Australian Disaster Resilience Handbook Collection

GUIDELINE 7-5

Flood Information to Support Land-use Planning

Australian Institute for Disaster Resilience

AUSTRALIAN DISASTER RESILIENCE HANDBOOK COLLECTION

Flood Information to Support Land-use Planning

Guideline 7-5

This guideline is supported by Practice Note 7-7

Supporting document for the implementation of *Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia* (AIDR 2017)

Australian Government
Attorney-General's Department

Edited and published by the Australian Institute for Disaster Resilience, on behalf of the Australian Government Attorney-General's Department.

Editing and formatting by Biotext, Canberra.

Copyright

Attribution

Where material from this publication is used for any purpose, it is to be attributed to the developer as follows:

Source: Australian Disaster Resilience Guideline 7-5 Flood Information to Support Land-use Planning (AIDR 2017).

Using the Commonwealth Coat of Arms

The terms of use for the Coat of Arms are available from the **It's an Honour** website (http://www.dpmc.gov.au/government/its-honour).

Contact

Enquiries regarding the content, licence and any use of this document are welcome at:

The Australian Institute for Disaster Resilience
370 Albert St
East Melbourne Vic 3002
Telephone +61 (0) 3 9419 2388

Disclaimer

The Commonwealth Attorney-General's Department and the Australian Institute for Disaster Resilience, in consultation with emergency management professionals and subject matter experts, exercise care in the compilation and drafting of this publication; however, the document and related graphics could include technical inaccuracies or typographical errors and the information may not be appropriate to all situations.

In no event shall the Commonwealth of Australia (acting through the Attorney-General's Department) or the Australian Institute for Disaster Resilience be liable for any damages whatsoever, whether in an action of contract, negligence or other tortious action, arising out of, or in connection with, the use of or reliance on any of the information in this publication.

Handbook 7 Collection

Handbook 7

Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia

Guideline 7-1

Using the National Generic Brief for Flood Investigations to Develop Project Specific Specifications

For use with Template 7-4

Guideline 7-2

Flood Emergency Response Classification of the Floodplain

Guideline 7-3

Flood Hazard

Template 7-4

Technical Project Brief Template

For use with Guideline 7-1

Guideline 7-5

Flood Information to Support Land-use Planning

For use with Practice Note 7-7

Guideline 7-6

Assessing Options and Service Levels for Treating Existing Risk

Practice Note 7-7

Considering Flooding in Land-use Planning Activities

For use with Guideline 7-5

Acknowledgements

This guideline was developed by the National Flood Risk Advisory Group (NFRAG), a reference group of the Australia – New Zealand Emergency Management Committee (ANZEMC) under the leadership of Duncan McLuckie (NSW Office of Environment). NFRAG members, the project working group, Angela Toniato (NSW Office of Environment and Heritage) and staff from the consultancy WMAwater Pty Ltd all made significant contributions to the guideline.

NFRAG membership during development included:

- Chair and New South Wales—Duncan McLuckie, NSW Office of Environment and Heritage
- Australian Capital Territory—Tracey Allen, ACT Emergency Services
- Northern Territory—Lakshman Rajaratnam, NT Department of Land Resource Management
- Queensland—Susan Mercer Nightingale, Qld Department of Infrastructure, Local Government and Planning
- South Australia—Chrissie Bloss, SA Department of Environment, Water and Natural Resources
- Tasmania—Chris Irvine and Andrew Lea (former chair and representative), Tasmania State Emergency Service
- Victoria—Michael Edwards, Vic Department of Environment, Land, Water and Planning
- Western Australia—Simon Rodgers, WA Department of Water
- Australian Government—Attorney-General's Department, Bureau of Meteorology and Geoscience Australia
- Australasian Fire and Emergency Service Authorities Council, and Australian Council of State Emergency Services—Kate White, Victoria State Emergency Service
- Australian Buildings Code Board—Ron de Veer
- Australian Local Government Association—Ian Dinham, President, Floodplain Management Australia
- Insurance industry—Karl Sullivan, Insurance Council of Australia
- Research community—Richard Thornton, Bushfire and Natural Hazards Cooperative Research Centre
- Risk Assessment, Measurement and Mitigation Sub-committee (RAMMS)—Andrew Sanders, representative.

This project was made possible by the financial contributions of the Australian Government Attorney-General's Department through the National Emergency Management Projects program. The NSW Office of Emergency Management assisted NFRAG by administering this grant on its behalf. The RAMMS oversight for this project was provided by Malcolm Cronstedt of the Western Australian State Emergency Management Committee.

Contents

List of Figures

List of Tables

This page is intentionally left blank

1 Introduction

Exposing the community and the built environment to the hazardous conditions caused by flooding creates a flood risk. *Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia* (ADR Handbook 7) (AIDR 2017), identifies the essential role of land-use planning activities in limiting the growth in flood risk because of new land uses and development in the floodplain.

ADR Handbook 7 outlines the floodplain-specific management process. The process provides the basis for understanding how flood behaviour and the factors that influence flood risk vary across the floodplain, between floods of different sizes, and to the community and the built environment. Effective and ongoing interaction and dialogue between floodplain managers, emergency managers and land-use planners will enable land-use planning activities to effectively consider flood risk to the benefit of the community.

ADR Handbook 7 recommends using the best available information to manage flood risk at all times. By considering the constraints flooding places on land early in the planning process:

- development can be steered towards land that is less exposed to flooding and has more manageable flood-related constraints
- development on land can be discouraged if it may alter flood behaviour, or if flood-related constraints may be difficult or impractical to manage.

This relies on access to reliable and timely flood information. Therefore, if a flood study contains relevant flood information, there is no need to wait until investigations into flood mitigation options are complete before this information is used to inform land-use planning activities.

The outputs of flood studies are often complex, which can inhibit clear communication on how flood-related constraints may interact and vary across the floodplain. This guideline provides a basis for a simplified grouping of this information into flood planning constraint categories (FPCCs) to better inform land-use planning activities rather than to use directly in land-use planning systems (Figure 1). This information includes a single map (or map series) outlining FPCCs and information on the implications of flooding in the different FPCCs.

This guideline supports community- or precinct-scale decisions where flow paths and flood extents can readily be defined. It was not developed to support consideration of changes in land use or development at the site scale.

This guideline is not intended to convey the message that potential development should be condoned if the key considerations in the guide are managed. Each jurisdiction will have different policies and approaches in place that govern land-use planning and development, involving a mix of land-use zoning, specific policies, and planning and building controls. Depending on the policies of each jurisdiction, procedures may apply at a jurisdictional, regional or local level, and complement land zoning and/or local planning policies. Generally a decision to allow development in an area with flood-related constraints will require the entity responsible for land-use planning in the area to consider how to address flood risk, and whether land with less flood risk or constraints is available and more suitable for development.

When using this guideline, ensure that the results are fit for the intended purpose. Particular care should be taken where the difference in flood levels, between the defined flood event and the probable maximum flood, or an equivalent extreme event, is significant. Where this is the case, additional care is needed when examining emergency management considerations.

1.1 Outline of this guideline

This technical guideline is broken down into the following sections:

- **Section 1** outlines the guideline and its relationship to ADR Handbook 7, other guidelines and the associated practice note.
- **Section 2** outlines how to develop FPCC mapping.
- **Section 3** identifies typical high-level floodplain management objectives, and provides examples of typical treatment options to address these objectives in different FPCCs.
- **Section 4** provides information on both the potential use of developments in community response to floods and the relative vulnerability of land uses and their users to flooding.
- **Section 5** discusses how this information should be reported in studies.
- **Appendix A** includes examples of how to derive FPCC mapping.

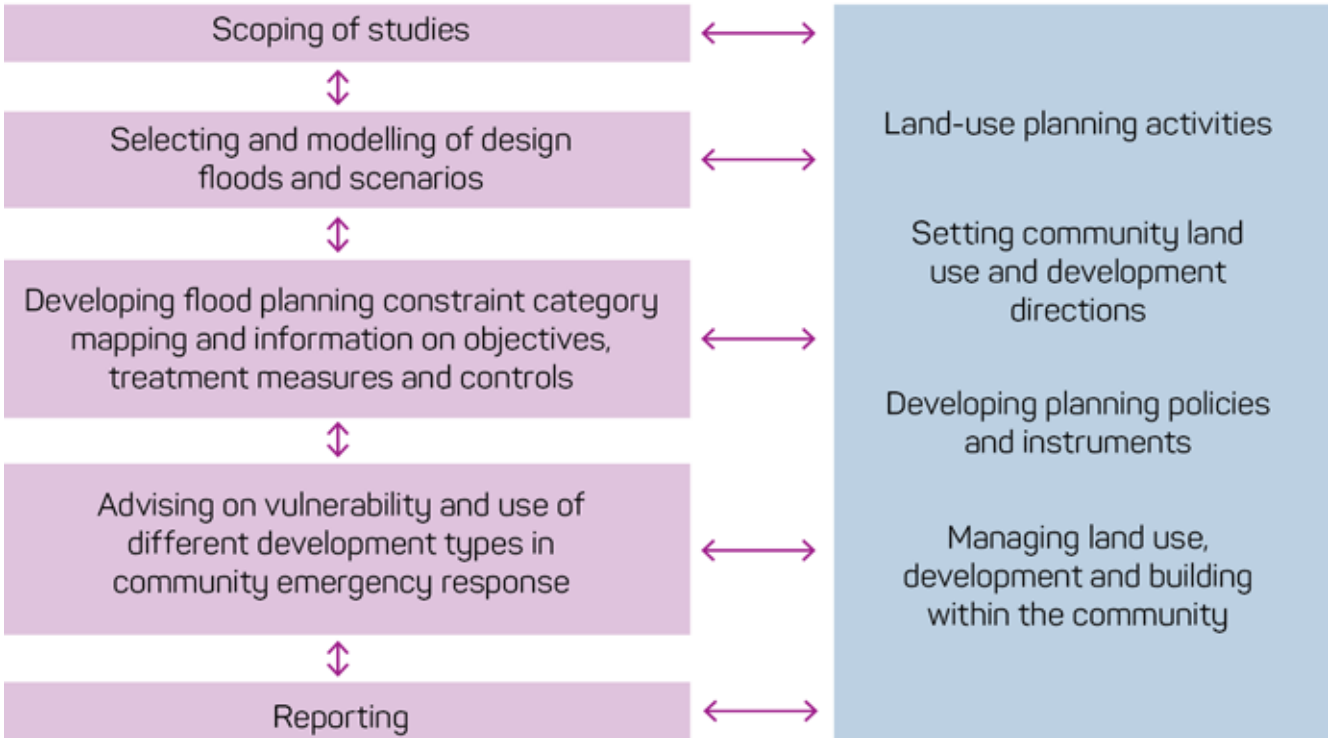


Figure 1: Development of flood information to support land-use planning activities

- **Appendix B** includes a simple example of the information that can be provided in a report, consistent with this guideline.
- **Appendix C** provides examples of how this information can be used to inform land-use planning activities.

1.2 Definitions

The majority of definitions used in this guideline can be found in ADR Handbook 7. However, the following terms relate to this guideline:

- **Land-use planning activities** inform the development of strategic directions for community growth, and the implementation of such directions through land-use planning and building control systems that enable the management of land use, development and buildings.
- **Flood-related constraints** are the constraints that flood behaviour or its management may place on an area of land.
- **FPCCs** group similar types and scales of flood-related constraints to support land-use planning activities.

1.3 Use with other guidelines

Australian Disaster Resilience Practice Note 7-7 Considering Flooding in Land-use Planning Activities (AIDR 2017) has been developed to outline how to use this guideline. The practice note and the guideline should be shared with land-use planning, floodplain management and emergency management practitioners.

The floodplain-specific management process can provide the basis for gathering the information necessary to inform land-use planning activities and decisions. To ensure that the information from studies includes the requirements of this guideline, include it as a deliverable in the scope of relevant flood studies. ADR Handbook 7, supporting technical guidelines and the following documents provide a sound starting point for specifying studies to support a range of floodplain management activities and meet the needs of a variety of end users:

- *Australian Disaster Resilience Template 7-4 Technical Project Brief Template* (AIDR 2017)
- *Australian Disaster Resilience Guideline 7-1 Guideline for Using the National Generic Brief for Flood Investigations to Develop Project Specific Specifications* (AIDR 2017).

ADR Handbook 7 and the associated guidelines are available for free download at **www.knowledge.aidr.org.au.**

2 Flood planning constraint categorisation

Factors that can influence flood behaviour and, subsequently, flood risk in a particular location include:

- sources of flooding
- catchment and floodplain size, shape and topography
- catchment and floodplain vegetation
- development within the catchment and the floodplain
- storm types that cause flooding
- varying sizes of storm events
- catchment and floodplain conditions before an event
- mitigation measures in place to reduce flood risk
- ocean and outlet conditions in coastal waterways.

A comprehensive technical investigation of flood behaviour provides an understanding of how these factors influence flooding for a range of flood events. This provides the basis for understanding existing flood behaviour in view of how flooding is currently managed. It can also provide an understanding of how flood behaviour may alter based on future catchment conditions (Section 2.7).

2.1 Flood planning constraint categories

Flood investigations typically produce a large number of maps, each focusing on a particular design event and element of the flood behaviour. Collectively, they provide a very detailed description of the flood behaviour and the issues that are important in different areas of the floodplain. Studies help to understand the following elements of flooding:

- how flood extents vary for a range of flood events (Section 2.2)
- how flood function varies within the floodplain (Section 2.3)
- how flood hazard varies within the floodplain (Section 2.4)
- how flood behaviour varies across the range of flooding and how this influences constraints on emergency management (Section 2.5).

This information relies on understanding the full range of flood behaviour and how it interacts with the landscape, transport links and key infrastructure facilities. Sources of this information are discussed in Section 2.6.

Considering flood behaviour during land-use planning activities can provide a sound basis for decisions, such as whether the land is suitable for more intense use or development, thus possibly limiting the development capability of the land. Where the land is considered suitable for development, understanding flood behaviour can inform the type of development suitable for the location, and the development and building controls necessary to limit an increase in flood risk because of the development. This information can steer development to areas where flooding can be more readily managed, and development is more compatible with flood behaviour and hazard. This can make the future community more resilient to flood risk.

However, combining these elements of flood behaviour can produce a succinct set of information that breaks the floodplain down into areas with similar degrees of constraint. These FPCCs can better inform and support land-use planning activities. FPCCs identify where flood-related constraints (or the tools used to manage these constraints) can be treated similarly in land-use planning activities.

Four FPCCs have been developed to separate areas of the floodplain from the most constrained (and therefore least suitable for intensification of land use or development—FPCC1), to the least constrained (and therefore more suitable for intensification of land use or development—FPCC4).

Where considered necessary, FPCC subcategory mapping can provide a further breakdown of FPCC1 and FPCC2. This may be useful when intensifying use or development on land within these highly constrained categories cannot be avoided and is being considered. It can provide a clearer understanding of the specific flood-related constraints and associated risk management considerations relevant at specific locations within these FPCCs. Base-element mapping

(Sections 2.2–2.5) can also provide valuable information in these circumstances.

Table 1 provides a recommended breakdown of these categories, and advice on the implications and key considerations when developing different FPCCs. Although this includes a breakdown on FPCC1 and FPCC2 into subcategories, these should be combined when developing FPCC mapping.

The way in which this information is developed and used in decision-making can vary between jurisdictions. For example, flood hazard H5 in the defined flood event (DFE) may be placed into FPCC1 rather than FPCC2 in some jurisdictions. (See Section 2.4 for information about flood hazard categories.) Elements within each FPCC may also vary depending on the flood situation—for example, if flood storage does not influence flood behaviour, it will not influence flood categorisation.

