IMPROVING NATIONAL BEST PRACTICE IN FLOOD RISK MANAGEMENT

Duncan McLuckie[1]
[1] National Flood Risk Advisory Group

Abstract

The National Flood Risk Advisory Group (NFRAG), a reference group of the Australian and New Zealand Emergency Management Committee (ANZEMC), worked with the Australian Emergency Management (AEM) Institute to update national best practice in flood risk management through the development of *AEM Handbook 7: Managing the floodplain: best practice in flood risk management in Australia (2013).* To support this national best practice manual NFRAG has recently completed the development of the provision of practical guidance to assist management of flood risk in relation to:

- The breakdown of the floodplain in relation to flood hazard to update the advice in *Appendix J of Floodplain management in Australia: best practice principles and guidelines*, prepared for the Standing Committee on Agriculture and Resource Management (SCARM) of the Agriculture and Resource Management Council of Australia and New Zealand (SCARM Report No. 73, 2000).
- The breakdown of the floodplain in consideration of the additional hazard resulting from isolation of an area from flood free land in a flood event.

In addition NFRAG led the development of practical technical specifications for mapping and modelling outputs and outcomes from flood investigations.

NFRAG is continuing to develop guidelines to support AEM Handbook 7. Guidance currently being developed encompasses the selection of design flood events for flood mitigation works, improving the way information on flood risk is provided to support informed decision making in land use planning and undertaking and making available a literature review on methodologies that are used to estimate fatalities from disasters.

This paper builds upon *McLuckie et al 2014* by discussing the use of practical technical specifications for mapping and modelling and the progress toward additional guidance on land use planning and design flood selection for mitigation works. It will also discuss how the guidelines will work with AEM Handbook 7 to inform flood risk management practice across Australia.

Introduction

Flooding is a natural phenomenon that occurs when water covers land that is usually dry. Flooding can have devastating impacts upon communities.

The *National strategy for disaster resilience*, adopted by the Council of Australian Governments on 13 February 2011 recognised that a national coordinated and cooperative effort is required to enhance Australia's capacity to withstand and recover from emergencies and disasters. A disaster resilient community is one that works together to understand and manage the risks it confronts. Disaster resilience is the collective

responsibility of all sectors of society, including all levels of government, business, the non-government sector and individuals. If all these sectors work together with a united focus and a shared sense of responsibility to improve disaster resilience, they will be far more effective than the individual efforts of any one sector.

Effective flood risk management can enable a community to become as resilient as practical to floods. This is achieved through planning and preparing for, responding to and recovering from floods. This requires a coordinated multidisciplinary approach and the active engagement of the community as outlined in Australian Emergency Management (AEM) *Handbook 7: Managing the floodplain: best practice in flood risk management in Australia (AEMI 2013)*.

AEM Handbook 7 provides guidance on best practice principles as presently understood in Australia. The term 'best practice principles' is used in its broadest sense to mean the underlying principles that need to be considered when formulating floodplain management plans, leading to effective and sustainable land use across Australia's floodplains. *AEM Handbook 7* and the completed technical guidelines and specifications discussed in this paper are available at: https://ema.infoservices.com.au/collections/handbook

Best Practice as outlined in AEM Handbook 7

Occupation of floodplains, whether due to the legacy of former decisions or as a result of future decisions comes with an inherent risk. Best practice promotes the consideration and, where necessary, management of flood impacts to existing and future development within the community. It aims to improve community flood resilience using a broad risk management hierarchy of avoidance, minimisation and mitigation to: reduce the health, social and financial costs of occupying the floodplain; increase the sustainable benefits of using the floodplain; and improve or maintain floodplain ecosystems dependent on flood inundation.

AEM Handbook 7 outlines that achieving best practice relies upon:

1. Developing clear and sustainable governance arrangements for managing flood risk.
2. Making information on flood risk readily available to inform decisions.
3. Understanding flood behaviour and risk.
4. Understanding and maintaining the natural floodplain functions.
5. Managing risk to improve community resilience to flooding, and manage growth of this risk due to development, and future changes to floodplain topography and climate.

Flood Risk Management Framework

The flood risk management framework (Figure 1) links the understanding of flood risk on a floodplain or catchment scale to its management via government floodplain management entities (FMEs). It provides a robust, fit-for-purpose approach that provides flexibility for FMEs with different levels of resources and information, to manage flood risk and work to improve their knowledge and management practices considering the scale and complexity of the flood threat faced by their community.

