73% of replacement cost or cost of repairs if damaged	OESC 2008
		Major arterial road (freeway, highway)		km	73% of replacement cost or cost of repairs if damaged	OESC 2008
		Minor arterial (main road through city, town)		km	73% of replacement cost or cost of repairs if damaged	OESC 2008
	Road signage			no.	50% of replacement cost or cost of repairs if damaged	OESC 2008
	Utilities	Electricity	Infrastructure	km, no.	85% of replacement cost or cost of repairs if damaged	OESC 2008
			Supply	kW		
		Gas	Infrastructure	km, no.	85% of replacement cost or cost of repairs if damaged	OESC 2008
			Supply	flow rate		
		Telecommunications	Infrastructure	km, no.	66% of replacement cost or cost of repairs if damaged	OESC 2008
			Supply			
		Water	Infrastructure	km, no.	% of replacement cost or cost of repairs if damaged	
			Supply	ML		
Property – Commercial	Structure			no., m²	85% of new market value or cost of repairs if damaged	OESC 2008
	Contents			% of total contents	50% of new market value or cost of repairs if damaged	OESC 2008
Property – Industrial	Structure			no., m²	85% of new market value or cost of repairs if damaged	OESC 2008
	Contents			% of total contents	50% of new market value or cost of repairs if damaged	OESC 2008
Property – Public	Structure			no., m²	85% of new market value or cost of repairs if damaged	OESC 2008
(i.e. Government)	Contents			% of total contents	50% of new market value or cost of repairs if damaged	OESC 2008

Object	Examples of direct impacts			Typical Measurement Unit	Possible Calculation Base	Source
Property – Residential	Principal place of residence	Home	Structure	no., m²	85% of new market value or cost of repairs if damaged	OESC 2008
			Contents	% of total contents	50% of new market value or cost of repairs if damaged	OESC 2008
		Caravan or something similar	Structure	no., m²	66% of new market value or cost of repairs if damaged	OESC 2008
			Contents	% of total contents	50% of new market value or cost of repairs if damaged	OESC 2008
	Non-principal place of residence	Home	Structure	no., m²	85% of new market value or cost of repairs if damaged	OESC 2008
			Contents	% of total contents	50% of new market value or cost of repairs if damaged	OESC 2008
Vehicles	Buses			no.	% of new market value or cost of repairs if damaged	
	Cars			no.	% of new market value or cost of repairs if damaged	
	Trucks			no.	% of new market value or cost of repairs if damaged	
	Other vehicle types			no.	% of new market value or cost of repairs if damaged	
Agricultural Products and Equipment	Feed	Hay		square bale equivalent, tonnes	Market price at time of loss	OESC 2008
		Grain		tonnes	Market price at time of loss	OESC 2008
		Pasture		ha	Cost of restoration	OESC 2008
		Other feed types		depends on feed type	Depends on feed type	OESC 2008
	Field crops	Barley		ha	Market price at time of loss less input costs avoided	OESC 2008
		Wheat		ha	Market price at time of loss less input costs avoided	OESC 2008
		Other field crops		ha	Market price at time of loss less input costs avoided	OESC 2008
	Livestock	Cattle	Beef	no.	Market value at time of loss using appropriate indicator	OESC 2008
			Dairy	no.	Market value at time of loss	OESC 2008
		Goats	Dairy	no.	Market value at time of loss using appropriate indicator	OESC 2008
			Wool	no.	Market value at time of loss using appropriate indicator	OESC 2008
		Horses		no.	Market value at time of loss	OESC 2008
		Poultry		no.	Market value at time of loss	OESC 2008
		Sheep	Meat	no.	Market value at time of loss using appropriate indicator	OESC 2008
			Wool	no.	Market value at time of loss using appropriate indicator	OESC 2008
		Other stock		no.	Market value at time of loss	OESC 2008

Object	Examples of direct impacts			Typical Measurement Unit	Possible Calculation Base	Source
	Apicultural product	Bees		no.	Market value at time of loss	OESC 2008
		Hives		no.	Market value at time of loss	OESC 2008
		Honey		tonnes, L	Market value at time of loss	OESC 2008
	Agricultural equipment	Tractors		no.	% of new market value or cost of repairs if damaged	
		Harvesters		no.	% of new market value or cost of repairs if damaged	
		Other equipment		no.	% of new market value or cost of repairs if damaged	
Horticultural Products and Equipment	Fruit and vegetable crops			ha, tonnes	Market price at time of loss less input costs avoided	OESC 2008
	Grape vines (i.e. for viticulture)			tonnes	Market price at time of loss less input costs avoided	OESC 2008
	Plants for the cut flower industry			no.	Market price at time of loss less input costs avoided	OESC 2008
	Plants for the nursery industry			no.	Market price at time of loss less input costs avoided	OESC 2008
	Horticultural equipment	Irrigation equipment		no.	% of new market value or cost of repairs if damaged	
		Fruit harvesters		no.	% of new market value or cost of repairs if damaged	
		Other equipment		no.	% of new market value or cost of repairs if damaged	
Natural Resources and Equipment	Aquaculture			no.	Market price at time of loss less input costs avoided	
	Timber	Private hardwood plantations on private land		ha, m^3	Market price at time of loss less input costs avoided	OESC 2008
		Private softwood plantations on private land		ha, m^3	Market price at time of loss less input costs avoided	OESC 2008
		Private softwood plantations on leased Crown land		ha, m^3	Market price at time of loss less input costs avoided	OESC 2008
		Government-owned softwood plantations		ha, m^3	Market price at time of loss less input costs avoided	OESC 2008
		Government-owned hardwood plantations		ha, m^3	Market price at time of loss less input costs avoided	OESC 2008
		State forest available for harvest		ha, m^3	Market price at time of loss less input costs avoided	OESC 2008
	Mining products			tonnes	Market price at time of loss less input costs avoided	OESC 2008
	Natural Resources equipment	Aquaculture operations		no.	% of new market value or cost of repairs if damaged	

Object	Examples of direct impacts			Typical Measurement Unit	Possible Calculation Base	Source
	For …	Timber operations		no.	% of new market value or cost of repairs if damaged	
		Mining operations		no.	% of new market value or cost of repairs if damaged	
Trade				Indirect impacts	Indirect impacts	
Natural Environment and Ecosystem Services	Air			PM_{10}[49], CO_2		EPA Victoria 2008, Taranto and Bell 2006
	Fauna (both native and introduced)			no.	Continent Valuation Method, Ecosystem services approach	OESC 2008
	Flora (both native and introduced)			no., ha	Continent Valuation Method, Ecosystem services approach	OESC 2008
	Soil			ha, tonnes	Continent Valuation Method, Ecosystem services approach	OESC 2008
	Waterways (i.e. rivers, lakes)			km, ML	Continent Valuation Method, Ecosystem services approach	OESC 2008

Appendix 3 Impacts Framework in use

The actual data populated framework is provided as an Excel spreadsheet available electronically with this report.

[49] PM_{10} refers to particulate matter smaller than 10 µm in diameter, i.e. fine particles (EPA Victoria 2008)

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