Table 1: Flood planning constraint categories

FPCC	Constraint	Implications	Key considerations	Subcategory
1	Flow conveyance and storage areas in the DFE	Development or changes to topography within flow conveyance areas and flood storages areas affect flood behaviour, which will alter flow depth or velocity in other areas of the floodplain. Changes can negatively affect the existing community and other property	The majority of developments and uses have adverse impacts on flood behaviour. Consider limiting uses and development to those compatible with maintaining flood function	a
	H6 hazard in the DFE	Hazardous conditions considered unsafe for vehicles and people. All building types are considered vulnerable to structural failure	The majority of developments and uses are vulnerable to failure in this flood hazard category. Consider limiting developments and uses to those that are compatible with flood hazard H6	b
2	Flow conveyance in events larger than the DFE	Flow conveyance areas may develop during an event larger than the DFE. For example, 0.2% AEP if 1% AEP is the DFE. People and buildings in these areas may be affected by flowing and dangerous floodwaters	Consider compatibility of developments and users with rare flood flows in this area	a
	Flood hazard H5 in the DFE	Hazardous conditions are considered unsafe for vehicles and people, and all buildings are vulnerable to structural damage	Many uses and developments will be vulnerable to flood hazard. Consider limiting new uses to those compatible with flood hazard H5. Consider treatments such as filling (where this will not affect flood behaviour) to reduce the hazard to a level that allows standard development conditions to be applied. Alternatively, consider a requirement for special development conditions	b

Table 1: Flood planning constraint categories (continued)

FPCC	Constraint	Implications	Key considerations	Subcategory
2	Emergency response—isolated and submerged areas	Area becomes isolated by floodwater or impassable terrain, with loss of evacuation route to the community evacuation location. The area will become fully submerged with no flood-free land in an extreme event, with ramifications for those who have not evacuated and are unable to be rescued	Consequences of isolation and inundation can be severe. Consider the consequences of: • evacuation difficulty or inundation of the area on the development and its users, which may include limitations on land use, or on land use that has occupants who are more vulnerable to disruption and loss • the development on emergency management planning for the existing community, including the need for additional treatments • the development on community flood recovery • disruption or loss of the development on the users and wider community	c
	Emergency response—isolated but elevated areas	Area becomes isolated by floodwater or impassable terrain, with loss of an evacuation route to a community evacuation location. The area has some land elevated above the extreme flood level. Those not evacuated may be isolated with limited or no services, and will need rescue or resupply until floods recede and roads are passable	Some developments and their users may be vulnerable to disruption or loss. Consider: • the consequences of disruption or loss of the development on the users and the wider community • limiting land use, or land use that has occupants who are more vulnerable to disruption and loss • additional emergency management treatment requirements • issues associated with the level of support required during a flood, particularly for long-duration flood events	d
	Flood hazard H6 in floods larger than the DFE	Hazardous conditions may develop in an event rarer than the DFE, which may have implications for the development and its occupants	Consider the need for additional development conditions to reduce the effect of flooding on the development and its occupants	e
3	Outside FPCC2—generally below the DFE and the freeboard	Hazardous conditions may exist creating issues for vehicles and people. Structural damage to buildings that meet building standards unlikely because of flooding	Standard land-use and development controls aimed at reducing damage and the exposure of the development to flooding in the DFE are likely to be suitable. Consider the need for additional conditions for emergency response facilities, key community infrastructure and vulnerable users	–
4	Outside FPCC3, but within the probable maximum flood (or similar extreme event)	Emergency response may rely on key community facilities such as emergency hospitals, emergency management headquarters and evacuation centres operating during an event. Recovery may rely on key utility services being able to be readily re-established after an event	Consider the need for conditions for emergency response facilities, key community infrastructure and land uses with vulnerable users	–

– = no category; AEP = annual exceedance probability; DFE = defined flood event; FPCC = flood planning constraint category

2.1.1 Flood planning constraint category 1

FPCC1 identifies the most significantly constrained areas, and should be based on the flood behaviour in the DFE. FPCC1 covers:

- areas of flow conveyance and flood storage, which are areas that, if altered (by topographic change or because of development), would have significant impact on current flood behaviour (Section 2.3)
- areas where flood hazard is H6 in the DFE (Section 2.4), which defines areas where all building are considered vulnerable to structural failure and flood conditions are considered unsafe for vehicles and people.

These constraints and subcategories will overlap, because they are not mutually exclusive.

Intensification of use in FPCC1 is generally very limited except where uses are compatible with flood function and hazard.

2.1.2 Flood planning constraint category 2

FPCC2 can be based on the following mapped flood-related constraints, but excludes FPCC1:

- flow conveyance in larger events than the DFE (Section 2.3.1)
- flood hazard H5 in the DFE (Section 2.4)
- flood hazard H6 in larger events than the DFE (Section 2.5.1)
- emergency response—areas that are subject to being isolated and submerged by flooding during a probable maximum flood (PMF) or a similar extreme event (Section 2.5.2)
- emergency response—areas that are subject to being isolated, with some area elevated above flooding during a PMF or similar extreme event (Section 2.5.2).

These constraints and subcategories will overlap, because they are not mutually exclusive.

FPCC2 areas are the next least suitable for intensification of land use or development because of the effects of flooding on the land, and the consequences to any development and its users.

Some areas of FPCC2 will be unsuitable for intensification of use. Other areas in FPCC2 will have the potential for more intense use but with significant constraints as outlined in Table 1.

2.1.3 Flood planning constraint category 3

FPCC3 can generally be determined based on the area within the flood planning area, but excluding areas within FPCC1 and FPCC2. This is the area of the floodplain where more traditional flood-related development constraints, based on minimum floor and minimum fill levels, will apply.

Development controls will generally apply to key community facilities—such as emergency hospitals, emergency management headquarters and evacuation centres—that have an important community role during a flood event, or to key utility services that need to be readily re-established after an event to aid recovery.

Constraints will also apply to developments where there are significant consequences to the community if failed evacuations occur, particularly where the difference in level between a DFE and a PMF or extreme flood is great. An example is residential aged care facilities, where occupants likely have mobility issues and, therefore, more difficulty during an evacuation.

In some cases, particularly where the range of flood level between the DFE and the PMF is substantial, broader constraints related to emergency management may also be considered.

2.1.4 Flood planning constraint category 4

FPCC4 is the area inundated in the PMF (extent of flood-prone land), but outside FPCC2 and FPCC3. Few flood-related development constraints would be applicable in this area. Constraints may apply to key community facilities and developments where there are significant consequences to the community if failed evacuations occur, as discussed for FPCC3 in Section 2.1.3.

2.2 Flood extent and associated mapping

Flood extents should identify areas subject to inundation for a particular flood or a range of flood events up to and including the PMF, considering the existing mitigation measures (e.g. levees). Information on the full range of flood behaviour informs a range of land-use planning activities and FPCC development in this guideline.

However, it is not uncommon for mapping to correspond to a particular flood event (e.g. the DFE) plus a freeboard (see Section 7.2.2 of ADR Handbook 7). This is typically called the flood planning area, which may be used to set many flood-related land-use and development controls. Using this approach in isolation can ignore the variation in flood function and hazard across the floodplain in the

DFE (Sections 2.3 and 2.4) and the potential range in flood behaviour (Section 2.5).

This guideline supports the broader consideration of flood behaviour and constraints as used in the development of FPCCs. Using FPCCs enables land-use planning activities to better consider the variation in flood behaviour and hazard across the floodplain and between events, which can result in the growing community being more resilient to flooding.

2.3 Flood function

Refinement of the floodplain into areas of different flood function can help identify locations where changes in topography or development may alter the existing flood behaviour. Maintaining areas of flow conveyance and flood storage is essential for managing flood behaviour, and relies on identifying these areas and limiting any changes that can adversely influence flood behaviour.

2.3.1 Flow conveyance

Flow conveyance areas are defined as those areas where a significant flow of water occurs. They typically flow continuously from the upper reaches of waterways and flow paths within the catchment to the outlet during a flood. These flows often align with naturally defined channels. They are areas that, even if only partially blocked by changes in topography or development, cause a significant redistribution of flood flow or a significant increase in flood levels. They are often, but not necessarily, areas of deeper flow or areas where higher velocities occur. In the DFE, they generally extend beyond the waterway banks.

2.3.2 Flood storage

During a flood event, significant amounts of floodwater can also extend into, and be temporarily stored in, areas of the floodplain. This water flows downstream as the flood recedes. Where storage is important in attenuating downstream flood flows and levels, areas storing this water are classified as flood storage areas. Filling of flood storage areas reduces their ability to attenuate downstream flood flows and, as a result, flood flows and flood levels may increase.

2.3.3 Flood fringe

Flood-fringe areas make up the remainder of the flood extent for the particular event. It is the area where the effects on flood function are not a constraint. Developing in flood-fringe areas is unlikely to significantly alter flood behaviour, beyond the broader impact of changes to run-off because of urbanisation within the catchment. However, other flood-related constraints may exist in flood-fringe areas.

2.4 Flood hazard

Flood hazard classification provides a description of how hazardous the physical conditions produced by a flood can be, independent of the population at risk. It is typically based on benchmarking the depth and velocity of the floodwaters against thresholds to determine how hazardous this combination may be to people, cars, infrastructure and buildings, if they were exposed to the flooding.

Flood hazard can influence the type of land use suitable for a location. Therefore, mapping that identifies the varying degrees of hazard across the floodplain can be useful to inform land-use planning activities.

Understanding the drivers for the flood hazard (whether dominated by velocity or depth, or both) can also be useful, because it can influence the ability to manage flood hazard and the appropriate management approach. For example, in an area with relatively high-velocity and low flood–depth waters can be hazardous, because people can be swept off their feet. Such a location may not be suitable as an overland escape route. Alternatively, floodwaters with substantial depth and relatively low velocity can result in the potential for drowning, or damage to the structural integrity of buildings or structures. In this instance, filling may be a suitable management approach to minimise the exposure to hazard, if this can be undertaken without significantly affecting flood behaviour.

As with flood function, flood hazard can vary according to the magnitude of the flood event and location within the floodplain for the same flood event. Consideration may need to be given to a range of flood events, including those rarer than the DFE, to identify areas that require specific constraints and management.

Australian Disaster Resilience Guideline 7-3 Flood Hazard (AIDR 2017) supports this delineation, and recommends grouping the floodplain into the following categories:

- H1—generally safe for people, vehicles and buildings
- H2—unsafe for small vehicles
- H3—unsafe for vehicles, children and older people
- H4—unsafe for all people and vehicles
- H5—unsafe for vehicles and people, and all buildings are vulnerable to structural damage
- H6—unsafe for vehicles and people, and all building types are vulnerable to structural failure.

Some management approaches broadly apply risk to people and to vehicles. Categories H2–H4 can be combined in many cases.

2.5 Range of potential flooding

Flood risk management relies on understanding how the consequences of flooding will change with event probability.

Historic flood information can provide an indication of areas that have been subject to inundation. However, it does not generally provide information on how flood behaviour varied across the floodplain in the event, nor does it provide an indication of how behaviour changes across the range of potential flood events. The limited knowledge from historic events, if used in isolation, can result in poor management decisions.

To provide an understanding of how flood behaviour varies between and during events, and across the floodplain, flood studies generally examine a range of design floods of different frequencies, up to and including the PMF or a similar extreme event.

Some land-use planning activities consider the full range of flood behaviour. However, in some cases, development controls relate to the DFE. Consideration of larger floods will provide information about how flood emergency management constraints will vary across the floodplain and how flood function (particularly flow conveyance) changes with the scale of flood event. This information can influence land-use planning activities.

2.5.1 Changes in flood function

The flood function in different areas of the floodplain typically varies with the magnitude of the flood event. This can be particularly important when areas with relatively benign flood conditions can develop into important flow paths, resulting in more hazardous conditions in rarer flood events. This effect is shown in Figure 2. At this particular location, an event slightly larger than the 0.2 per cent annual exceedance probability (AEP) event (Figure 2b) washed away three houses, and resulted in significant structural damage to another house and an industrial building.

The effects of the 1 per cent AEP flood at this location are limited (Figure 2a). Without examining more severe events, the location may be considered suitable for development with the same development controls as generally applied to other flood-affected properties. However, examining the 0.2 per cent AEP shows that a new flow path forms, and creates significant risks to the development and its users. In the extreme event (Figure 2c), the hazardous conditions within the newly created flow path increase further.

An understanding of this significant change in behaviour identifies this additional flow path. Therefore, it can be considered in land-use planning activities and associated decision-making. Understanding the potential impacts of this change can promote land uses more compatible with the flood behaviour. It can support decisions to steer development to other available land that is not exposed to these additional constraints during rarer flood events.

2.5.2 Emergency management

Identifying areas with potentially difficult evacuation problems can highlight locations that need to be treated differently in land-use planning activities. For example, an area of the floodplain that becomes isolated from flood-free land and totally inundated as a flood rises presents a difficult emergency management issue. Here, the consequences of failed evacuation are more serious and may warrant consideration in land-use planning activities and influence associated decisions. However, if an area can be readily evacuated to flood-free land with appropriate facilities within the available warning time, it is unlikely that significant additional emergency management considerations would be required in land-use planning activities. This information can be used to:

- advise on whether a location is suitable for more intense development and, if considered to be suitable, what constraints should apply
- influence the location of facilities, such as hospitals, with an emergency response function during a flood event
- advise on where to locate land uses whose occupants may be more vulnerable or need significant support during an evacuation, such as the occupants of residential aged care facilities.

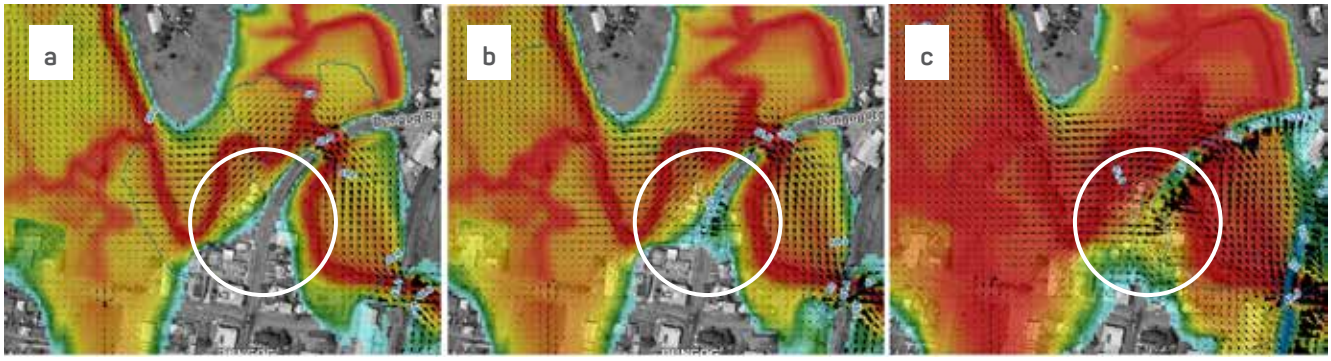


Figure 2: Examples of changing flood function with event scale: a) 1% annual exceedance probability (AEP), b) 0.2% AEP and c) extreme event

Areas that enable relatively straightforward evacuation, where the consequences of a failed evacuation are limited, or are outside the floodplain may be more suitable for these types of uses.

If there is ample warning time, and safety of the existing and future community can be demonstrated, emergency evacuation during a flood may not be a significant issue. However, locating communities in areas that are isolated for extended periods without essential services and ready access to community facilities places an additional burden on agencies that assist communities in emergency response during a flood event.

ADR Guideline 7-2 Flood Emergency Response Classification of the Floodplain (AIDR 2017) provides definitions and a method for classifying a floodplain based on the following emergency response difficulties and consequences of failed evacuation or extended periods of isolation:

- whether the area is flooded during a PMF or similar extreme flood (flooded or not flooded)
- whether the area has access to evacuation facilities that remain flood-free (isolated or has an exit route)
- the potential consequences of flooding in the area (fully submerged, partially elevated or has indirect consequences).

The overall classifications are:

- Flooded Isolated Submerged (FIS)
- Flooded Isolated Elevated (FIE)
- Flooded Exit Route (FER)
- Not Flooded Indirect Consequences (NIC).

2.6 Sourcing flood information

Base information may be developed in new flood studies or possibly derived, at least partially, from existing flood studies. It may be refined in floodplain management studies.

2.6.1 New flood studies

Specifying a flood study to provide this information can ensure that it informs land-use planning activities without waiting for the completion of a floodplain management study and plan.

A key consideration in scoping studies is model selection and resolution, to help ensure that the modelling is fit for purpose to provide the base information in sufficient detail for the required outputs and to consider the level of post-processing required. This depends on the accuracy required, the scale of the base information used for inputs, the flood data available to validate the model and the shape of the floodplain. Guidance on this is available in *Australian Rainfall and Runoff* (Ball et al. 2016).

A study generally considers a range of flood events, including historic events and design floods. This provides an understanding of the full range of flood risk, to inform decision-making. For FPCC mapping, key design events include information on:

- **the DFE.** This is generally set considering the local flood risk. Its selection may be influenced by jurisdictional advice, such as default or minimum design floods, or by industry guidance
- **additional flood events above and below the DFE** to provide an indication of how flood behaviour and consequences change with event likelihood. These may include some or all of the 20 per cent, 10 per cent, 5 per cent, 1 per cent, 0.2 per cent, the 0.5 per cent AEP floods, as well as the PMF or an equivalent extreme event.

2.6.2 Existing studies

Existing studies may hold some or all of the base information needed to support FPCC mapping. When considering using an existing study to develop FPCC mapping, a decision should be made about whether the best available information is sufficient without further work, whether a partial study is worthwhile to provide the missing information, or whether a new study is needed. This decision may be guided by addressing the quality and currency of the available information by answering the following questions:

- Have conditions on the floodplain changed?
- Is the topographic information relatively current?
- Is there information on flood emergency response classification on the floodplain?
- How old is the flood study?
- Is there sufficient information on flood behaviour for a range of floods?
- If an extreme event or the PMF has not been mapped, how critical is this for understanding the flood impacts?

To make this decision, it may be useful to gain advice from a specialist flood practitioner on whether the information available is fit for purpose, and whether any missing elements can be approximated, or modelled and mapped.