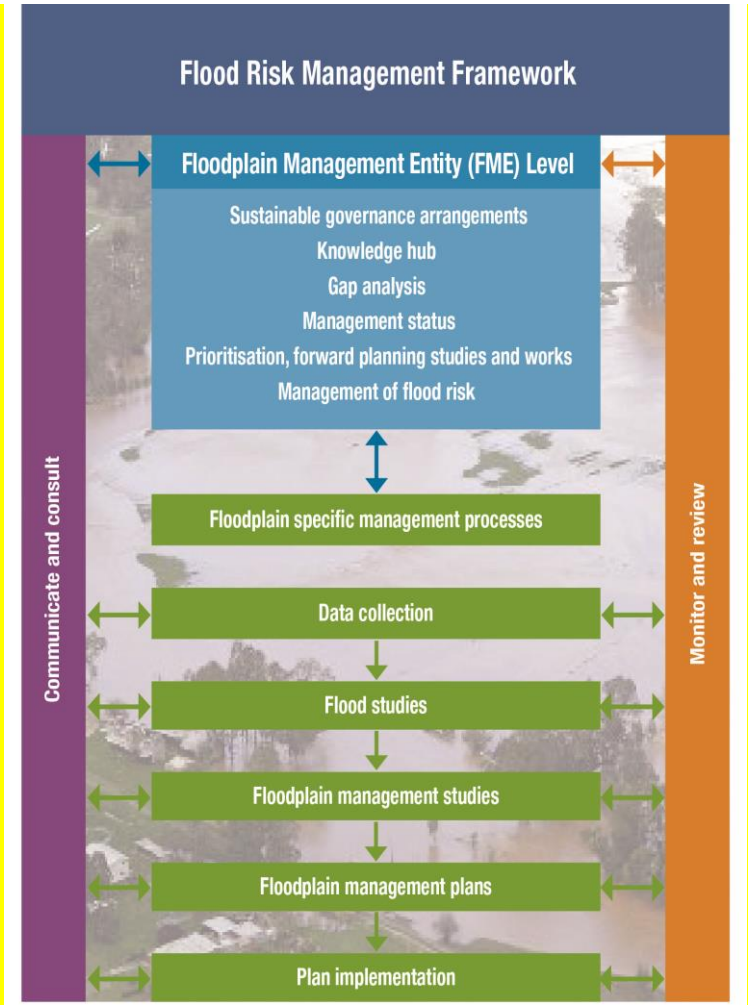

Figure 1: Flood Risk Management Framework (Source *AEM Handbook 7 Figure 3.1*)

Completed Guidelines

To support this *AEM Handbook 7* NFRAG has recently completed the development of the provision of practical guidance to assist management of flood risk in relation to:

- *Technical flood risk management guideline – Flood hazard (AEMI 2014c)*. This helps inform the breakdown of the floodplain into areas where hazard may require different management responses. This is dealt with in a paper *Smith, McLuckie (2015)* at this conference and replaces guidance in SCARM (2000).
- *Technical flood risk management guideline – Flood emergency response classification of the floodplain (AEMI 2014b).* This provides a basis for breaking down the floodplain into different flood emergency response classifications so that this can be considered in management. A short précis is provided in this paper.
- *Technical project brief template for flood investigations (AEMI 2014d).* This provides a starting point for developing a project brief for a specific study. It is designed to be used in association with the guideline discussed below. This paper provides a short outline of the scope of the technical project brief.
- *Guideline for using the national generic brief for flood investigations to develop project specific specifications (AEMI 2014 a).* This provides advice on where to start when you want to do a flood investigation and helps to scope the project using the technical project brief.

Identifying Differences in Isolation by Floodwaters

Flooding can isolate parts of the landscape and cut-off routes to evacuation centres on flood-free land (above the probable maximum flood, PMF, which provides an estimate of the upper limit of the scale of flood behaviour for a location). This can result in a dangerous situation, because people may see the need to cross floodwaters to access services, employment or family members. Many flood fatalities result from the interaction of people, often in vehicles, with floodwaters. Any situation that increases people's need to cross floodwaters increases the likelihood of an injury or fatality.

