Emergency Management Australia

DISASTER LOSS ASSESSMENT GUIDELINES

Emergency Management Australia

Queensland Government
Department of Emergency Services

"safer sustainable communities"

ATTORNEY-GENERAL'S DEPARTMENT

Emergency Management Australia is a Division of the Attorney General's Department

AUSTRALIAN EMERGENCY MANUALS SERIES

Part III
Emergency Management Practice

Volume 3—Guidelines

Guide 11

DISASTER LOSS ASSESSMENT GUIDELINES

Emergency Management Australia

ISBN 0-642-50250-1

Copyright

Disclaimer

Edited by Illycroft Pty Ltd, Brisbane and PenUltimate, Canberra

Printed in Australia by Paragon Printers Australasia Pty Ltd

The Australian Emergency Manuals SERIES

The first publication in the original AEM Series of mainly skills reference manuals was produced in 1989. In August 1996, on advice from the National Emergency Management Principles and Practice Advisory Group, EMA agreed to expand the AEM Series to include a more comprehensive range of emergency management principles and practice reference publications.

The Australian Emergency Series has been developed to assist in the management and delivery of support services in a disaster context. It comprises principles, strategies and actions, compiled by practitioners with management and service delivery experience in a range of disaster events.

The series has been developed by a national consultative committee representing a range of State and Territory agencies involved in the delivery of support services and sponsored by Emergency Management Australia (EMA).

Parts I to III are provided as bound booklets to State and Territory emergency management organisations, students, community organisations, appropriate government departments for further dissemination to approved users including local government and over 70 countries around the world.

Parts IV and V (skills and training management topics) are normally only issued as training guides in loose-leaf (amendable) form to all relevant State agencies through each State and Territory Emergency Service.

Australian Emergency Manuals Series Structure and Content

		Publishing Status Jan 2003
PART I—THE FUNDAMENTALS		
Manual 1	Emergency Management Concepts and Principles (3rd edn)	A/R
Manual 2	Australian Emergency Management Arrangements (6th edn)	A
Manual 3	Australian Emergency Management Glossary	A
Manual 4	Australian Emergency Management Terms Thesaurus	A
PART II —APPROACHES TO EMERGENCY MANAGEMENT		
	Volume 1—Risk Management	
Manual 1	Emergency Risk Management – Applications Guide	A
Manual 2	Implementing Emergency Risk Management — *A facilitator's guide to working with Committees and Communities*	A
	Volume 2—Mitigation Planning	
Manual 1	Planning Safer Communities	A
	Volume 3—Implementation of Emergency Management Plans	
	Titles to be advised	P
PART III —EMERGENCY MANAGEMENT PRACTICE		
	Volume 1—Service Provision	
Manual 1	Emergency Catering	A
Manual 2	Disaster Medicine (2nd edn)	A
Manual 3	Disaster Recovery	A/R

		Publishing Status Jan 2003
	Volume 2—Specific Issues	
Manual 1	Evacuation Planning	A
Manual 2	Safe and Healthy Mass Gatherings	A
Manual 3	Health Aspects of Chemical, Biological and Radiological Hazards	A
Manual 4	Post Disaster Survey and Assessment	A
Manual	Civil Defence	D
Manual	Community Emergency Planning (3rd edn)	A/R
Manual	Urban Search and Rescue (Management)	P
Manual	Lifelines	D
Manual	Land Use Planning	D
	Volume 3—Guidelines	
Guide 1	Multi-Agency Incident Management	A
Guide 2	Community and Personal Support Services	A
Guide 3	Managing the Floodplain	A
Guide 4	Flood Preparedness	A
Guide 5	Flood Warning	A
Guide 6	Flood Response	A
Guide 7	Emergency Management Planning for Floods Affected by Dams	A
Guide 8	Reducing the Community Impact of Landslides	A
Guide 9	Psychological Services: Emergency Managers' Guide	D
Guide 10	Psychological Services: Mental Health Practitioners' Guide	D
Guide 11	Disaster Loss Assessment Guidelines	A
Guide	Community Development	D
Guide	Gathering Community Information	D
Guide	Disaster Victim Identification	U/R

PART IV—SKILLS FOR EMERGENCY SERVICES PERSONNEL

Manual 1	Storm Damage Operations (2nd edn)	A
Manual 2	Operations Centre Management	A
Manual 3	Leadership	A
Manual 4	Land Search Operations (2nd edn—Amdt 1)	A
Manual 5	Road Accident Rescue (2nd edn)	A
Manual 6	General Rescue (4th edn—formerly Disaster Rescue)	A
Manual 7	Map Reading and Navigation (Amdt 1)	A
Manual 8	Four-Wheel-Drive Vehicle Operation (Amdt 1)	A
Manual 9	Communications (2nd edn)	A
Manual 10	Flood Rescue Boat Operation (2nd edn)	A
Manual 11	Vertical Rescue (2nd edn)	A
Manual	Structural Collapse Search and Rescue	D

PART V—THE MANAGEMENT OF TRAINING

Manual 1	Small Group Training Management (2nd edn)	A
Manual 2	Managing Exercises	A

Key to status: A = Available A/R = original version Available/under Review
D = under Development; P= Planned; R = under Review/Revision

FOREWORD

These Guidelines and the associated case study 'Economic and Social Costs of the North Queensland January 1998 Floods', which is available online at www.emergency.qld.gov.au/cdrs/mitigation/pdf/case_study.pdf, have been developed by the Queensland Department of Emergency Services and Emergency Management Australia in order to provide emergency management practitioners across Australia with a comprehensive method to assess the economic impact of a disaster in a regional context. These Guidelines follow 'Economic Costs of Natural Disasters in Australia' published in 2001 as Report 103 by the Bureau of Transport and Regional Economics which focuses on the national economy and highlighted the need for a local or regional approach. These Guidelines provide a methodology for that approach.

Proposed changes to this Manual should be forwarded to the Director General, Emergency Management Australia, at the address shown below, through the relevant State/Territory emergency management organisations.

This publication is provided free of charge to approved Australian organisations. Copies are issued to relevant users automatically (and upon request) through their State or Territory emergency management organisations.

The Australian Government will allow approved overseas organisations to reproduce the publication with acknowledgement but without payment of copyright fees. Manuals and Guides may be supplied to other Australian or overseas requesters upon payment of cost recovery charges.

Enquiries should be sent to the Director General, Emergency Management Australia, PO Box 1020, DICKSON ACT 2602, AUSTRALIA, (Facsimile +61 (0)2 6257 7665, E-mail: EMA@ema.gov.au).

Authors and acknowledgements

The Disaster Loss Assessment Guidelines and the accompanying case study, *Economic and Social Costs of the North Queensland January 1998 Floods*, result from work commissioned by the Department of Emergency Services, Queensland.

The financial support for the project provided by the following organisations is acknowledged:

- Department of Emergency Services, Queensland
- Emergency Management Australia
- Department of State Development, Queensland
- Queensland Transport
- Department of Main Roads, Queensland

The Guidelines were prepared under contract by Professor John Handmer, Cassia Read and Oliver Percovich of the Centre for Risk and Community Safety at RMIT University-a collaborative centre between RMIT, Emergency Management Australia (EMA) and the Centre for Resources and Environmental Studies at the Australian National University (ANU), based in the Department of Geospatial Science at RMIT University, Melbourne.

The authors appreciate the work on intangible losses by Philip Buckle of the Centre for Risk and Community Safety and Victorian Department of Human Services.

Sincere thanks and appreciation are extended to all individuals and organisations that assisted in production of the guidelines by providing meaningful comments.

Guidance for the project was provided by a project management board comprising:

- Carolyn Honeywill, Department of Emergency Services
- Alice Zamecka, Department of Emergency Services
- Jonathan Abrahams, Emergency Management Australia
- Peter Baddiley, Bureau of Meteorology
- Errol Colman, Department of Natural Resources & Mines, Queensland
- Alex Cook, Queensland Transport
- Russell Fisher, Department of Main Roads, Queensland
- Abay Gunaratna, Queensland Treasury
- Alan Laird, Queensland Transport
- Colin Lyons, Department of Main Roads, Queensland
- Neville Patterson, Queensland Transport
- Suzanne Steer, Department of State Development, Queensland

CONTENTS

Figures and tables

1. INTRODUCTION

The purpose of these Guidelines

These Guidelines provide an explanation of the process of loss assessment, and then will lead the reader through the steps required to carry out an economic assessment of disaster losses. There is a separate worked example of a loss assessment, in the accompanying case study, to show how the steps described in these Guidelines have been applied.

The aim has been to set down processes that will:

- be applicable to regional Australia, since existing guides for economic assessment are intended for national economies only;
- be accompanied by a separate detailed case study using the same worksheets as those used in the Guidelines;
- cover all types of loss, including losses affecting different aspects of an area, economic and financial losses, and total and avoidable losses;
- set out what to do on a step-by-step basis; and
- apply to both actual disasters as well as to hypothetical events.

Estimates of disaster loss may serve many purposes, and these are set out in the Guidelines. The most common reason for carrying out a loss assessment is to consider whether proposed investments in mitigation actions will provide value for money, and which one(s) can be economically justified.

Although this document concentrates on assessing losses from hazards that produce inundation, the principles and much of the supporting material would apply to assessments of loss from other hazards.

There are sound reasons for having a standard approach to loss assessment based on economic principles, primarily:

- to ensure that works done to provide mitigation or warning systems etc. in a certain area produce a sound return on the investment. With limited resources the aim is to provide such a return—or at least a politically acceptable return on the investment;
- to have a common measuring tool for assessing alternative mitigation proposals for their effectiveness in reducing loss, and to be able to see the benefits and/or consequences of choosing one over others;
- to assist with post-disaster recovery planning and management. Knowing the extent and type of losses to be expected in existing areas is a great help in recovery management by enabling better targeting of resources to identified key areas.

Of course, there are some other practical objectives in having a clear process to follow in making loss assessments, and they are that the process should be:

- transparent—so that the assessment procedures can be followed easily;
- consistent and standardised—to enable meaningful comparisons;
- replicable—to enable the assessments to be checked;
- based on economic principles—so that assessed losses represent properly the real losses to the economy. Sometimes the main interest may be on financial rather than economic losses (See ‘The difference between an economic and a financial assessment’); and
- documented in such a way that the approach can be easily checked or modified in the light of new information. This also ensures transparency and accountability.

These Guidelines have been prepared to meet these needs. It is important to note that economic assessment of any loss situation is not a solution in itself, but it is a key input to informed decision making. In disaster mitigation there are a number of limitations to its use, particularly where there are important factors which cannot be valued in dollar terms.

The Guidelines are written for all those interested or likely to be involved in making a disaster loss assessment. Although this document sets out the steps to be followed in making a real loss assessment, the process is complex and requires some specialist expertise. At the least, there ought to be members of the assessing team with some more formal experience or training in disaster loss assessment or economics than these Guidelines alone provide.

The structure of these Guidelines

Chapters 1 and 2 set out the framework within which a loss assessment would be carried out. Chapter 3 sets out the process to follow in assessing loss from hypothetical or actual hazard events and includes checklists to follow in progressively developing an overall loss assessment for a typical inundation loss.

The Guidelines also refer to a separate case study, which is a completed loss assessment for a real north Queensland flood using the processes described in the Guidelines. The Case Study is available on the Queensland Department of Emergency Services website which can be found at www.emergency.qld.gov.au.

Both the Guidelines and the Case Study provide references to sources of further information, including information about making assessments of losses following disasters other than inundation.

Terms appearing in **bold** within the text are further explained in the glossary.

2. THE FRAMEWORK FOR DISASTER LOSS ASSESSMENT

Loss assessment and why it is carried out

Economic and social **loss** assessment is an integral part of overall **risk** assessment and management. It helps all levels of Government to make informed decisions in support of sustainable and safe community development. Without a rigorous process for assessing losses—either before or after a **disaster** event—decision makers at all levels would not have objective information upon which to base decisions on how to mitigate the effects of any future disaster.

They need to be able to integrate economic, social and environmental considerations, and to have facts and figures about all three areas. A strategic **economic loss** assessment provides essential support for analysing and developing **mitigation** proposals. It helps decision makers develop new policies, programs or development plans, and to identify issues that may require further consideration.

The most likely reasons for making a loss assessment would be to:

- establish the cost of a specific event, either actual (post-impact) or hypothetical;
- establish the losses as a guide for recovery management;
- establish the likely cost of losses as quickly as possible-using the averaging method which will be described later;
- support local or regional risk assessments, noting that simpler methods become necessary and more valid when studying larger areas;
- estimate the **average annual damages** (AAD) from a **hazard** such as flooding at a specified location, probably as an input to cost-benefit analysis;
- estimate the AAD to evaluate alternative mitigation strategies at a single location—in which case only the relative AADs would be important; and
- estimate the AAD to set priorities between different locations—in which case consistency of approach and avoidance of bias in assessment are important. (Note that the survey method—to be discussed later—is not appropriate for setting priority areas for loss mitigation, as survey data is hard to keep consistent across different locations.)

Loss assessment follows the principles of economics, and in addition draws on a long established concept of unit loss assessment when applied to flood loss considerations. The approach and methodology presented in these Guidelines (and in the separate worked case study) draws on the work of the UK Flood Hazard Research Centre, work at the Centre for Resource and Environmental Studies at the Australian National University, the Victorian rapid appraisal method (RAM) approach for 'averaging' (discussed later), the New South Wales *Floodplain Management Manual* and much other published and unpublished material. The approach is compatible with the natural hazard loss estimation methodology (HAZUS) developed by the US Federal Emergency Management Agency (FEMA), and can be used in conjunction with computer-based methodologies such as ANUFLOOD.

Damage assessments can be made after a real event, or on the basis of a hypothetical situation. For many years, most loss assessments have been made on hypothetical events, generally to provide comparative data for establishing mitigation action priorities. This technique generally estimates the damage or losses in terms of 'average annual damages' rather than damages from a specific event. By themselves, event damages are not enough to do a proper cost-benefit analysis, but they do help in this work.

Unfortunately it takes a real disaster to provide understanding of the full range of social and economic losses. The process of loss assessment is based on these established principles and concepts:

The context of each loss assessment is set by the principles of risk management—as set out in the *Australian Emergency Risk Management Applications Guide* (EMA, 2000) and the Queensland *Disaster Risk Management* material (Zamecka and Buchanan, 1999) and related publications.

Determining the extent of **financial loss** is based upon principles of economics—as set out in the Bureau of Transport Economics (BTE) report *Economic Costs of Natural Disasters in Australia* (BTE, 2001), and *Economic Assessment of Disaster Mitigation* by Thompson and Handmer (1996). BTE is also a useful source for information on counting losses from deaths and injuries.

Flood loss assessment draws on the long established concepts of stage-damage curves and unit loss assessment.

Other goals of loss assessment are to enable assessment of mitigation options or to carry out a cost-benefit analysis requiring an estimate of AAD. (See 'The relationship between event losses and average annual losses' and step 10.)

Loss assessment cannot be carried out without the involvement of all stakeholders, so their engagement follows actions suggested by the Australian *Emergency Risk Management Applications Guide* (EMA, 2000) and other areas of natural resource management publications, such as the NSW *Floodplain Management Manual* (DLWC, 2001). These publications are listed in the references.

The difference between an economic and a financial assessment

The objective of an economic analysis is to assess the impact of an event on the economy of the area selected for analysis. Selection of this area—it could be a local government area, region or a whole state—is explained in step 3. You are interested in the net economic cost of a disaster to the area. To calculate this net cost, you need to identify all **costs** and benefits resulting from that event and, where possible, quantify them (using estimates if necessary). Any **intangible** costs and benefits, such as social or environmental items, are still important components of this analysis and must be identified in the economic analysis.

A financial analysis, on the other hand, is usually undertaken to assess the return or loss on an investment from the perspective of a commercial enterprise. Commercial enterprises are interested in the impact of a disaster on their own profits rather than the impact on the economy. Some impacts, not counted as a financial loss by a business affected by a disaster, can be counted as losses to society. Such losses would generally include all intangible losses, much of the disruption caused by disaster, and losses to the residential and governmental sectors.

Similarly, there are financial losses that are not economic losses. For example, one company may be forced to close following a disaster and thereby lose its sales market, but others may then reap the lost business—resulting in no **net loss** to the economy. Such impacts depend on the structure and boundary of the economy. Table 1 summarises the key differences between an economic and a financial assessment.

There may be some extra costs incurred in transferring production, for example additional labour costs in modifying a production line or additional costs of transporting key inputs to the new site. These additional costs are economic costs, even if the production is made up by a firm within the same region. Damage to, or destruction of, assets (direct losses, that is, losses resulting from contact with the hazard agent) is not offset by gains elsewhere within the economy. It is the indirect losses (losses incurred as a consequence of an event occurring, but not due to direct impact) that may be offset by gains elsewhere within the economy under study. We will talk more about different kinds of losses in step 7.

Table 1: Comparison of financial analysis and economic efficiency analysis

Method	Scope	Objective	What is counted	Values used	Method to bring impacts to a common base date
Financial analysis	Single economic unit (business or household)	Net income or profit	Any change in unit's finances	Market prices, taxes on unit are costs, subsidies are benefits	Discount using market rate relevant to this unit
Economic analysis (benefit-cost analysis)	All members of society, with boundary determined by decision maker	Economic efficiency	All impacts affecting any member of society Impacts for which there is no consensus on social values may be omitted Distributional aspects left to other policies and instruments	Market values adjusted to reflect economic costs; for example shadow pricing	Discount rate—compromise between social time preferences and opportunity cost of capital

Source: Parker, Green and Thompson (1987) Urban Flood Protection Benefits: a project appraisal guide.

How loss assessment compares to an insurance assessment

The loss assessment approach described in these Guidelines and the case study is different to the way the insurance industry operates in assessing insurable loss. Insurance assessments can produce estimates higher than those prepared using the economic principles promoted here. This is because household insurance policies commonly provide 'new for old' replacement coverage for insured losses, whereas an economic analysis only counts the market value of goods lost or damaged. Market value may be only half the replacement value. See also, 'The limitations of loss assessments'.

How to apply economic analysis to derive total cost of assessed losses in a specific area

First of all, why do you need a structured loss assessment? The answer is that nowadays anyone needing an assessment of disaster losses is going to expect to see a full and auditable analysis. Decision-making in all areas of public policy, including disaster management, depends upon having a fully creditable proposal, with all estimates of expected savings backed up with verifiable data. Standardised procedures have to be used to identify losses to local, state or national economies, and to keep these separate from losses to individual businesses.

The intention of economic analysis as part of a flood loss assessment is to assess the deviation from likely economic activity as a result of the flood, not to take into account the financial losses to individual enterprises. This is not always easy to do, and you will commonly have to make approximations to this ideal.

There are, however, some circumstances where rigorous application of all elements of an economic approach may not be appropriate. For example, a local authority might want to know the loss likely to be carried by individuals in their area from a given event, rather than the loss to the local economy.

The basic economic principles for loss assessment are first to define the area for loss analysis, and then specify the timeframe for assessment purposes. We will discuss both of these steps shortly, but first we will look at what has to be done in the selected area to assemble all the economic data.

These are the steps you will need to follow in making an economic analysis:

- Count all losses to the economy within the specified area, but not to individuals or individual enterprises within that area. Losses to some may have presented gains to others within the area of analysis. An enterprise will count as a loss, any business lost to a competitor, either temporarily or permanently, as a result of a disaster. This is an economic loss rather than a financial loss only if it affects the economy of the region of analysis, for example the nation or the state. To decide whether indirect **tangible** losses are real economic losses or simply financial losses the geographic extent of analysis must be defined (see 'Disaster loss assessment process').You need to be sure that one business's loss is not offset by another's gain within that defined economy.
- Avoid double counting and incorrect attribution of loss. Counting a loss that is a benefit to someone else within the assessment area is double counting. Also, you shouldn't count something like a business's inability to trade during a flood as a loss, if that business is going to recoup its lost business after the flood, but during the assessment timeframe. But if that business lost machinery in the flood, and then suffered lost production while the machinery was being replaced, the market value of the lost machinery or lost profits should be counted—but not both.
- Assess the impacts of the event on all the people in the area of analysis.
- Apply a 'with and without the event' comparison, not a 'before and after' review. Economic, social and environmental trends which have no connection with the disaster or hazard will be included in a 'before and after assessment'.
- When assessing how much potential disaster-inflicted damage could be prevented or reduced by mitigation proposals, it is important to count only the losses each proposal is expected to save. For instance, a new or raised levee would provide flood protection up to a certain level only, but if the flood exceeds that level, then warning systems should still help to avert some of the loss.

Distributional effects

These Guidelines follow the foregoing basic economic principles. Economic criteria are not concerned with distributional effects. However, distributional issues are likely to be important to any assessment of social impacts, and should be explicitly identified and documented. So the Guidelines also indicate, as appropriate, where the principles can be varied to provide estimates of losses to local businesses rather than for the local economy. Where loss estimates for a particular business are required, a key element of the approach set out here will be inappropriate: losses would be counted to individuals rather than to the specified economy.

There may be other aspects of mitigation planning for which assessment of a single event is inappropriate. For example, where property or infrastructure that suffers repeated loss is concerned, it may be appropriate to consider the **total losses** from a series of events from the same hazard. For residential properties, such circumstances are likely to lead to increased intangible losses and decreased quality of life for those involved.

If the risk is expected to change after the economic assessment has been completed, for example, through expected development or even climate change, this should be taken into account.

The relationship between event losses and average annual losses

Natural hazards and disasters are infrequent events, generally seen to occur at random. When assessing the costs of a particular disaster, you will only be concerned with that event: this is an 'event loss'. Such event loss estimates do not, in themselves, help to determine what investment in disaster mitigation is appropriate—although they would be relevant to deciding on relief and reconstruction assistance, and for emergency planning.

Appropriate investment in mitigation should be determined by the benefits of the mitigation measure being considered. In an economic sense, these benefits are equal to the disaster losses prevented by the mitigation measure. The benefits continue for the life of the mitigation measure.

However, since the future pattern of disaster events cannot be known—other than in terms of their probabilities or likelihood of occurrence in any given time period—any investment in disaster mitigation has to be economically justified in terms of benefits expected on average every year. This is achieved by calculating average annual losses or AAD (see step 10).

How risk management connects with loss assessment

The context for loss assessment and the processes for involving all stakeholders are set by the principles of risk management described in the various publications referred to earlier. The techniques for involving stakeholders are described in greater detail in *Implementing Emergency Risk Management* (EMA, 2001). As well as discussing the emergency/disaster risk management process this handbook also covers principles of getting the community engaged in helping to manage risk.

The assessment of losses (both actual and potential) fits well within the processes covered in *Implementing Emergency Risk Management* (EMA, 2001) and in the *Disaster Risk Management* book (Zamecka and Buchanan, 1999). The aim of any risk assessment process is to be:

- transparent, accountable, informative and focused on the key problems and issues;
- flexible where appropriate;
- rigorous, credible, practical and relevant (based on reliable, useful information);
- cost effective;
- adaptive;
- participative; and
- inclusive.

The concepts of stage-damage curves and unit loss assessment

There are two other basic loss assessment concepts that need to be introduced here, both of which are measures of the extent of loss. We are talking about the concepts of stage–damage curves and unit losses, both of which have been developed as tools for assessing inundation (flooding) losses (see Figure 1).

Stage–damage curves

'Stage' refers to the depth of flood water. **Stage (or depth)—damage curves** graphically represent the relationship between expected loss and varying depths of flood water. These are typically used for assessing loss to housing and other structures, where the stage or depth refers to depth of water inside a building and the damage refers to the damage expected from that depth of water. They may be thought of more generally as representing the relationship between hazard magnitude and loss.

The basic expectation from flooding is that deeper water will result in greater loss. At floor level, floor coverings will be damaged and there may be losses to furniture and those other items normally kept at floor level. At two or three metres of water inside the building, all contents will be lost and the structure itself may be endangered.

Stage–damage curves can be developed by:

- using data on building contents and structure repair costs to produce synthetic or artificial estimates of damage curves, and
- using information on losses measured following flooding combined with estimates of water depth-stage-damage curves of actual losses can be constructed this way.