2.7 Future catchment conditions

Land-use planning activities may also require consideration of future catchment conditions for a planning horizon that may extend over decades. This may involve analysing the following factors:

- The cumulative impacts of development intensification within the catchment considering the demands for new development within the planning horizon. Urbanisation increases the amount of run-off from flood events. Modelling can determine the cumulative impacts of the changing scale

of development on flood behaviour and examine management options to consider when setting development controls. This can provide increased certainty of limiting the growth of flood risk because of new development over the planning horizon.

- Future climatic conditions for relevant future planning horizon(s) may need to be considered if
  - the frequency, severity and seasonality of flood-producing rainfall events are predicted to change. The sensitivity of the catchment to changes in flood flow can initially be tested by comparing flood behaviour for the DFE against larger events (e.g. the 0.5 per cent and 0.2 per cent AEP event if the DFE is the 1 per cent AEP event). If the change in flood behaviour is significant, then more detailed modelling may be required, based on best estimates of the changing hydrological regime informed by relevant jurisdictional or industry advice
  - sea levels are predicted to continue to rise. For coastal areas, the downstream ocean boundary conditions of the hydraulic model can be altered to incorporate relevant sea-level rise projections. The DFE should be run for these conditions and results compared with the DFE for current conditions, to test the sensitivity of flood behaviour to changes in sea level. Changes to the frequency of flooding should also be considered, because this can affect the ongoing viability of land for development within and beyond the planning horizon.

Advice on changes should inform land-use planning responses in accordance with relevant jurisdictional advice. In the case where the frequency of flooding of an area changes substantially, the need to reconsider the viability of the area to support new development may be triggered. This may lead to decisions to steer future development to areas where the effects are more manageable and sustainable in the long term.

Analysing the above factors may also lead to the need to provide FPCC mapping that considers future conditions, and advice on the ramifications of change of flood behaviour and management.

3 Developing objectives, treatment measures and controls

Land-use planning activities should aim to support land use and development that is compatible with the floodplain management objectives and the varying flood-related constraints on land in the floodplain. This involves varying types and degrees of treatment to manage the varying constraints in flood planning constraint categories 1–4 (FPCC1–FPCC4). Development intensification is most likely to be compatible with the flood function and exposure to flood hazard if it occurs in FPCC3 and FPCC4.

3.1 Floodplain management objectives

Floodplain management objectives for new development include to:

- minimise any changes to flood behaviour
- minimise any changes in flood risk to the existing community
- minimise any impacts on the safety of the existing community responding to floods
- reduce the impacts of flooding on the new development
- consider risk to life of the users of new development in all events, including extreme events.
- consider the role and functionality of key community uses, such as community hospitals, in all events, including extreme events
- consider adaptability to changing risks because of climate change.

These floodplain management objectives can equate to land-use planning objectives, including to:

- ensure that risk to life is considered for events up to extreme events
- ensure that key community uses consider functionality in all events up to extreme events
- ensure that the risks posed by flooding to existing development are not increased by new development likely to occur in the floodplain
- ensure that the risks posed to the existing community by flooding are not increased by new developments that are likely to occur in the floodplain
- ensure that the economic and social costs that may arise from damage to new development from flooding are not be greater than that can be reasonably managed by the community
- consider adaptability to changing risks because of climate change.

3.2 Treatment measures and controls to meet floodplain management objectives

Table 2 provides a starting point for developing land-use planning and building treatments and controls for different FPCCs in consideration of the floodplain management objectives outlined in Section 3.1.

The example shown in Table 2 should be used within the context of jurisdictional and local flood policies, and the relevant planning system. Application should also consider the availability of more suitable land for development. This may be land that has less negative impact on the flood risk to the existing community, and where flood function and exposure to flood hazard is more compatible with that particular type of development. The effectiveness of these measures to meet floodplain management objectives should be tested as discussed in Section 3.3.

Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia (AIDR 2017) outlines a range of treatment options that may, to some extent, limit growth in flood risk as a result of the introduction of new development into the floodplain. Typical treatment options include:

- planning and building controls
- flood prediction and flood-warning systems
- flood access and evacuation routes
- emergency response arrangements, including augmentation of existing arrangements where additional development is considered feasible
- community-scale flood awareness and readiness.

This guideline does not delve into individual property-level controls. However, it is important to consider how more-detailed planning and building controls align with broad treatment options. Property-scale development and building controls often include:

- maintenance of flow paths through properties, including consideration of fencing styles
- filling land and, in some cases, minimum fill levels
- floor-level controls and flood-compatible building components
- structural soundness
- site access
- car parking
- evacuation or on-site refuge requirements
- management of flood impacts on other developments and properties.

Table 2: Examples of land-use planning, and building treatment options and controls in consideration of floodplain management objectives

FPCC	Constraint	Possible land-use planning, and building treatment options and controls for area in consideration of the floodplain management objectives (outlined above)	Sub-category
1	Overall	In addition to the controls in FPCC2	–
	DFE event flow conveyance and storage areas	Development is discretionary, provided it does not adversely affect flood function. This is likely to result in a significant restriction on intensification of development	a
	H6 hazard in DFE	Intensification of existing and new key community, utility, and vulnerable, residential and commercial uses may be prohibited. Intensification of other existing uses and new uses is discretionary, provided a detailed risk assessment can demonstrate that an appropriate mix of planning, building and emergency management controls can effectively manage the risks to the use and the occupants	b
2	Overall	In addition to the controls in FPCC3	–
	Flow conveyance in floods larger than the DFE	Development is discretionary provided it is compatible with flood function. May result in some restrictions on intensification of development	a
	Flood hazard H5 in DFE	New key community, utility and vulnerable uses may be prohibited. Intensification of existing uses and other new uses are discretionary, provided that a detailed risk assessment demonstrates that an appropriate mix of planning, building and emergency management controls can effectively manage the risks to the use and the occupants	b
	Emergency response—isolated and submerged (FIS)	Consider whether to minimise or prohibit more intense development in these areas. New key community, utility and vulnerable uses may be prohibited. Intensification of existing uses and other new uses or developments is discretionary, provided that a detailed risk assessment can demonstrate that an appropriate mix of planning, building and emergency management controls can effectively manage the risks to the use and the occupants and not result in adverse emergency management impacts to existing developments and their users	c
	Emergency response—isolated but elevated (FIE)	Consider whether to minimise more intense development in these areas. Intensification of use is discretionary, provided that a detailed risk assessment demonstrates that an appropriate mix of planning, building and emergency management controls can effectively manage the risks to the use and the users. Where key community, utility and vulnerable uses are being considered they also need to address continuity of service and not result in adverse emergency management impacts to existing developments and their users	d

Table 2: Examples of land-use planning, and building treatment options and controls in consideration of floodplain management objectives (continued)

FPCC	Constraint	Possible land-use planning, and building treatment options and controls for area in consideration of the floodplain management objectives (outlined above)	Sub-category
2	Flood hazard H6 in floods larger than the DFE	All uses and developments, including key community and utility uses, are discretionary, provided a detailed risk assessment demonstrates that an appropriate mix of planning, building and emergency management controls can effectively manage the risks and ensure continuity of service	e
3	Outside FPCC2. Usually below the DFE plus the freeboard	In addition to controls in FPCC4. All other uses and developments are permitted, provided they meet flood-specific planning conditions such as meeting minimum fill and floor-level requirements, and specific building and access requirements	–
4	Outside FPCC3, but within the PMF (or similar extreme event)	Key community facilities are discretionary, provided a detailed risk assessment demonstrates that an appropriate mix of planning, building and emergency management controls can effectively manage the risks and address continuity of service and safety of occupants during an extreme event. Uses with vulnerable users are discretionary, provided a detailed risk assessment demonstrates that an appropriate mix of planning, building and emergency management controls can effectively manage the safety of occupants during an extreme event. All other uses and developments are generally permitted without any flood-specific provisions	–

– = no subcategory; DFE = defined flood event; FPCC = flood planning constraint category; PMF = probable maximum flood

3.3 Ability of controls to meet objectives

Having established an initial set of land use planning and building treatment options and controls, it is important to test their ability to achieve management objectives. This can be influenced by a range of factors, including whether:

- existing flood mitigation measures (e.g. levees and flood-warning systems) aimed at reducing the flood risk to the existing development within the community are relied on to reduce the flood risk to new development areas
- flood evacuation is constrained by the available flood-warning time, the capacity of evacuation routes or the adequacy of the flood-warning system (Section 4)
- the type of development considered, or their users, are particularly vulnerable to flooding (Section 4)
- flooding affects the ability of the development to perform its community emergency response function (Section 4).

Testing the effectiveness of the proposed treatments and controls on their own, or if they need adjustment or complementary treatments to meet management objectives can involve:

- understanding the current mitigation measures that affect flood risk to future development and identify any inadequacies or limitations in these treatment measures—for example, whether
  - flood risk is influenced by an existing levee or flood warning system that are fit for purpose to support new development and there is a commitment to their ongoing maintenance and operation
  - the existing levee and flood warning system need upgrading to support new development and there is a commitment to this upgrade and the ongoing maintenance and operation of these systems
- understanding the proposed land uses and associated development types, their particular vulnerabilities (Section 4) and the constraints proposed
- assessing whether the new development affects the flood behaviour, and the flood risk or emergency management arrangements of the existing community
- assessing the risks to the different developments and uses proposed in different FPCCs, with the

planning controls in place to see whether they compare favourably to the objectives.

3.4 Need for additional controls

If testing finds that the treatment options proposed for a particular FPCC do not meet the management objectives, then consideration should be given to the need for additional treatment measures for the FPCC. Alternatively, particular types of development may be considered unsuitable for the FPCC. The following are examples of when this may happen:

- If all developments, or a particular type of development, in a specific FPCC cannot meet the floodplain management objective. Consider restricting the development to an FPCC where it can meet these objectives, or introduce additional controls that enable the objectives to be met.
- If objectives cannot be met for all types of development in a range of FPCCs, consider the need for broad changes to controls. For example, where there is a broad issue relating to excessive damages or exposure of structures to flooding for all developments, then consider whether raising the DFE will address this issue.
- If development opportunities are likely to be limited because of inadequate flood warning, current emergency management issues or access problems, part of the strategic planning may be to
  - steer development away from less-suitable locations to FPCCs where these constraints can be managed—for example, where these conditions exist, steer development towards areas where people can readily self-evacuate without adding to the burden of emergency services
  - consider the constraints and limit the scale of development within certain areas
  - identify opportunities to reduce the constraints (e.g. roads with better flood immunity, flood-warning system improvements or more effective emergency management plans).

Any recommendations for additional planning, or development controls or treatment measures should be documented and used to inform land-use planning activities.

4 Relative vulnerability to flooding

Understanding both the potential use of developments in community response to floods, and the vulnerability of land uses and their users to flooding can inform decisions about developing in the floodplain.

Some land uses and their users are more vulnerable to flooding than others. Understanding the vulnerability of different land uses relative to general residential development and how particular facilities are used in flood emergency management is important to inform land-use planning activities. Table 3 provides general guidance on both the relative vulnerability of different land uses and their general users to flooding. It also provides advice on the emergency management use of key types of developments. This information can be considered when developing specific advice for a study. It may influence land-use planning activities—some developments may require more stringent controls or additional risk treatments to meet floodplain management objectives. This can be illustrated by considering three examples of vulnerable development.

Example 1 is a development whose users have mobility issues. The occupants are likely to be more vulnerable in emergency response than the general population. Therefore, they would best be located in areas that will not need evacuation during a flood, or where the consequences of failed evacuation are limited.

Example 2 is an emergency relief centre, which is required to function in all floods. This should preferably be located outside the area affected by the probable maximum flood. However, if this is not possible, the implications of evacuating a large number of already-displaced people who have been evacuated to this centre need to be considered.

Example 3 is a community hospital with medical emergency facilities that is required to operate during floods. It is best located in an area where flooding does not occur. If this is not possible, the structure may be able to be designed to have facilities above the flooding level, but it will still need to be accessible in a medical emergency and fully operational during a flood. If this is not possible, the hospital will need to consider developing safe evacuation plans for patients and staff (preferably before the flood occurs) and making alternative arrangements for medical emergencies during a flood event.

Table 3: Examples of vulnerability to flooding relative to standard residential development for the same exposure to flooding

Type of use	Building at risk	Contents at risk	Occupants at risk	Use in emergency response	Comments
Standard residential	Base	Base	Base	No	This provides a baseline for assessing the relative vulnerability of other types of development
Medium- to high-density residential	Lower	Higher	Higher	No	Higher-density than standard residential, but buildings are often stronger
Rural residential	Lower	Lower	Lower	No	Lower-density area than standard residential
Community hospital with medical emergency facilities	Lower	Higher	Higher	Yes	Occupants, on average, more vulnerable than average during an evacuation. Facility needs to be able to operate and be accessible during a flood event, or have an alternative and evacuation plan
Residential aged care facilities	Lower	Higher	Higher	No	Occupants, on average, more vulnerable than average during an evacuation
Schools	Lower	Lower	Higher	Possible	Occupants, on average, more vulnerable than average during an evacuation
Community facility	Lower	Lower	Varies	Possible	The type of occupants and their exposure to flooding will depend on the nature of the development
Service club	Lower	Lower	Higher	Possible	Emergency procedures in response to a flood may be able to be developed and associated training provided to employees. Customers likely to be unfamiliar with location or flood issue
Emergency response facility	Lower	Lower	Lower	Yes	Facility needs to be able to operate and be accessible during a flood event or have alternate arrangements
Commercial	Lower	Varies	Employees —lower; customers —higher	No	Emergency procedures in response to a flood may be able to be developed and associated training provided to employees. Customer density high, and unlikely to be familiar with location or flood issue
Industrial	Lower	Varies	Lower	No	Emergency procedures in response to a flood may be able to be developed and associated training provided to employees. Customer density low, and unlikely to be familiar with location or flood issue
Agricultural	Lower	Lower	Lower	No	

5 Study reports

Where a flood study is meant to produce advice consistent with this guideline, the scope of this report should reflect the requirements of this guideline.

To include the advice of this guideline, a study report should include a section to inform land-use planning activities. It should document the analysis undertaken, provide clear and concise recommendations on how this information can support land-use planning activities, and outline any limitations or assumptions on which this advice is based. In addition, this section should include:

- flood planning constraint category mapping and the basis on which mapping was produced, which should identify any existing mitigation works included in the analysis, and whether the mapping considers changes in land use and climate
- supporting information on the management objectives, and the controls in place to manage growth in flood risk to the existing and future community
- advice on the adequacy of controls in meeting management objectives and any relevant policies or guidance
- advice on any additional land-use planning or supporting treatment measures needed to address the effects of new development on the flood risk, the emergency management arrangements of the existing community, and the flood risk to new development and its users
- advice on any complementary treatment options needed to support development or offset impacts. If these measures are not done, the ramifications should be documented
- advice on the effects of climate change on flood risk and how it may influence land-use planning activities
- any additional specific advice that is included in the technical specification for the project
- advice on the cumulative impacts of development within the planning horizon and how this may be managed.

The report should be made available electronically and accompanied by all mapping in an agreed spatial format referenced to an appropriate coordinate system.

A simple example is provided in Appendix B.

Appendix A
Floodplain planning constraint category mapping examples

Examples of four floodplains with different characteristics demonstrate floodplain planning constraint category (FPCC) mapping of constraints described in Sections 2 and 3 across a range of flood situations. Examples describe the main flooding mechanism and the mapping components used to develop the FPCCs. Example 1 includes intermediate steps and forms the basis for the reporting example in Appendix B.

A.1 Example A1—major river, small rural town

Example A1 is for a rural town located on a major river with broader rural flooding to the north and south (not shown). A levee system north and south of the river protects most of the town from the defined flood event (DFE). The town has several weeks of warning of the arrival of a flood and can be isolated for weeks as the flood rises to a peak and then recedes. The town's population is approximately 2,000, with a further 1,000 that rely on the town's services living in the rural floodplain. The town is the commercial centre for the area and the base for emergency operations. Because of the extensive warning time and access to services, evacuation from inundated areas to higher areas within the town is possible. Therefore, evacuation is not considered a critical element for locating development. However, because the flooding can be of long duration, isolation can be a significant issue for the community, and emergency services and should be considered in land-use planning activities.

Example A1 has ten figures (Figures 3–12):

- base maps—DFE and probable maximum flood (PMF) extents, flood function in the DFE, hydraulic hazard in the DFE and flood emergency response classification (Figures 3–5, 7 and 9)
- intermediate maps—different stages of development (Figures 6, 8 and 10)
- FPCC and flood planning constraint subcategory mapping (Figures 11 and 12).

Table 4 summarises the constraints related to elements making up each FPCC and the reason why these constraints require consideration, and indicates the relevant base mapping.

A.1.1 Flood extent mapping (Section 2.1)

Figure 3 shows the DFE extent. The addition of a freeboard to the DFE provides the basis for determining a traditional flood-planning area. Figure 4 is the PMF extent, the extent of flood-prone land and the outline of FPCC4.