Technical flood risk management guideline – Flood emergency response classification of the floodplain (AEMI 2014) was developed to provide advice in this area for a national audience building upon the work of Steve Opper (Opper et al 2000), guidance in NSW (DECC 2007) and had significant input from the NSW SES in relation to the categorisation. The terminology used in the guide is different from that used in NSW as it reflects national consensus on terminology. However, the use of existing terms is not discouraged by the guide.

Classification provides the basis for understanding the varying nature, seriousness and scale of isolation problems. Classification can be used with information on the full range of flood risk, local topography and evacuation routes, the rate of rise of floodwaters, the effective warning time and the duration of isolation, to support management decisions in emergency management, flood risk management and land use planning.

Classification is undertaken at three levels.

- Primarily classification concentrates on whether the area is flooded by the probable maximum flood, or a similar extreme event. For those areas that are flooded:
    - Secondary classification examines whether or not a community or precinct area has an exit to community evacuation facilities in a flood-free area outside the broader floodplain during a flood event.
    - Tertiary classification relates to the potential consequences of flooding on the area and any limitations of available evacuation routes.

For areas that are not flooded, there is no secondary classification, and the tertiary classification relates to whether there are any indirect consequences on the area.

The overall classifications are defined and shown in Table 1.

Figure 2 provides a flowchart to assist in determining flood emergency response classifications of different areas (generally communities or precincts) on the floodplain, based upon the probable maximum flood (PMF) or a similar extreme flood. Where classifications are retrofitted to existing studies and information on the PMF or a similar extreme flood is not available the flow chart can be used by reading PMF as 'largest available flood'. However, such classifications should be clearly indicated as '***preliminary based upon the largest flood available***' and used with caution as discussed in Section 3.2 of *Technical flood risk management guideline – Flood emergency response classification of the floodplain*.

Figure 3 is a map showing the location of some of these categories in an example floodplain. *Figures 2 to 8 of AEMI (2014b)* provides diagrammatic examples of these categories.

Table 1 Flood emergency response classifications (Extract from Table 1 *Technical Flood risk management guideline – Flood emergency response classification of the floodplain AEMI 2014*)

Primary classification	Description	Secondary classification	Description	Tertiary classification	Description
Flooded (F)	The area is flooded in the PMF	Isolated (I)	Areas that are isolated from community evacuation facilities (located on flood-free land) by floodwater and/or impassable terrain as waters rise during a flood event up to and including the PMF. These areas are likely to lose electricity, gas, water, sewerage and telecommunications during a flood.	Submerged (FIS)	Where all the land in the isolated area will be fully submerged in a PMF after becoming isolated.
				Elevated (FIE)	Where there is a substantial amount of land in isolated areas elevated above the PMF.
		Exit Route (E)	Areas that are not isolated in the PMF and have an exit route to community evacuation facilities (located on flood-free land).	Overland Escape (FEO)	Evacuation from the area relies upon overland escape routes that rise out of the floodplain.
				Rising Road (FER)	Evacuation routes from the area follow roads that rise out of the floodplain.
Not Flooded (N)	The area is not flooded in the PMF			Indirect Consequence (NIC)	Areas that are not flooded but may lose electricity, gas, water, sewerage, telecommunications and transport links due to flooding.
				Flood Free	Areas that are not flood affected and are not affected by indirect consequences of flooding.

Notes:

1. Classifications are based upon the probable maximum flood (PMF) or a similar extreme flood, if the PMF is not available. Where classifications are being retrofitted to areas covered by existing studies and the PMF or a similar extreme flood is not available, and a decision is made to not estimate or approximate an extreme event, classifications should be clearly indicated as 'Preliminary based upon the largest flood available'.
2. Isolated areas may also be known as:

- flood islands, where areas are isolated solely by flood waters. Where flood islands are completely submerged in the PMF, these may be called low-flood islands. Where flood islands have elevated areas above the PMF, they may be called high-flood islands.
- trapped perimeter areas, where areas are isolated by a combination of floodwaters and impassable terrain. Where trapped perimeter areas are completely submerged in the PMF, these may be called low-trapped perimeter areas. Where trapped perimeter areas have elevated areas above the PMF, they may be called high-trapped perimeter areas.