The first approach: synthetic damage assessment

This involves compiling detailed average inventories of property contents for different structure types, and synthesising hazard severity tables or curves (depth-damage curves for floods) classified by potential loss for properties having similar susceptibility to flood damage. In the original work for flood damage assessment (Penning-Rowsell and Chatterton, 1977), the contents component of commercial and residential damage curves was constructed by estimating the ownership pattern and typical height above floor for each item in each building type, and then the flood susceptibility of all main items.

Structural damage is derived from estimates of the cost of repairing the damage caused by flooding to building fabric for each building type. Undated information of this type is available from the Flood Loss Assessment Report (FLAIR) database at the Flood Hazard Research Centre, Middlesex University, London, and has been applied in Australia. A similar approach can be used for any hazard agent with appropriate modifications-for example, for wind hazard increasing wind strength will be related to increasing loss.

The second approach: using actual loss data

Stage-damage curves can be based on post-event loss assessments using a single event or an amalgam of events. The ANUFLOOD curves were devised in this way, as are others available from consultants who work in his area.

Comment and example

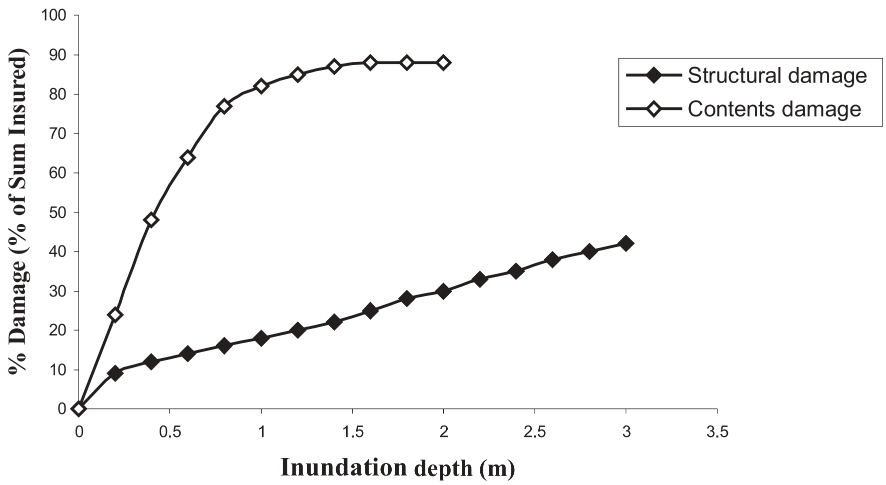
The accuracy of both methods chosen depends on:

- the reliability of the datasets, including:
  - the hazard severity by loss data;
  - the inventory of affected property, and on
- how indirect and intangible losses are handled.

A major issue in the use of a synthetic approach is the conversion of potential into actual damages. (See also 'Precis of the loss assessment process—a process guide' and step 9.)

Modern building techniques and furnishings, as well as contemporary furnishings and contents, may be making the stage–damage concept less relevant. Loss curves may disguise enormous variation in individual cases and uncertainty about their true value.

Figure 1: Stage–damage curve from Risk Frontiers-integrated contents and structure loss curves (both are potential loss curves)



Source: Natural Hazards Research Centre

Table 2: Data used in the stage–damage graphs in Figure 1

Depth (m)	% structural damage (insured)	% contents damage (insured)
0	0	0
0.1	6	12
0.2	9	24
0.3	11	38
0.4	12	48
0.5	12	54
0.6	14	60
0.7	15	66
0.8	16	72
0.9	18	78
1	18	82
1.1	19	84
1.2	20	85
1.3	21	86
1.4	22	87
1.5	23	87
1.6	24	88
1.7	26	88
1.8	28	89
1.9	29	89
2	30	89
2.1	32	
2.2	34	
2.3	35	
2.4	36	
2.5	37	
2.6	38	
2.7	39	
2.8	40	
2.9	41	
3	42	

The unit loss approach

The unit loss approach refers to the calculation of loss to individual properties, which are then added together to give a total loss figure for the event in question. For losses from flooding, this usually involves calculating the loss to each property (or unit) by survey, stage-damage curves, or the use of average figures. The losses for each unit (property) are then added together to give an estimate of total event loss.

What information is needed and where to get it

Information requirements vary greatly, depending on the type of assessment to be undertaken, the scale of the area involved, and the distribution of different types of losses. At a minimum, the assessment will need basic information about all of the following:

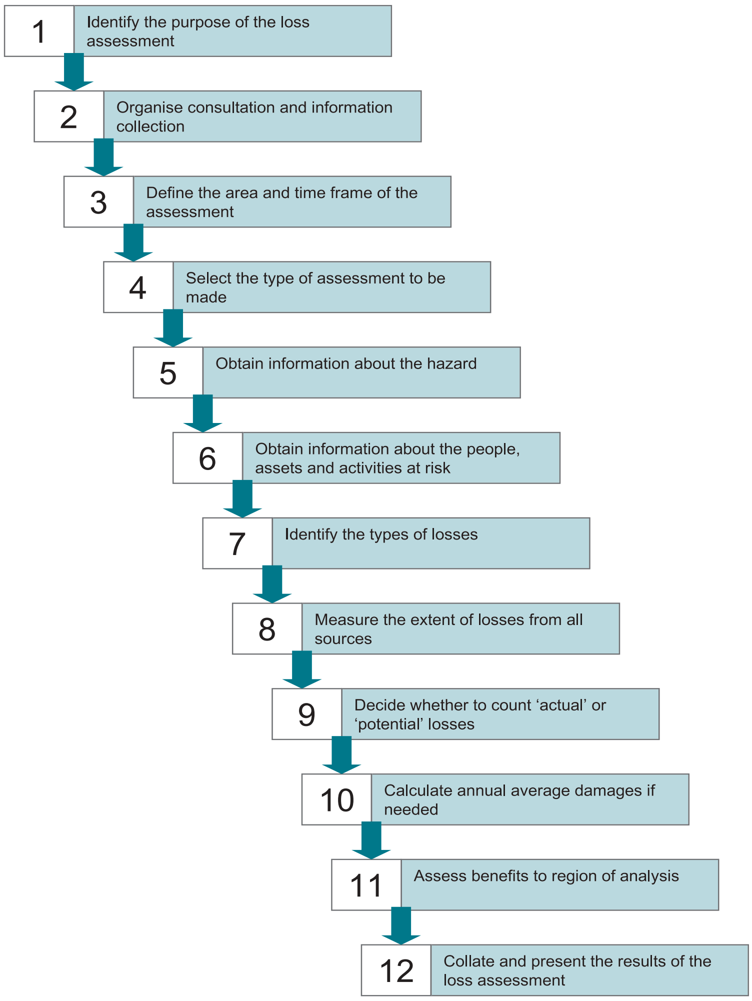
- The hazard—where is or was it? How severe? (for example, depth and velocity of flood water, or wind speed).
- The people—how many people are or were exposed to the hazard? How are or were they vulnerable?
- Which assets and activities are or were at risk? You will need to have some system recognising the distribution of assets such as buildings and infrastructure, and **vulnerability** of production and other activity to disruption.
- What different categories of loss are or were involved—does most of the loss result from direct contact with flood water, or are/were there losses resulting indirectly from the flood (consequential losses) that are or were more important? Or are intangible losses, such as stress, environmental damage or damage to assets with heritage or other non-marketed values, significant?

3. DISASTER LOSS ASSESSMENT PROCESS

Overview of sequence of actions to follow in the loss assessment process

Every loss assessment should be approached in a logical structured way, getting information directly and by consultation, and setting it out clearly as the study progresses. The process is set out in Figure 2, which will be the key to all the steps in both the Guidelines and the Case Study.

Figure 2: The loss assessment process



The step-by-step assessment process shown in Figure 2 is for use with inundation hazards. Much of the supporting material is generic and can be applied to all hazards. So with minor modifications, the assessment process set out in these Guidelines could be applied to other hazards. The modifications you might have to make are set out in Table 20, which identifies differences in economic analysis for different hazards.

The steps outlined in Figure 2 are in a logical sequence, but this does not have to be followed slavishly. The starting point should always be to identify the purpose of the assessment, but beyond that, progress will often be iterative—especially going back to steps between 1 and 6 as more information emerges to modify what has already been covered.

For example, the extent of resources available may not become apparent until some preliminary scoping work has been done. It may be necessary to collate material on the hazard and other components of the risk, and to make a preliminary assessment of the types of damage, before being able to argue for significant resources for the full assessment task. Some key decisions may be made before or as the assessment commences, such as the approach to be used and whether actual to potential loss ratios are to be considered.

Precis of the loss assessment process—a process guide

Estimates of disaster loss may serve many purposes, and these are set out in the Guidelines. Although they consider losses from inundation, the principles in this Process Guide can be applied to assessments of loss from other hazards. There has to be a standard approach to loss assessment, primarily to:

- ensure that works done to provide mitigation or warning systems etc. produce a sound return on the investment;
- have a common measuring tool for assessing alternative mitigation proposals; and
- assist with post-disaster recovery planning and management-knowing the extent and type of losses to be expected in existing areas is a great help in recovery management by enabling better targeting of resources to identified key areas.

Loss assessments have to be:

- transparent-so the assessment procedures can be followed easily;
- consistent and standardised-to enable meaningful comparisons;
- replicable-to enable the assessments to be checked; and
- based on economic principles-so assessed losses represent properly the real losses to the economy.

There are two categories of loss to be assessed:

Direct losses: Those losses resulting from direct contact with the hazard, for example, flood and wind damage to buildings and infrastructure

Indirect losses: Losses resulting from the event but not from its direct impact, for example, transport disruption, business losses that can't be made up

In both loss categories, there are two clear sub-categories of loss:

Tangible losses: Loss of things that have a monetary (replacement) value, for example, buildings, livestock, infrastructure etc.

Intangible losses: Loss of things that cannot be bought and sold, for example, lives and injuries, heritage items, memorabilia etc.

There has to be a clearly defined area and time-period set for any loss assessment. Structured mechanisms have to be set up for consultation, assembly and processing of data on the hazard and on assets and activity affected by the hazard, so there is a logical progression of work.

Figure 2 listed the 12 steps in making any loss assessment. This Precis sets out each step with a brief introduction, (drawn from more extensive description that follows) and then provides a basic checklist to follow in completing each step. User judgment will prevail in deciding whether every step will apply to, or be needed, in every loss assessment.

Step 1: Identify the loss event and purpose of the assessment

Define what the assessment is intended to be used for, what problem(s) its results might be used to address, and what level of accuracy it hopes to achieve. Detailed description of the event, its timing and location come later. At this stage there has to be a definition of the event, in sufficient detail to define the area and time boundaries.

So step 1 in the loss assessment should address these issues in whatever detail and form is considered both sufficient and appropriate:

STEP 1 CHECKLIST:

- ➢ Define the primary purpose of the loss assessment.
- ➢ Define what was (or could be) the event generating the loss.
- ➢ Include any other background information that might put the assessment into context.

Step 2: Organise the consultation and information-gathering processes

No loss assessment can be successful unless a clear process has been set up beforehand to define and manage it. There has to be a centre for operations and collecting/processing data; a set work plan with milestones for consultation, assessment, feedback and final reporting; and a timeframe within which all this has to happen. Budget limitations may need to be set and observed.

A loss assessment involves input from a lot of people and organisations, and from assembled bodies of knowledge. This generally needs a committee or board, made up of stakeholders, to advise on the project. The consultation process not only means talking to people, but also covers setting up and running surveys, collecting and manipulating database information, and generally getting access to information in any form that would add value to the overall loss assessment. So consultation and information gathering has three aims:

- Public relations—letting people know who's doing what, when, where and why.
- Sharing information—getting to know the scope of loss and defining losses into the categories mentioned in the introduction to this Process Guide.
- Consultation—not just for this loss assessment, but also where policy or the law requires it to be done.

When setting up the consultation processes and defining what is being sought by such consultation, develop a table similar to Table 3:

Table 3: Defining the consultation processes

Type of information	Source	Method and responsibility
Hazard type		
Direct loss information		
Tangible loss information		
Indirect loss information		
Intangible loss information		

So these are the steps to follow generally in organising the consultation and information-gathering processes:

STEP 2 CHECKLIST:

- ➢ Set up a process to manage and conduct the detail of the assessment, and define its goals.
- ➢ Draw up a detailed management process to track inputs and activities, their timing, progress, actual versus budgeted cost, progress reporting, review mechanisms and form of delivery of the assessment.
- ➢ Define the processes that will be used to consult and gather different types of information, bearing in mind the purpose of the assessment.
- ➢ Prepare a table to define what information is to be collected, where from, by what means and by which person or agency.

Step 3: Define the area and timeframe of the assessment

In any loss assessment there has to be a clear boundary within which the impact of the event on the economy of that area can be defined and evaluated. There may be some information needed beyond that area, and the originally defined study zone may enlarge or contract as adjusting information comes in. It is important to define the area being assessed, especially when estimating indirect losses and benefits in the form of insurance payouts and aid.

When defining the area of the assessment, make sure it represents the local economy affected by the actual or hypothetical disaster—not just a nominal space such as shire boundary, or a convenient topographic line such as a range or a watercourse. The nominated area can be sub-divided for detailed study of some specific loss components, and needs to be able to have flows of goods and services in and out defined clearly. Keep the study area in harmony with the budget for the assessment, and/or the extent of resources available to conduct it.

There also has to be a timeframe set to define how long after the disaster event the assessment will be considering losses associated with it. Clearly, any assessment needs start and finish dates, especially if the event being assessed is one of a sequence in (say) a cyclone season. Use an extended timeframe of at least 3–6 months to assess indirect and intangible losses—unless indirect and intangible losses are judged to be unimportant in the event in question. Ideally, the loss assessment should be conducted six months after the event. If the assessment has to be done much sooner after the event, there may have to be estimates made of the likely indirect losses.

So these are the steps to follow in defining both the study area and the timeframe for the assessment:

STEP 3 CHECKLIST:

- ➢ Define the study area in a way that includes the area impacted directly as well as its surrounding local economy.
- ➢ Define the core period date from the event's first effects to the end of the assessment period, during which losses from that event will be considered.
- ➢ Set the timeframe for the assessment itself to begin and end, allowing time for losses to be counted from any extension of the core study dates.

Step 4: Decide the type of assessment to be made and level of detail

There are three commonly used approaches in assessing losses after a disaster event, or in a simulated event for evaluating the effectiveness of mitigation measures. They are:

- An averaging approach, based largely upon pre-existing data for losses from similar previous events.
- A synthetic approach, based upon predictions of losses technically derived-rather than historical-data and options.
- A survey or historical approach, where surveys after the event being assessed are used to establish actual losses.

Some combination of approaches would normally be used as, for example, surveys are the usual method for assessing losses to large businesses, most infrastructure and intangibles. In selecting appropriate assessment methods, take account of the advantages and disadvantages of each method (set out in step 4). Note any limitations that may have to be considered in meeting the various selection criteria. See Table 4.

Decision criteria	Averaging method	Synthetic method	Direct survey method
Event within last 5 years	✔	✔	✔✔
Need for consistency etc.	✔✔	✔✔	✔

STEP 4 CHECKLIST:

- ➢ Examine the selection criteria in Table 4 and establish which are relevant and how relevant they are.
- ➢ Select the appropriate approaches against the relevant criteria.
- ➢ List and weight the criteria that were considered in deciding on the form of assessment to be followed as illustrated in the table above.
- ➢ Nominate the assessment approaches selected and comment on any limits to the depth of detail or any constraints on using this approach.
- ➢ Remember that more than one approach would normally be used.

Step 5: Describe the extent/timing of the hazard event so affected assets can be defined

Detailed definition of the hazard event is a critical part of any loss assessment. A ‘hazard’ refers to the natural event, such as flood water, hailstorm or earthquake. It does not include human assets or activities. When combined with information on people, assets and activities, hazard information provides the basic data for loss assessment. Hazard event size and **occurrence probability** is essential for calculating average annual damages (AAD), which in turn are needed for cost-benefit analysis of alternative mitigation options.

The aim of this part of a loss assessment is not to go into precise definition of the extent and characteristics of the hazard event for its own sake, but to focus on key aspects of the hazard in sufficient detail for the purposes of the assessment.

The starting point is generally a map, in whatever format best describes:

- the extent of the affected or assessed area, and
- the route of a moving hazard such as a cyclone.

A map or maps would of course be supported by a wide range of source data from:

- the time sequence or duration of the event,
- automated or manual field measurements during and after the event (such as flood depths and flow rates),
- logs of significant events such as flood heights at key locations, effectiveness of levees etc.,
- photographs, television or private videotape records, and eyewitness accounts, and
- reports on any other secondary disaster impact events (such as resulting contamination events or building/infrastructure failures).

So to address this part of the loss assessment, these are the typical steps to follow:

STEP 5 CHECKLIST:

- ➢ Obtain a map or other descriptions of the hazard for the affected area.
- ➢ Obtain other information on the hazard, as relevant to loss assessment.
- ➢ In the absence of a map, obtain field data or local estimates of relevant hazard characteristics.
- ➢ Record, index and store all documented information about the hazard event, its progress or lifecycle, identifying the source of each item.
- ➢ For a loss assessment this information is needed only in the context of hazard impacts on people, assets and activities.

Step 6: Obtain information about the people, assets and activities at risk

Closely associated with step 5 above is the need to make a record of people, things and activities that were or could be affected by the hazards event. If the loss assessment is being carried out for a hypothetical event, the same kind of information needs to be assembled, but from projections and simulations of the event.

Disaster loss assessment is a measure of damage and disruption to assets and the effect this has on people and businesses in the affected and other areas. Environmental losses may also be important. Unfortunately, loss assessment sometimes also has to measure the extent of death and injury resulting from the disaster event.

There are many details to record in compiling the record from which the loss assessment is made, and the Guidelines describe available data sources (see Tables 6 and 7) to assemble this record. There is no exhaustive list to work through-it just needs a full list to be prepared in consultation with informed parties after an actual loss event, or in preparing a simulated event for study. The outcome should be a database of everything likely to be affected by the actual or simulated event.

The table in step 2 is a good place to start preparing a list of people, assets and activities at risk. Typical content would be:

STEP 6 CHECKLIST:

- Draw up a list of what has been (or could be) affected under three headings of 'people', 'assets' and 'activities', including environmental assets, within the area.
- Identify sources for all the actual or intended information.
- Identify how all the information is going to be collected, for example, surveys, census data, reports on the event etc.

Step 7: Identify the types of losses

In this step, the information derived in steps 5 and 6 is used to separate losses into categories, generally described as direct or indirect losses, and tangible/intangible. This helps define where the major loss components will be likely to arise and what measurement techniques will be needed. Measurement techniques will depend on the approach selected in step 4. The Guidelines identify many typical loss areas to be considered, especially in the intangible category. Intangibles are often ignored, yet are frequently identified as the most significant losses by the people affected.

The information can be sorted using a table with headings like this:

Usually bought and sold for money?	Direct loss (eg damage from contact with flood water)	Indirect loss (eg no contact with flood water, consequential damage)
Yes-tangible losses		
No-intangible losses*		

* Direct and indirect intangible losses are usually treated as one category.

The steps required in identifying types of loss would be:

STEP 7 CHECKLIST:

- Identify likely losses from the hazard event.
- Prepare a table categorising the losses as direct, indirect and intangible.
- Pay special attention to intangibles.

Step 8: Measure the losses from all sources

This is where the counting of losses starts. Elsewhere in these Guidelines there is detailed information on ways of addressing loss measurement in the 'survey', 'synthetic' and 'averaging' approaches to loss assessment, when looking at direct, indirect and intangible losses. There are tables in step 8 showing typical loss categories with suggested estimation principles for each one, along with the kinds of sources of data needed in each loss category for averaging or synthetic assessment methods.

Rather than grouping all losses by each category of loss (direct, indirect and intangible), it may be more practical to collate them by 'loss sectors', and determine indirect, direct and intangible losses for each sector at a time. For a typical flooding event, loss sectors like these could be used to separate the items into study areas:

- residential (including memorabilia and ill health),
- vehicles and boats,
- commercial (including tourism and hospitality),
- industrial,
- infrastructure,
- cultural heritage,
- environmental, and
- other.

So the steps to be followed in assessing loss by sector would be:

STEP 8 CHECKLIST:

➢ Identify and record what the main loss sectors are in the event being studied.

➢ Begin by assessing direct losses in the first sector, applying the method selected as most appropriate for use in this sector to derive losses.

➢ Continue with an assessment of indirect losses in the same sector, and include estimates from the Guidelines that represent the identified losses.

➢ Identify and document the intangible losses in that sector, and where possible quantify these using procedures set out in the Guidelines.

➢ Work through all the loss sectors, writing accompanying text to record specific actions and interpretations made from the 'survey', 'synthetic' or 'averaging' approach used to derive the dollar values and the equivalent for intangibles.

➢ The result should be a well documented and explained set of assessed losses for further review.

Step 9: Decide whether to count 'actual' or 'potential' losses in the assessment

When data is collected by 'synthetic' or 'averaging' approaches, this is generally part of work to estimate the losses that could occur in a hypothetical hazard event. This is a common approach, because it is rare to experience a real version of something that can normally only be done 'on paper'—like considering the likely outcome of a major storm surge. So you will get 'potential' losses as the outcome of such a study.

In contrast, loss assessments carried out after a real disaster, normally record all of the losses as 'actual' ones. 'Actual' losses already take into account all kinds of measures that people take to minimise the damage wherever possible, such as heeding warnings, moving cattle and valuable items to high ground etc.

This part of the loss assessment considers whether, and by how much, predicted or 'potential' losses should be trimmed back because of known preventive or protective actions that might be taken in a real event. However, the use of 'actual' losses raises a number of issues:

- It is difficult to determine the correct ratio between actual and potential loss (see Table 17 for estimates).
- Actual losses may discriminate against well prepared communities if the loss assessment is used to decide the worth of mitigation options.
- Actual losses may discriminate against poorer communities as they will typically have fewer assets and less economic activity to be damaged by a hazard.

- The difference between actual and potential losses will change a lot over time as people move and as other circumstances change.

So there are some hard issues to consider in making a loss assessment for a simulated disaster event where different community responses and lifestyles may prevail:

STEP 9 CHECKLIST:

➢ It is recommended that, wherever possible, potential losses should be used rather than actual losses.

Step 10: Calculate annual average damages if needed

Investment in disaster mitigation can be economically justified in terms of losses avoided in an average year, using an estimate of AAD. AAD is calculated by plotting loss estimates for a given hazard at a range of magnitudes, against the probability of occurrence of the hazard event.

So the steps to be followed in calculating annual average damages would be:

STEP 10 CHECKLIST:

➢ Make a table that lists a range of possible events for a given hazard, the annual occurrence probability of each event and a loss estimate for each event.

➢ Using a minimum of three distinctly different events, plot the loss estimates against their event occurrence probability.

➢ The shaded area under the curve is equal to AAD (see Figure 7) and can be obtained mathematically by integration.

Step 11: Assess benefits to the region of analysis

Economic assessment measures the net loss to the economy of the area of analysis. To obtain net loss, any benefits to the economy resulting from the disaster need to be subtracted from the assessed losses. Assessment of benefits is particularly important within a regional context because post-disaster aid and insurance payouts are more likely to partly offset the tangible losses suffered, as the area of analysis becomes smaller. This step is only relevant for economic loss assessment.

So the steps to be followed in assessing benefits to the region of analysis would be:

STEP 11 CHECKLIST:

➢ For a post-disaster assessment, identify the major flow of funds into the region: Commonwealth funds (for example Natural Disaster Relief Arrangements), State or Territory disaster relief payments, and insurance estimates from the Insurance Council of Australia).

➢ For a hypothetical assessment, estimate the likely amount of NDRA funds using the results of a completed assessment. Include insurance estimates from the Insurance Council of Australia, if available, or make estimates through experience with similar events

Step 12: Collate and present the results of the loss assessment

Present the results of the loss assessment in a simple format, such as in Table 18. The table should include all of the assessed losses for each of the loss categories (direct, indirect and intangible) and a total of the benefits to the region of analysis. The benefits are deducted from the losses to give an estimation of the economic cost of the event (or net economic loss). A statement on the importance of intangibles should also be included to ensure they are not overlooked in mitigation proposals.

So the steps to be followed in collating and presenting results of the loss assessment would be:

STEP 12 CHECKLIST:

- ➢ Prepare a table that shows the net of the losses and benefits to the region of analysis and calculate net economic loss.
- ➢ Include a statement on the importance of the intangible losses.