A.1.2 Flood function mapping (Section 2.2)

Figure 5 shows the various flood functions for the DFE. In this case, changes in the flow conveyance areas greatly affect flood behaviour, and are extracted and included in FPCC1 in Figure 6. Filling of flood storage areas does not significantly affect flood behaviour.

A.1.3 Flood hazard mapping (Section 2.3)

Varying flood hazard for the DFE is shown in Figure 7. H6 presents the greatest constraints and goes into FPCC1. H5 may be manageable with significant constraints and goes into FPCC2. H1–4 are included in FPCC3 because they are more readily manageable. Figure 7 builds on Figure 6.

A.1.4 Considering the range of potential flooding (Section 2.4)

Examining flood range can identify areas where significant changes in flood behaviour occur and areas with different degrees of evacuation difficulty. Comparing Figure 3 with Figure 4 shows no significant issues with changes in flood function or hazard as floods get larger. However, areas behind the levees will be flooded in larger events and potentially because of local drainage when the river is flooded. This may require additional development considerations (discussed further in Appendix B).

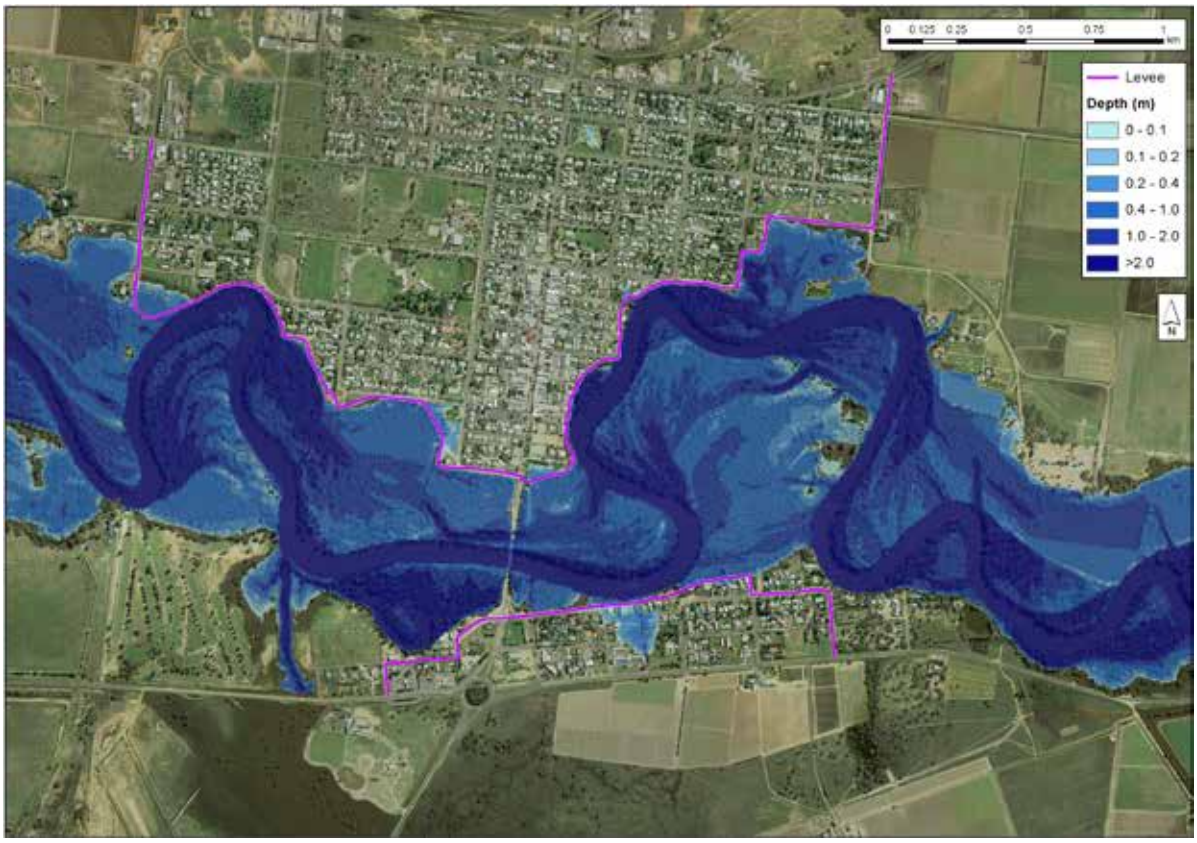


Figure 3: Example A1—flood depth and extent for the defined flood event

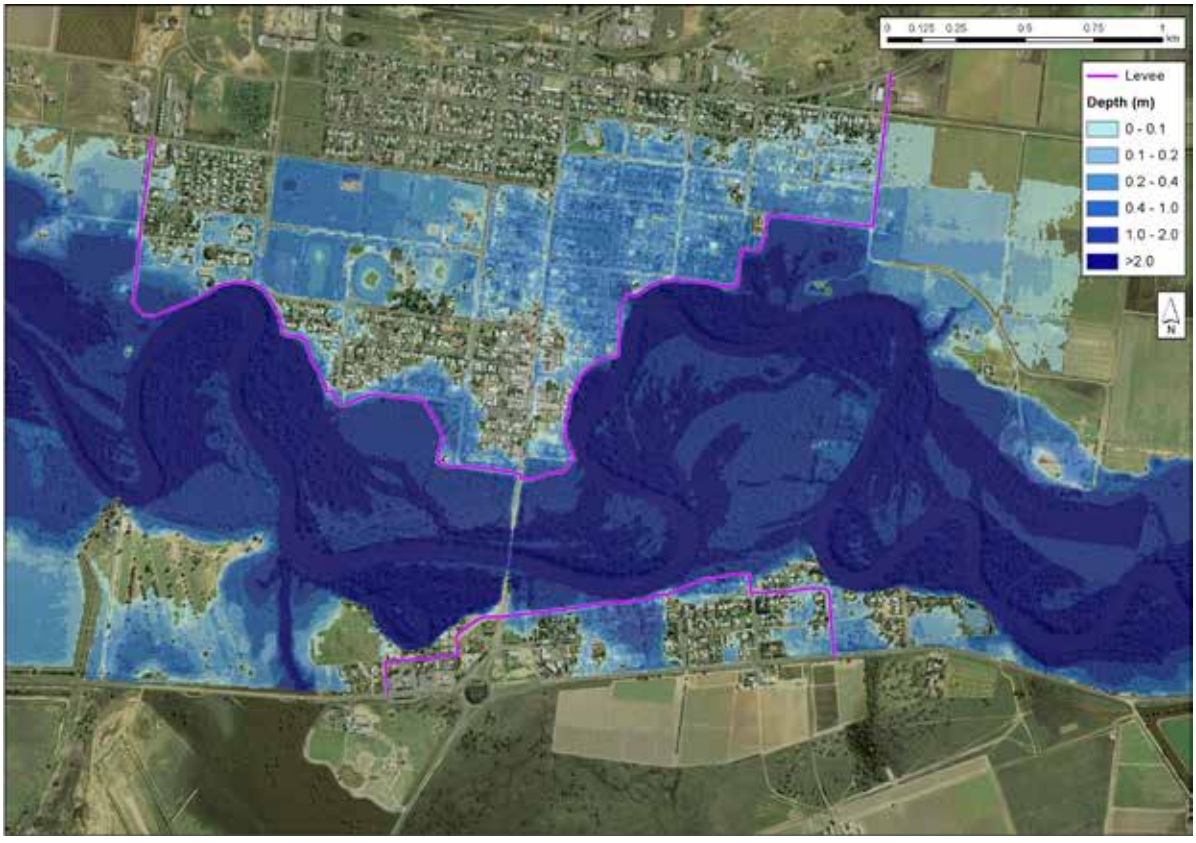


Figure 4: Example A1—flood depth and extent for the probable maximum flood

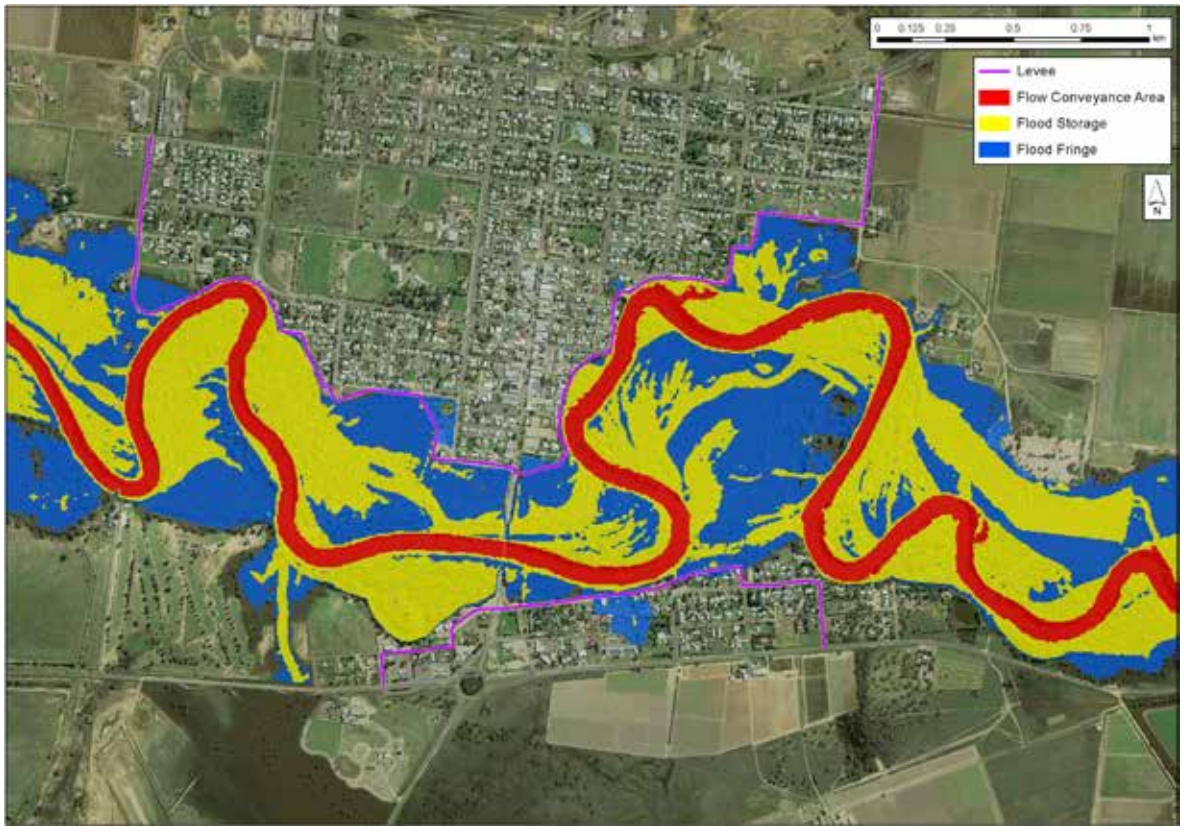


Figure 5: Example A1—flood function for the defined flood event

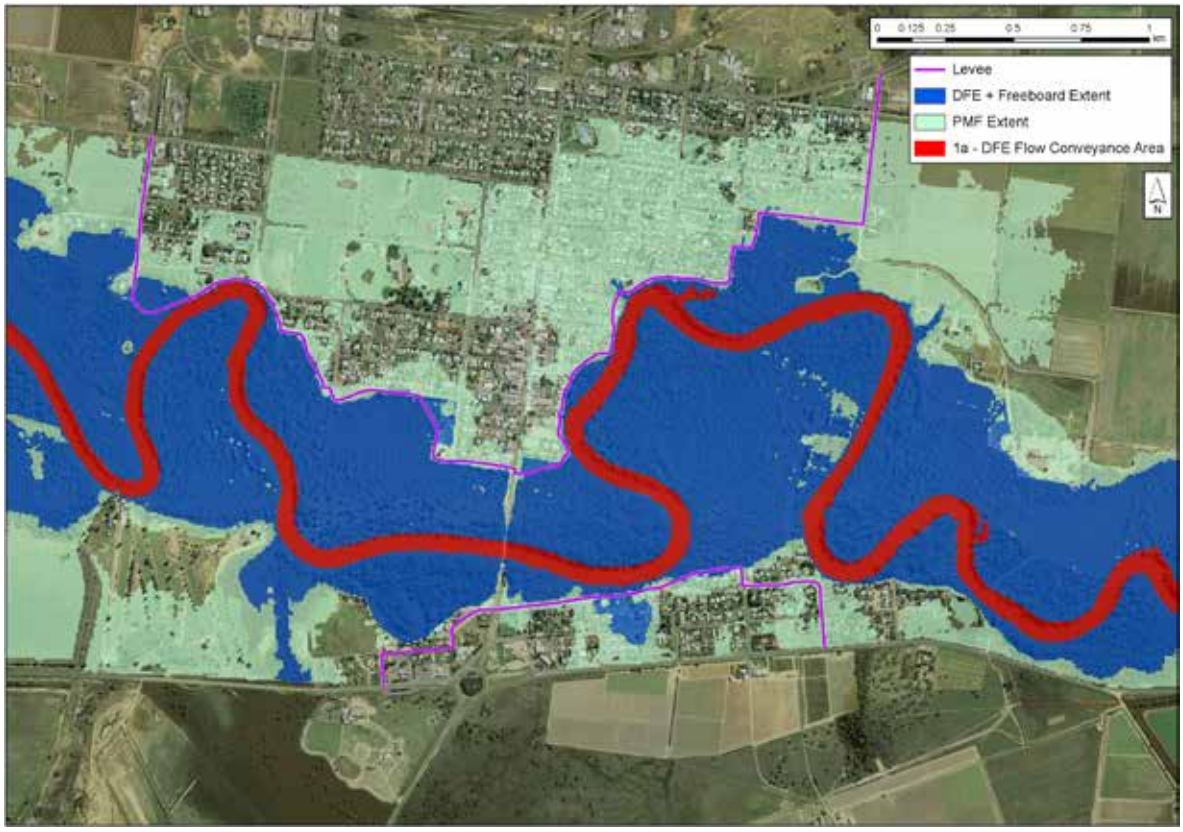


Figure 6: Example A1—defined flood event (DFE) and probable maximum flood (PMF) extents, and the DFE flow conveyance area

Table 4: Example A1—floodplain planning constraint category mapping

FPCC	Constraint	Reason why the constraint is considered	Reference figure
1	Flow conveyance and storage areas in the DFE	Changes in topography can significantly affect flood behaviour in the DFE	Conveyance only; storage not considered significant in this case (derived from Figure 5)
	H6 hazard in the DFE	All buildings types have the potential to structurally fail in these conditions in the DFE	Derived from Figure 7
2 (excludes 1)	New flow conveyance paths develop in larger events than the DFE	New flow conveyance paths could create particularly dangerous conditions to development and occupants	No new significant flow paths develop in larger events; therefore, not included in this case
	Flood hazard H5 in the DFE	All building types have the potential for substantial damage requiring management	Derived from Figure 7
	Flood hazard H6 in larger events than the DFE	All buildings have potential to structurally fail during events rarer than the DFE	No significant change in slightly larger flood; therefore, not included in this case
	Emergency response—areas subject to isolation, some of which may also be submerged	Potential ramifications for individuals, community and emergency response organisations	Derived from Figure 9
3 (excludes1 and 2)	Areas within hazard H1–H4 in the DFE plus DFE flood extents plus the freeboard allowance	Area still affected by flood events, and needs controls to manage the scale and frequency of negative effects	Outer extent derived from Figure 3 and adjusted for the freeboard
4 (excludes 1, 2 and 3)	Within PMF (or similar extreme event)	Area still has the potential to be affected by a rare flood event, which may warrant planning constraints for some types of vulnerable development and essential facilities during flood emergencies	Outer extent derived from Figure 4, and internally excluded FPCC1–FPCC3

DFE = defined flood event; FPCC = floodplain planning constraint category; PMF = probable maximum flood

The town has substantial warning time; therefore, evacuation does not impose a particular development constraint. However, isolation of areas south of the river from the main township for extended periods will increase the risk to users and the support they require during a flood. Figure 9 shows the flood emergency response classifications with all isolated areas fully submerged in a PMF (Flooded Isolated Submerged—FIS). These are added to FPCC2. Figure 10 summarises all factors that make up FPCC mapping.

A.1.5 Derived flood planning constraint categories as discussed in Section 2

Table 4 summarises the elements used in FPCC mapping (Figure 11). FPCC subcategory mapping (Figure 12) and base element mapping (Sections 2.1–2.4) can help to identify the location-specific constraints within FPCC1 and FPCC2. In Figure 12, the emergency response classification of FIS represents the extent of FPCC2 and will apply in this area.