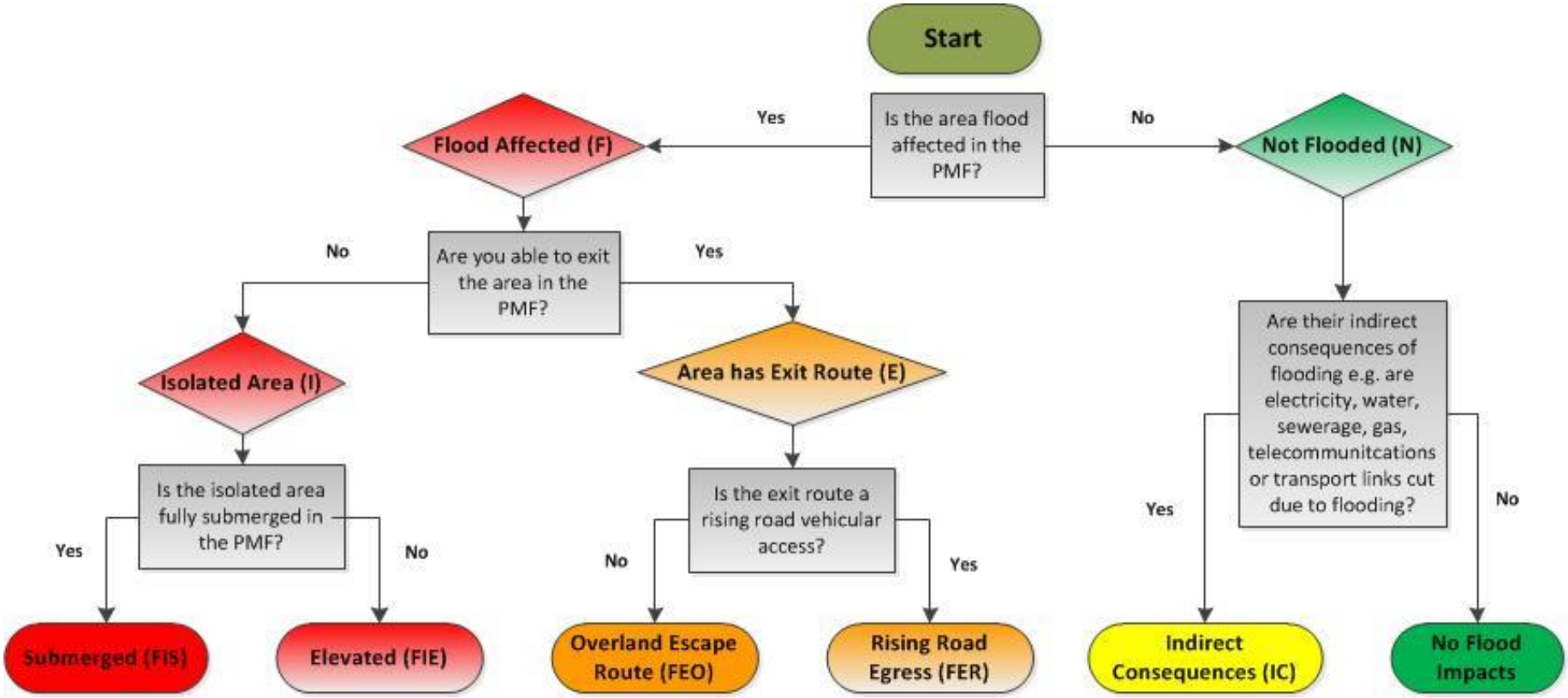

Figure 2 Flow chart for determining flood emergency response classifications (Reproduction of Figure 10 from the Technical Flood risk management guideline – Flood emergency response classification of the floodplain AEMI 2014)