Detailed description of the loss assessment process

Step 1: Identify the loss event and purpose of the assessment

As shown in the checklist for step 1, the first part of the process for any loss assessment has to define what the event was (or could be, if it is an assessment of a hypothetical event), in sufficient detail to define area and time boundaries for the study being reported. This only has to be a summary description, as the details follow later. However, it needs to include all pertinent conditions, describe real or projected events, and the area and timeframe involved.

The second thing to be made clear in step 1 is the reason (or reasons) for carrying out the loss assessment. This could have been directly as a result of a disaster, or to report on an entirely simulated event as a means of assessing the likely effectiveness of different loss mitigation measures, or a re-run of the actual conditions imposed by a past event to test specific mitigation measures.

Step 1 could also refer the reader to various items of background detail, such as previous studies or assessments identifying the sources of specific studies that could contribute data to this loss assessment.

Step 2: Organise consultation and information gathering process

A loss assessment involves input from a lot of people and organisations, and from assembled bodies of knowledge. The consultation process not only means talking to people, but also covers setting up and running surveys, collecting and manipulating database information, and generally getting access to information in any form that would add value to the overall loss assessment. So consultation and information gathering has three aims:

- Public relations—letting people know who's doing what, when, where and why, and securing their support.
- Sharing information—getting to know the scope of loss and defining losses into the categories mentioned in step 7.
- Consultation—where policy or the law requires it to be done.

When setting up the consultation processes and defining what is being sought by such consultation, develop a table similar to the one below:

Type of information	Source	Method and responsibility
Hazard type		
Direct loss information		
Tangible loss information		
Indirect loss information		
Intangible loss information		

The kind of consultation process chosen depends a lot on what you want the information for. Is it mainly to ensure people are aware of a possible mitigation project? Is it to obtain information? Or is it to help establish locally appropriate mitigation strategies? Consultation and fact-finding processes will vary. Depending on the scale and resources of the assessment project, consultation will range from letters through to local meetings and to having stakeholders on a project board. It may include newsletters, surveys, focus groups, talk-back programs, meetings with local stakeholders and publicity via a website.

Hazard and flood-related consultation processes are set out in detail in *Emergency Risk Management Applications Guide* (EMA, 2000), *Implementing Emergency Risk Management* (EMA, 2001), *Disaster Risk Management* (Zamecka and Buchanan, 1999), and the NSW *Floodplain Management Manual* (DLWC, 2001). These approaches are recognised and supported by groups around Australia.

Consultation generally needs a committee or board made up of stakeholders to run or advise on the project. That group would be set up and given logistical and technical support by those undertaking the loss assessment, but need not be directly involved with running the project. Key stakeholders would normally include those funding the work, those with a strong interest in the project outcomes, government agencies with responsibility in the areas involved, including local authorities, commercial groups affected by the disaster as well as local action groups who may have useful perspectives to contribute.

People experienced with disaster loss assessment could be members of the panel or board, but would normally be better placed as members of the project team.

At a minimum, key local and state authorities, residents' representatives (if active or likely to become active), local business representatives, and others as locally appropriate (for example, primary producers, environmental organisations), should be consulted formally as the area for assessment is being finalised. Table 7 suggests the kinds of people to involve, how to get information and for what purpose. Planning all aspects of the consultation process is one of the key steps in conducting a loss assessment.

Consultation should be initiated early in project development before any significant assessment work begins. This is necessary to ensure those being consulted feel the consultation is genuine, and to ensure the project gains needed information.

Step 3: Define the area and timeframe of the assessment

The area of the assessment

Any loss assessment has to measure the impact of a disaster (such as a flood) on the economy of a specified area. The process applies assessment analysis to the economic activity within that area, so an important initial step is to identify the area concerned. This area may change slightly during the analysis as you find out more about the impact of the event. The boundary of analysis is especially critical for the economic valuation of indirect disaster losses. Where you are using loss assessment as a means of evaluating alternative mitigation measures, having a clear boundary helps in assessing the indirect impacts of disaster mitigation measures.

Jurisdictions with boundaries based on physical features, such as catchment authorities, may seem the logical boundaries for loss assessment. However, often they could be inappropriate if they do not align with the location of the local economy and the importance of indirect losses to that economy. Here are some criteria to consider in drawing the boundaries of a loss assessment area, but they will need to be applied with some judgement:

- Select an area consistent with the purpose of the assessment, such as to provide mitigation for a specific area. If the purpose is to assist with mitigation or recovery management, the chosen area should be consistent with the area benefiting directly from the proposed mitigation (consistent with the scale of government involved in likely decision-making).

- The area may be subdivided according to the type of mitigation (such as levee, buy-back, warning systems, or road-raising); or by community sectors involved (such as agricultural, industrial or residential). Different assessment approaches with different levels of detail may be applied to different sectors.
- Ensure the area selected can be isolated in terms of flows of goods and services, so that such flows can be identified (unless it is thought that indirect flows will be unimportant). Note that the aim is to identify major flows of goods and services, rather than spend effort tracking down the numerous minor transactions. In rural and remote areas this is normally straightforward. In urbanised or heavily populated areas the exact boundary may have to be finalised after assessment begins. This is because feasible boundaries may not become clear until after data collection starts.
- Ensure the area is feasible in terms of the resources available to carry out the intended loss assessment. If the area is too large, re-examine it in terms of each of the criteria above. If there is still a problem, you may have to consider using the less demanding averaging approach.
- The impacts of disaster mitigation measures must also be modelled in physical and economic terms. There is a particular problem with flood mitigation structures (such as levees) which may confine the floodplain and increase the risk in adjacent or upstream areas, occasionally in areas far from the structure. Any such economic impacts of mitigation must also be assessed in the usual way. These are counted as negative benefits of the proposed measure. The boundary for physical impacts is the specified economy, not the area benefiting from, or damaged by, a measure. Impacts, both positive and negative, should be modelled and assessed for this economy.

For a disaster event affecting north Queensland, Figure 3(a) shows that, when the boundary of analysis is drawn around the whole of Australia, there is no economic loss to the nation (or to the state of Queensland) although there is a financial loss to company ‘X’. Its products may be inputs to company ‘Y’, and these can be supplied at short notice by another Australian (or Queensland) company (company ‘A’).

Figure 3(a): If the boundary of analysis is the whole of Australia

However, if you redraw the boundary of analysis, as in Figure 3(b), there is an economic loss to the region of North Queensland. The needed products came from a competitor outside the region. In both examples an economic loss would have occurred if there was no alternative supply of the needed products, or if the alternative supplier was overseas.

Figure 3(b): If the boundary of analysis is only North Queensland

Similarly, if you were conducting a loss study for an isolated country town, you should make it clear whether you are calculating losses for the town, the region or the state. Thus sales losses to shops in the town might be transferred to another town (which would be a loss to the town but not to the region), but production from the local animal feed factory might be taken up by another factory on the opposite side of the state (loss to the region but not the state).

If the factory was just over the state border there would be a loss to the state but not to Australia. All these statements about 'no loss' ignore the 'transfer' costs , that is, the costs incurred in using an alternative supplier. These are usually mainly extra transport expenses. The disaster might even bring benefits to the town if it receives state or federal grants to rebuild new houses for old or to establish new industries where declining industries were put out of business, but as far as the state economy is concerned, these are transfer payments.

In general, the more isolated the disaster-affected economy the greater indirect losses are likely to be since there will be greater costs incurred in making up losses, exports will be lost or imports will increase. The extreme example is in small island economies where what would be merely a local transfer in a larger economy can be a loss to the nation.

The important thing to remember is that the scale of indirect business losses depends on the boundary set for the loss analysis. The same comment applies to the assessment of benefits from the event being assessed. A major disaster may result in losses to the nation but locally there may be both losses and dollar benefits as insurance payouts and aid flows into the affected area.

Example of defining the area of the assessment

This is how the area was defined for the Tully (Queensland) flooding assessment which is covered in more details in the accompanying Case Study. The criteria for defining the area of assessment from the Guidelines applied to the case study were:

Criteria for defining the area of assessment	Application to case study
Select an area consistent with the purpose of the assessment. For example, the purpose may be to serve some political or other purpose related to mitigation for a specific area	The Tully area was chosen in advance. It became clear that the flood had caused major damage in Townsville so that area was included. Cairns was included as it was thought that the closure of the Bruce Highway may have had significant economic impacts on the city
The area may be subdivided according to the type of mitigation (such as levee, buy-back, warning systems, or road-raising) or sector involved	Not relevant
Ensure that the area selected can be isolated in terms of flows of goods and services so that such flows can be identified (unless it is thought that indirects will be unimportant). The aim is to identify major flows of goods and services	The limited transport routes, isolation of the area from the rest of Australia, and identification of the event by insurers and others as having the same boundaries we selected, vindicated the boundaries chosen
Ensure that the area is feasible in terms of the resources available for the assessment	Resources appeared to be appropriate

Defining the timeframe of the assessment

In an economic analysis it is important to acknowledge that some losses, in particular indirect losses, may change greatly with time. Typically, some losses are reduced as companies make up lost sales and production. Conversely, lengthy periods of disruption may lead to increased indirect losses.

If both time and space boundaries are not specified, the assessment will not be economically sound. Also, it will not be possible to replicate or check the results, particularly for any indirect losses.

So start by specifying the start and end dates of the event in question. If the event is clearly part of a sequence of events (for example, if it is one of a number of floods during the northern wet season) care must be taken to separate the impact of the event being examined. Under these circumstances, it can sometimes be very difficult to separate the impacts and the losses resulting from each event in the sequence. Where this is the case, it may be appropriate to use the averaging or synthetic methods rather than a survey of actual losses (see step 4).

Use an extended timeframe of at least 3–6 months to assess indirect and intangible losses unless indirect and intangible losses are judged to be unimportant in the event in question. The reasons for this judgement should be set out as part of the indirect/intangible assessment.

Ideally, the loss assessment should be conducted six months after the event, as this allows enough time for accurate assessment of most indirect and intangible losses. Where assessment must be conducted closely following the event, the assessors should ask businesses for their best estimates of how much indirect losses will be reduced over time.

Where losses may change significantly over time, this should be assessed and documented. This might be the case where indirect losses and/or intangibles are relatively large or where chemical contaminants or other events are involved.

Loss assessment following an actual disaster typically has been seen as making a statement about losses at a moment in time, usually a month or so after the event in question. Assessments based on hypothetical events should take the same approach, although they may use assessments of indirect losses and intangibles based on longer-term analysis.

For an assessment after an actual event, there can be problems if that event was one of a sequence of events, or if the time between the event and loss assessment varies greatly for different events and for different attempts at loss assessment.

For an assessment after both real and hypothetical events, there can be problems if the timing of the event is unclear. Start and end dates are usually clear for floods, fires, storms, earthquakes, but may be unclear for droughts or spills of toxic chemicals, for example. Also, losses may change over time, which is important from the perspective of loss assessment, as some types of loss only emerge over time and some, (including the affects of contaminants) may worsen with time.

Example of selecting the timeframe for analysis

The following is an example from the Tully flooding case study which covers this issue in more detail.

Criteria	Application to case study
Specify the start and end dates of the event in question—care must be taken to separate the impact of the event being examined	9–12 January 1998: but a variety of dates were used to classify this event—the flood causing rain was associated with cyclone Sid which was active in December 1997, and some reports use this date for flood damages resulting from the heavy rain in January The time was not specified clearly at the start of the case study (see text)
Use an extended timeframe to assess indirect and intangible losses of at least 3–6 months—unless intangibles and indirects are judged to be unimportant	See explanation in text
The loss assessment should be conducted at least three months after the event; the ideal period is six months as this gives enough time for assessment of most indirect and intangible losses	Done: the assessment was undertaken three and a half years after the event
Where assessment must be conducted close to the event	Not applicable
Where losses may change significantly over time—this might be the case where indirects and/or intangibles are important	Appears not to be relevant, however, by conducting the assessment well after the event these changes should be picked up

Step 4: Decide the type of assessment to be made and level of detail

Three basic approaches to loss assessment are set out in these Guidelines. They are:

- **A rapid assessment or averaging approach**, based largely on pre-existing average data on losses, for example, an average loss per flooded property;
- **A synthetic approach**, which is a detailed assessment, based on pre-existing databases, covering a range of average building types and contents. Losses are based on assumptions about the age and condition of the items, and the effect of the hazard, and are often developed theoretically or synthetically, as opposed to being based on experience; and
- **A survey or historical approach**, which is based on detailed surveys of a recent event to establish the actual loss.

These methods have been chosen as representing the range of assessment methods used worldwide, which range from very detailed post-disaster surveys attempting to calculate precise losses, through to rapid estimates. The assessment can be made either after a disaster or on the basis of a scenario or hypothetical event, applying average losses derived from experience elsewhere.

As far as possible the material contained in these Guidelines is consistent with other disaster loss assessment guides based on economic principles:

- It follows principles and practices defined in the BTE report *Economic Costs of Natural Disasters in Australia* (2001) (summarised at the end of this section). The economic methodology in these Guidelines is similar to that in the BTE report. The Guidelines also draw on well-established figures used by BTE for deaths, injuries and, so on.
- It is generally consistent with, and in places draws on, the Victorian rapid appraisal method (RAM) (Read, Sturgess and Associates, 2000) (summarised at the end of this section). This approach forms the basis of the 'averaging method' set out in these Guidelines
- It can be used in conjunction with computer-based methodologies such as ANUFLOOD. These deal only with direct losses (see later for an explanation of direct loss) and can be applied to that part of the loss calculation.
- It is broadly compatible with the HAZUS methodology developed by FEMA.
- The series of manuals developed by the UK's Flood Hazard Research Centre at Middlesex University.

These approaches and the approach in these Guidelines vary from those developed exclusively for the insurance industry as their requirements differ from those of government. (For an explanation of the differences see 'How loss assessment compares to insurance assessment').

Globally, most disaster damage estimates collect actual damages. They are also generally financial estimates rather than measurements of economic losses, that is, they are the damages actually measured following a disaster.

Because you cannot measure the benefits of, for example, flood mitigation work by staging a major flood at the right place and right time, you have to estimate the losses such a flood might inflict. This needs a 'synthetic' approach based on synthesised stage-damage curves, and an 'averaging' method based on an average loss value per property.

Application to other hazards

All three approaches, with modifications, can be used to assess losses for other hazards. Most examples in these Guidelines are drawn from flooding as loss assessment is most developed for inundation hazards, and the data needed for the synthetic and averaging approaches are generally available.

How to select a loss assessment approach

The criteria for selecting an approach are not rigid and inevitably some judgement can be exercised to combine approaches as needed, depending on the level of detail and accuracy required, and according to the importance of different types of flood loss.

Approaches are commonly combined, primarily because it is difficult to undertake a complete loss assessment without a survey component, especially of large commercial and industrial enterprises and intangible losses. In some cases these losses may be relatively unimportant or easily estimated, in which case there would be no need for any surveying. Approaches can and should be combined for two additional reasons: according to the level of detail and accuracy required and according to the importance of different types of flood loss. As knowledge and datasets improve, it will become easier to undertake an assessment entirely by averaging or synthetic approaches.

Where an actual flood event is being assessed, as opposed to a hypothetical flood, the main problem with using a survey approach as well as averaging or synthetic approaches is that the survey approach will normally indicate actual losses. The other approaches will estimate potential loss (see step 9). There would normally be a significant difference between actual and potential losses, especially where direct loss is concerned. For that reason we recommend collecting data on what was saved as well as the losses experienced when using the survey approach. This will enable a potential loss estimate to be made.

To get a quick result with limited resources the averaging approach is appropriate but, where accuracy is important, the synthetic method is generally preferred. The synthetic method also offers the best balance between consistency and local accuracy, and is cheaper than the survey approach for all but very small affected areas.

Recent work by Read, Sturgess and Associates suggests that complex synthetic methods used to estimate household and small business losses provide results that are similar to those obtained with much simpler and cheaper averaging methods.

Standard assessment methods (averaging and synthetic) are at their best when assessing direct tangible damages. If it appears that indirect and intangible losses are going to be particularly important in the area under study, these losses should be assessed through surveys. Criteria for approach selection are summarised in Table 4.

Table 4: Criteria for selecting an assessment approach

Decision criteria	Averaging method	Synthetic method	Direct survey method
Flood within last 5 years	**A**	**A**	**G**
Consistency required	**G**	**G**	**A**
Assessment of potential losses for planning purposes	**G**	**G**	**N**
Low resource availability (funds and time) relative to area concerned	**G**	**A**	**N**
Only limited expertise available Specialist expertise unavailable	**G**	**A**	**N**
Large area	**G**	**G**	**A**
Small area (<100 properties)	**N**	**N**	**G**
Low precision satisfactory	**G**	**N**	**N**
Significant indirect or intangible loss	**N**	**A**	**G**
Only poor quality data available	**G**	**A**	**N**
Suitable existing database unavailable	**N**	**N**	**G**

Legend: **A** = Adequate; **G** = Good; **N** = Not appropriate

When undertaking loss assessments, answering the questions in the following table may help establish the most appropriate approach for each type of expected major loss.

Questions to establish most appropriate method	Comments
What is the purpose of this assessment?	This will often set a clear path to the preferred method
Was there a flood?	If there was no flood, the direct survey method is inappropriate for direct tangible damages.
What resources will be available to carry out the assessment?	If funds and time are particularly short and the area is large, an averaging method may be best. If the area is small, a survey may still be viable. It should be noted that a survey, especially of a poor or small rural area, may produce low loss figures (see step 9 for a description of 'actual and potential' losses).
What expertise is likely to be available to support the assessment?	The averaging approach requires the least specialist expertise. A survey seems easy, but requires specialist expertise to carry out with confidence.
What degree of precision is needed?	If a high degree of precision is needed, the averaging method is inappropriate (see also 'Concluding remarks about the philosophy behind loss assessment').
What are expected to be the major types of loss?	If the major losses are indirect or intangible, a survey approach may be the most appropriate. For example, this might be the case when there is a high degree of disruption or trauma, but relatively little direct loss.
How accurate will the data be?	There may be no point in a detailed analysis if the data availability or quality does not support the intended level of detail.

In summary

The survey approach is appropriate where actual event losses need to be assessed (although the synthetic approach is also appropriate). It can also be used where synthetic data is not available and either the affected area is small or that particular hazard is very localised. The synthetic approach is generally preferable for consistency and economy, provided there is sufficient time and budget to compile applicable data sets.

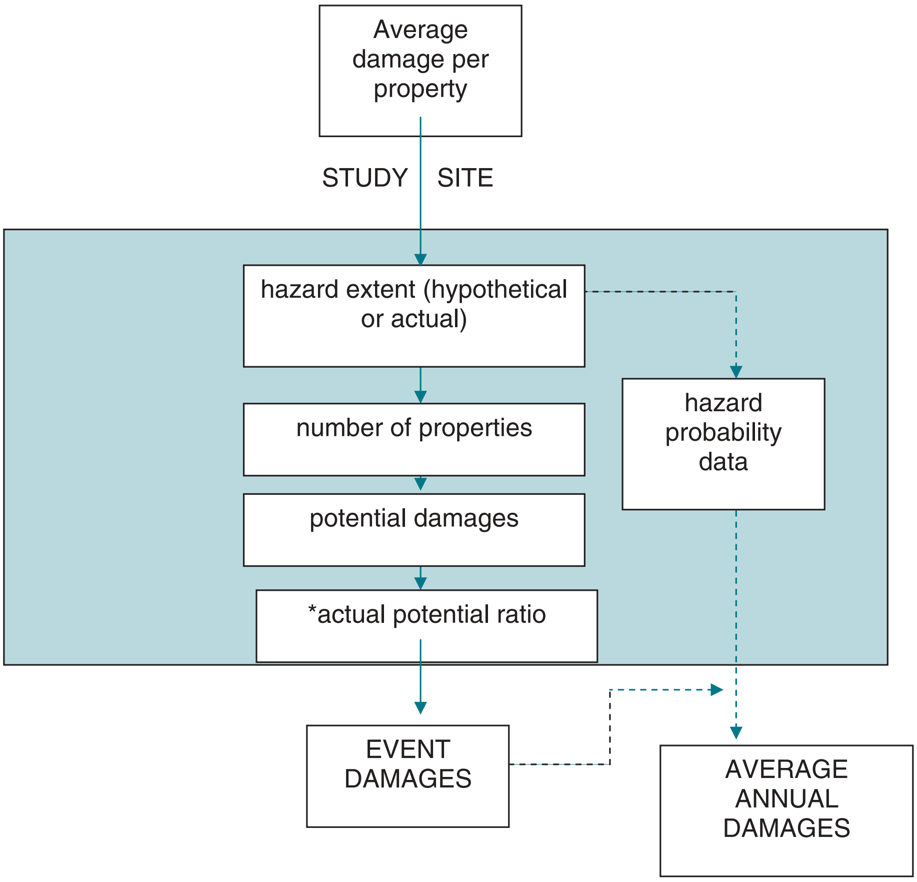
Therefore, the synthetic approach is economic where there are many locations potentially at risk, and the data can be used over a long period for different assessments, as is the case with floods.

Standard assessment methods (averaging and synthetic) are at their best when assessing direct tangible damages. For indirect and intangible losses some surveying would normally be required. A survey or historical approach is specific to a given event at a given location, and combines loss data and hazard data for the same affected properties. By comparison, the synthetic and averaging approaches separate loss data sets from the particular properties and hazard characteristics.

The averaging approach

Figure 4 shows the steps involved in making a loss assessment using the averaging approach. The steps inside the shaded area refer to information needed from the place being assessed.

Figure 4: The averaging approach



* see also step 8

The averaging approach may be the most appropriate in the future as data sets are developed and tested, but currently it has certain limitations. It was developed by Read, Sturgess and Associates (2000) for use in Victoria at a catchment authority level, primarily to help set priorities for flood mitigation.

The averaging approach has the advantage of great simplicity and relatively low resource requirements compared with other approaches. It also suggests considerable even-handedness with one outcome being that the loss potential of very poor areas will be valued much the same as very wealthy areas. Allowance can be made for disaster experience and warning time. However, we recommend against this practice (see step 9 and Appendix 7).

The averaging approach uses an average loss per impacted dwelling, with average values for business premises based on the area of the structure. These values are provided in Table 11. Percentage figures for indirects and indexes for intangible losses are also available.

However, the approach may under or over value indirect and intangible losses. It also treats very serious and dangerous flood hazards the same as shallow flooding which results in little damage and poses little threat to safety. The worked example of the use of the Loss Assessment Guidelines (that is, the case study of the 1998 Tully floods, provided separately) shows that averaging can overvalue losses in these circumstances. However, with further development the approach should be able to overcome this problem.