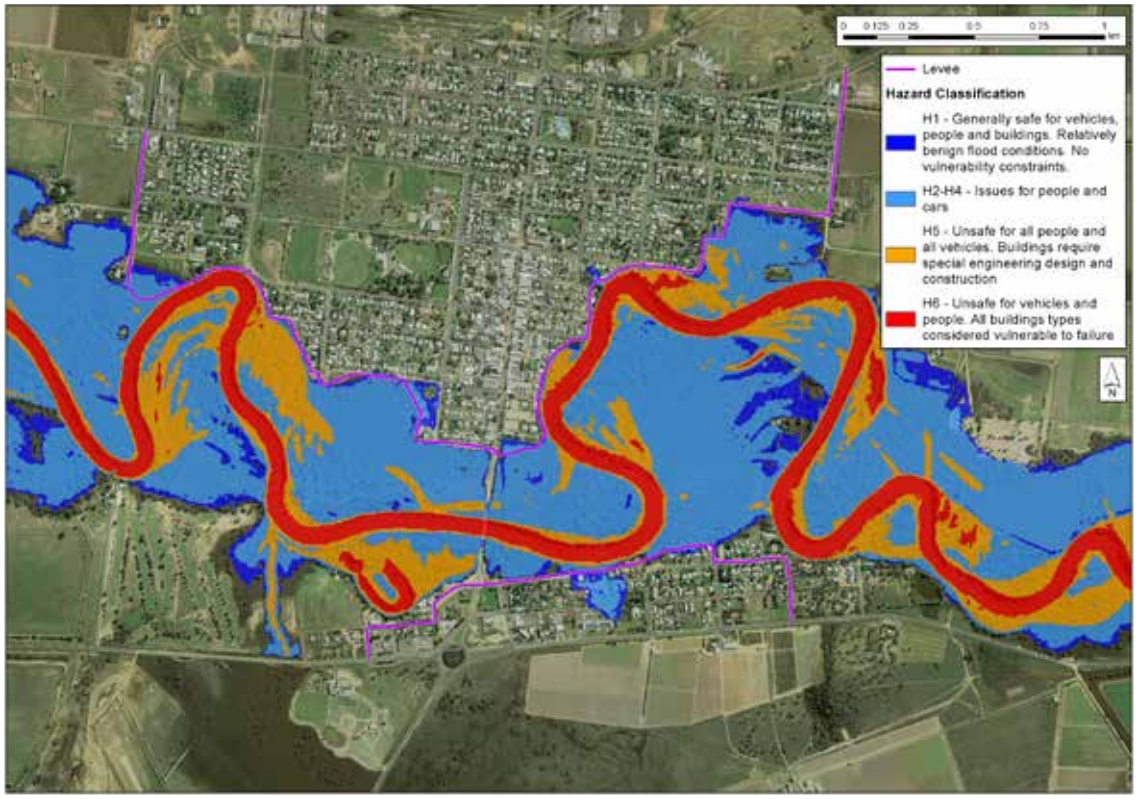


Figure 7: Example A1—flood hazard for the defined flood event

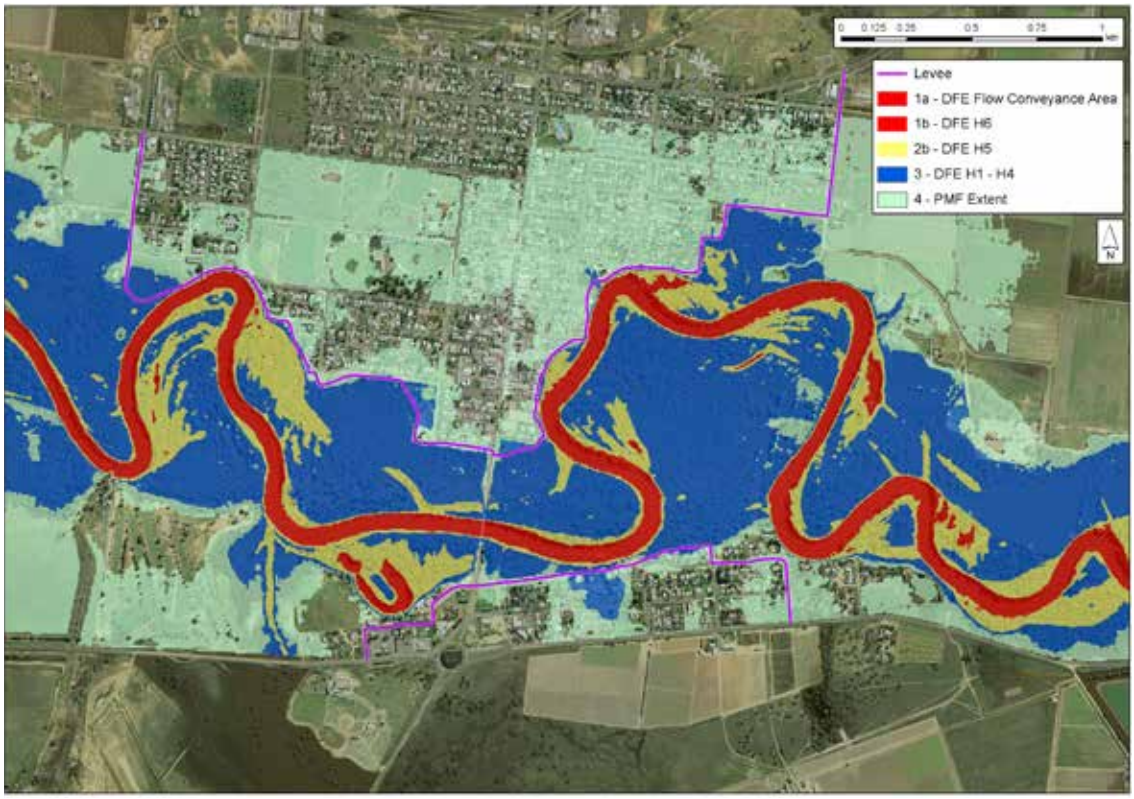


Figure 8: Example A1—defined flood event (DFE) and probable maximum flood (PMF) extents, DFE flow conveyance and DFE H6

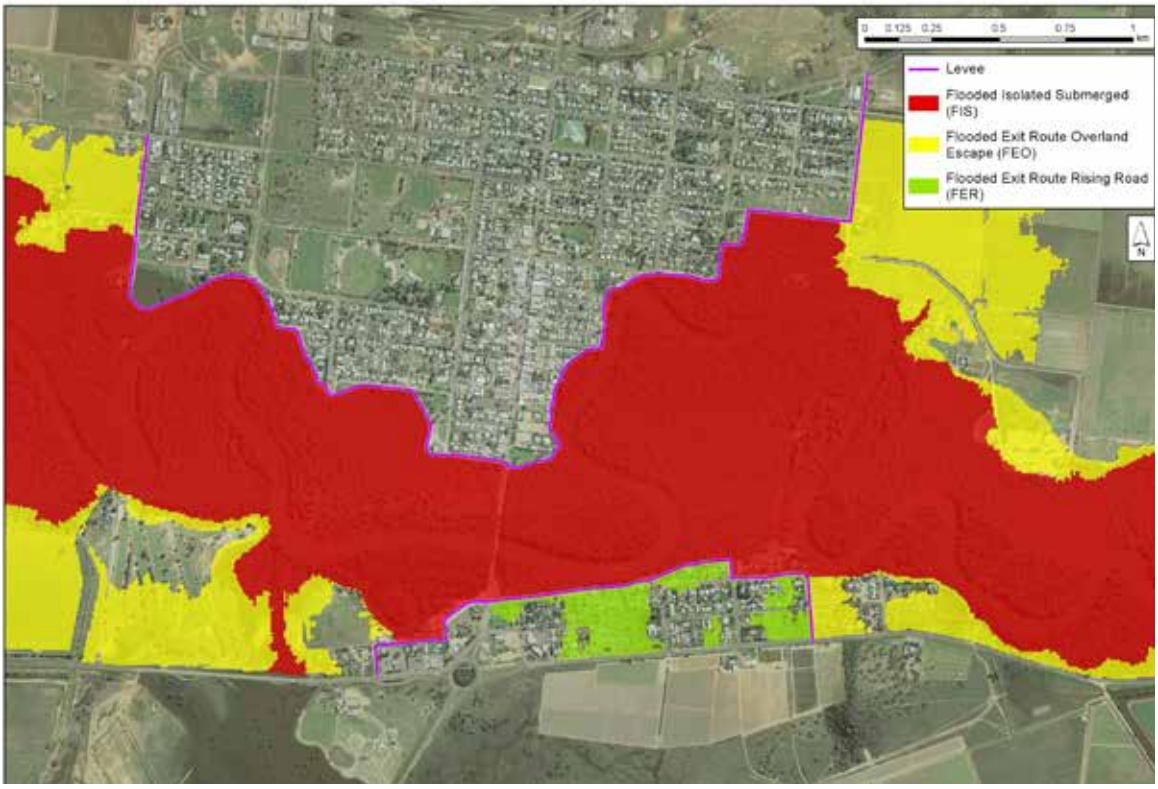
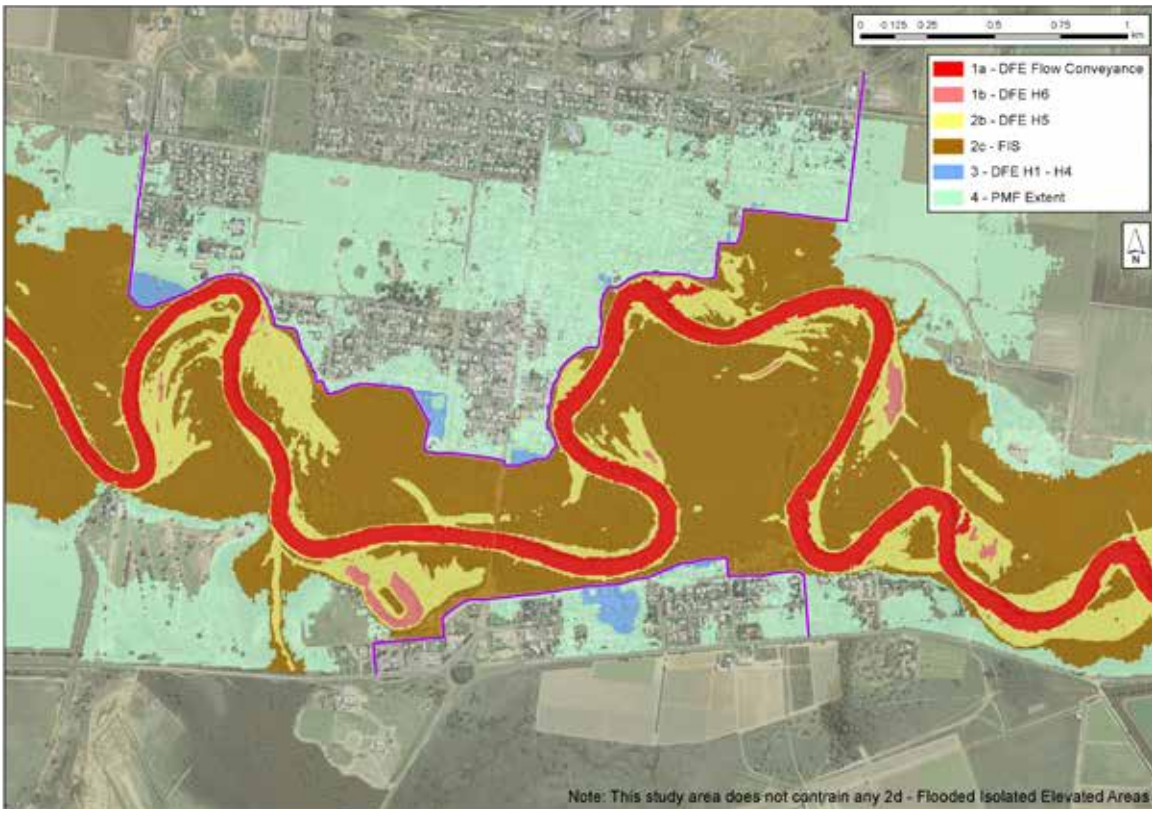


Figure 9: Example A1—flood emergency response classifications



DFE = defined flood event; FIS—Flooded Isolated Submerged; PMF = probable maximum flood

Figure 10: Example A1—summary of elements making up flood planning constraint category mapping

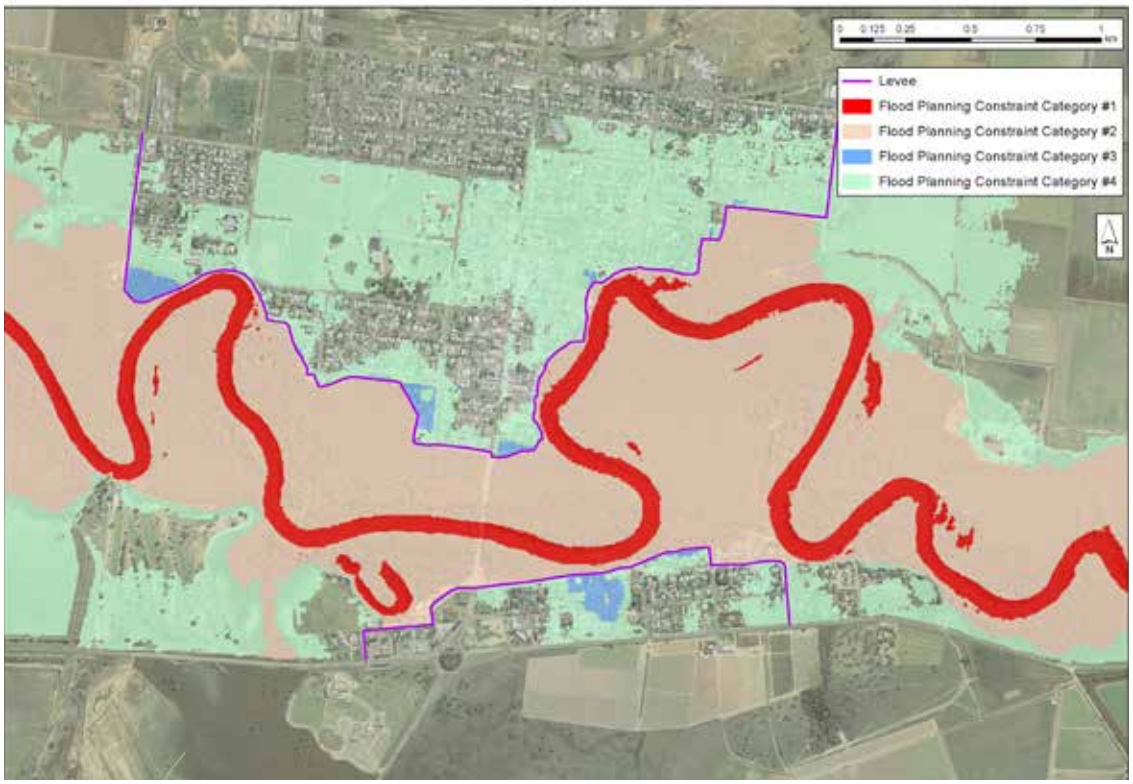
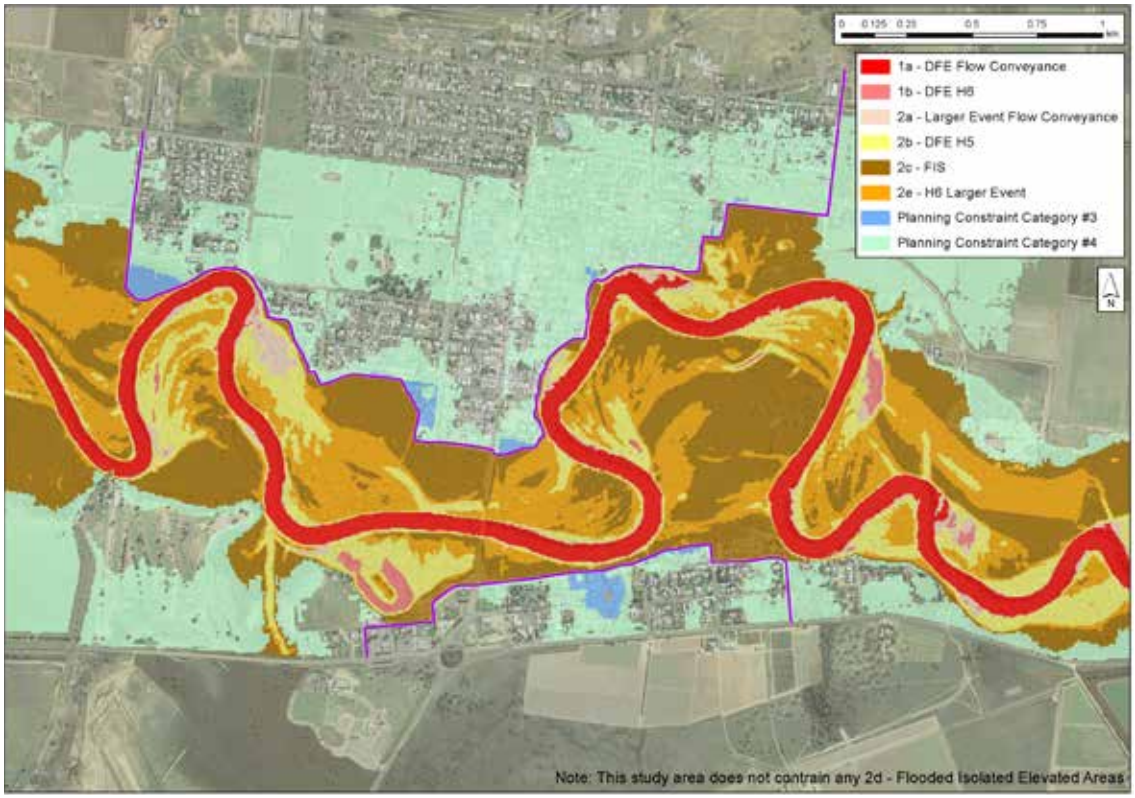


Figure 11: Example A1—flood planning constraint categories



DFE = defined flood event; FIS—Flooded Isolate Submerged

Figure 12: Example A1—flood planning constraint subcategories

A.2 Example A2—major drainage channel, urban area

Example A2 is a small residential area where mainly high-density residential development is permissible. It currently has 1,000 dwellings, and commercial and industrial sites. Land-use planning activities are focused on redevelopment of existing lots and potential for residential infill.