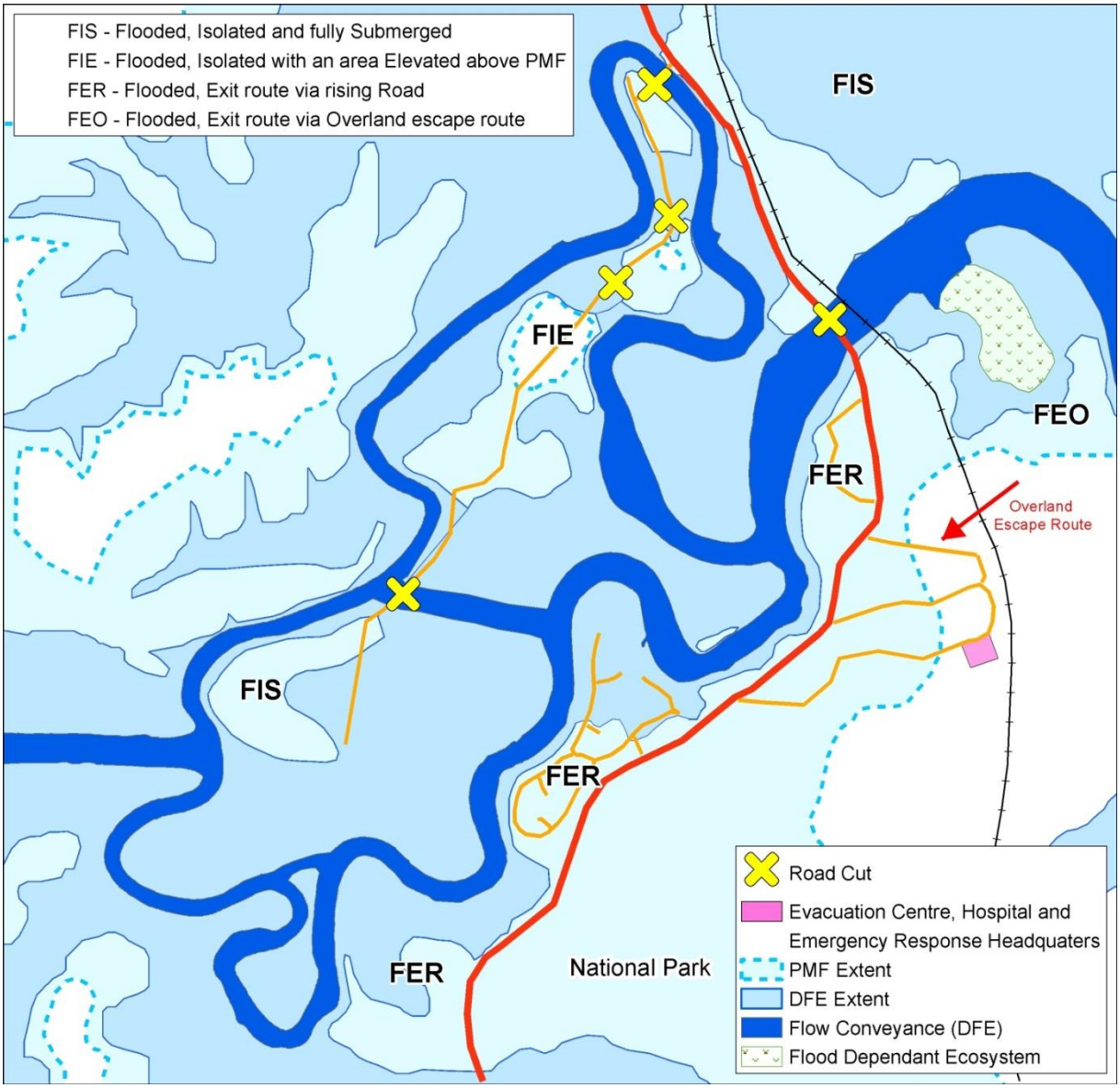

Figure 3 Map of floodplain showing examples of some classifications (Reproduction of Figure 9 from the Technical Flood risk management guideline – Flood emergency response classification of the floodplain AEMI 2014)

Technical Specifications for Flood Investigations

Effective management of flood risk requires a coordinated, multidisciplinary approach across all levels of government and between agencies with different responsibilities along with the support of a range of non-government organisations and industry professionals in a range of activities and fields, as well as the active engagement of the community.

A key step in flood risk management is the completion of studies that improve our knowledge of flood risk, and provide a basis for assessing and making decisions on options to treat flood risk. Technical specifications form the basis of completing this work.

NFRAG led the development of both *AEMI 2014a and AEMI 2014d.* When used together, this guideline and the associated national best practice generic brief provide a consistent basis for the development of specifications for flood investigations, in consideration best practice principles from AEM Handbook 7. NFRAG has agreed to bring back advice on lessons learnt in their use so that these can be improved over time.