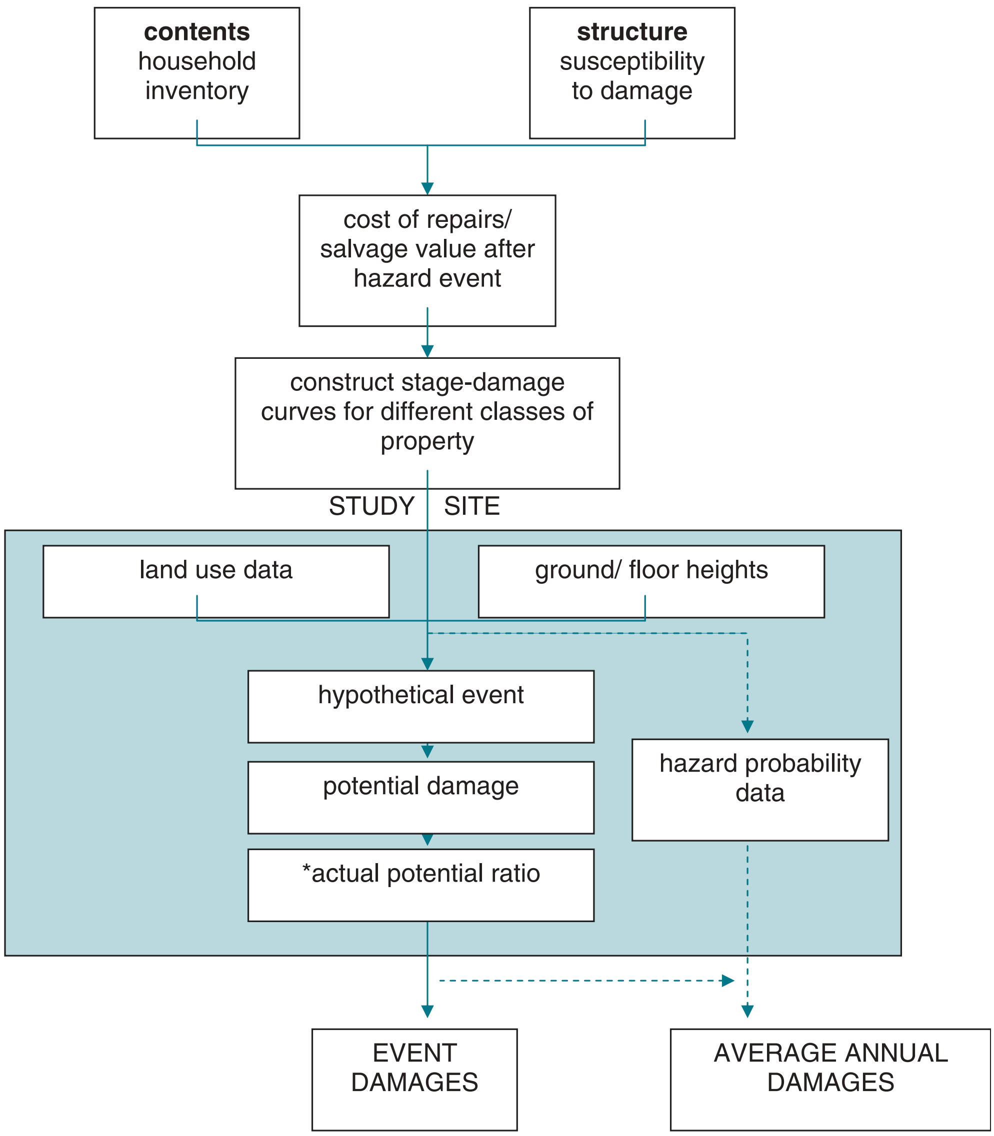
The synthetic approach

The synthetic approach is probably the most flexible and currently the most widely used of the three approaches. It can make use of a variety of existing computer packages with their own stage–damage curves for calculating residential and small business direct losses. However, this extensive use and availability of calculation packages disguises considerable debate over the accuracy of the stage–damage curves and resulting figures. These computer packages are held by consulting and research groups.

Synthetic damage assessment involves compiling detailed average inventories of property contents for different structure types. You have to measure hazard severity by potential loss tables or curves (stage– or depth–damage curves for floods—see also 'The concept of stage–damage curves and unit loss assessment') that are devised or synthesised for properties having similar susceptibility to flood damage. A range of stage–damage curves, producing a variety of results, are presently in use across Australia to assess flood damage. (A major study into the issue by *Risk Frontiers* at Macquarie University may suggest a national standard). Alternatively, the severity by loss curves can be based on an amalgam of post-event assessments. The ANUFLOOD curves were devised in this way, and others are available from consultants who work in this area.

In the original work for synthetic flood loss assessment (Penning-Rowsell and Chatterton, 1977), the contents component of commercial and residential damage curves was constructed by estimating the flood susceptibility of all main items and then the ownership pattern and typical height above floor for each item in each building type (see Figure 5).

Figure 5: The synthetic approach



* see step 8

In this method, structural damage is derived from estimates of the cost of repairing the damage caused by flooding to the building fabric for each building type. (Undated information of this type is available from the FLAIR database at the Flood Hazard Research Centre, Middlesex University, London, and has been applied in Australia).

The synthetic approach can be used to assess losses resulting from any hazard agent with appropriate modifications, for example, for wind hazard increasing wind strength will result in increasing loss.

The synthetic approach is generally preferable for consistency and economy, provided there is sufficient time and budget to compile applicable data sets. It is economic where there are many locations potentially at risk, and the data can be used over a long period for different assessments, as is the case with floods.

The accuracy of the synthetic method depends, therefore, on the reliability of the available data sets, that is:

- the way the hazard severity is reflected by loss data;
- the extent and accuracy of the inventory of affected property; and
- how indirects and intangibles have been handled.

A major issue in the use of the synthetic approach is conversion of potential into actual damages. This issue is examined in step 9.

The survey approach

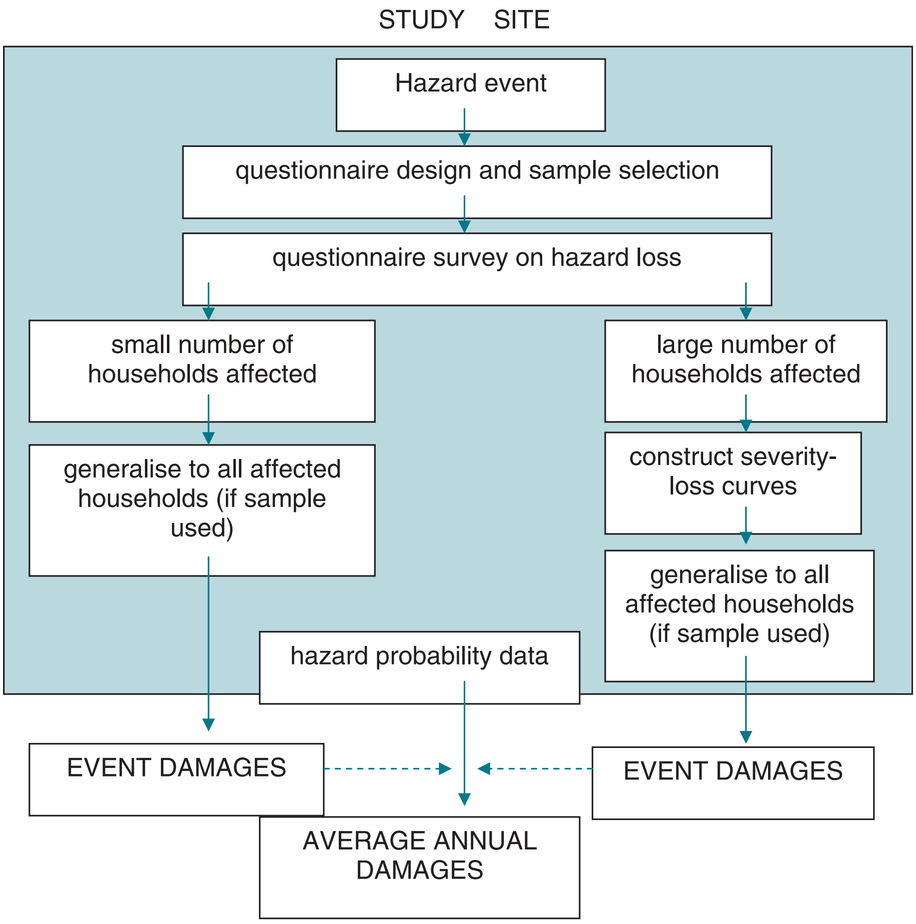
A historical or survey loss assessment (see Figure 6) depends on interviewing event victims and others involved (such as government agencies and utility companies) to ascertain the extent of the loss. Often this will involve taking a sample of households or enterprises and generalising the results to the affected population.

Where a substantial number of properties are involved, a more sophisticated analysis is usually attempted and hazard severity-loss tables or curves (such as stage–damage curves) may be constructed for different activities and structure types using regression techniques. The curves produced in this way are based on a sample of affected properties, and are used to estimate losses for all affected properties, sampled and unsampled.

The accuracy of the results depends, among other things, on rigorous sampling and careful survey design. This is different from the synthetic approach as the survey approach generalises from loss data obtained from the area in question. The synthetic approach applies loss data generated synthetically or from other areas. High quality sampling and survey design should be undertaken by experienced professionals.

Historical loss assessment provides results that define the losses experienced at one point in time, given the community's preparedness, length of warning and so on. Unfortunately this fact is often neglected when estimates are transposed through time and extrapolated for larger events, or when they are used to estimate losses at a different community. The method cannot be used where an event has not occurred recently.

Figure 6: The survey approach



Step 5: Describe the extent/timing of the hazard event so affected assets can be defined

We have to define the hazard which caused the damage, now being assessed in the area of analysis. In these Guidelines, a hazard is considered to be any source of potential harm, such as a geophysical agent like a flood, cyclone, or earthquake.

Knowledge of the hazard is an essential component of loss estimation, wherein this knowledge is combined with information on what is exposed to the hazard, and its vulnerability to loss. You need the information on the hazard to be able to calculate average annual losses and to carry out a cost–benefit analysis.

This information is needed only so you can determine losses resulting from the event being assessed. The proper question is: 'For the event in question what assets and activities are or were affected and how are or were they affected?' This puts a different slant on the question: that is, you are not trying to define the precise extent and characteristics of the hazard. This section is written to describe actions in defining the flooding hazard, but it can be interpolated to apply to other major hazards.

Assuming the hazard was a flood, the best way to start is with a map or other clear means of portraying the extent of the flood. If you are going to be calculating AAD you will need to know the extent of at least three floods of very different probabilities. You should also try to locate the approximate extent of the **probable maximum flood** if the assessment is going to be used to quantify AAD or guide emergency planning. The extent of historic events can usually be obtained from local authorities, the Department of Emergency Services or the Bureau of Meteorology. Typical information sources are set out in Table 5.

In the absence of an accurate flood map, the minimum requirements for a loss assessment will be to have details of assets and activities affected by the flood. Ideally, key characteristics of the flood, such as water depth and velocity, contaminants, duration etc., would need to be identified and documented if they appear significant from a loss perspective. For a loss assessment using the averaging approach you do not require a high degree of accuracy for most aspects of the flood hazard.

Other key information needed to be able to assess losses resulting from a flood hazard are:

Flood depth

Once flooding occurs, the key determinant of flood damage is generally taken to be the water depth. The basic instruments of flood damage measurement are stage–damage curves, which are a function of water depth (see 'The concept of stage–damage curves and unit loss assessment'). In using these, 0.3 metres is considered critical, as this is the height above ground specified in typical regulations for slab-on-ground construction. For houses with suspended wooden floors the height above ground is typically about 0.8 metres in Queensland. At these depths, and depending on the local building style, most houses will have water inside, and roads will start becoming blocked to most vehicles. Evacuation will be dangerous.

A second critical measure of a flood's impact is when the water reaches a depth of 3 metres over the ground. At this depth, building collapse is increasingly likely. Where many houses are elevated (as in much of tropical Australia), these figures will need to be adjusted. In areas with high-set housing, a critical flood depth of 1.8 metres is suggested. At this depth water will be entering most houses and the average loss figure would apply.

The flood extent should be mapped for the key depths. If, as sometimes happens, only the extent of flooding is available, the assessment will have to proceed without depth data. If resources are available, flood depth can be estimated in a Geographic Information System (GIS) from digital elevation data (see step 6). Ideally, depth should be combined with velocity, as the damage resulting from the hazard is generally a function of the two components.

Flood velocity

Low velocity (less than 1 metre per second) flooding events are relatively safe. In contrast, flood water moving at high velocity is dangerous and generally causes much greater direct loss. If accompanied by little or no warning, there will also be more intangible damage.

Flood duration

Long duration floods (greater than 12 hours) result in greater structural damage. More importantly, they may result in much greater indirect losses due to extended disruption. The key threshold time for most flooded crops is five days, after which the crop will lose most of its value. Where the local farming sector is dominated by one crop, the critical duration for that crop should be established. Flooding duration may also affect assets like buildings and infrastructure. The critical time is around 12 hours, beyond which there will be significantly increased losses. Given the inaccuracies in loss estimates, it is not recommended to apply this 12-hour observation for buildings. Infrastructure losses will normally be assessed by interview or through assessing repair costs that should include factors like damage relating to the duration of inundation.

Duration is also critical for assessing the impact of flooding in interrupting business activity. Be aware that much of this may be made up by other unaffected businesses, still within the area of assessment, so does not count as a loss to the local economy.

But if lost business means it is lost to the area, there will be a real economic loss. For example, tourism in the affected area may lose business but there might be gains by operators outside the area of analysis. This highlights the importance of determining the boundaries of the area for loss assessment.

Contaminants etc. in the flood water

Most flood water will be contaminated to some extent with mud and plant material. However, contamination with sewage or chemicals will increase all direct losses. Cleaning these up after the event may increase indirect losses by prolonging clean-up times and disruption, such as removing large amounts of silt and other debris.

Salvage of furniture and other items may not be possible under these circumstances. Damage to previously stable contaminants such as asbestos in buildings poses a more difficult and expensive problem. Loss estimates will need to be obtained through local interviews to get the true picture.

If flooding is the result of sea water inundation for example from a storm tide, losses are likely to be much higher. Where salt water is over-floor by more than 0.3 metres the contents are a total loss. Structure damage would also be greater.

Some loss assessments take into account the effect that weather warnings might have had, by applying a factor to adjust the estimated losses for emergency damage-reducing action taken by those at risk. Where there is limited warning time (less than 12 hours) there is little opportunity to avoid losses, so intangible losses can be higher.

Where any of the foregoing flooding characteristics varies significantly from ‘moderate’, the average values of loss are likely to be misleading, and the study should be adjusted as appropriate. For example, if the flooding event lasts more than a week, indirect losses should receive special attention.

The sort of information needed to assess losses from flood impact would be:

For residential and commercial areas

You need to know the depth of the flood water in relation to floor levels. In areas where many buildings are raised, water will be deep before it enters the living floor of the building. (At a minimum, how many buildings had over-floor flooding?)

For agricultural areas

You need to confirm the duration of flooding. Duration is particularly important for agriculture because many crops may be destroyed after a certain period under water. As a lost asset, this is an economic loss. In addition, agricultural machinery may not be able to operate—again potentially resulting in a lost asset.

Single events, such as a flood, do not occur in isolation. The antecedent conditions are very important. If the ground is soaked from rain or earlier inundation, additional heavy rain is more likely to run off causing flooding; strong winds are more likely to blow weakened trees over, and so on.

Flooding itself is a multi-variate issue. Losses in the farming sector, in particular, will be dependent on the season, and can be severely affected by variables like wind and heavy rain.

For loss assessment, these issues mean that care needs to be taken to separate out the event being assessed. It also means that decisions may be needed on the extent to which the attributes of the individual events influence the assessment. In many cases, especially in urban areas, the attributes probably have limited impact on the final loss figure. When the purpose of the assessment is to help decide on mitigation proposals, simplicity and comparability across a wide range of events and circumstances should be the priority.

Levels of certainty and detail

It is not worth continually refining detailed knowledge in one area of the analysis when other areas are vague or uncertain. Also, in many cases, further detailed analysis has little impact on the final result, so the additional effort is not worthwhile.

Actual loss experienced will vary greatly depending on:

- aspects of the hazard itself
- **exposure** to the hazard
- the vulnerability of the property, activities and people exposed

Table 5: Sources for data on hazards

Hazard	Data source
Flood	Government Department of Natural Resources and Mines (Queensland) Bureau of Meteorology state offices Consultancy groups, such as, Waterstudies Ltd (Coffey International), Snowy Mountains Engineering Corporation, Hatch Associates, Fisher Stewart, Connell Wagner Other Local government, local newspapers, local historical societies
Storm surge (tide)	Government Bureau of Meteorology, Environmental Protection Agency (Queensland)
Earthquake	Government Earthquake database (Geoscience Australia) Centre for Earthquake Research in Australia (CERA) Universities Queensland University Advanced Centre for Earthquake Studies (QUAKES) Geoscience Australia
Tsunami	Government Tsunami database (Geoscience Australia)
Landslide	Government Mines Division Department of Natural Resources and Mines (Queensland), Landslide database (Geoscience Australia) Consultancy groups, such as, Waterstudies Ltd (Coffey International), Snowy Mountains Engineering Corporation
Bushfire	Government Australasian Fire Authorities Council (National body) Rural Fires Division Queensland Fire and Rescue Authority, and state equivalents Universities PerilAUS (Risk Frontiers) Natural Hazards Research Centre

Step 6: Obtain information about the people, assets and activities at risk

Before loss can be assessed you need to document what people, assets and activities were or could be exposed to the hazard. The reason you do this is so disaster loss can be assessed in terms of damage and disruption to assets, activities and people. Besides knowing what is at risk within, say, a flood risk area, you have to include those likely to be disrupted or otherwise impacted by the flood.

To assess **direct losses**, you need details of every affected item within the flooded area. As a minimum requirement you need to know the numbers of dwellings and people, the type and size of commercial enterprises, and the transport, infrastructure and other assets. Critical infrastructure should receive special attention as indirect losses may be large if such facilities are damaged or disrupted. They include water, power, communications and control systems. You will also want to know the areas and types of primary production affected.

In making a basic assessment of **indirect losses** and **intangibles** you have to examine the losses to those within the flood risk area as well. However, significant indirects should be assessed for the whole area of assessment, as flooding disruption may extend well beyond the actual flooded area—things like access to schools, national parks, transport routes, crop harvesting, grazing and business disruption due to loss of essential inputs such as flood-bound staff. It is stressed that only significant losses should be calculated and included, normally identifiable through interviews or advice from stakeholders.

In many cases the additional effort involved in further detailed analysis may have little worthwhile impact on the final result. For example, losses to individual shops in a rural area may be insignificant compared with the agricultural losses in the area those businesses service (which in any case would often reflect some of the local retail losses). In a large urban area, losses are likely to be dominated by direct damage to assets, by disruption to peoples' lives and, if many people had their homes flooded, by intangible losses. Many commercial losses are likely to be made up in time or by increased business of other non-flooded firms.

You must judge what the appropriate level of detail is in each area of analysis. In some cases, detailed up-to-date studies of the flood hydrology and hydraulics will be available. If this is so, and if significant investment has been made in getting that information, it may be worth examining the losses in detail.

Data sources

Most needed data can be obtained from local government, emergency services, relevant state agencies and in some cases the Australian census (see Table 6). Table 7 indicates the needed data and likely sources. The stakeholders involved in the consultation process should be able to help you locate needed local data.

It is also important to be aware of how old the information is and whether it needs updating. This is also an issue when information on housing and people is projected forward in time for assessment of mitigation options.

The number of people can be estimated from the number of dwellings, however the exact figure varies greatly between areas. Census data provides precise figures on average dwelling occupancy and should be used wherever possible. A default figure is 2.6 people per dwelling, except where multi-occupancy dwellings, such as blocks of flats, are common. People in such structures, whose dwelling units are not actually flooded because they are elevated, will nevertheless incur significant indirect losses (see step 7).

No information is perfect. This should not, however, stop you using it, but be aware that even the best datasets have limitations. Granger (1998) discusses some of these issues in *ASDI (Australian Spatial Data Infrastructure) from the ground up: a public safety perspective*.

Geographic information systems

The great majority of local authorities now use computer-based Geographic Information Systems (GIS) to support their planning and management information roles. Many have included hazard information in their systems, and may contain a readily accessible source of information on local exposure and vulnerability to a number of hazards. Useful information from GIS, ranges from the position of infrastructure and buildings, through to demographic details. The Geoscience Australia previously Australian Geological Survey Organisation—AGSO), Cities Project demonstrates one approach to how this information can be used in spatial risk modelling of natural hazards in parts of Queensland (see www.ga.gov.au).

Use of these systems and data sets in loss assessments will depend on the scope of, and resources available for the assessment, and the ease of access to the systems.

Examples of data sources

For more detailed analysis, additional demographic information will be needed. Table 6 shows typical sources of data on people, assets and activities at risk.

Table 6: Sources of data

Element at risk	Demographic data sources	Risk data sources		Examples
		Informal *	Technical **	
People	Census, ABS, local government	Key people within local government emergency services and state agencies	Local government GIS risk modelling Geoscience Australia (http://www.ga.gov.au/) and http://www.auslig.gov.au/acres Australian Earth Data On Line (http://aedol.anu.edu.au or http://earthinsite.com)	Granger 1998 AGSO Cities Projects 1999–2001
Assets	Local government, ABS, utilities			
Activities	Local government, emergency services			

ABS = Australian Bureau of Statistics; GIS = Geographic Information System; AGSO = Australian Geological Survey Organisation

* Informal or colloquial: Risk data or information that is held by an individual from their experience in risk management

** Technical: Spatial modelling of risk. Dynamic hazard element superimposed on map (definition and classification: Rick McRae)

Table 7 contains examples of the types of information needed, the likely sources of that information and methods of obtaining that information. It has been drawn from the Tully case study used as the worked example.

Table 7: Information types, sources and methods

Type of information required	Sources	Methods
Hazard (floods, cyclones, bushfires, earthquakes, etc)	Local governments Water, natural resources and environmental agencies Bureau of Meteorology, Geoscience Australia, fire authorities	Letters from assessment organisation requesting information, interviews, published documents, Bureau of Meteorology etc. web sites
Intangible losses	Health and family/support services People with hazard experience Local health professionals Environmental/national park organisations	Letters from assessment organisation, interviews Focus groups or surveys

Table 7: Information types, sources and methods (continued)

Type of information required	Sources	Methods
Indirect losses	Main industry and primary producer groups Local governments (directly affected and adjacent) Local businesses State government departments (Main Roads, Primary Industry, Transport) State Emergency Service and volunteer groups such as the Red Cross	Letters from assessment organisation, surveys and telephone or face-to-face interviews Possibility of a group meeting with local governments
Direct losses	State government departments (Housing, Education, Primary Industry, Environment, etc) Local government Australian Bureau of Agriculture and Research Economics Local businesses and industry primary producers Utility owners/managers State disaster coordination centre Households	Letter (Department of Emergency Services, Queensland), survey and telephone or face-to-face interviews

Step 7: Identify the types of losses

People who work with loss assessment generally refer to losses as either **direct** or **indirect.** These are the major categories of loss, which can be further subdivided into **tangibles** and non-market impacts, or **intangibles**, according to whether or not the loss can be easily valued in dollars.

In practice, the two types of tangible loss are distinguished from intangible losses giving three overall loss categories: direct, indirect and intangible. Table 8 will help you decide what makes up each category of loss in a flooding event.

Table 8: Identifying loss types

Can the lost item be bought and sold for dollars?	Direct loss Loss from contact with flood water	Indirect loss No contact, loss as a consequence of flood water
Yes—tangible	For example, Buildings and contents Cars Livestock Crops Infrastructure	Disruption to transport etc. Loss of value added in commerce and business interruption where not made-up elsewhere Legal costs associated with lawsuits
No—intangible	For example, Lives and injuries Loss of memorabilia Damage to cultural or heritage sites Ecological damage	Stress and anxiety Disruption to living Loss of community Loss of non-use values for cultural and environmental sites and collections

Distinctive types of loss result from any disaster, with each type requiring different assessment methods or estimation procedures. The detail of assessment varies within each of the major approaches according to the specific type of loss. Some types of loss are best assessed by one of the three approaches set out in these Guidelines. The importance of each type of loss will vary by event.

Direct losses

Direct losses result from the physical impact of the hazard. They are generally the most visible, and often represent the largest loss component. Damage to buildings and infrastructure from cyclones would be counted as direct losses, as would:

- damage to building structure, gardens and contents
- damage to vehicles
- damage to public buildings and contents
- damage to infrastructure (including riverbank damage)
- loss of livestock, aquaculture stock and loss of standing crops
- damage to fencing and equipment
- damage to vegetation—loss of carbon credits
- clean-up costs

Indirect losses

Indirect losses arise as a consequence of the impact of the hazard. They reflect disruption to economic and other activity within the designated area of analysis, which flow from the effects of flooding, wind, fire, etc.—hence the term 'indirect'. They include:

- disruption of transport when roads are cut by floods or other events
- loss of value-added from affected businesses
- loss of value-added due to manufacturing disruption and loss of value-added in retail, distribution and services (including networks), where not taken up elsewhere in the specified economy
- agriculture (for example, agistment) and reduction in yield if not due to direct damage
- additional costs of maintaining production or service incurred by businesses
- marginal costs of providing alternative public services
- disruption to public utility systems outside hazard-affected area
- increased travel and congestion costs including food spoilage during transport
- additional costs of emergency services in a hazard event
- additional costs borne by volunteer groups such as the Red Cross and Salvation Army

Loss of business confidence, reluctance to invest in the area and loss of a positive image are all indirect losses as far as **commerce** is concerned, as they have clear dollar costs. In some cases, typically as a result of a sequence of events, the affected area may go into serious decline as investment shrinks, businesses close and people move. There can often be an influx of aid and insurance money that offsets a temporary loss of confidence, but this will not offset a longer term problem of image resulting from repeated disasters. 'Loss of image' is an intangible, included here because of its occasional significant indirect dollar impacts.