The catchment has a very quick response time, so flood duration and warning time is short, which limits emergency response. Run-off flows from the bottom to the top of Figures 13–20. Flow conveyance areas are mainly contained within the channel and along the roadways, although during the DFE, secondary flow paths develop and bypass the main rail crossing (upper left to mid-right in Figures 13–20), and existing development and other obstructions affect flood behaviour, resulting in a complex flow pattern. No new flow paths develop in floods larger than the DFE.

The modelling method used to represent the obstructions presented by buildings means that some interpretation or manipulation of the direct model outputs may be required to develop a FPCC map. In this example, there are no overlapping elements in FPCC2 and a subcategory map has not been developed.

Figures 13 and 14 show the flood extents for the DFE and the PMF. Figure 15 shows the flood functions for the DFE. Flood hazard for the DFE is shown in Figure 16, with flow velocities rather than flood depths the key consideration. Hazard classifications H6 and H5 in the DFE are contained within the channel and therefore do not change categories. Figure 17 identifies flood emergency response classifications. Areas that have evacuation issues are identified as FIS, because no areas are Flooded Isolated Elevated (FIE).

Consideration of events rarer than the DFE allows changes in flood function or hazard to be identified.

Table 5 and Figure 18 summarise the constraints that make up FPCC mapping in Figure 19.

Figure 20 removes the gaps in flood extents where buildings are included in the model, and is clearer for land-use planning activities.

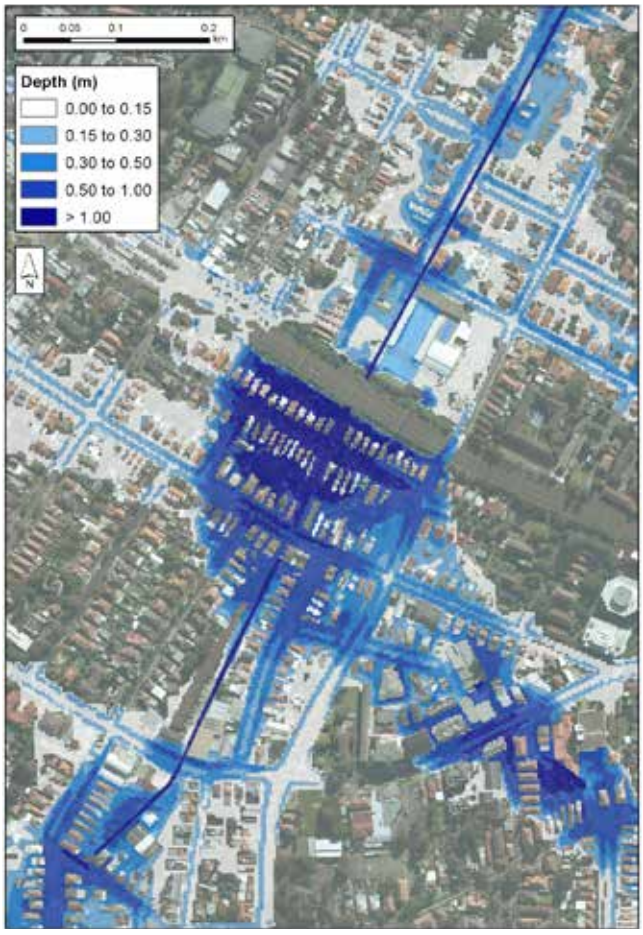


Figure 13: Example A2—flood depth and extent for the defined flood event

Figure 14: Example A2—flood depth and extent for the probable maximum flood

Table 5: Example A2—flood planning constraint category mapping

FPCC	Constraint	Reason why the constraint is considered	Reference figure
1	Flow conveyance and storage areas in the DFE	Changes in topography can significantly impact flood behaviour in the DFE	Conveyance only, as storage not significant in this case (derived from Figure 15)
	H6 hazard in the DFE	All buildings types have the potential to structurally fail in these conditions in the DFE	Derived from Figure 16
2 (excludes 1)	New flow conveyance paths develop in larger events than the DFE	New flow conveyance paths could create particularly dangerous conditions to development and occupants	All significant flow paths operate in DFE, so no additional flow paths to consider
	Flood hazard H5 in the DFE	All building types have the potential for substantial damage, which requires management	Derived from Figure 16
	Flood hazard H6 in larger events than the DFE	All buildings have the potential to structurally fail in these conditions in rarer events than the DFE	No significant change in slightly larger flood; therefore, not included in this case
	Emergency response—areas subject to isolation, some of which may also be submerged	Potential ramifications for individuals, community and emergency response organisations	Derived from Figure 17
3 (excludes 1 and 2)	Areas within hazard H1–H4 in the DFE plus DFE flood extents plus the relevant freeboard allowance	Area still affected by flood events, and needs controls to manage the scale and frequency of these effects	Outer extent derived from Figure 13 and adjusted for the freeboard
4 (excludes 2 and 3)	Within PMF (or similar extreme event)	Areas still has the potential to be affected by rare flood events, which may warrant planning constraints for some types of vulnerable development and facilities that are essential during flood emergencies	Outer extent derived from Figure 14, and internally excluded FPCC1–FPCC3

DFE = defined flood event; FPCC = floodplain planning constraint category; PMF = probable maximum flood

Figure 15: Example A2—flood functions for the defined flood event

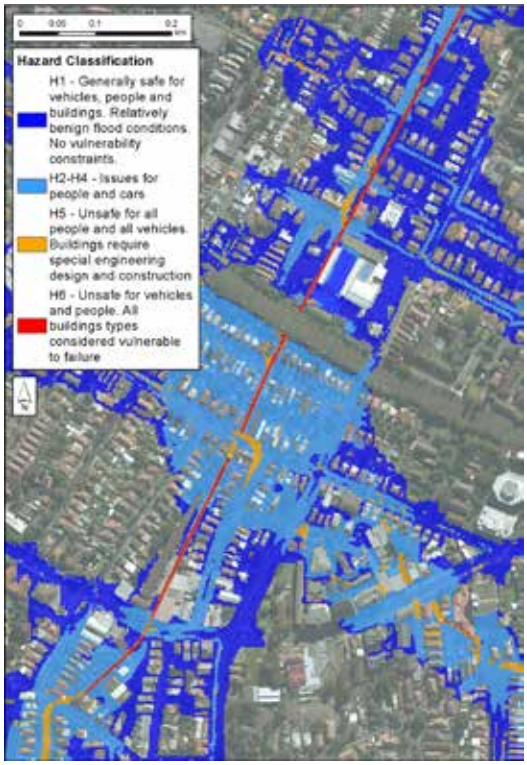


Figure 16: Example A2—hydraulic hazard for the defined flood event

Figure 17: Example A2—flood emergency response classifications

DFE = defined flood event; FIS = Flooded Isolate Submerged; PMF = probable maximum flood

Figure 18: Example A2—summary of elements in flood planning constraint category mapping

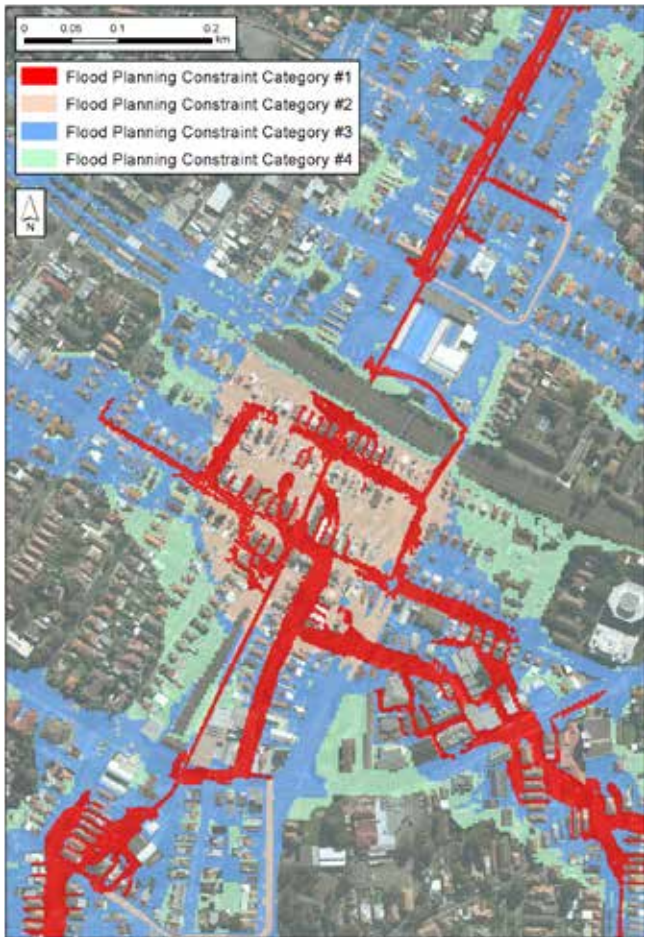


Figure 19: Example A2—flood planning constraint categories

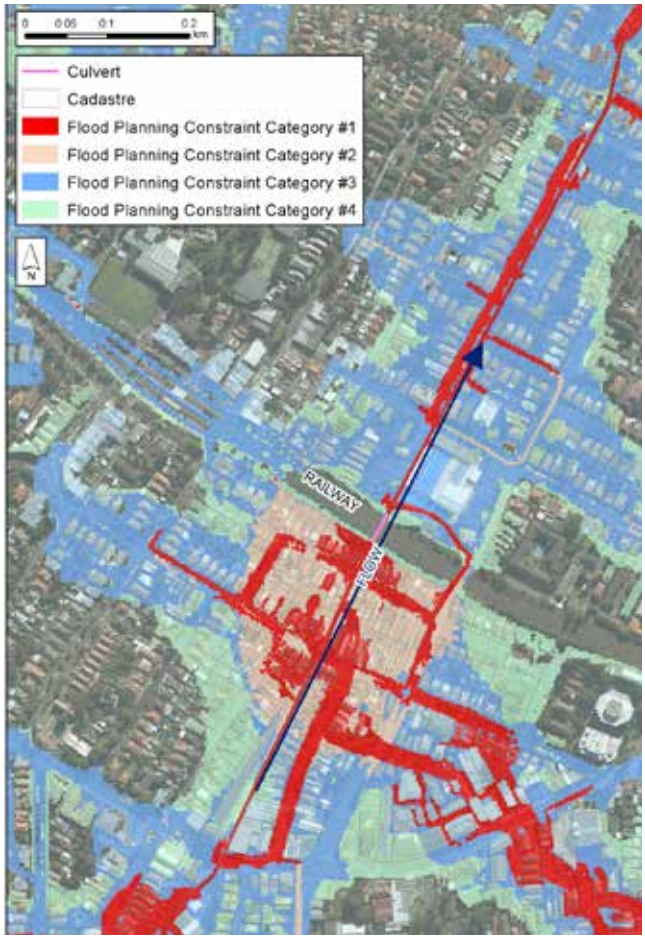


Figure 20: Example A2—refined flood planning constraint categories

A.3 Example A3—major creek, coastal town

Example A3 is a small coastal town (top right-hand corner of Figures 21–28) on a major coastal creek. The majority of the catchment is undeveloped, with a small community located closer to the coast and the creek's ocean outlet. The catchment has a moderate response time of nine hours, allowing for emergency response, including evacuation, activities to occur. The town is divided in two by the river, with access between the north and south areas (shown on Figure 21 in yellow and orange, respectively) via a bridge. When moderate flooding occurs, the bridge is overtopped and access between the two areas is restricted. Evacuation to emergency centres in larger towns to the north and south is possible with a well-coordinated response, and is an important element to consider if planning to intensify the use of the floodplain. No new significant flow paths develop in larger flood events.

Figures 21 and 22 show the flood extents for the DFE and the PMF, respectively. Figure 23 shows the various flood functions for the DFE, with flow conveyance areas mainly contained within the creeks. Flood hazard for the DFE is shown in Figure 24. Figure 25 identifies flood emergency response classifications of FIS and FIE for the study area.

Table 6 and Figure 26 identify the information synthesised into the composite FPCC map in Figure 27. Figure 28 identifies a breakdown of FPCC1 and FPCC2 into subcategories to provide more detail on the constraints in these FPCCs.

Table 6: Example A3—flood planning constraint category mapping

FPCC	Constraint	Reason why the constraint is considered	Reference figure
1	Flow conveyance and storage areas in the DFE	Changes in topography can significantly affect flood behaviour in the DFE	Conveyance only, as storage not significant in this case (derived from Figure 23)
	H6 hazard in the DFE	All buildings types have the potential to structurally fail in these conditions in the DFE	Derived from Figure 24
2 (excludes 1)	New flow conveyance paths develop in larger events than the DFE	New flow conveyance paths could create particularly dangerous conditions to development and occupants	No new significant flow paths develop in larger events
	Flood hazard H5 in the DFE	All building types have the potential for substantial damage, which requires management	Derived from Figure 24
	Flood hazard H6 in larger events than the DFE	All buildings have the potential to structurally fail in these conditions in rarer events than the DFE	No significant change in slightly larger flood; therefore, not considered in this case
	Emergency response—areas subject to isolation, some of which may also be submerged	Potential ramifications for individuals, community and emergency response organisations	Derived from Figure 25
3 (excludes 1 and 2)	Areas within hazards H1–H4 in the DFE plus DFE flood extents plus the relevant freeboard allowance	Area still affected by flood events, and needs controls to manage the scale and frequency of these effects	Outer extent derived from Figure 21 and adjusted for the freeboard
4 (excludes 1, 2 and 3)	Within PMF (or similar extreme event)	Area still has the potential to be affected by rare flood events, which may warrant planning constraints for some types of vulnerable development and facilities that are essential during flood emergencies	Outer extent derived from Figure 22, and internally excluded FPCC1–FPCC3

DFE = defined flood event; FPCC = floodplain planning constraint category; PMF = probable maximum flood