The brief and guideline provide advice on specifying projects to manage flooding within the floodplains and catchments of waterways, due to: catchment flooding from prolonged or intense rainfall; coastal flooding due to tidal- or storm-driven coastal events, including storm surge, in lower coastal waterways and combinations of these sources in the lower portions of coastal waterways, where both can be produced by the same storm or a series of storms.

The technical specification was set up to provide flexibility for specifying studies dealing with small and large communities and with simple and complex flood situations in consideration of the needs of the different end users of flood information. This is consistent with the *National Strategy for Disaster Resilience* and *AEM Handbook 7*, with the latter promoting access to information for improved decision making and fit for purpose approaches.

The generic technical brief covers the development of floodplain management plans and the linkage of these into relevant government floodplain management entity (FME), and the information systems and decision-making processes, identified in the flood risk management framework (see Figure 1). The approach aims to provide flexibility in study objectives and deliverables, the scope of investigations and methodology considering the needs of end users, the type and scale of the flood problem, and the available data. The brief does not cover general tendering or contractual matters.

The guidance document that assists FMEs to develop project-specific technical briefs from the generic brief aims to deliver the outcomes needed for the end users of the project. It does include some guidance on contractual and tendering matters that can be neglected. These include: intellectual property issues, which can limit the availability of information to the range of potential end users; handover of models and deliverables; and the recommendation to include a clear statements from the tenderer on any limitations of proposals to meet the full requirements of the brief.

The generic brief and this guidance document are a package and should be read together. The brief can be applied or adapted to the management of floods in urban and rural areas, including water flowing overland through urban areas to waterways. Its use with different flood problems should consider the different issues to be addressed, for example:

- Local overland flood catchments respond quickly to rainfall and often have ill-defined flow paths that may follow roads, go through private property, or be inhibited by buildings and fences. These may need specific requirements in the brief.
- In rural floodplains, the scale of flood-dependent ecosystems and agricultural activity means that environmental issues, flood duration (resulting in crop losses) and maintenance of flow to these areas are important issues that may need specific requirements within the brief.

The development of the brief and guideline examined end user needs (from flood risk managers, emergency response managers, hydrologists doing flood predictions, strategic and development control planners, strategic decision makers, insurers, and the community) to the types of outputs generally available from studies using different modelling techniques to examine different types of flood problems (from simple to

complex) and the scale of the community at risk (small to large). A key difference between end user needs from studies was found to be whether the flood emergency response managers required sophisticated logistical information due to the scale of the evacuation problem relative to the time available to undertake the evacuation (*Babister et al 2014*).

The technical specification is broken down into the following sections:

1. *Introduction.* This section outlines who is funding the study and where it is being undertaken and provides high level advice on why the study is being undertaken. For example in NSW this may relate to the NSW Flood Prone Land Policy and Floodplain Development Manual (DIPNR 2005).

2. *Objectives of the study.* This section aims to state what the project will achieve within the study area and how this broadly fits within flood risk management in the floodplain management entity (FME) service area. These may include aspects such as better understanding of the: flood behaviour in the area; impacts of a range of flood events on the community; flood risk in the study area; and the effectiveness of current management measures. They also include facilitating information sharing on flood risk across government and with the community.

   It also aims to identify the key end users of the information from this study, such as:
   - High-level strategic decision makers (including elected officials)
   - Community
   - Flood risk management professionals
   - Engineers involved in designing, constructing and maintaining mitigation works
   - Emergency management planners
   - Land use planners (strategic planning and development control planning)
   - Hydrologists and meteorologists involved in flood predictions and warnings
   - Insurers

3. *Background and Study Area.* This section provides for descriptions of the study area, the catchment, the political context of the study area, flood behaviour and history, discussion of the impacts of flooding on the community and the flood emergency management problem. It also enables the FME to outline any software preferences for deliverables, and how the outcomes from the study are to be used.

4. *Available information*. This section provides a series of tables to complete to reference relevant information for use in the study, a brief description of these and outlining their accessibility for both tendering and the project. If information is openly available for review during the tender period, particularly electronically, this ensures that it can be more effectively considered by the consultant in preparing their proposal. The tables provide for summaries of previous studies, local policies and emergency management plans, available data (e.g. historic flood information, stream gauges, survey, GIS layers, hydrologic and hydraulic models) and to outline other organisations that may have relevant data.

5. *Current Guidance and References*. This section enables reference to current guidelines, manuals and reference documents that are to be considered or adhered to during the study. Table 2 provides a sample for a flood study in NSW.