Business continuity planning is an increasingly popular strategy to deal with indirect loss. The approach received a major boost with concerns of Y2K and its potential impacts on the ability of businesses to operate normally. It acknowledges that some businesses likely to be at risk should be managed through risk reduction strategies and plans made for the continuation of business under adverse conditions. The result should be reduced indirect losses for both individual enterprises and the economy.

Another distinct category of indirect loss is the potential impact of a disaster on financial markets. This would be linked with the cost of rebuilding and of insurance payouts. Such financial impacts are only likely to be severe in the case of a major disaster, where the value of insurance claims may challenge the ability of the industry to pay. The costs of rebuilding may also trigger an indirect loss as resources are diverted from other areas, thus causing disruption elsewhere in the economy. To have these impacts, a disaster would need to be much larger than any yet experienced in Australia, or be of a type with massive legal liability implications.

Indirect losses are more complex to evaluate, particularly because of the need to avoid double counting losses which have already been assessed as direct losses. Many loss assessments have counted lost turnover and lost sales as flood losses, whereas only the lost profit should be counted. The application of economic principles have the most impact in dealing with indirect loss assessment, generally reducing the loss estimates.

Intangible losses

Intangible losses or 'non-market impacts' is a catch-all term which identifies direct and indirect impacts for which there is no commonly-agreed method of evaluation and not normally a market. Table 9 is an indicative (incomplete) list showing the wide range of intangible losses which could be incurred.

Table 9: Types of intangible losses

Personal	Community
Death and injury due to flood (eg drowning)	Long term depression
Deaths and injuries due to use of secondary roads	Loss of community—access to networks, services and assets including recreation areas
Stress induced ill health and death	Damage to cemeteries
Suicide	Increased demand on existing services
Bereavement	Diminished community activity as effort goes to individual recovery
Loss of memorabilia	Negative image of place
Loss of gardens	Damage to cultural and heritage sites
Health effects including respiratory illnesses and leptospirosis	Damage to ecological sites— changed habitats and landscape
Disruption to living, including isolation and evacuation	Non-use values of lost heritage and environmental sites and collections
Disruption generated by the rebuilding process	Changed water regime
Loss of social contact	Loss of genetic diversity
Loss of pets	
Relationship breakdowns	
Increased substance abuse	
Temporary loss of utilities	
Disruption to education	
Sense of invasion	
Forced to continue working	
Lower income earning capacity	
Reduced land values	
Increased dependence	
Near destitute	
Feel trapped	
Worry over future hazard events	

Methods for estimating the impact of intangible losses in dollar terms are either difficult to apply, experimental, or not generally accepted; but this does not mean they are unimportant. Intangibles are often found to be more important than tangible losses, and effort therefore should be made to identify, assess and include them. It is hardly surprising that intangibles are considered so important when you appreciate that they include death and injury as well as destruction of memorabilia. To many people memorabilia gives their lives meaning.

As well as memorabilia, intangibles include lives, health, ecological damages, destruction of community life, cultural artefacts, and loss of leisure. Studies of vulnerability may provide insight to social and community intangibles. However, the measurement of vulnerability remains problematic.

Most research shows that people value the intangible losses from a flooded home—principally loss of memorabilia, stress and resultant ill-health—as at least as great as their tangible dollar losses. Yet, most studies relegate intangibles to little better than footnote status. This is because, in the absence of clearly defined markets, there are no agreed methods for valuing these losses. Environmental losses are discussed in Appendixes 2 and 3.

Step 8: Measure the losses from all sources

After any event you have to be able to make loss estimates at the level of detail and accuracy required for the identified categories of loss. The steps in each approach were set out in Figures 4, 5 and 6, each one having a distinct method for assessing tangible direct loss. Table 10 reviews the basic aspects of each assessment approach and sets out techniques generally applied when measuring direct, indirect and intangible losses for each assessment method. We will review these techniques before going into detail about the steps to follow in using them when following one or more of the loss assessment methods.

Table 10: Review of basic elements of the three approaches to loss assessment

Loss assessment approach	Direct loss			Indirect loss	Intangible loss
	Houses/small business	Commerce, farming (>1000m³)	Infrastructure		
I Averaging	Average loss per flooded structure	Average loss per m2 for types of enterprise and surveys	Average per km of road and surveys*	Examine $ flow and use surveys or % of direct	Identify types and magnitude Surveys
II Synthetic	Standard stage: damage curves for types of property	Stage: damage curves applied to m3 for different types of business	Stage: damage and average loss per km depending on type of infrastructure	Examine $ flow and use surveys	Identify types and magnitude Surveys
III Survey (based on sampling)	Surveys: new stage–damage curves	Surveys	Surveys	Surveys	Surveys

* Much public infrastructure does not generate income directly, so future revenue cannot be used to assess loss, nor is its social benefit necessarily related directly to the infrastructure cost

In most assessments some combination of the three approaches will be necessary. It is clear from Table 10 that, at the present state of knowledge, only surveys enable collection of detailed data for some categories of loss.

In both the 'III Survey' and 'II Synthetic' approaches, damages are generally calculated using the average damage sustained by a property in a specified property class (such as a single-storey brick-veneer residence), at different hazard severity (such as depth of flooding, wind strength, or ground shaking intensity). The use of hazard severity using loss-tables or curves enables extrapolation of survey damage estimates to non-surveyed areas, and are an essential part of the synthetic damage assessment process. The averaging approach is more straightforward as it uses an average value per directly affected property, regardless of other factors.

Tables 11, 12 and 13 are examples of what would be measured following the most common disaster event—flooding—in making a post-event loss assessment. They show typical approaches that would be taken in applying all three assessment methods, with most of the examples relating to the averaging and synthetic methods. The survey approach itself is not set out in the tables because surveys could be carried out for all loss categories (these tables draw heavily on BTE 2001). Tables 14 and 15 show RAM suggested damages for large non-residential buildings (greater than 1000m2) and RAM unit damages for roads and bridges.

Table 11: Direct losses

Loss sector	Estimation principle	Data sources—averaging	Data sources—synthetic
Residential buildings—structures and contents	Depreciated economic value	1. $20 500 per flood damaged residential building (Read, Sturgess and Associates, 2000) 2. $23 200 per bushfire damaged building (BTE estimate based on NSW Coroner (1994)) 3. $189 000 for destruction of a residential building (BTE, 2001)	Stage–damage curves (eg Figure 2)a
		Adjusted insurance claims	
Commercial and industrial buildings—structures and contents	Depreciated economic value	$20 500 per flood damaged commercial building, (Read, Sturgess and Associates 2000 and see Table 14 for buildings >1000m^2)	Stage–damage curves (eg Figure 1), Survey of businesses
		Adjusted insurance claims	
Public buildings—structures and contents	Depreciated economic value	$20 500 per flood damaged public building, excluding >1000m^2 (Read, Sturgess and Associates, 2000)	Survey
		Adjusted NDRA + ineligible costs	
Infrastructure	Depreciated economic value	Major sealed road $59 000 per km Minor sealed road $18 500 per km Unsealed roads $8350 per km	Survey
		For other types of infrastructure use surveys, or adjusted NDRA + ineligible costs	
Crops	Harvest value minus input costs avoided (Value added or profit)	* See Read, Sturgess and Associates 2000	Survey of organisations representing agricultural industries, farmers

Table 12: Indirect losses

Loss sector	Estimation principle	Data sources—averaging	Data sources—synthetic
Business disruption	Loss of value added not taken up elsewhere in the area within specified timeframe	<100 businesses: do not count losses unless indications are that losses are large; then use survey >100 businesses: use survey National perspective: likely to be minimal	Survey of businesses, organisations representing commerce, local government, households
Transport network disruption	Increased vehicle operating costs. Value of time for delayed people and freight (BTE 2001) Value of freight if spoilt by delays Cost of disruption elsewhere in the network	*	Only applicable if no alternative main arterial and annual average daily traffic is >4000, (not usually an issue in urban areas) Car (non-business) $12.94 per vehicle hour Car (business) $31.67 per vehicle hour Bus or truck $24.10 per vehicle hour Articulated truck $27.89 per vehicle hour (BTE 2001)
Disruption of public services	Cost of provision (BTE 2001)	*	Survey of public service providers
Agriculture reduced agricultural yield (only applicable if crop not lost and yield significantly affected by disaster)	Loss of profit on to lost proportion of crop	*	Survey of organisations representing agricultural industries, farmers, agricultural authorities
Disaster response and relief	Marginal costs incurred by relevant agencies. Opportunity costs of volunteer labour	*	NDRA to emergency services

* The RAM averaging method does not breakdown indirect losses into categories. It suggests the total of the indirect losses be taken as 30 per cent of the direct losses. This percentage can be altered to 20 per cent for rural areas with a small population or increased to 45 per cent for urban areas with substantial tourism.

Table 13: Intangible losses

Loss sector	Estimation principle	Data sources—averaging	Data sources—synthetic
Death	Human capital approach	Value at $1.3 million per case (BTE 2001) data from survey of health authorities (Standard approach of transport planning)	
Serious injury	Human capital approach	Value at $317 000 per case (BTE 2001) data from survey of health authorities (Standard approach of transport planning)	
Minor injury	Human capital approach	Value at $10,600 per case (BTE 2001) data from survey of health authorities (Standard approach of transport planning)	
Health effects, stress and anxiety	Refer to Handmer, Lustig and Smith (1986), set out in BTE (2001) for 'lost time' method	Cases x cost of average episode of care for specific illness, eg leptospirosis OR Survey of households and health authorities for qualitative data	Use 'lost time' approach
Memorabilia	*	Survey of households to assess loss qualitatively OR assume all those flooded to more than 30 cms over-floor level suffer significant loss	
Disruption	*	May be possible to quantify in terms of time	Information from local authorities, businesses, and surveys of those at risk
Cultural and heritage sites and artefacts	Replacement or restoration costs where feasible	Averaging and synthetic approaches are not applicable Obtain estimates from specialists, eg heritage organisations, museums, galleries, etc. Households where appropriate	
Environmental loss	Refer to Appendix 2: Evaluating the environmental losses and benefits from flooding $ value may be ascribed where cost of restoration is known and feasible	Survey of environmental protection authorities and organisations following procedures set out in the accompanying section Where restoration is feasible obtain cost estimates from specialists	

This table sets out approaches for assessing major categories of intangible losses. It should be used in conjunction with other material on intangibles in these Guidelines. Longer-term issues of declining socioeconomic status are not dealt with here as they can only be assessed on a case-by-case basis.

*All losses should be clearly documented. A number of approaches are available for assessing intangibles in dollar terms. They are summarised in Table 30. The methods are complex and expensive to apply. We recommend their valuation only where resources permit and intangibles appear to be large.

Table 14: RAM suggested damages for large non-residential buildings >1000m2 in 1999 dollar values

Value of contents	Mean potential damages per m 2 ** ($)
Low (eg offices, sporting pavilions, churches)	45
Medium (eg libraries, clothing businesses, caravan parks)	80
High (eg electronic, printing)	200

** includes external, internal contents and structural

Table 15: RAM unit damages for roads and bridges (expressed per km of road inundated in 1999 dollar values)

Road type	Initial road repairs ($)	Subsequent accelerated deterioration of roads ($)	Initial bridge repair and subsequent increased maintenance ($)	Total cost to be applied per km of road inundated ($)
Major sealed roads	32 000	16 000	11 000	59 000
Minor sealed roads	10 000	5 000	3 500	18 500
Unsealed roads	4 500	2 250	1 600	8 350

Table 16: RAM suggested livestock values ($ per head in 1999 dollar values)

Price	Dairy	Beef	Sheep for wool production	Sheep for lamb production
High	650	480	33	50
Average	560	410	27	45
Low	460	340	23	35

An example of actions that would be taken in each approach when carrying out a post-flood loss assessment

For all three approaches you would need to take these assessment actions:

1. Establish the relevant attributes of the flood, drawing on material described earlier about making an inventory of people, assets and activities at risk. If the aim is to carry out AAD calculations, you will also need information on hazard occurrence probability (for example, flood frequency).
2. Drawing on information collected about the flood event and the types of losses incurred, identify and list the assets and activities inundated, (that is, those that suffered direct loss).
3. Identify and list the activities that may have been affected indirectly by the flood. Identify all likely intangible losses. Apart from the people directly affected by the flood, are there any environmental, heritage or cultural loss issues arising from the flood? Having a stakeholder committee or group set up should be useful here.
4. In consultation with such a stakeholder committee or group establish whether there are any types of loss that should receive special attention and document these.
5. Establish whether the assessment is to be based on economic principles or is to be a 'financial' assessment. If it is to be a 'financial' one, see 'The difference between an economic and a financial assessment'.

6. Set up an appropriate system for storing and manipulating the data. Unless the study is very small, the database should have the capacity to receive and allow analysis of material collected by surveys of key stakeholders, and (depending on the approach adopted), surveys of the people who have been affected by the flood.
7. Decide whether 'actual' rather than 'potential' losses are to be used. Take this into consideration in deciding how to handle the losses to be assessed (see step).
8. If the loss assessment is to be used for AAD calculations, assessments from at least three events will be needed. These events should be very different sizes to enable accurate calculation of the AAD. The loss from these events will need to be integrated as set out in step 10.

Remembering that some surveying would normally be required in all approaches, the *survey approach* needs these specific actions:

1. There has to be good information about the flood extent, but just knowing what was affected by flooding may be enough. If stage–damage curves are to be generated and applied to this specific event, then detailed flood depth and extent information will be required. Figure 1 is an example of a stage–damage curve.
2. Assemble information on affected assets as set out in the common steps above.
3. Develop survey forms and appropriate sampling. This step (discussed on page 36) would normally require specialist assistance.
4. Pre-test the survey forms to be used and refine them for use.
5. Collect information with surveys.
6. Enter loss information into the established database.
7. Collate and analyse the data to produce a final loss assessment.
8. Write a covering report.

The *synthetic approach* needs these steps:

1. Get detailed flood depth and extent information, normally for every affected building.
2. Existing synthetic approaches for direct loss require sophisticated computer analysis. This is because the method combines data on buildings and contents with information on flood depth across the flooded area. This, in turn, is analysed against stage–damage curves (in the case of flooding) to produce loss estimates. The database referred to in the common work for all approaches would have to be compatible with the chosen assessment method. Select appropriate stage–damage curves from existing reports, such as those referred to in Table 10 above. Such curves are available from the FLAIR database held at the Flood Hazard Research Centre at Middlesex University England, from Risk Frontiers at Macquarie University, from FEMA in the United States, and from various consultants. Consideration should be given to using the curves developed by Risk Frontiers—with any adjustments needed to convert them from reflecting insurance to economic losses—when these become available.
3. Develop survey forms and carry out appropriate sampling to test them, normally using specialist assistance.
4. Pre-test the finalised survey forms and amend as necessary.
5. Collect information with surveys etc.
6. Run computer analysis of the results with stage–damage curves.
7. Enter loss information into the established database.
8. Collate and analyse the overall results to produce the final loss assessment.
9. Prepare a covering report.

The *averaging approach* needs these steps:

1. Obtain information about the extent of flooding, perhaps reducing the amount of information to be sought by relying upon finding out what has been affected by flooding.
2. Assemble the information on affected assets. Identify the main types of loss and, in consultation with the stakeholder steering committee, decide on the appropriate level of effort. The key here is to decide how much to use surveys, and to ensure that important losses, apart from those for which there are standard estimates, are captured.
3. Review the points listed in the tables earlier in this section, and follow an iterative process though points 1–2 above to refine and record loss estimates.
4. Develop surveys/question forms as needed.
5. Pre-test the survey forms and amend as necessary.
6. Collect information with surveys.
7. Enter loss information into database.
8. Collate and analyse the overall results to produce the final loss assessment.
9. Prepare a covering report.

See Appendix 4 for some examples of direct, indirect and intangible losses from an actual flooding case study.

Step 9: Decide whether to count 'actual' or 'potential' losses in the assessment

This section discusses how to establish whether data collected by the synthetic or averaging methods should be adjusted for specific local circumstances at the time of the assessment.

We need to do this because:

- 'actual' losses are the losses actually experienced in an event. They take account of the unique features of the event, the warning system, peoples' experience with the hazard, and their preparedness. Surveys typically enable this type of estimate; and
- 'potential' losses are the maximum losses likely to occur in a given event. Potential losses are averages in the sense that they do not take account of the unique features of the event or of the affected population. The synthetic and averaging approaches described in these Guidelines provide estimates of 'potential' loss.

Many of those assessing flood losses in Australia have adjusted potential losses so they are closer to actual losses. Potential losses could also be adjusted for hazards where warnings are normally provided and where protective action can be taken, such as cyclones and bushfires. However, there are a number of problems with this approach, and it is not recommended. Where the loss assessment is not to be used for comparative purposes then 'actual' estimates may be acceptable.

The use of 'actual' losses may be discriminatory against those who take action to reduce their losses, as well as against poorer sections of the community. In addition, it is not easy to estimate the ratio between actual and potential losses for different flood-prone communities. And the 'actual' loss estimates are unstable as people move or as circumstances change. See Appendix 7 for additional material.

The recommended method is to use 'potential' loss estimates. Where 'actual' loss information is collected through surveys for indirect and intangible loss, this should be used as collected. Actual losses may be appropriate where the assessment is not to be used for comparative purposes.

Where it is decided to convert 'potential' loss estimates into 'actual' values, the table set out in RAM and reproduced in Table 17 should be used. The figures in the table are not necessarily accurate as the information comes from only few studies that were undertaken some years ago, but reflect the state of knowledge in this area and are being applied in Victoria. An experienced community is taken as one which has experienced a flood within the previous five years.

Table 17: RAM proposed ratios of actual : potential damages

Warning time	Experienced community	Inexperienced community
Less than 2 hours	0.8	0.9
2 to 12 hours	Linear reduction from 0.8 at 2 hours to 0.4 at 12 hours	0.8
Greater than 12 hours	0.4	0.70

Table 17 highlights that significant losses are usually avoided by actions taken by those at risk unless: there is no warning; people are unable to return to the places at risk; or are physically unable to take action.. As people are spending less time at home, it is likely that, on average, less will be saved.

NOTE: The survey approach would normally produce results reflecting actual losses. This is because the survey asks for details of actual losses. In some circumstances surveys might ask for estimates of potential damages, that is, damages without any action taken to reduce them.

Step 10: Calculate annual average damages (if needed)

It is not possible to conduct cost–benefit analysis to assess mitigation options without AAD data. Estimates of losses from the hazard in question are needed over some specified time into the future—typically 30 years or so. AAD estimates provide this information.

Natural hazards and disasters are infrequent events, generally seen as random. When assessing the costs of a particular disaster an estimate is made for that event. This does not in itself help to determine what investment in disaster mitigation is appropriate (although it would be relevant to deciding on relief and reconstruction assistance, and for emergency planning).

Since the future pattern of disaster events cannot be known (other than in terms of their probabilities or likelihood of occurrence in any given time period) any investment in disaster mitigation has to be economically justified in terms of the losses avoided on average every year. This is achieved by calculating average annual losses.

AAD enable easy comparison with the costs of mitigation proposals, and allow priorities to be set between different locations.

The benefits of mitigation will be the average annual losses prevented by the mitigation measure. This is usually assumed to be a constant figure each year over the life of the measure, unless it is known that the hazard will change over time.

How to calculate average annual damages or losses

To calculate AAD you need loss assessments for a range of possible events each with its annual occurrence probability. These loss estimates are plotted against their event occurrence probability as shown in Figure 7. At least three distinctly different events should be plotted to give some confidence in the resulting graph (four are used in the example in Figure 7). It is useful to have an event of about the level when significant loss starts to occur. One representing a very rare event which would result in severe loss in the area being assessed, and at least one intermediate event.

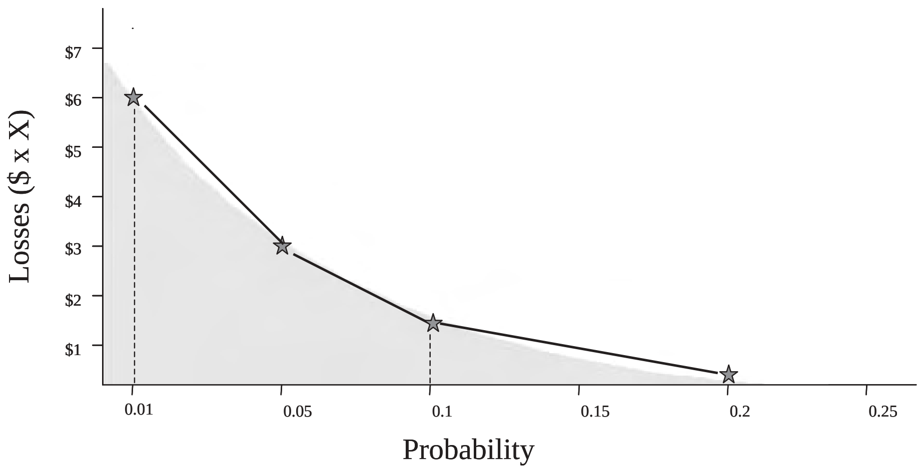
The average annual losses are equal to the area under the curve in Figure 7, which can be obtained mathematically by integration. Thus the high damages resulting from an extreme event would be multiplied by a very low probability, so that its average annual contribution would be small although the event loss would be very large. The opposite applies for frequent events. The AAD does not have to be obtained from a graph. It can be estimated, using the same event loss assessments as used in the graph, mathematically.

Hazard magnitudes and probabilities

There are different possible magnitudes of events for a given hazard, and associated with each is a probability that it may occur or be exceeded. Lower probability events are larger and are therefore associated with potentially greater loss. For example, an event with a 10 per cent probability of being at least achieved in a given year is known as a 10 per cent or a 1-in-10 year event: to be precise there is one chance in 10 in any year of an event equal to or greater than that level occurring. This is also known as the event's **'annual exceedance probability'**. The degree of confidence in these occurrence probabilities varies widely depending on the type of hazard and the length and quality of the local record. Confidence is much lower for low probability events.

Figure 7: Probability of an event versus extent of losses due to that event

In Figure 7, the shaded area under the curve represents AAD. Note that different approaches to curve fitting have little affect on the AAD figure. The normal zero point on the X axis is unmarked. In theory, the probable maximum event (known by different terms for different hazards) would be located here and should have an occurrence probability approaching zero. In practice however, a probability of about 1:10 000 to 1:1 000 000 may be assumed or the event may be estimated by deterministic methods.



A major shortcoming of annual average damages

An inherent problem with this approach is that low-probability high-consequence events will appear insignificant when converted to AAD because of their very low probability of occurrence. Nevertheless, it may be considered socially desirable to consider them in the analysis because such events may have large impacts. In additon, awareness of such events is useful for developing warning systems and emergency planning

If the hazard will change over time, this should be accommodated

For example, climate change scenarios may indicate that events now considered extreme will become relatively frequent, or demographic trends may show that the population density in hazardous areas will increase or become more affluent.

Step 11: Assess benefits to the region of analysis

A critical aspect of an economic loss assessment is to examine potential benefits from the event being assessed. Within a regional context this is particularly important as insurance and aid funds are likely to flow into the area following a disaster. These may partly offset the tangible losses suffered.

Economic loss assessment counts the losses to the local economy as well as the benefits. (A financial type loss assessment would not normally include benefits.) These benefits may be very large and offset much of the loss. Dollar benefits are normally offset against dollar losses only. Intangible losses are not included in this part of the analysis.

How to assess benefits

Attention should be given only to the major flows of funds into the region that are clearly a result of the event under assessment. This can generally be assessed fairly easily after an actual event, but poses difficulties when hypothetical events are being assessed.

For a post-disaster assessment

Identify the major flows of funds into the region. The rules and procedures governing disaster relief arrangements vary by state, so the relevant officials should be approached for assistance. For significant events, the Insurance Council of Australia should be able to provide an estimate.

For a hypothetical assessment

Once the assessment is complete, the state officials responsible for disaster relief funds should be approached for assistance. Using the assessment it should be possible to estimate the likely amount of disaster relief funds that would flow into the region. Insurance estimates may be available from the Insurance Council of Australia. If not, they may be estimated by drawing on experience with similar events. However, as there are many variables involved with insurance payouts, this estimate should be made in consultation with an appropriate specialist.