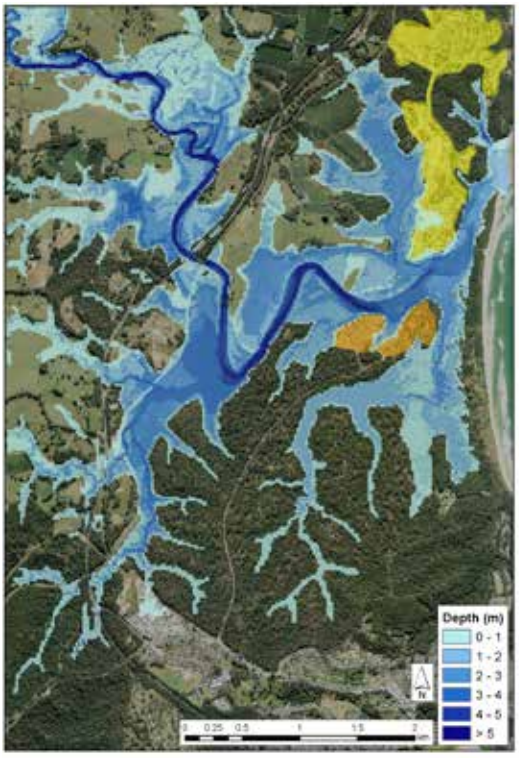


Figure 21: Example A3—flood depth and extent for the defined flood event

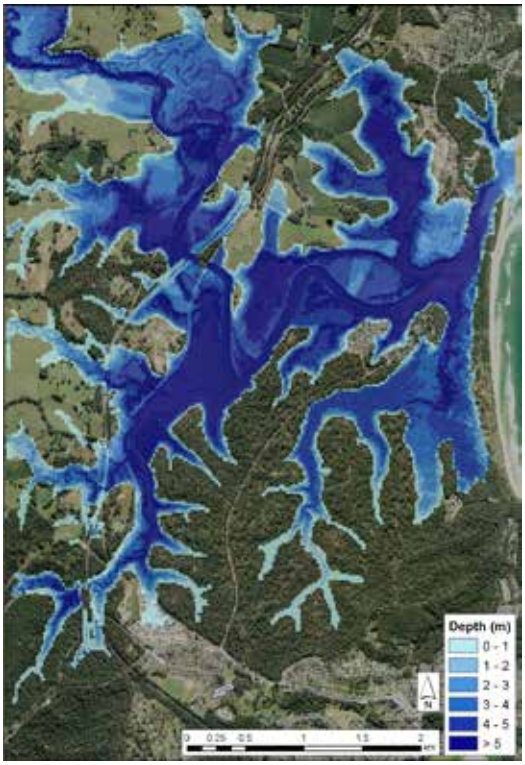


Figure 22: Example A3—flood depth and extent for the probable maximum flood

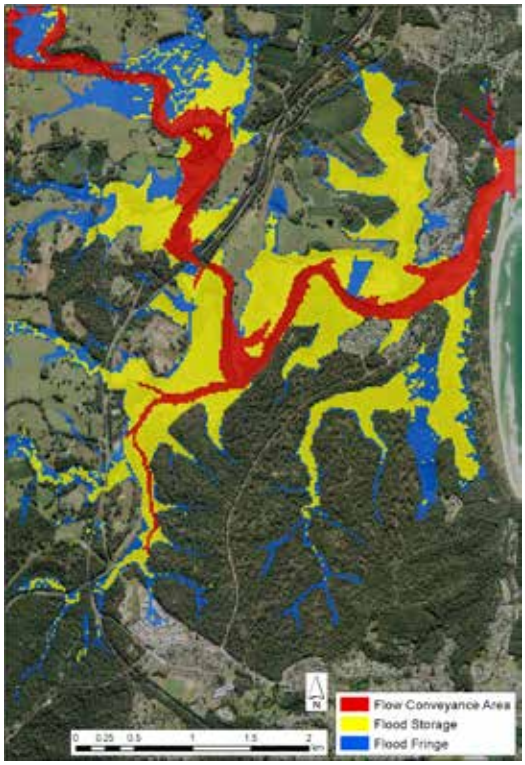


Figure 23: Example A3—flood function for the defined flood event

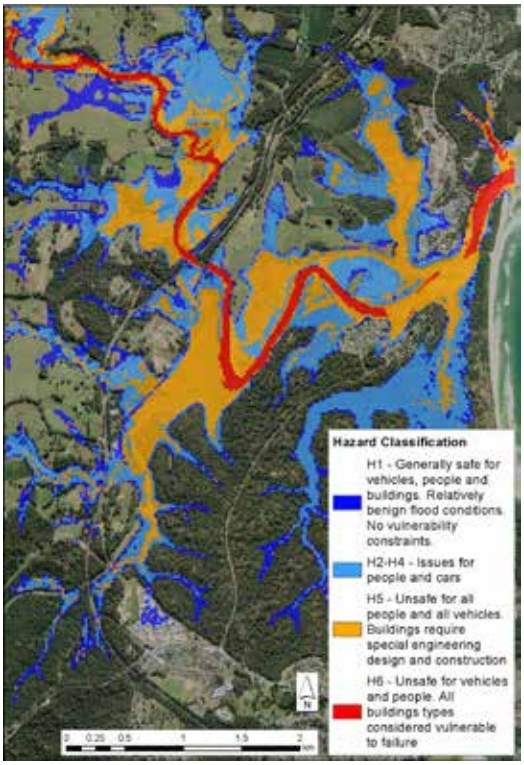


Figure 24: Example A3—hydraulic hazard for the defined flood event

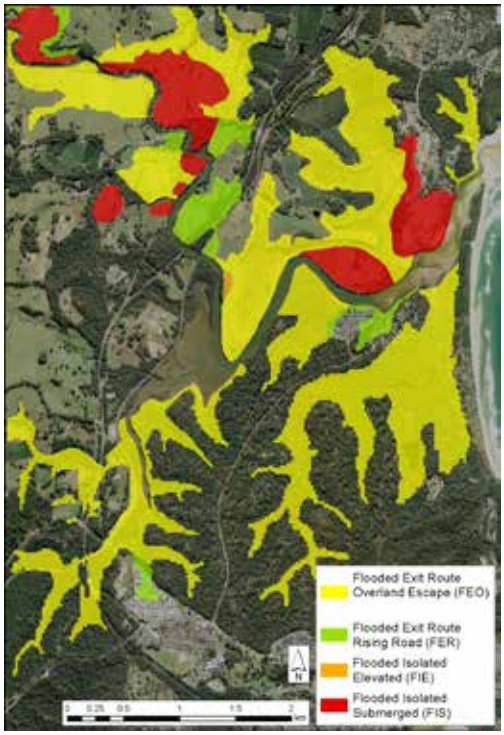
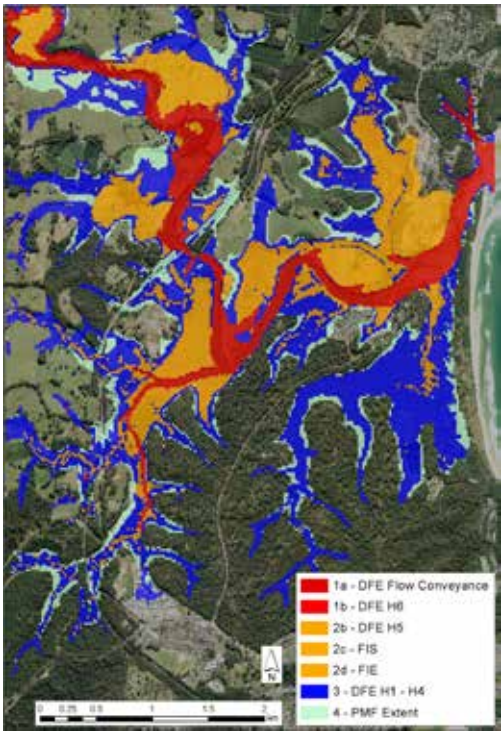


Figure 25: Example A3—flood emergency response classifications



DFE = defined flood event; FIE = Flooded Isolated Elevated; FIS = Flooded Isolated Submerged; PMF = probable maximum flood

Figure 26: **Example** A3—summary of elements in flood planning constraint category mapping

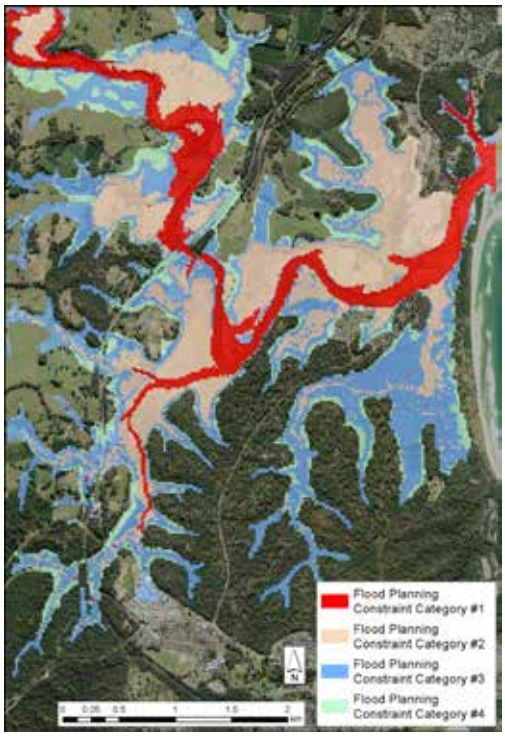
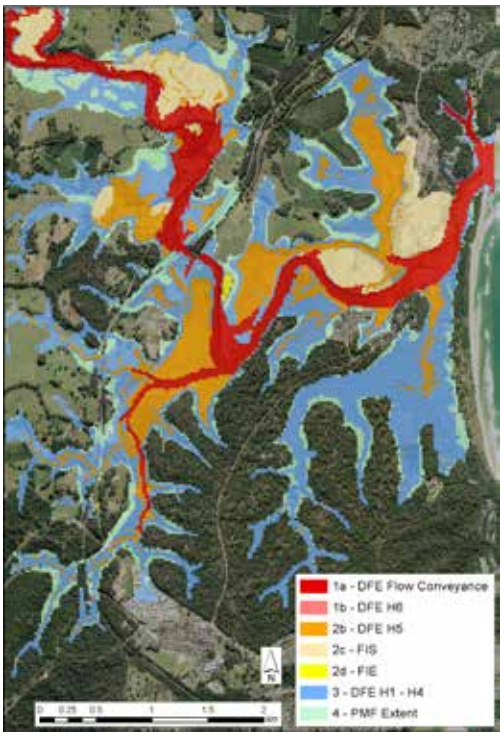


Figure 27: Example A3—flood planning constraint categories



DFE = defined flood event; FIE = Flooded Isolated Elevated; FIS = Flooded Isolated Submerged

Figure 28: Example A3—flood planning constraint subcategories

A.4 Example A4—major river, urban area

Example A4 is an urban residential area on a tributary of a major coastal river near a major urban centre. There are a number of tributaries throughout the catchment, with the urban development currently focused on one of the smaller tributaries. The remainder of the catchment is undeveloped. The location is experiencing significant development pressure for both residential and commercial uses. Land-use planning activities would focus on urban expansion and the redevelopment of existing lots.

The catchment has a moderate response time and a flood-warning system adequate for the developed tributary, so evacuation from existing residential areas may be possible. However, the system is only adequate in areas within or adjacent to the existing urban area.

Figures 29 and 30 show the flood extents for the DFE and the PMF, respectively. Figures 31 and 32 show the various flood functions and flood hazard categories for the DFE. Figure 33 identifies flood emergency response classifications for the study area. The floodplain has FIS areas that need consideration in land-use planning activities.

Consideration of events rarer than the DFE indicated that no significant changes in flood hazard or flow paths occurred that needed to be considered.

Table 7 and Figure 34 summarise the constraints that make up FPCC mapping in Figure 35. Figure 36 identifies a breakdown of FPCC1 and FPCC2 into subcategories to provide additional detail on how constraints vary within these FPCCs.

Table 7: Example A4—flood planning constraint category mapping

FPCC	Constraint	Reason why the constraint is considered	Reference figure
1	Flow conveyance and storage areas in the DFE	Changes in topography can significantly affect flood behaviour in the DFE	Conveyance only, as storage not significant in this case (derived from Figure 31)
	H6 hazard in the DFE	All buildings types have the potential to structurally fail in these conditions in the DFE	Derived from Figure 32
2 (excludes 1)	New flow conveyance paths develop in larger events than the DFE	New flow conveyance paths could create particularly dangerous conditions to development and occupants	No new significant flow paths develop in larger events
	Flood hazard H5 in the DFE	All building types have the potential for substantial damage, which requires management	Derived from Figure 32
	Flood hazard H6 in larger events than the DFE	All buildings have the potential to structurally fail in these conditions in rarer events than the DFE	No significant change in slightly larger flood; therefore, not considered in this case
	Emergency response—areas subject to isolation, some of which may also be submerged	Potential ramifications for individuals, community and emergency response organisations	Derived from Figure 33
3 (excludes 1 and 2)	Areas within hazard H1–H4 in the DFE plus DFE flood extents plus the relevant freeboard allowance	Area still affected by flooding, and needs controls to manage the scale and frequency of these effects	Outer extent derived from Figure 29 and adjusted for the freeboard
4 (excludes 1, 2 and 3)	Within PMF (or similar extreme event)	Area still has the potential to be affected by rare flood events, which may warrant planning constraints for some types of vulnerable development and facilities that are essential during flood emergencies	Outer extent derived from Figure 30 and internally excluded FPCC1–FPCC3

DFE = defined flood event; FPCC = flood planning constraint category; PMF = probable maximum flood