Table 2 Guidelines and reference documents – NSW Sample

Reference	Source/Link	Comment
National		
Australian Emergency Management Handbook Series, *Managing the floodplain: A guide to best practice in flood risk management in Australia* – AEM Handbook 7	https://ema.infoservices.com.au/items/HB7-2ND	Adhere
Australian rainfall & runoff (ARR; this includes the current version of ARR and specific advice published on the ARR website, such as Project 18 – Interaction of coastal processes and severe weather events and Project 11 – Blockage of hydraulic structures)	http://www.arr.org.au/revision-projects/project-list/	Adhere
Australian Emergency Management Handbook Series, *AEM Handbook 7, supporting document* Technical flood risk management guideline – Flood Hazard	https://ema.infoservices.com.au/items/HB7-2ND	Adhere
Australian Emergency Management Handbook Series, *AEM Handbook 7, supporting document* Technical flood risk management guideline – Flood Emergency Response Classification of Communities	https://ema.infoservices.com.au/items/HB7-2ND	Consider
New South Wales		
Section 733 of the Local Government Act, 1993		Adhere
NSW Government's *Floodplain Development Manual – the management of flood liable land*, April 2005, incorporating the NSW Flood Prone Land Policy.	http://www.environment.nsw.gov.au/floodplains/manual.htm	Adhere
Floodplain Risk Management Guidelines	http://www.environment.nsw.gov.au/floodplains/StandardFloodplainRiskManagement.htm	
Floodway Definition		Consider
Flood Emergency Response classification of communities		Consider
SES requirements from floodplain risk management process		Consider
Practical consideration of climate change		Consider
Modelling reports and supporting information (including model files) for review		Adhere
NSW OEH Data Handover requirements		Adhere
LPMA Standard LiDAR Product Specifications (Including RCD105 Imagery) Version 2.0	Copy available from OEH on request	Adhere

6. *Scope of Work.* The scope of work depends upon the study and what it aims to achieve. The guideline aims to assist in the scoping of work by informing decision making by stepping through a series of sections that, depending upon the objectives of the study, may or may not form part of the scope of work. These sections include:
   - data collection,
   - site visit,
   - consultation considering the different types of consultant that may be needed at different points of a project (Table 3 provides an example),
   - flood behaviour analysis (include hydrology and hydraulic modelling),
   - specifying modelling events (Table 4 provides an example),
   - model calibration and verification,
   - assessment of flood function and flood hazard
   - identification and assessment of management options
   - flood emergency management aspects
   - flood damage assessment
   - land use planning controls for floods
   - One of the key elements in reporting will be limitations of studies in terms of where results are applicable and what the results are fit for purpose to achieve.

Table 3 Example - Consultation points and tools

Consultation Point	Consultation tools	Comment/aim
Project initiation	newsletter, media release	Inform community of study and ask for information on flooding
Progress update – 6 monthly	newsletter	Inform community of progress
Community feedback on calibrated modelling behaviour for key historic events	newsletter, media release, mapping	Provide community members the opportunity to feedback on whether modelled behaviour matches their recollections
Public Exhibition	newsletter, media release, workshops by registration	Allow for final input from the community into the study
Study Finalisation	newsletter, media release	Inform community of study completion

Table 4 Example - Flood events/conditions to be assessed

Scenario ID	Scenario Type	Event Description/Information
1	Historical calibration/ validation flood events – historic conditions	[Month, year]
2	Design flood events existing conditions	[Events]
3	Design flood events fully developed for permissible land uses	[Events]
4	Design flood event to test climate change sensitivity	[Events]
5	Design events for levee assessment	[Events]
6	Design events for assessment of proposed works	[Events]
7	Design events for model parameter sensitivity analysis	[Events]
8	Design events for assessment of flood hazard	[Events]
9	Design events for assessment of flood function	[Events]
10	Design events for assessment of management measures	[Events]

7. *Deliverables.* This section outlines both the materials that are expected to be delivered from the project (see example in Table 5) and their format. This specifically allows for electronic delivery of mapping beyond the extent of the mapping included in the report.

8. *Timings and hold points.* Outlines the timeframes of different stages of the project and the hold points that require a decision prior to the consultant proceeding past a point.

9. *Meetings.* Outlines the type, purpose and number of different types of meetings, their location and the expectation of the consultant at these meetings.