Example from the Tully case study

The main regional benefit was the flow of funds into the Tully region through disaster relief payments and insurance payouts. These are much more significant than all other benefits combined. Due to the location and isolation of the region you can assume that all the insurance and disaster relief funds come from outside the region.

Insurance payouts were $69 million (from the Insurance Council of Australia) and NDRA payments were $53 213 518. This did not include $1.81 million in payments for ‘personal hardship and distress’. This is not included as a benefit as it relates to an unquantified intangible loss, which has not been included in the dollar losses for the region.

For an economic assessment of the costs of the flooding to the region these amounts should be deducted from the estimated costs. For a financial assessment, they can be ignored so long as care is taken to avoid double counting.

Other sources of benefit from flooding are listed below. These are relatively minor compared with the NDRA and insurance payments, and have not been assessed in detail or included in the final estimate of benefits. They were:

- increased local income after event through spending by out of town builders
- road/rail repair contractors and accommodation providers benefit when transport routes cut due to flooding
- building and road contractors gain employment

- cattle/grazing
- irrigation and water supply
- environmental benefits (see Appendix 2)

Step 12: Collate and present the results of the loss assessment

Loss assessment results need to be collated and presented in a simple form, with assessments of different types of loss identified, together with information on any benefits from the event. This makes it easy to see the major components, ensures that nothing is overlooked, and enables the whole assessment to be checked easily so it will be a straightforward process to calculate the total loss.

To do this successfully, the various assessments should be organised into a table format like the one shown below in Table 18. This is a compilation of the results of all the different assessments, and it should include a statement about the importance of intangibles.

Table 18: Loss assessment compilation

1. Loss type	2. Losses to region ($m)		3. Benefits to region			4. Total economic loss ($m)
			3a NDRA	3b Insurance	3c Total ($m)	
Direct						
Indirect						
Intangible (enter both quantitative and qualitative information)						
Totals						
(Qualitative statement on the importance of intangibles)						

Example from the Tully case study

Table 19 is the summary table from the case study, which is reported separately.

Table 19: Total economic cost of the January 1998 floods to North Queensland

Loss type	Losses to region ($m)		Benefits to region			Total economic loss ($m)
			NDRA ($m)	Insurance ($m)	Total ($m)	
Direct	Residential	89.16	N/A	25.9	25.9	63.26
	Commercial	39.1	N/A	29.1	29.1	10
	Public assets and infrastructure	82.63	50.6	0.13	50.73	31.9
	Agriculture including farm infrastructure	8	0.7	1.4	2.1	5.9
	Vehicles and boats	15.35	N/A	12.82	12.82	2.53
Indirect	Business disruption	2	N/A	Close to nil	N/A	2
	Disruption to transport networks	2.5	N/A	0	N/A	2.5
	Tourism	?	N/A	?	N/A	
	Agriculture	?	N/A	?	N/A	
	Emergency and relief	1.5	1.26	N/A	1.26	0.24
Intangible	Memorabilia	N/A				
	Death and injury (two deaths and some injuries)	4.86				4.86
	Health impacts					
	Loss of quality of life Environmental River bank erosion **		(1.81*)			
Totals		245.1	52.56	69.35	121.91	123.19
Notes on intangible losses	Apart from the deaths and injuries, the major impact appears to have been widespread disruption of virtually every aspect of people's lives in much of the region studied. Many people were isolated without basic services for days, as in the case of power failure in Townsville. Households flooded to over-floor level experienced significantly increased disruption, loss of memorabilia and resultant stress and anxiety. Some rural areas see the flood as contributing to the long-term decline of the area's fortunes. Environmental losses appear to have been limited apart from some nearshore loss of seagrass, coral bleaching and extensive riverbank erosion.					

* This amount was made available for personal hardship under the NDRA. It is not counted as a benefit to the region as it is related to an unquantified intangible loss.

** Riverbank erosion was valued at $12.5 million (NDRA contribution + 25 per cent ineligibles) based on the costs of restoration. As the 'intangible' loss was valued in dollar terms and could be at least partly restored, the NDRA funds paid have been counted as a benefit offsetting the loss. They are included under 'public assets and infrastructure'.

4. LOSS ASSESSMENT AND DISASTER MITIGATION

How to assess the benefits of mitigation measures as part of loss assessment

The benefits of any disaster mitigation measure are measured in terms of the losses avoided by introducing that measure. The type of loss and the type of mitigation measure determines how complex it is going to be to include it in an economic assessment. Usually measures which prevent the disaster event, such as carrying out structural works to avoid direct losses, are easier to evaluate than measures that modify the disaster outcome, such as warnings. Smaller-scale building modifications, such as floodproofing or retrofitting for earthquake and cyclone protection, (which might become a statutory requirement in a building code) are simple to assess, but compliance with such requirements may have to be estimated.

A similar problem arises with various mitigation measures which rely on public response to advice (or even directions), such as warning systems, flood management schemes and other matters open to interpretation, such as land use regulations. These mitigation measures are easily specified on paper, but there is great uncertainty over how they work out in practice—and the economic outcome will depend on the reality of how well they work in the event of a disaster.

The issue here is the gap between written regulations and harsh realities of implementation; and between the assumptions about near perfect warning message dissemination and the reality of patchy dissemination and slow response.

Unfortunately, relatively little attention is paid to this gap between what should happen and what does happen. For example, a reasonable assumption may be that a normal warning system will achieve an appropriate response from half its intended audience. In the interests of consistency and comparability, you have to assume that regulations will achieve full compliance.

Therefore if mitigation measures are taken, such as building embankments or dams (which positively exclude floods from an otherwise flood-prone area), and by imposing strict land use controls which exclude people from hazardous areas, then almost all of the losses which would otherwise have been expected in a given event will be prevented. This means all the expected losses can be counted as a clear benefit of the mitigation measure. However, most disaster mitigation measures can only alter the outcome of the event by changing the pattern or amount of loss, rather than preventing all losses. Community awareness programs, warnings and emergency response actions are examples of loss modification.

Unfortunately, it is very hard to estimate the amount of loss reduction that will be provided without fail from some mitigation measure. If the measure is a structure such as a flood levee, normally some allowance should be made for the chance that it might fail. Where measures are likely to increase exposure to the hazard, although at a reduced risk, such as levees encouraging new development in the newly protected areas, this should also be taken into account as possibly leading to higher loss than before if the levee is ever breached or over-topped. Mitigation measures may also create new hazards or transfer the problem elsewhere rather than eliminating it.

How to assess mitigation measures for different hazards

The economic and other principles of assessment are generic and can be applied to all types of hazard. However, there are important differences between hazards:

- *hazard characteristics vary*—for example, hazard warning times can be long (days for cyclones) or zero (for earthquakes). The attributes relating to the size and/or extent of the hazard can vary, making it difficult to estimate likely direct losses, such as flood water depths and velocities, wind speeds, earthquake magnitude etc;
- *mitigation options may be very different between hazards*—floods offer the widest range of options including planning solutions which are of limited use for severe storms or heatwaves, while warnings are not available for earthquakes;
- *determining exposure and vulnerability may be difficult*—potential exposure of people, assets and activities to the hazard may be unknown, especially if there is no history of the hazard in the area concerned. (At the present state of knowledge, vulnerability is very poorly documented.);
- *probability information may be unavailable*—probability is poorly understood for some hazards, such as earthquakes and many technological hazards; and
- *loss assessment may not be straightforward*—there may be no agreement on the most appropriate method to follow.

Table 20 summarises the situation for a range of hazards.

In the past, a lot of effort has been applied in assessing flood losses and developing flood mitigation strategies, probably because historically, powerful and well funded agencies had responsibility for all water-related issues—including flood management. Not surprisingly, flooding is the best documented and probably the easiest hazard to measure and prepare for. But assessment of mitigation measures for earthquakes, cyclones, bushfires, among others, is also possible. Where it is difficult to identify the extent and occurrence probability of the hazard, and where mitigation options are limited or otherwise problematic, there is limited value in applying loss assessment to support selection of mitigation strategies.

How to compare the loss reduction potential of mitigation proposals

The easiest way to see what effect different hazard mitigation proposals might have in reducing potential losses, is to carry out a with–without comparison. There are two points to remember in doing such a comparison:

- modelling of a major disaster should compare the system with and without the event, rather than before and after; and
- economic assessment of disaster mitigation should compare the situation through time *with* the mitigation measures, to the situation *without* those measures.

Changes induced by disaster, particularly environmental and social impacts, may be gradual over a long period and may not be picked up in a brief post-event assessment. The 'without' projection should include social and economic trends, so losses are not wrongly attributed to a disaster. For example, manufacturers may close down after an earthquake, flood or other event, but the closure loss may be only partly attributable to the disaster if they were already in financial difficulties.

The net impact of a mitigation measure is the difference between the economy with and without the measure over that measure's life. The mitigation measure itself may have other impacts which should be included in the analysis, for example impacts on hazards or the environment in adjacent areas.

Table 20: Factors to be considered in applying economic analysis to disaster mitigation measures, compared to flooding

Factor	Bushfire	Cyclone	Earthquake	Flood	Severe storm*
Risk definition					
Ease of mapping exposure to hazard	Good, but event extent depends on many local factors	Good, but individual tracks unknown until happen. Much loss is from associated weather	Good for known faults and soil conditions. Poor for intra-plate earthquakes. Micro-zonation possible	Good from past data and models. Events have predictable extents but floods can occur anywhere	Poor
Probability estimates for AAD	Difficult. Risk changes over time with fuel load	Possible	Possible but requires detailed study	Good, for river floods on basis of past records	Some information
Past records	Yes	Yes	Yes	Yes	Poor
Loss severity					
Function of parameters	Locational factors (for example, slope). Hazard characteristics (for example, fuel, wind). Building parameters	Hazard parameters (distance from coast, velocity, depth of storm surge etc). Building parameters	Hazard parameters (shake etc). Soil conditions. Building type and details. Associated fire risk	Function of flood depth and velocity, duration, warning time. Building types and contents	Local storm characteristics(wind, rain, hail, floods). Building construction
Past loss records	Some, percentage salvaged not clear	Some, needs to be disaggregated	Good for major events. Poor otherwise	Yes, but financial rather than economic. Can be estimated	No. Difficult to standardise
Frequency	Recurrent, quite frequent	Annual season. But strikes infrequent for most areas	Infrequent, little experience	Relatively frequent and recurrent in hazardous areas	Frequent, but rare in same area
Mitigation opportunities					
Prevention/ exclusion	Yes. Requires public participation	No for high winds Yes for storm surge	No	Yes. Either for larger area or individual properties	No
Long-term individual loss reduction	Yes: construction improvements	Yes: improved buildings, sea defences	Yes: improved buildings	Yes: improved buildings	Yes: improved buildings
Short term loss reduction	Yes: individual responses, fire fighting	Yes: response to warnings	Yes: save lives and reduce building and other losses	Yes: response to warnings and flood information	Yes: in response to warnings

*Tornadoes, very heavy rain, flash floods, hail, and high winds.

How to count the potential for loss reduction after mitigation action

The benefits of a disaster mitigation measure can only be counted in terms of the loss it is effectively preventing. This is known as the **avoidable losses**, and it is important to distinguish between avoidable and **unavoidable losses**. Which losses are avoidable depends on the hazard, its magnitude, the type of losses predicted to result from it, and proposed mitigation measures. The loss avoided would normally be a subset of the total losses from the hazard. In some circumstances and for some mitigation options, all the potential loss might be avoided, for example by relocating a structure out of a hazardous area or moving an asset out of harm's way. You might also be interested in reviewing the potential losses remaining with the mitigation measure in place.

For example, you would expect a warning system to provide benefits by giving people time between receiving the warning and the onset of the hazard, in which they could take actions to reduce potential loss. Typically, loss benefits from warnings would be the avoidance of direct hazard-related deaths, and reduced losses to assets that can be moved or protected before the hazard arrives, such as cars, machinery and the contents of buildings.

As an example, assessing the loss-avoidance value of a warning system upgrade would mean:

- estimating which losses are avoidable in principle and which are not (for example, a warning would normally do little to save losses to a building's structure);
- estimating the extent of potentially avoidable losses which could be saved by people responding to the onset of the event itself or to warnings from pre-existing systems; and
- estimating how much more of the potentially avoidable losses would be likely to be saved by the improved warning system.

The concept can become complicated if carried to major loss avoidance action, such as installing moveable structures like flood-gates that can be activated on receipt of a warning. Such an action may provide complete flood protection for a town or commercial complex, so that previously unavoidable losses would thereby become fully avoidable.

5. CONCLUDING REMARKS ABOUT LOSS ASSESSMENT PHILOSOPHY

The purpose of loss assessment may have a major impact on the results of that assessment. You need to ask:

- Is the assessment being conducted according to economic principles, which usually results in a relatively low estimate?; or
- Is the assessment being carried out to estimate local financial losses (that is, losses to businesses, individuals and governments) or to be consistent with household insurance policy specifications, which usually result in a relatively high estimate?; or
- Is the assessment being done just to satisfy those who suffered the loss—usually resulting in a high outcome, and maybe (unintentionally or deliberately) including some allowance for intangible loss?

Another significant, though usually less important, factor is whether the estimated losses are adjusted to give so-called 'actual' losses (see step 9). This factor is based on the experience of those at risk and on the warning time. It can reduce loss estimates by over one-third for a community with considerable experience of the hazard, and with a good warning system. For inexperienced communities with no warning system, the 'actual' loss would be similar to the 'potential' loss.

The most obvious difference in the outcome of loss assessments is the difference between those made for insurance purposes, and those made to estimate local financial loss versus those based on economic principles. The reason is essentially that when following an economic approach you try to establish the direct loss in terms of the market value of the items damaged or destroyed. The most widely used synthetic approaches assume that everything is on average halfway through its economic life. Old items will have rather less value than this.

In contrast, most household insurance policies replace destroyed or badly damaged items with new items. The result is that insurance estimates, especially for residential areas, will typically be two or three times greater than those adhering to a strictly economic approach, provided it is assumed that everyone has insurance for the full value of their house and contents.

The complexity of loss assessments

There is often uncertainty about the precise extent and attributes of the hazard, such as a storm or flood: where did it go, how strong was the wind or water flow, what contaminants were in the water, and so on. There will also be uncertainty—often much greater—about the precise state of repair of items immediately before the event. This is less of an issue where the assessment estimates the cost of replacement or when the analysis is applied to a large area.

There are standard agreed approaches to the measurement of direct losses (although these are now being challenged). This is not the case for indirect and intangible losses and at best you will only be able to gain an approximate value for intangibles and many indirects.

The extent to which indirect and intangible losses are identified and measured varies greatly. It is rare for assessments to place a value on intangible losses, although they will often be identified. For many long-lasting events, such as contamination episodes where the contaminant may remain indefinitely, or where flood water remains high for weeks, indirect and intangible losses may be much larger than directs. However, existing standard methods do not assess this properly.

Uncertainties are inherent in every part of the data and analytical methods applied to economic assessment and natural phenomena. When assessing the value of mitigation strategies, it is important that uncertainties over public response and compliance with regulations are not ignored.

Those rare high-consequence–low-probability events, such as an extreme storm or flood with the massive damage such events bring, count for little in standard economic assessments. This is because calculation of AAD in economic assessments considers the likely loss from each event on an annual basis. Extreme events, by definition, have a very low chance of occurring in any given year. When the large potential loss is multiplied by this very low annual chance of occurrence the result is usually insignificant. However, such events are very important in the development of response planning, for example where levees may be overtopped by a flood larger than the design event, or a storm surge overwhelms a major urban area.

This may be a serious limitation of the method, as it may ignore an extreme event resulting in a large death toll or widespread destruction and economic disruption. If the purpose of the loss assessment is to provide an overview of potential loss, or to help with decisions on appropriate mitigation, the potential of extreme events should be considered. They are most likely to have serious impacts in urban or other areas of intensive economic activity.

Predicting the future through forecasting land-uses, commodity prices and environmental conditions, for example, is itself hazardous and prone to uncertainty. Yet estimating the economic benefits of disaster mitigation is wholly dependent on predictions of the future. Assuming it will be the same as the present is a typical approach, but one which is almost always incorrect. Efforts to predict the future should be consistent with the scale of the project being evaluated. Assessment of large projects should incorporate climate change scenarios.

Appropriate resources should be directed to assessing likely response and compliance where these are critical to the economic assessment.

The limitations of loss assessment

It is important to appreciate that disaster losses can only be estimated. It is not usually possible to arrive at an exact uncontestable figure. Loss estimates typically vary greatly between similar events, and estimates for the same event may vary greatly. This is the case whether the event being examined is hypothetical or real. When assessing losses resulting from actual events, minor differences in hazard characteristics may result in major differences in loss. For example, flood depth may be just below or just above a critical level, such as floor level or levee top.

Here are three basic reasons for variations in estimates, listed in no particular order of importance:

1. Differences in the philosophy you bring to loss assessment.
2. The inherent complexity of loss assessment.
3. Variations in the funds, expertise and time available for assessments.

These limitations strengthen the case for adopting an averaging approach at the current state of knowledge. The emphasis here is on achieving a transparent and consistent approach while maintaining a reasonable degree of accuracy. To control the extent of the problems listed above, wherever possible, the assessment team should include someone with experience in assessing loss from the hazard under study. If this is not possible, the work should be monitored and reviewed by someone with appropriate experience.

Consistency enables confidence with comparisons between areas, as well as between mitigation options—where that is the reason for the assessment. This is considered more important than striving for great accuracy in any single case. A very high degree of accuracy may be an illusion anyway: for example, loss estimates of residential areas for insurance purposes will typically be twice those prepared using economic principles. This is because most household insurance policies provide ‘new for old’ replacement, whereas economics is interested in the market value of the goods, which is taken to be, on average, about half their ‘as new’ value.

From an economic perspective, the direct damages to any asset resulting from the physical impact of the flood should reflect the loss of income normally generated by that asset. Where an asset is lost or written off you need to use the depreciated value of the asset, as this is generally easier to estimate. Value should accurately reflect the market value of the asset in question. A common error, from an economic perspective, is to use the cost of obtaining a new asset, following the practice of many home insurance policies mentioned above. However, unless the damaged asset was new, the economic loss would not equal the replacement cost. For example, most new cars or computers lose value dramatically with time. A five-year-old car might be worth half its new value: this is the car's depreciated value. A five-year-old computer might be worth only 10 per cent of its new price.

APPENDIXES

APPENDIX 1: Summaries of key work

Rapid appraisal method (RAM) [1]

The rapid appraisal method provides the means of carrying out rapid and consistent evaluation of floodplain management measures in a cost–benefit analysis framework. The approach assesses potential flood losses as well as the costs of mitigation measures, puts these in a cost–benefit framework and comes up with project priorities. It was originally developed for use in Victoria.

Consistency is needed to ensure comparability between RAM evaluations. Because of the number of floodplain management programs requiring evaluation, and also because limited funds are available for evaluating those programs, the RAM approach provides timely and cost-effective results in studies on benefits and costs of floodplain management.

RAM is only a rapid and robust process because it needs people using it to make judgements when structuring and standardising the form of their analysis, and to organise the processes by which they form their judgements.

In using RAM, you want to achieve the main benefits of effective floodplain management, which include:

1. reduced flood damage, including social and environmental impacts of flooding;
2. enhancement of the natural values associated with floodplains; and
3. lower operational costs of floodplain management.

Reduced flood damage costs may be the goal of many individual programs or activities, but changes in natural values and operational costs of floodplain management are also likely to be relevant, particularly in determining priorities at a strategic level. The RAM also provides a method for rapidly estimating flood damages, which will assist in compiling a state-wide database.

In common with most studies of flood damage costs, RAM makes the distinction between three groups of damages: direct, indirect and intangibles. RAM can be used to estimate flood losses in a simulation of an actual flooding event.

Mean unit values are used to estimate flood damages. These mean values will apply in many flood events on floodplains throughout Victoria, but analysts using RAM must be conscious of the unique characteristics of the regions they are studying, and alter the proposed (mean) values as appropriate.

There are eight steps in applying RAM:

- define the study areas
- estimate damages for key flood events
- calculate annual average damages
- evaluate tangible benefits and costs of floodplain management measures
- evaluate intangible benefits and costs of floodplain management measures
- summarise cost–benefit analysis
- develop project priorities
- develop cost sharing arrangements

1 These notes are taken from the summary provided by Read, Sturgess and Associates (2000) who developed the rapid appraisal methodology (RAM) or, as it is also known in a generic description, as 'the averaging approach'.

The RAM performs well in studies where you are interested in determining flood damages and for assessing and prioritising structural works, flood warning systems, flood studies, floodplain management studies and floodplain management plans.

The RAM is less well suited to assessing those programs whose effects on variables that affect the AAD are not easily specified or measured. These include programs concerned with land use planning, asset management, information management, and educational and training programs.

Summary of 'Economic costs of disasters in Australia' [2]

Good information on the costs of natural disasters is required to assess the effectiveness of expenditure on mitigation measures. The key objectives of the project were to establish the costs of natural disasters in Australia over time, to examine the trends in these costs and to develop a model for costing future disasters.

The analysis was limited to floods, storms (including hailstorms), cyclones, tsunami, storm surges, bushfires and earthquakes—as these hazards are covered by the Commonwealth NDRA. Landslides were also included, as they are included in the NDRA when they are consequential to an eligible event.

The focus of the study was on national economic costs. A local or regional approach may be more appropriate for an assessment of individual disaster mitigation measures.

Availability of data

Australian data used for the analysis were derived from a database maintained by Emergency Management Australia (EMA). Although the BTE considers the EMA database as the best currently available in Australia for purposes of the project, it has limitations. It is only since 1967 that reliable insurance data, on which the most reliable cost estimates in the database are based, became readily available.

The analysis in the report was also limited to events having an estimated total cost greater than or equal to $10 million each, excluding the costs of deaths and injuries.

Framework for estimating costs

A framework for estimating the economic cost of natural disasters was developed. Although drawing heavily on flood literature, the framework should be suitable for use in determining the cost of all disaster types. Nevertheless, the unique character of each disaster means that the framework should only be used as a guide, rather than an exact model to determine the cost of any particular disaster.

The report identified the economic costs related to an event, rather than the financial cost. Economic costs are the additional resources used by the Australian community as a result of a disaster. Financial analysis is concerned with the financial impact on the individual or the entity directly affected by the disaster. In estimating the economic costs of disasters, caution needs to be exercised to avoid double counting of costs and to ensure the use of appropriate economic values of assets.

Classification of losses

The BTE's approach was to analyse the costs in three broad categories—tangible direct, tangible indirect and intangible (comprising the direct and indirect intangible cost).

One area of contention is the costing of the disruption to business. The cost of lost business is often included in the estimated cost of a disaster. However, when examining the impact of the disaster from a national perspective, business disruption costs typically should not be included. This is because business disruption usually involves a transfer between producers, without a significant loss in national economic efficiency.

2 This section is drawn from the Executive Summary of the Bureau of Transport Economics (BTE) report published in 2001.

Regional findings

- New South Wales and Queensland accounted for 66 per cent of total disaster costs and 53 per cent of the total number of disasters over the period 1967 to 1999. The Northern Territory ranked third in terms of total disaster costs (13 per cent).
- Floods were the most costly of all disaster types, contributing $10.4 billion or 29 per cent of the total cost. Storms (26 per cent of total cost) and cyclones (24 per cent) caused similar levels of damage. Together, the combined cost of floods, storms and cyclones was almost 80 per cent of total disaster cost.

Findings on methods of estimation

- There is considerable variation in the methods used to estimate past disaster costs, mostly in the estimation of indirect costs.
- The use of a consistent framework for estimating cost, based on that developed in this report, can provide a better basis for assessing mitigation proposals.
- There is no simple relationship between indirect and direct costs of a disaster. Previous disaster reports indicate that, as a broad estimate, indirect costs are usually in the range of 25 to 40 per cent of direct costs.
- There are very few methods for the adequate estimation of intangible costs and more research is needed in this area.

Next steps in disaster cost research

The purpose of the framework and discussion of estimation methods was to provide a first step in attempting to develop a more consistent approach in measuring the cost of disasters in Australia. Historically, indirect costs, and particularly intangible costs, have not been well documented and incorporated into estimates of disaster costs. Another weakness is the failure to consider the reliance of communities today on technology.

Obtaining a more accurate cost estimate would require a system for the consistent collection of disaster costs in the wake of a disaster occurring.

APPENDIX 2: Evaluating the environmental losses and benefits from flooding[3]

This appendix sets out a process for assessing environmental losses and benefits from flooding. These generally fall within the intangible classification. The environment should be a key consideration in post-flood assessments, because recognition of the environmental effects of flooding will enable a more holistic and realistic evaluation of the total costs of flooding. This in turn may alert us to the costs of flood mitigation procedures that ignore the environmental, social and economic benefits of a more natural flood regime.

Flood events are natural disturbances with a multitude of environmental benefits. Floods are an integral part of the dynamic character of river flows and play a key role in maintaining the ecological integrity of many systems. However, human activities such as current river-management and land-use practices have increasingly modified natural flow regimes and natural landscapes, such that individual flood events may have long-term, negative effects on the environment. Global warming will also increase the likelihood of environmentally damaging floods in the future.

Biodiversity and ecosystem function are taken to be the overarching valued elements of the environment, against which you can evaluate environmental losses and benefits from flooding. The key environmental effects of flooding are summarised in Table 21, with consideration of the effects of flooding in different ecological systems.

The approach outlined below recognises the value of ecological integrity and uses environmental indicators to assess and quantify the impact of flooding on ecosystem condition. By measuring environmental indicators it will be possible to provide an ecosystem scale assessment of whether the environment's capacity to maintain biodiversity and ecosystem function has been enhanced or degraded by a flood event. The results of the assessment can be presented simply in an environmental report card.

Indicators have been chosen that are relatively simple and allow for a rapid assessment with limited resources. However, in simplifying the ecological complexity inherent to environment systems, these indicators inevitably simplify the environmental issues and subtle or more complex changes will not be detected. There are many indicators that are more complex and have potential application to the assessment of post-flood impacts and it is hoped that new information and methodologies will be incorporated as they come to light.

Rapid appraisal method for assessing the environmental effects of flooding

Before undertaking an environmental assessment, two important issues should be considered:

- A timeframe for assessment must be established because what may appear to be an ecological disaster in the short-term may actually ensure the viability of the populations of plants and animals living in flood-prone communities in the long-term.
- Understanding human land-use in the flooded region will help focus the assessment process, because the environmental impact of the flood and the direction of recovery will be influenced by the history of anthropogenic disturbance. Increased levels of human activity may result in changed hydrology and an increased likelihood of spread and transfer of pollutants, invasive organisms, nutrient loads and unstable sediments.

Simple environmental indicators are presented in Table 22 for the assessment of changes in ecosystem condition due to flooding. In most situations there will be no baseline data available for comparison of post-flood impact to the condition of the system prior to the flood event. Hence qualitative judgements by experts and individuals who are familiar with the system under investigation may be the only means of assessment. The indicators recommended are coarse enough that such judgments can be made.

3 This section has been contributed by Cassia Read. The approach outlined here is based on Read (in review).

Six steps for environmental assessment

There are six main steps in the process of assessing environmental flood losses and benefits:

1. Characterise the flood regime and compare to it to historical hydrological data.
2. Score ecological communities affected by flooding in terms of ecological condition prior to the flood event.
3. Score indicators of flood losses and benefits for each ecological community.
4. Provide an estimate of certainty for each indicator.
5. Present results in the form of an environmental report card.
6. Repeat assessments over time to determine whether losses or benefits are short- or long-term.

Step 1

Individual floods must be viewed in context of flood regimes and cannot be understood in isolation. The five components that characterise the flood regime are magnitude, frequency, velocity, timing, and duration. These should be recorded and if possible compared to historical hydrological data, to estimate the difference between the flood event and what would be expected in the absence of human activity. This information will indicate the potential for the flood to have environmental losses or benefits.

Step 2

Each ecological community should be scored according to the ecological condition of the community prior to the flood event and environmental impacts of flooding viewed in this context. Scores are as follows:

1 = Poor/degraded condition

2 = Medium condition

3 = Good–excellent condition

Step 3

Environmental assessment must be tailored for each ecological system. Indicators for the assessment of flooding in the six broad ecological communities are outlined in Table 22 in five categories. These indicators account for both environmental losses and benefits. A score should be given for each indicator of flood impact on each community. Scores are as follows:

–3 = high negative impact

–2 = medium negative impact

–1 = low positive impact

0 = no impact

1 = low positive impact

2 = medium positive impact

3 = high positive impact

Step 4

In order to be defensible and scientifically credible, there should be a formal method of presenting the quality of a guess. Thus each indicator should be accompanied by a value, between 1 per cent and –100 per cent, that defines the certainty that this guess is correct.

Step 5

Present results in the form of a Report Card for each ecological community. See the example template provided below.

Step 6

Assessment should be repeated over time to determine the extent and direction of ecosystem recovery and whether the effects are short- or long-term. It is recommend that a minimum of three assessments be undertaken, with the first assessment made shortly after flood waters subside, another at six months and a third assessment two years after the event. Scores for each assessment can be compared after the second and third assessment to determine whether there has been environmental recovery, ongoing degradation or no change.

Template Report Card for environmental assessment

This template is an example report card for the assessment of Wetlands. Use different indicators (outlined in Table 22) for each ecological community.

Community: Wetland

Flood regime
Magnitude:
Frequency:
Velocity:
Timing:
Duration:

Ecosystem condition prior to flood (score and list the main human disturbances)

Indicators	Score and comment		
	Time 1 (1–3 weeks after flood)	Time 2 (6 months)	Time 3 (2 years)
Loss and degradation of vegetation and seagrass beds			
Change in abundance and distribution of aquatic plants			
Change in numbers or abundance of significant species			
Fish kills			
Germination and establishment of indigenous riparian species			
Change in number and abundance of exotic fish species			
Change in number and abundance of exotic weed species			
Extent of siltation, aggradation and sediment deposition			
Extent of scour, erosion, stripping, slumping, gully incision and avulsion			
Chemical and biological pollutants—identified from potential sources			
Other effects not included in list of indicators			

The effects of flooding will differ between various ecological communities. The main losses ('–') and benefits ('+') are detailed below for six ecological communities in 5 categories.[4]

4 Other ecological communities affected by flooding, but beyond the scope of this report for independent consideration, include: embayments, inshore lagoons, littoral zone, outer reef, inland lakes, coastal wetlands, mangrove swamps and freshwater swamps.

Table 21: The effects of flooding

Ecosystem	Key environmental effects of flood
In-channel	Habitat '+' Increase in snags (habitat for fish, insects and snails and hard provide surfaces for algae to grow) '+' Re-establishment of aquatic macrophytes '–' Loss and fragmentation through scouring, erosion, and deposition of sediments
	Biota '+' Reproduction, dispersal and establishment of indigenous species; exploitation of new food and habitat resources '–' Death, injury and local extinction of indigenous species through direct action of flood waters, decreased water quality, altered habitat and food resources '–' Dispersal of exotic species
	Physical structure and stability '– /+' Erosion and sedimentation; change in-channel width and depth '+' Increase in snags creates friction to slow water flow
	Water quality '–' Increased turbidity, sedimentation and nutrients loads; chemical and biological pollution
	Nutrient cycling '–' Transfer of nutrients and organic matter between floodplain and stream
Riparian	Habitat '+' Re-establishment of riparian plants through seed dispersal and germination '–' Loss and fragmentation of riparian vegetation
	Biota '+' Reproduction and dispersal of indigenous species and exploitation of new food and habitat resources '–' Death, injury and local extinction of indigenous species '–' Dispersal of exotics species
	Physical structure and stability '–/+' Erosion, avulsion and sedimentation, particularly unstable erosion due to loss of riparian vegetation
Floodplain and wetland	Habitat '+' Re-establishment through seed dispersal and germination '–' Loss and fragmentation through stripping, sedimentation or inundation for a prolonged period
	Biota '+' Reproduction and dispersal of indigenous species and exploitation of new food and habitat resources '–' Death, injury and local extinction of indigenous species through direct action of flood and/or poor water quality '–' Dispersal of exotics species
	Physical structure and stability '–' Erosion, avulsion and sedimentation
	Nutrient cycling '–' Transfer of nutrients and organic matter between floodplain, wetlands and stream

Table 21: The effects of flooding (coninued)

Ecosystem	Key environmental effects of flood
Estuary	Habitat '–' Loss of seagrass beds through water pollution from fine sediments and action of flood waters
	Biota '+' Reproduction and dispersal of indigenous species
	Water quality '–' Plumes containing increased nutrient loads, sediments, phytoplankton, chemical and biological pollution
	Change in physical structure '–' Erosion, avulsion and sedimentation
Inshore reef	Water quality '–' Turbid flood plumes containing increased nutrient loads, sediments and phytoplankton, chemical and biological pollution
	Biota '–' Possible loss of coral through decreased water quality (these impacts are poorly understood at present)

Table 22: Indicators for the assessment of environmental losses and benefits from flooding

Effect category	Indicators	Ecosystem	Suggested data sources
Habitat	Loss and degradation of vegetation and seagrass beds	Riparian Wetland Estuary	Expert opinion of individuals on River Trusts and Catchment Authorities, Council Environment Officers, Land Managers Assessment through the Environmental Protection Authority, Great Barrier Reef Marine Park Authority; University academics
	Fragmentation: increased number and isolation of habitat patches	Riparian	Assessment by expert opinion of individuals on River Trusts and Catchment Authorities, Council Environment Officers, Land Managers
	Increased abundance of snags	In-channel	Assessment by expert opinion of individuals on River Trusts and Catchment Authorities, Council Environment Officers, Land Managers
	Change in abundance and distribution of aquatic plants	In-channel Wetland	Assessment by expert opinion of individuals on River Trusts and Catchment Authorities, Council Environment Officers, Land Managers
Biota	Change in numbers or abundance of significant species (listed at National, State, regional levels: score impact for each species affected)	In-channel Riparian Wetland Floodplain Estuary Inshore Reef	Assessment by expert opinion of individuals on River Trusts and Catchment Authorities, Council Environment Officers, Land Managers
	Fish kills	In-channel Wetland Estuary	Observation by community, individuals on River Trusts and Catchment Authorities, Council Environment Officers, Land Managers
	Change in fisheries production (for example, prawns and barramundi)	In-channel Estuary	Fisheries officers
	Reduction in extent and condition of coral	Inshore Reef	Great Barrier Reef Marine Park Authority
	Germination and establishment of indigenous riparian species	Riparian Wetland Floodplain	Assessment by expert opinion of individuals on River Trusts and Catchment Authorities, Council Environment Officers, Land Managers
	Change in number and abundance of exotic fish species	In-channel Wetland	Local Fishing clubs, expert opinion of individuals on River Trusts and Catchment Authorities, Council Environment Officers

Table 22: Indicators for the assessment of environmental losses and benefits from flooding (continued)

Effect category	Indicators	Ecosystem	Suggested data sources
	Change in number and abundance of exotic weed species	In-channel Riparian Floodplain Wetland	Assessment by expert opinion of individuals on River Trusts and Catchment Authorities, Council Environment Officers, Land Managers
Physical structure	Extent of siltation, aggradation and sediment deposition	In-channel Floodplain Wetland Riparian	Assessment by expert opinion of individuals on River Trusts and Catchment Authorities, Council Environment Officers, Land Managers
	Extent of scour, erosion, stripping, slumping, gully incision and avulsion	In-channel Floodplain Wetland Riparian	Assessment by expert opinion of individuals on River Trusts and Catchment Authorities, Council Environment Officers, Land Managers
Water quality	Increased nutrient loads (N and P)	In-channel	Water Watch, Environmental Protection Authority
	Increased turbidity (nephelometric turbidity units – NTU)	In-channel	Water Watch, Environmental Protection Authority
	Chemical and biological pollutants identified from potential sources	In-channel Floodplain Wetland Estuary Inshore Reef	Community consultation, Water watch, Environmental Protection Authority
	Extent of turbid flood plumes containing increased nutrient loads, sediments and phytoplankton	Estuary	Inshore Reef Great Barrier Reef Marine Park Authority

APPENDIX 3: Discussion of some issues related to environmental assessment

An approach to assessment of environmental losses and benefits from flooding is outlined in Appendix 2. There are three issues that were encountered during development of this approach that require brief discussion:

1. An interpretive framework was required to understand what we mean by environmental losses and benefits.
2. Providing a methodology for the economic evaluation of environmental losses and benefits was beyond the scope of this report.
3. The indicators suggested in these Guidelines are for the purpose of rapid assessments and there is a danger of missing important environmental effects of flooding through over-simplification. These issues and some suggestions are outlined briefly below.

Framework for understanding environmental losses and benefits due to flooding

The approach to environmental loss assessment outlined in these Guidelines is embedded within a holistic framework that recognises the value of ecological integrity, and is placed in the context of natural disturbance cycles and modified environmental systems. This simple framework for understanding environmental losses and benefits from flooding, in terms of the event impact as well as the direction of recovery, has two main components (see Read in review):

> What may appear to be an ecological disaster in the short term may actually ensure the viability of the populations of plants and animals living in flood prone communities in the long-term. It is therefore essential that a timeframe is established for the monitoring and evaluation of environmental losses that identifies a period deemed acceptable by society over which natural recovery can take place. If the system has not recovered within this period, a loss can be counted.
>
> The environmental impact of the flood and the direction of recovery will be influenced by the history of anthropogenic disturbance to the system. Increased levels of human activity in a region will increase the likelihood of spread and transfer of biological and chemical pollutants, invasive organisms, nutrient loads and unstable sediments. Also, changed hydrology due to urbanisation, current river management practices and global warming, has significant environmental consequences.

Economic evaluation

Because many environmental resources are not traded in markets, they do not have a clearly defined price. The assessment methodology outlined here is a quantitative assessment in non-monetary units and does not include economic evaluation of environmental losses and benefits. However, this document provides an excellent starting point for developing an economic evaluation methodology, as it identifies key environmental effects of flooding (for which an economic assessment could be developed). Economists have developed a number of techniques for the monetary valuation of environmental goods and services. These ecosystem services include purification of air and water, production of food and fibre, and fulfilment of peoples spiritual, cultural and intellectual needs. Valuation methods include:

- contingent valuation
- hedonic pricing
- travel-cost method
- production function analysis
- replacement or restoration cost technique

Future developments

Because the indicators recommended in these Guidelines are relatively simple to allow for a rapid assessment with limited resources, they inevitably simplify the ecological complexity inherent in environmental systems, and subtle or more complex changes will not be detected. There are many indicators that are more complex and have potential application to the assessment of post-flood impacts. It is recommended that in the future, application of these indicators be investigated further and adopted into the assessment methodology recommended here. Examples of these indicators include:

- *AUSRIVAS* (Australian River Assessment System), which formed part of the Federal Government's National River Health Program, uses data on macroinvertebrate community structure, combined with predictive modelling to assess the biological health of Australian rivers. Advantages of using macroinvertebrates for assessing the condition of aquatic systems, include their functional importance, their availability and wide distribution, and the ease of sampling.
- *Indicators of River Health*, which are currently being developed by the Cooperative Research Centre for Freshwater Ecology for the Murray Darling Basin Sustainable Rivers Audit.
- *The AUDIT program on Estuary Health* uses fish fauna as indicators of estuary health. The composition and diversity of fish fauna are recognised internationally as a robust indicator, and have large existing data sets.

APPENDIX 4: Case study examples of different losses[5]

This case study focuses on the 1998 flood event which affected coastal communities from Townsville to Cairns, and was centred on Tully. Flooding was caused by a monsoonal low that was the remains of cyclone Sid.

Direct damages

Measurement detail will depend on the assessment approach. For the synthetic approach, assessment of household and small business direct losses are conventionally undertaken by an appropriate computer program. Assessment of large commercial, government and primary industry losses is generally carried out by individual surveys. There are standardised procedures which could be adapted using data collected in the initial runs of this methodology.

For the averaging approach, assessment of household losses is based on an average value per property. Assessment of losses in other small buildings is based on the same procedure. Larger buildings are handled on an area basis as set out in Table 23. Standard loss tables exist for roads (Table 24) and some livestock (Table 25) as well. Most other elements of loss should be based on survey at the current level of knowledge.

Table 23: RAM–suggested damages for large non-residential buildings >1000m2 in 1999 dollar values

Value of contents	Mean potential damages per m^2 ** (includes external, internal contents and structural) ($)
Low (eg offices, sporting pavilions, churches)	45
Medium (eg libraries, clothing businesses, caravan parks)	80
High (eg electronic, printing)	200

Table 24: RAM unit damages for roads and bridges (expressed per km of road inundated in 1999 dollar values)

Road type	Initial road repairs ($)	Subsequent accelerated deterioration of roads ($)	Initial bridge repair and subsequent increased maintenance ($)	Total cost to be applied per km of road inundated ($)
Major sealed roads	32 000	16 000	11 000	59 000
Minor sealed roads	10 000	5 000	3 500	18 500
Unsealed roads	4 500	2 250	1 600	8 350

Table 25: RAM suggested livestock values (per head in 1999 dollar values)

Price	Dairy ($)	Beef ($)	Sheep for wool production ($)	Sheep for lamb production ($)
High	650	480	33	50
Average	560	410	27	45
Low	460	340	23	35

5 This appendix has been derived from a loss assessment made after a north Queensland flood and is from the full report, *Economic and Social Costs of the North Queensland January 1998 Floods*.

Coming now to the direct losses arising from the January 1998 floods. In this example, Table 26 illustrates how more than one method may be required to estimate regional economic losses, it is then a matter of choosing the most appropriate. The background economic climate, the timing of the event, the flow of money within the local economy and local information all have to be taken into consideration to get accurate flood loss estimates.

Table 26: Using different methods to estimate direct losses

Direct loss category	Estimated economic loss ($m)	Source of estimation
Residential structures and contents	Approx. 89.16	BTE method and survey
Commercial and industrial buildings	39.1	Insurance data and survey
Infrastructure	82.63	NDRA and survey data
Agriculture	8	Survey and NDRA
Vehicles	15.35	Insurance data
Totals	Approx. 234.24	

Using the RAM in the January 1998 flooding example overstated the estimate of residential losses, as shown in Table 27 because a large percentage of houses suffered only slight damage. The direct household losses were estimated to be approximately $90 million using the best data available. This is a good demonstration of the preferred use of the RAM where the severity of damage to buildings is more evenly distributed.

Table 27: Direct residential losses to the North Queensland region from the January 1998 floods

Estimation method	Insurance data	Survey	Best data available	RAM
Flood damaged	All insured	Over floor	All over floor	Above and below floor
Average loss/building ($)	3735	24 491 (in-depth interviews)	11 961	20 500 (RAM)
Number of buildings	6955	7454	7454	>7454
Total economic loss ($m)	25.98	182.55	89.16	>152.81

Direct losses to the commercial sector, as shown in Table 28, were estimated to be $39.1 million using insurance and survey data. Use of insurance data can sometimes lead to inaccurate estimations due to low levels of cover for flooding and policies providing cover for business disruption, which is counted as an indirect loss. However in this case, flood insurance data provided the best estimation of direct commercial losses because there was minimal business disruption and companies had high levels of flood insurance. The business survey found direct losses to small enterprises in the commercial sector averaged $15 998 and the total losses were estimated to be $18.12 million.

Table 28: Direct commercial losses to the North Queensland region from the January 1998 floods

Estimation method	Insurance data	Survey (small enterprises only) RAM
Average loss/building ($)	46 000	15 998 20 500
Number of buildings	850	1133 1133
Total estimated loss ($m)	39.10	18.12 23.23

When assessing direct losses to agriculture we first need to check whether a crop had a fixed price regardless of the effect of crop losses in the region's total market. For example, economic losses to the banana industry were minimal because the market value of the unaffected banana crops rose after flooding destroyed crops in lower lying areas, thus enabling the industry to generate a near-normal return for the season. Conversely, because the value of the sugar cane crop is dictated by a global market price and foreign exchange rates, the reduced cane harvest resulted in an economic loss to the region. Losses to agriculture were estimated to be $8 million using NDRA and survey data.

Indirect damages

Indirect losses arise as a consequence of a disaster, reflecting losses to economic activity within the designated area of analysis. These losses are a follow-on to the direct losses caused by the hazard, rather than resulting directly from contact with wind, fire or (in this example) flood water, etc., hence the term 'indirect'.

Indirect loss assessment is plagued by double counting and over counting, essentially because losses to one party are frequently gains to another, and some losses are quickly made up through deferred, rather than lost, business. Another problem with indirect losses is that they can also be included separately for assessment as direct losses. An example of this occurs when a business double-counts its loss of profits as well as the direct damage to its assets.

Many loss assessments also make the error of counting lost turnover and lost sales as losses, instead of counting only the lost profit. Application of economic principles helps keep indirect loss assessment on track and generally reduces the final loss estimates.

In an economic loss assessment, benefits to the local economy can offset some of the losses. These benefits typically take the form of insurance payouts and government relief money. Benefits, as a proportion of loss, become more significant as size of the assessment area becomes smaller.

Here are some of the difficulties in viewing indirect losses, which can lead to errors in loss assessments:

- Many apparent losses are really losses to one business only, as local businesses (and farmers) pick up what is lost to others. Some business can be deferred and picked up again after the flood, meaning there is no net loss apart from any additional costs incurred in deferring. But if businesses outside the area of analysis gain at the expense of those within the area, this counts as losses in the assessment area.
- Losses of income or business to enterprises outside the area of analysis cannot be counted as losses within the area.
- Costs which are gains to local enterprises as a result of the event are not losses, for example, evacuees being housed at local hotels in otherwise vacant facilities.
- Losses to business are measured in terms of the loss in value added or profit, not the total loss of turnover as this includes the costs of inputs which cannot be counted. But inputs damaged by flood water can be counted and are normally considered part of direct losses.
- Losses, such as declining incomes, lost employment opportunities and the social disruption resulting from flooding, are important and noteworthy examples should be documented, even though it is difficult to place monetary values on these losses.

Table 29 shows some examples of indirect losses from the January 1998 North Queensland floods, which included disaster response and relief costs and the economic losses resulting from business and transport network disruption.

Table 29: Indirect losses to North Queensland due to the January 1998 floods

Source	Survey	EMATrack	BTE	RAM
Business disruption ($m)	minimal	15	–	18.66 Combined business and transport disruption (50.5% of indirect losses)
Transport network disruption ($m)	N/a	–	$2.5m	
Emergency response and relief ($m)	1.42 (NDRA + volunteer hours)	–		18.29 (49.5% of indirect losses)
Total estimated economic loss ($m)	3.92 (estimated using a combination of the BTE and survey methods)			36.95 (30% of direct losses)

Disaster response and relief costs associated with the event were approximately $1.5 million. They were calculated from the NDRA amounts received by the Queensland Department of Emergency Services.

The NDRA only covers the specific event, so it provides a good estimate of these losses. The running costs of the regional emergency services are not included in the estimation of losses.

Transport network disruption was calculated using average daily traffic figures for the sections of roads that were blocked by flood waters, and costed using BTE figures for the value of each hour of disruption. The overall economic loss of $2.5 million for transport network disruption was an upper limit due to the double counting of vehicles travelling through more than one flooded section of the Bruce Highway. It was appropriate to include traffic disruption costs, as there are no major alternative routes for the Bruce Highway and average daily traffic flow in both directions is more than 4000 vehicles.

Regional perceptions of flood losses can also differ from actual economic losses: in this case, losses to tourism. The local belief was that tourism is significantly affected by flooding events, but no evidence could be found which linked the January floods with significant losses to the tourism industry.

Reporting of flooding costs by the media, especially indirect economic losses, may also be incorrect. The total of the business disruption losses was reported to be as high as $15 million. As mentioned previously, only lost profit may be counted and then only if it is not made up by a competing business. The overall disruption to business was limited by the inundation occurring on the weekend during the school holidays, which was already a period of limited business activity. Other factors that limited business disruption losses were quick cleanup times and that the main impact was on a city (Townsville) where local competitors undoubtedly made up any losses experienced by any flooded business. For these reasons the business disruption costs are estimated to be in the vicinity of $1–2 million and the manufacturing sector experienced the largest losses. Other studies have often, correctly, not included business disruption losses due to a national perspective being taken.