Other aspects to consider.

- Tendering requirements and assessment need to be included. One item to consider is explicitly asking the consultant to outline any limitations their proposal may have in meeting the objectives and any specific end user needs requirements outlined in the project scope.
- General and special contract conditions. Need to be included.
- Intellectual property. This is an important aspect to ensure that the primary IP rests with the floodplain management entity (FME) and not the consultant and to enable others to access study outputs (both reports and spatial layers in hardcopy and electronically in formats that enable ready digestion by relevant spatial databases) to inform decision making of end users. IP of all models and other input data should rest with the FME but under a more restrictive licence allowing the FME to control and condition access and usage.

Table 5 Example - Output deliverables

Deliverable	Specifics	Comment	Format
Data to Meet OEH Data Handover Requirements	Meet all requirements	To support NSW Flood Database and OEH backup of all data	Various
Processed model results study area wide	maximum water level, water depth, velocity, hazard	For design events	GIS layers (grid) and figures (A3)
	flood extents	For design events	GIS layers (polygons) and figures (A3)
	flood planning area		GIS layers and figures
	flood function	Floodways and flood hazard for specified events	GIS layers and figures
	flood emergency response classification maps	For the floodplain	GIS layers and figures
Model results specific locations	Level, depth, flow velocity, rate of rise, inundation time locations	For design event(s)	Graphs/Figures and tables
	Levels/AEP at which properties affected		Tables and figures
Model DEM		Consistent with model results	GIS layers and figures
Visualisation/ Animations	whole study area	For selected design events	Able to run independently
Report	Final report		5 hard copies, 1 electronic
	Figures of flood layers	A3 overlaid on cadastral map or aerial photography, include legend	
Flood data	e.g. collected historical information	All data to be summarised and handed over	Electronic copy of all data
Model and Model set-up/log files	To enable third parties to rerun and recreate results.	Third party would need to acquire software licence	Electronic

Continuing work on Guidance

NFRAG is continue to develop guidance with work commencing on guidance on selection of design floods for mitigation works and land use planning advice for flood risk management including selecting designated flood events and determining flood planning areas. In addition a literature review is about to commence on techniques that may be relevant to assessing potential fatalities from floods. A short outline of the intent of this new work is provided below.

Selection of design floods for mitigation works

Best practice flood risk management supports the practical management of flood risk which may involve the implementation of mitigation works to reduce risk. This project aims to provide advice on how to compare different design floods and select a design flood and determine a level of service for mitigation works that protect a community or a key infrastructure project.

Planning advice

Best practice in flood risk management supports informed decision making based upon the best available information and making efforts to improve this information where required. *Babister et al* (FMA Conference 2013) outlines a number of different degrees of sophistication of current approaches and practices for land use planning. These approaches each require different levels of sophistication of information on flood risk to inform decision making.

The intent of the project is to provide advice on how fit for purpose flood risk management can be effectively considered in planning schemes through: support for strategic and development scale land use planning early in the floodplain management process; influencing strategic planning (at a jurisdictional, regional and local level as appropriate) and inform development control planning; support for different approaches (risk based and general design standard approaches) to manage flooding; the need to consider the impacts of development of different areas of the floodplain on flood behaviour, impacts on development due to flood behaviour, the variation in hazard and emergency response issues across the floodplain and variation in risk factors (including risk to life) across the floodplain

Conclusion

AEM Handbook 7, guidelines on hazard and flood emergency response classification, and national technical specifications and the associated specification development guidelines are now complete and available through the AEMI website at: https://ema.infoservices.com.au/collections/handbook. These documents aim to provide the basis for best practice is flood risk management in Australia. *AEM Handbook 7* has been designed to be able to be used by jurisdictions in conjunction with administrative and technical guidance.

NFRAG is continuing to work on improving practice by developing practical guidelines to support the effective management of flood risk when using *AEM Handbook 7*, where desired, as part of the policy framework for flood risk management in individual States and Territories as outlined in this paper.

The current guidance being developed is scheduled to be completed in 2015 and will then be made available on the web with a linkage to *AEM Handbook 7*.

At this stage NFRAG has not applied for additional funding under the National Emergency Management Program to continue development of guidance in 2015-16. Development of additional guidance to support AEM Handbook 7 will be further considered in the future.

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