Intangible losses

'Intangibles' or non-market impacts is a catch-all term which simply identifies direct and indirect impacts for which there is no market and as a result, no commonly agreed method of evaluation. Methods for estimating these impacts in economic terms are either difficult to apply, experimental, or not generally accepted; but this does not mean they are unimportant. Intangibles are often found to be more important than tangible losses, and we therefore need to try to identify and include them.

Studies in Australia, the United Kingdom and the United States have consistently shown that householders place very high value on intangible losses. Most such studies show that people value the intangible losses (principally loss of memorabilia and resulting stress) from, for example, a home destroyed by fire or water at least as highly as their tangible dollar losses. Yet, most studies relegate intangible losses to little better than footnote status.

This is because, in the absence of clearly defined markets, there are no agreed methods for valuing these losses. Putting dollar values on some intangible losses is highly controversial—rather like trying to value a life. However, many economists argue that we value these things implicitly, for example through how much we are prepared to spend on safety or on making sure memorabilia are always secure.

Table 30 summarises some methods that have been used to place a monetary value on intangibles. These methods have been used extensively in Britain in a loss assessment context and are recommended in the recent BTE report. None is without significant problems but, where resources permit and where some intangibles may be very large, the effort is worthwhile so losses can be identified and documented.

Example of intangible losses from the January 1998 floods

There was a range of intangible losses from the January 1998 floods, including:

- death and injury;
- health effects, such as leptospirosis, respiratory illnesses, fear, stress and depression;
- loss of memorabilia;
- quality of life losses, such as isolation from work, school and social activities;
- temporary loss of utilities and amenities;
- relationship breakdowns; and
- losses arising from environmental degradation.

Although all fall in the same category, the severity of the documented losses ranged from a minor inconvenience through to the loss of life.

The BTE, in keeping with normal practice in transport planning, has assigned values to the intangible losses of death and injury. Fatalities have been given a value of $1.3 million, serious injuries $319 000 and minor injuries are valued at $10 600. Using these figures the economic cost of the death and injuries for the January 1998 floods totals $4.68 million. Table 31 provides a summary of the intangible losses from the 1998 floods.

Table 30: Formal economic methods for estimating intangible losses

Method	Approach	Values estimated	Data availability	Suited to	Problems and advantages
Travel Cost Method	Estimate demand curve for resource based on costs incurred by users	Consumer surplus minimal	Simple survey of users and origins plus secondary data	Major recreational sites distant from population centres	Only estimates benefits to present users
Hedonic Price Method	Estimate house price differences related to variations in environmental characteristics	Revealed willingness to pay to live in different environments	Requires public availability of house price data, or interview survey, plus house survey	Valuing local environmental quality	Can be used to estimate value for differences in hazard risk, but theoretical basis uncertain and likely to double count
Contingent Valuation Method	Direct estimation of willingness to pay using questionnaire 'bidding' methods	Consumer surplus or total loss of utility	Requires well designed, implemented, and validated interview survey	Recreational sites, environmental hazards	Widely criticised and widely used. Can estimate non-use values (option, bequest) but cannot be done 'off the shelf'
Least Cost Alternative	Uses market values for alternate uses of resources absorbed in non-market activity	Opportunity cost/ cost forgone by present preferences	Requires values for alternatives and that there are alternatives	Implications of land use controls	Avoids interview surveys, but value may not relate with consumer surplus
Shadow Project/ replacement cost	Cost of recreating a site	Opportunity cost of rebuilding.	Assumes recreating possible	Smaller ecological sites	Not applicable if value depends on an undisturbed location

For a detailed explanation see Thompson & Handmer (1996) and BTE (2001). Application of these methods requires specialist knowledge.

Table 31: Summary of intangible losses from the 1998 floods

Intangible loss categories	Survey descriptions of intangible losses
Injuries and fatalities	2 fatalities, 6 serious injuries and 34 minor injuries
Health effects	Allergies, respiratory diseases including asthma and leptospirosis, heart illness including heart attacks, rheumatism, colds, bronchitis, pneumonia, nerves, depression, loss of sleep, weight loss, fatigue, total exhaustion, stress, fear and trauma
Memorabilia	Loss of motorbike from deceased brother, photos, university notes with original ideas and thoughts, books, toys, baby records, video of daughter's wedding and jewellery
Short-term quality of life losses:	
Employment or business	Difficulty or prevented getting to work, problematic to work on farm, longer work hours, lost reputation of business when known to be flood-prone or perception that business is unreliable
Disruption to routines	Difficulty accessing services and supplies, difficulty or prevented from getting children to school, when the Townsville port closed Magnetic Island residents were isolated, major disruption to police work, missed appointments with specialists, students with disabilities affected disproportionately, elderly cannot receive aged care
Discomfort and/or inconveniences	Loss of utilities (power and water and telephone), generally cut off/isolated, stay indoors, tranquillity lost, leisure-time affected, can't participate in school or social activities due to extra financial pressures, vermin in roof after floods, tap water undrinkable, isolation, physical separation of family members, children frustrated when they have to stay indoors, stench in water from sewerage, poisons and rubbish, tourists stranded when automatic teller machines (ATM's) don't work (power failure)
Long-term quality of life losses	Lowered socioeconomic status, economic marginalisation, long-term psychological problems if left destitute
Environmental degradation	Seagrass bed loss, coral bleaching, heavy metals entering environment from mine site and sewerage entering the stormwater drain system

APPENDIX 5: What is involved in surveying and sampling

This Appendix is provided to familiarise those undertaking loss assessments with the issues surrounding surveys and sampling.

In all methods of getting information about the effects of a hazard event on a community, it is likely that some surveying will be required. Even where this is limited to collecting information from stakeholders such as government agencies and utility companies, effective survey design procedures should be followed. This is to ensure that the information sought is what is actually needed. Collection of information on indirect and intangible losses will be largely through survey or other social science methods.

Designing a survey and implementing it with rigorous sampling techniques are difficult tasks for the non-specialist. We recommend that you engage appropriate expertise for these tasks, and there are many major organisations whose businesses are based on continually collecting facts and opinions through surveys. These include market and political research groups, the large polling and public opinion companies and government statistics and census offices. Many universities also have survey research centres, so there is no shortage of expertise, experience and literature available on the topic of survey design. Nevertheless, fundamental design problems affect many surveys including many of those set up to investigate flood disasters.

A well designed and implemented survey is generally expensive and time consuming. The first steps in survey design are to decide exactly what information is needed and why, and then to decide whether a survey is the most appropriate approach consistent with the resources available. Is the information available from anywhere else? Would other methods provide better answers? For example, if the intent of the survey is to get a better understanding of the social impacts of flooding, focus groups might provide more insight. (Focus groups require an experienced facilitator in order to be successful.)

Basic design issues in preparing a survey

Although survey design may seem to be just applying simple commonsense in asking the right questions, there are some basic principles that can easily be overlooked. These are some of the common failings of surveys:

- The most basic principle has already been stated: the person preparing a survey has first to determine exactly what information is needed, and then ensure the questions ask for it without ambiguity.
- The design of question wording is not easy, as questions must not be leading, and must be clear about what sort of answer is required. They need to be in the language of those being surveyed, rather than the language of those designing the survey, which can be markedly different. Surveys should be designed by a team in the sense that a variety of people should examine and comment on drafts as one way of reducing the ambiguity and other problems with question wording and order.
- The survey should be designed to be as easy as possible to analyse.
- Once a complete draft survey is ready, it should be pre-tested (or piloted) on a group of people as similar as possible to the main group of intended participants. Often, pre-tests are carried out on colleagues for convenience. However, this approach may fail to expose the draft to people with different ways of seeing the flood problem and is a serious potential inadequacy of many pre-tests.
- Good surveys take time to develop. Lack of preparation time and the accompanying resources is a typical reason for poor survey quality. However, there are many completed surveys of reasonable quality which can serve as useful starting points and thereby avoid the initial phases of survey design. Possible examples include the survey forms appended to the 1998 North Queensland flooding case study report accompanying these Guidelines. Other references would be the forms in the Thompson and Handmer (1996) reference, those included in the manuals produced by the Flood Hazard Research Centre at Middlesex University, and those used by ANUFLOOD.

Resources and mode of survey delivery

There several commonly-used ways of implementing a survey, which vary considerably in cost, quality of results, and sampling difficulties. The ways surveys are generally carried out are:

- Face-to-face interview is probably the most common form of survey with disaster-related research. Trained and experienced interviewers with well-designed survey forms should produce good quality results, and it is generally possible to monitor the non-responses for systematic bias. But this approach is expensive: much time is often spent on each interview, on travelling, on calling back at a more convenient time for people, and so on.
- Mail survey is very inexpensive, but is not recommended for getting public reaction or opinion in an area which may be at risk. This is because mail surveys are renowned for producing very low response rates, thereby limiting their value. There are ways of managing this, but the response rate may still remain disappointingly low. It may still be the best method for a specialist group or government agency to get specific information.
- Telephone survey seems to be a reasonable compromise between the quality of face-to-face interviews and the cost advantages of mail surveys. Some researchers argue that they also reduce certain types of interviewer-induced bias. However, the proliferation of telephone sales of all kinds may be affecting this. It is also important to establish how well the area covered by the telephone directory matches the area to be surveyed, and what categories of households are not listed.

Some common problems with surveys

Although many of the problems likely to arise in conducting surveys can be solved (or at least greatly reduced) through survey designers being aware of the problems and by careful pre-testing of the draft survey, there can still be difficulties such as:

- the draft survey is not properly pre-tested (or piloted)—all surveys should be field tested and modified as required;
- the purpose of the survey is not properly explained so people are unsure about it and respond with caution;
- the survey does not ask the sort of questions which, afterwards, are found to have been needed to achieve the desired results;
- the questions are all ‘closed’ (giving the interviewee a list of responses they must choose from), reflecting the survey designer’s understanding of the problem and precluding collection of information from people with other views on the problem;
- the wording of a closed question is ambiguous or vague, allowing multiple interpretations of the question and non-comparable results;
- there are too many vague ‘open’ questions (that is, questions which do not specify a choice of responses, the interviewee decides on an appropriate response), meaning the survey takes too long to analyse, and analysis may be difficult because it may not be clear what question was actually being answered;
- the survey is too long, so people either refuse it or give inadequate or off-hand responses;
- the survey contains questions worded in ways which interviewees find off-putting, which may undermine the credibility of the whole survey; and
- questions are included which are interesting but will not be used in the analysis.

Some problems with sampling

Unless very few properties are affected or a basic averaging is used, a sample will be needed. The overall accuracy of loss assessment results will often depend on the care taken with sampling. Unfortunately, all too often in disaster research, sampling is done simply as a matter of convenience and sampling procedures are ignored completely (or at least they are not documented) making it impossible to assess the validity of the assessment. Results derived from poor samples are therefore not statistically valid and cannot be extended with confidence to the population, which the sample is meant to represent.

In reality, sampling is a compromise between some ideal goal, the limits imposed by available time and money and the fact that some groups may be relatively inaccessible. The implications of any apparent systematic bias, such as not being able to include households where everyone works, should be considered for their impacts on the results of the survey. Even where resources are plentiful, judgements must be made about the use of quotas and stratified sampling as opposed to simple random sampling. For instance, it would normally be desirable to survey people who have experienced different degrees of flooding, but judgements are required as to what the categories of flooding should be.

A sample size of less than 30 is not considered statistically valid. Samples slightly larger than this may be valid but will have very wide error bands, meaning the results are of little practical value. Exceptions would be when the population under study is very small. Normally samples are expected to be in the 200 plus range. The precise figure depends on the size of the population under examination, the number of relevant sub-groups (such as flood experience), and the acceptable error. Size and error issues are handled by various formula used by sampling specialists.

APPENDIX 6: How to improve and update loss assessment knowledge and practice

The relevance, usefulness and currency of these Guidelines can only be maintained by taking advantage of experience with their use and by adding to them from the developing body of knowledge about loss assessment.

Although natural disasters and their effects on people in communities have always been a fact of life, our knowledge of disaster losses is still limited. In many areas there is little agreement about the size of losses or how to measure them, so these Guidelines need to take full advantage of every piece of new knowledge and experience.

There is a special need to build up loss assessment data in a form suitable for reference in applying the averaging approach. Each new loss assessment study potentially provides additional information to strengthen the data basis of loss assessment.

The way to review and improve these Guidelines is to:

1. test the methodology on a continual basis; and rewrite relevant parts to incorporate improved assessment procedures and changed methodology (this will be relatively straightforward for the web-based version); and
2. continually adjust and update average damage figures, stage–damage curves; and improved indirect and intangible assessments. As improved average loss figures, stage–damage curves and other data sources become available they could be used in preference to those published here. Future editions of the Guidelines will incorporate the most current data sources.

APPENDIX 7: Use of 'actual' or 'potential' loss estimates

Sometimes you need to decide whether data collected by the synthetic or averaging methods needs to be adjusted for specific local circumstances at the time of the assessment. This is because many disaster loss estimates are the losses experienced as a result of an event, that is, they are the damages actually measured following the event and are known as 'actual' losses. Such estimates incorporate all the unique features of that particular event and of the affected population at the time of the disaster, and may not reflect average losses experienced over several similar events. This is what is measured by the 'survey' approach. As assessed by surveys, events that appear very similar often have widely varying losses.

If you are trying to compare the benefits of several hazard mitigation options, it would be rare indeed to get a major event triggered by the hazard agent in question at the right place and right time to provide the necessary data for average annual losses to be estimated (see step 10). A series of disasters of exactly the right kind is extremely unlikely, so methods are used to estimate disaster losses in the absence of an event, using the 'synthetic' approach, and an 'averaging' method.

Both the synthetic approach and the averaging method deal only in estimating the 'potential' losses from an event, that is the damage that would result from the event being studied if no action was taken to reduce loss, and as if the event occurred without any unique characteristics that either significantly increased or decreased losses.

As people usually take action to reduce losses, actual losses will almost always be less than the potential loss. Situations where this is not the case are:

- where no warnings are provided and therefore there is no opportunity to reduce losses, and
- where people are not available, or otherwise unable to take action, through being at work or away, or simply by not knowing what to do.

Most of the work on the issue of actual versus potential losses has been on flooding, where warning are usually provided or those at risk can see that flooding is likely. Exceptions include flash floods, sudden over-topping or collapse of levees or sea walls, dam breaks or an unexpected storm surge. In areas where the population is highly mobile, a significant proportion of the population is likely to be inexperienced with flooding and unaware of appropriate mitigation actions. Nevertheless, research in Australia suggests that, provided people are at home and realise that they are about to be flooded, they will reduce damages by a significant margin. The same comments would apply to other hazards, such as cyclones and bushfires, where warnings are normally provided and where protective action can be taken.

There are four important issues in addressing potential effects of a hazard:

1. It is hard to decide what margin of warning is needed for different hazard-prone communities. Australian data suggests that warnings make between zero difference and a 60 per cent reduction in loss where flooding is concerned. However, much of this information is old and may not reflect what would happen in contemporary communities.
2. If the damage estimates are being used as part of assessing the worth of single or alternative investments in mitigation, the use of actual damages may be discriminatory for two reasons: as actual damages will be less than potential losses, actual assessments will penalise people and communities that effectively reduce loss in response to warnings; and the same statement applies to those taking longer-term action to reduce hazard-related loss.
3. There is another reason the use of actual damages (especially as assessed by survey) might be discriminatory: actual damages will be much less in poorer areas, as there is less property to be damaged, and what is there is of a lower value. The policy question this raises is whether it is appropriate to use an averaging approach so that all hazard-prone (for example, flood-prone) communities compete for mitigation funds on a similar footing. If this is not done, poorer communities will have trouble satisfying cost–benefit criteria, and will always find that richer communities are ahead of them in the queue for mitigation funds.

4. An important limiting factor with the use of actual losses, is that they represent loss at a moment in time given certain factors which are unstable. In areas where the population is highly mobile, any assessment of local experience will become quickly dated. Loss reduction is presumed to be due largely to prior experience with the same hazard at the same location. Calculating AAD involves projecting loss assessments into the future as are the assumptions upon which they are based. Because circumstances in most communities change rapidly, especially in terms of those things determined by the population base, it can be argued that 'actual' figures should not be used for calculating AAD.

ACRONYMS

AAD	annual average damages
ANU	Australian National University
ANUFLOOD	Computer program designed to assess tangible flood damage
BTE	Bureau of Transport Economics
DLWC	Department of Land and Water Conservation (NSW)
EMA	Emergency Management Australia
EMATrack	EMA publication listing disasters in Australia
FEMA	Federal Emergency Management Agency (USA)
FLAIR	Flood Loss Assessment Report
GIS	Geographic Information System
HAZUS	Natural hazard loss estimation methodology developed by FEMA
NDRA	National Disaster Relief Arrangements (Commonwealth)
PerilAUS	Database of natural perils (Risk Frontiers)
RAM	Rapid Appraisal Method (Read, Sturgess and Associates, 2000)

GLOSSARY

annual average damages	The damages expected from all episodes of a particular hazard (for example, in the case of floods, from floods of every size) averaged (in theory) over an infinite period. AAD estimates enable easy comparison with the costs of mitigation proposals, and allow priorities to be set between different locations. This is because the cost of mitigation can also be expressed on an average annual basis in the same way as a mortgage. An inherent problem with this approach is that low-probability high-consequence events will appear insignificant when converted to AAD because of their very low probability of occurrence (see step 10). Nevertheless, it may be considered socially desirable to consider them in the analysis. It is not possible to conduct a cost–benefit analysis without AAD data.
annual exceedance probability	the likelihood of occurrence of a flood of a given size or larger in any one year, usually expressed as a percentage (see also **occurrence probability**)
avoidable losses	Losses that can be avoided through mitigation.
commerce	In a loss assessment context, 'commerce' refers to the retail, wholesale, service industries and the manufacturing sectors.
costs	In a loss assessment context, the resources or alternative consumption which must be sacrificed to achieve the desired end result, such as implementing mitigation (Thompson & Handmer, 1996).
disaster	A serious disruption to community life which threatens or causes death or injury in that community and/or damage to property which is beyond the day-to-day capacity of the prescribed statutory bodies. A disaster requires special mobilisation and organisation of resources other than those normally available to those authorities (EMA 1998, p. 42).
depth–damage curves	Depth–damage curves (also known as stage–damage curves) are graphical representations of the losses expected to result at a specified depth of flood water. Such curves are typically used for housing and other structures where the stage or depth refers to depth of water inside a building and the damage refers to the damage expected from that depth of water. They may be thought of more generally as representing the relationship between hazard magnitude and loss, and can be adapted to cover other hazards.
economic loss	See 'loss/damage'.
exposure	Assets, activities, people, and things people value, such as the environment, which are exposed to the impacts of some hazard.
financial loss	See 'loss/damage'.
hazard	A source of potential harm or a situation with a potential to cause loss. In an emergency risk management context, a hazard is a situation or condition with potential for loss or harm to the community or environment.
intangible	Items which are not normally bought or sold (such as memorabilia, lives, health and the environment) and for which, therefore, no agreement on their monetary value exists.

loss/damage	A loss is counted if it is an economic loss, unless otherwise specified. An economic loss is a measure of the impact of the disaster on the specified economy. It is taken as being equal to the resources (expressed in time, money or intangible loss) lost by the specified area as a result of the disaster (see also 'net loss'). This is distinct from financial losses due to the disaster which are losses borne by individual enterprises as well as the other sectors. Many individual business losses do not amount to economic losses as their losses are offset by other businesses gaining the trade, or are made up over time.
mitigation	Any measure intended to reduce the severity of, or eliminate the risk from, disasters. Mitigation is usually thought of in terms of prevention and community preparedness.
probable maximum flood	The largest flood expected from a specified catchment at the current state of knowledge. The probability of such an event occurring is very low, such as 1:10 000 or less in any year. A PMF may also be estimated deterministically from knowledge of flood-producing processes. Although these floods (or their equivalent for other hazards) are extremely rare, their impacts may be devastating.
net loss	The disaster loss experienced by an economy minus any benefits to that economy which resulted directly from the same disaster.
occurrence probability	The chance of a hazard event of a specific magnitude at a specific place occurring in a given time period. It is usually expressed as a chance per year, for example a 10 per cent flood is the flood with a 10 per cent probability of occurring (or being exceeded) in any year. Also expressed as a probability of 0.1 per year, or a recurrence interval of 10 years being the theoretical average time between a flood of that magnitude.
risk	The chance of something happening that will have an adverse impact on community, business or individual objectives. In emergency risk management, risk is used to describe the likelihood of harmful consequences arising from the interaction of hazards, exposure to the hazards, and the vulnerability of what is exposed (EMA, 1998). It is usually considered in terms of communities and the environment.
stage–damage curves	See 'depth–damage curves'
tangible	Items which are normally bought or sold and which are therefore easy to assess in monetary terms.
total loss	The sum of avoidable losses and unavoidable losses.
vulnerability	In a loss assessment context, 'vulnerability' refers to the susceptibility to loss of what is exposed to the hazard, and the ability of what is exposed to recover from the impact of the hazard.
unavoidable loss	Unavoidable losses occur when mitigation action cannot be taken to counter the effects of a potential hazard, or cannot reduce the resulting loss. Changes in knowledge and approaches will alter what is considered unavoidable through time.

NB: This Glossary is consistent with definitions used in EMA (1998)

REFERENCES AND FURTHER READING

BTE 2001, *Economic Costs of Natural Disasters in Australia*, Report 103, Bureau of Transport Economics, Canberra.

DLWC (NSW) 2001, *Floodplain Management Manual: the management of flood liable land*, Department of Land and Water Conservation, Sydney.

EMA 1998, *Australian Emergency Management Glossary, Australian Emergency Manuals Series, Part 1, The Fundamentals, Manual 3*, Emergency Management Australia, Canberra.

EMA 2000, *Emergency Risk Management Applications Guide, Part II, Approaches to Emergency Management, Volume I, Risk Management*, Emergency Management Australia, Canberra.

EMA (Draft), *Draft Guidelines on Community Information Gathering in Emergency Management, Emergency Management* Australia, Canberra, Draft No. 6:36.

EMA 2001, *Implementing emergency risk management*, Emergency Management Australia, Canberra.

Granger, K. 1998, *ASDI (Australian Spatial Data Infrastructure) from the ground up: a public safety perspective*, Australian New Zealand Land Information Council and AGSO, Canberra.

Handmer, J. and Smith D.I., 1994, *Cost-effectiveness of Flood Warnings*, Centre for Resource and Environmental Studies, Australian National University, Canberra.

Handmer, J., Lustig, T.L. and Smith, D.I. 1986, 'Assessing intangible flood damages for evaluating urban floodplain management option', in preprints for Hydrology and Water Resources Symposium 1986, Institution of Engineers, Brisbane, Australia.

HAZUS, 'Natural Hazard Loss Estimation Methodology', Federal Emergency Management Agency, URL http://www.fema.gov/hazus/hazus4a.htm (last accessed 6/5/02).

Parker, D.J., Green, C.H., and Thompson, P.M. 1987, *Urban Flood Protection Benefits: A Project Appraisal Guide*, Gower Technical Press, Aldershot.

Penning-Rowsell, E.C., Green, C.H., Thompson, P.M., Coker, A.M., Tunstall, S.M., Richards, C., and Parker, D.J. 1992, *The Economics of Coastal Management: A manual of assessment techniques*, Gower Technical Press, Farnborough.

Penning-Rowsell, E.C. and Chatterton, J.B. 1977, *The benefits of flood alleviation: A manual of assessment techniques* (Blue manual), Flood Hazard research Centre, Middlesex University, Pub. No. 18.

Thompson, P. and Handmer J. 1996, *Economic Assessment of Disaster Mitigation: An Australian Guide, Centre for Resource Environmental Studies*, ANU and Flood Hazard Research Centre, Middlesex University, for the Australian IDNDR Committee.

Read, C.F., (in review) 'Evaluating the environmental losses and benefits from flooding', *Australian Journal of Environmental Management*.

Read, Sturgess and Associates 2000, *Rapid Appraisal Method (RAM) for Floodplain Management*, Department of Natural Resources and Environment, Melbourne, Victoria.

Zamecka, A. and Buchanan G., 1999, *Disaster Risk Management*, Queensland Department of Emergency Services.

www.ema.gov.au