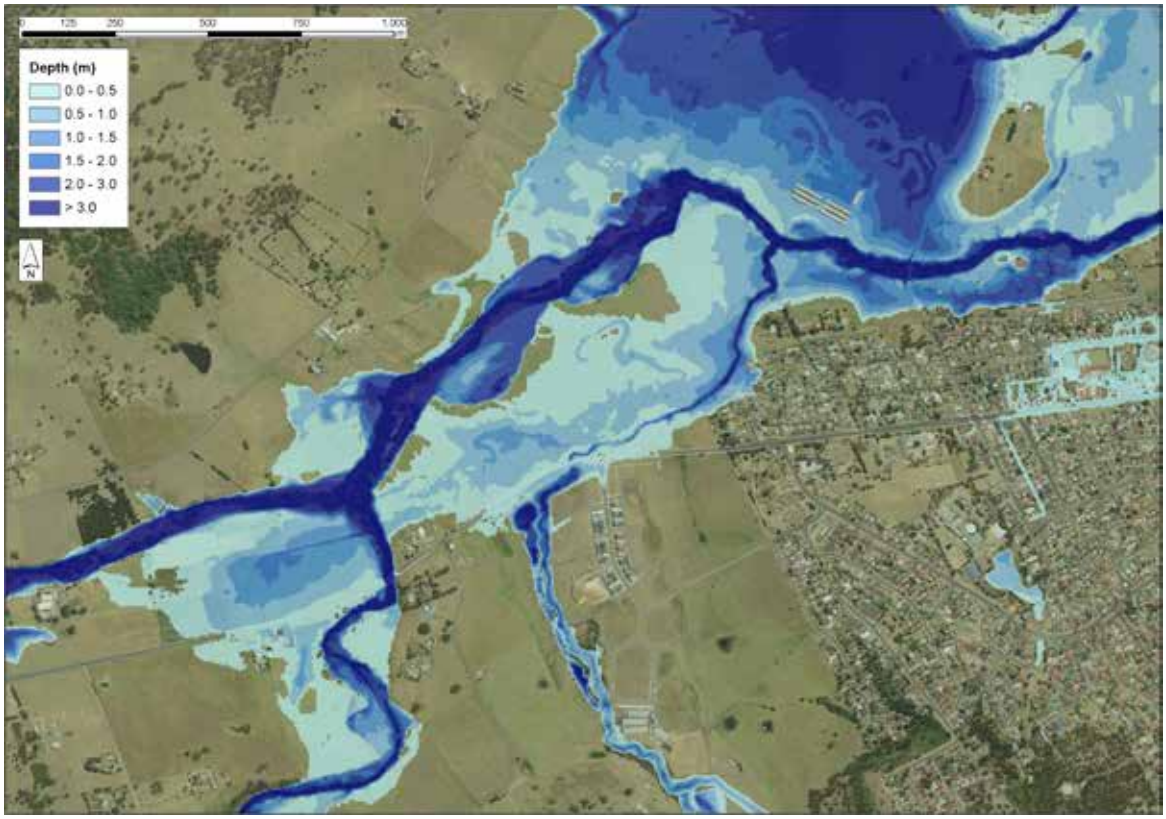


Figure 29: **Example** A4—flood depth and extent for the defined flood event

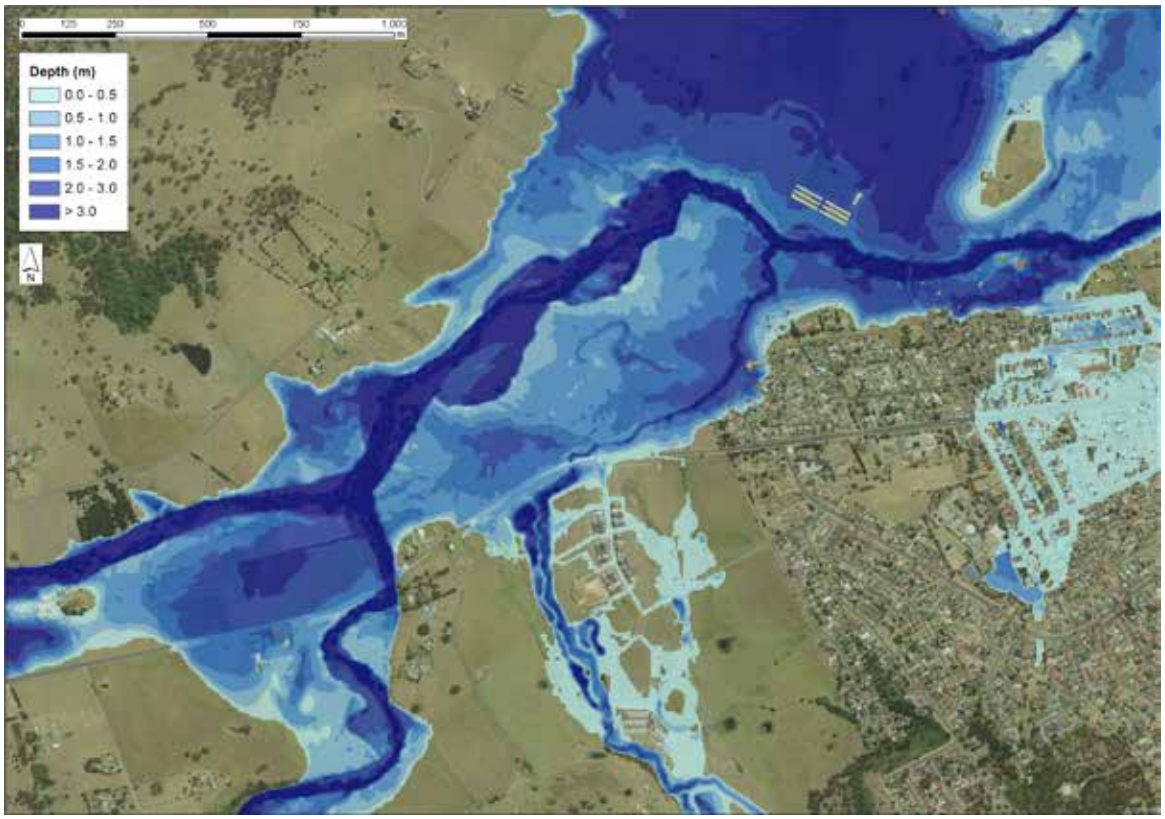


Figure 30: **Example** A4—flood depth and extent for the probable maximum flood

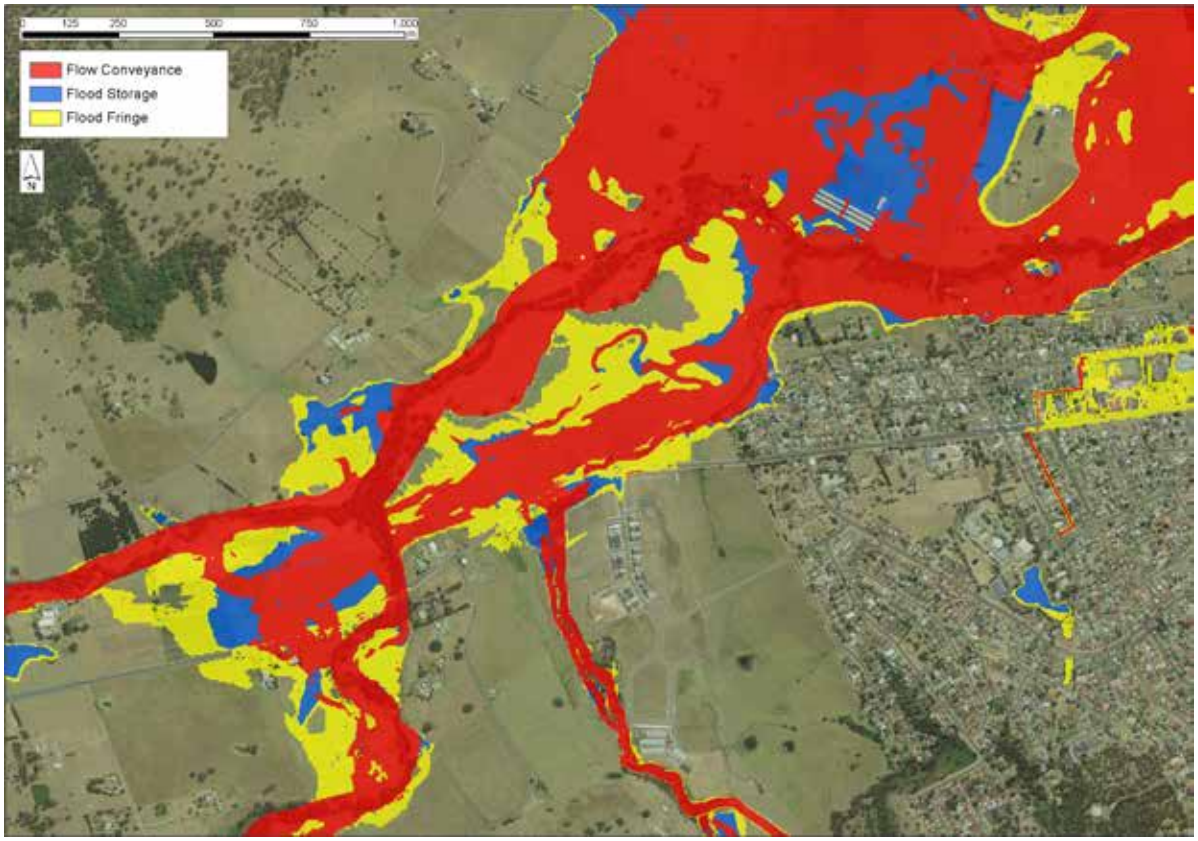


Figure 31: Example A4—flood function for the defined flood event

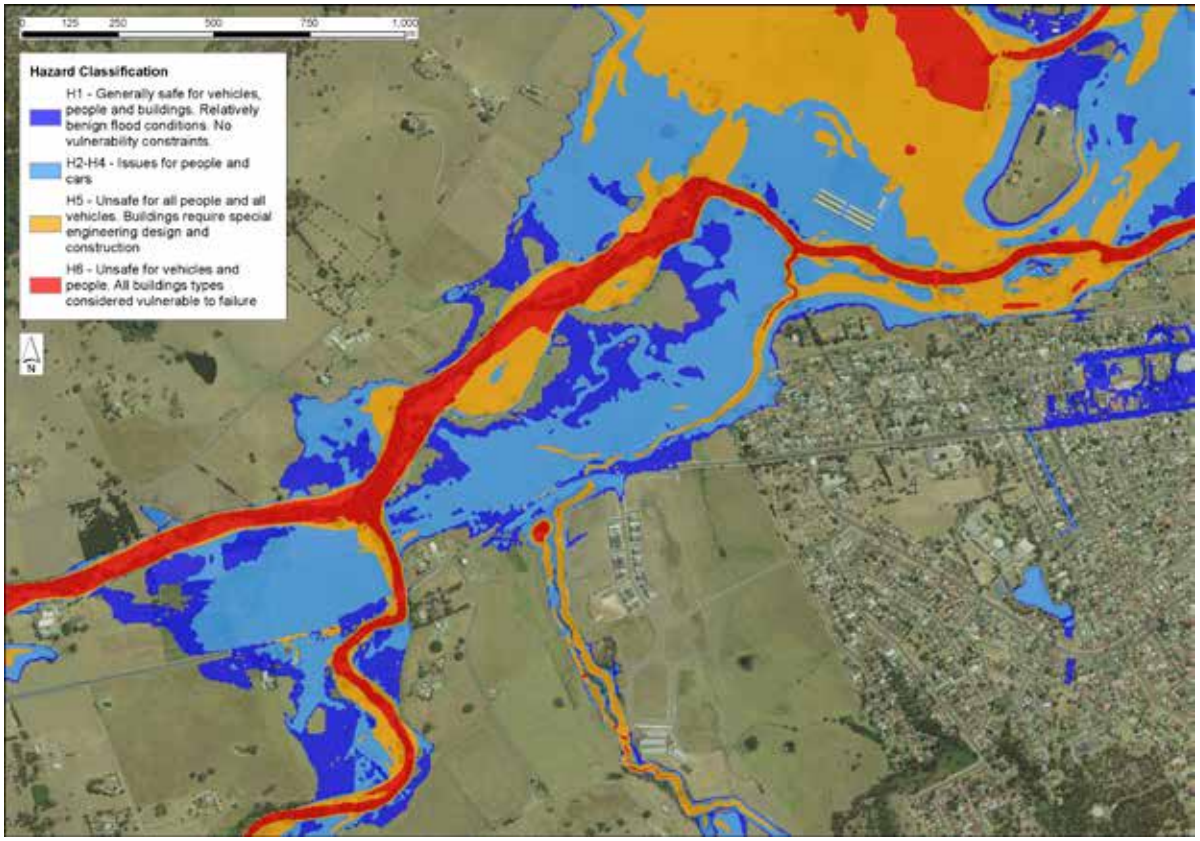


Figure 32: **Example** A4—hydraulic hazard for the defined flood event

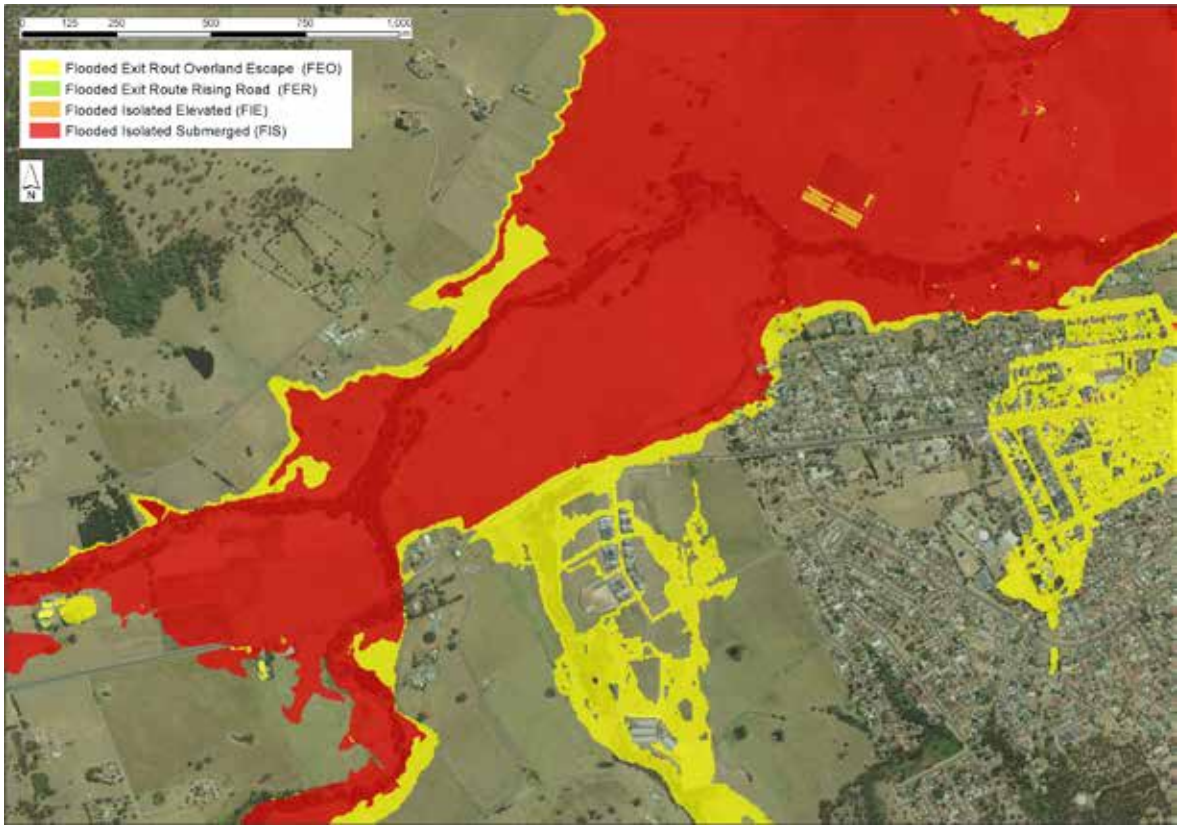
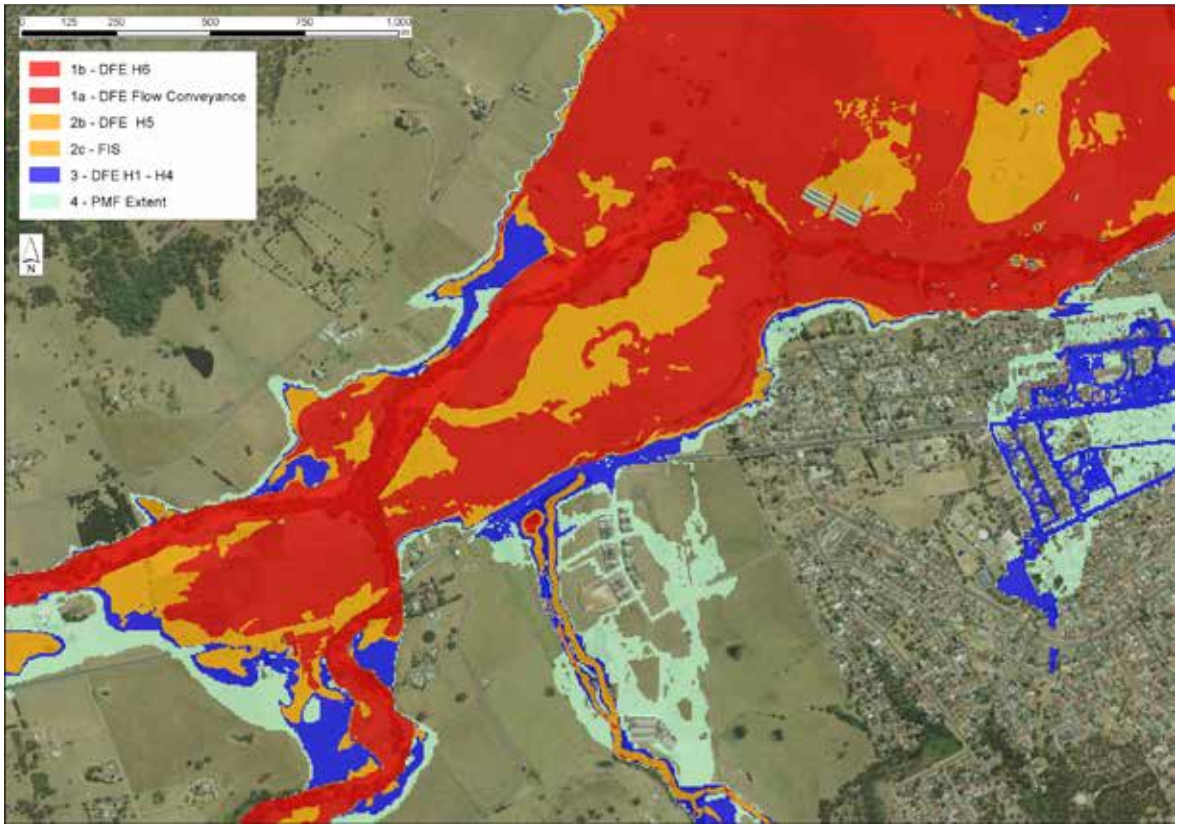


Figure 33: **Example** A4—flood emergency response classifications



DFE = defined flood event; FIS = Flooded Isolated Submerged; PMF = probable maximum flood

Figure 34: **Example** A4—summary of elements in flood planning constraint category mapping

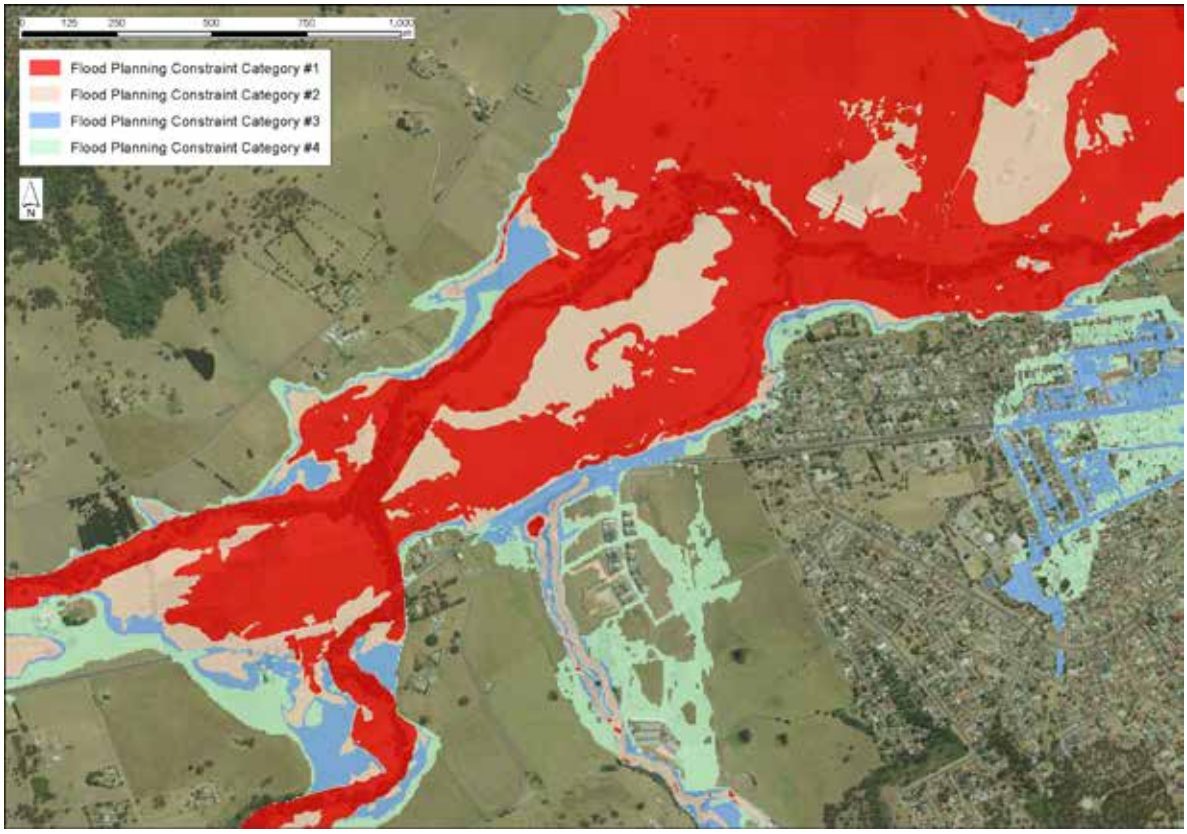
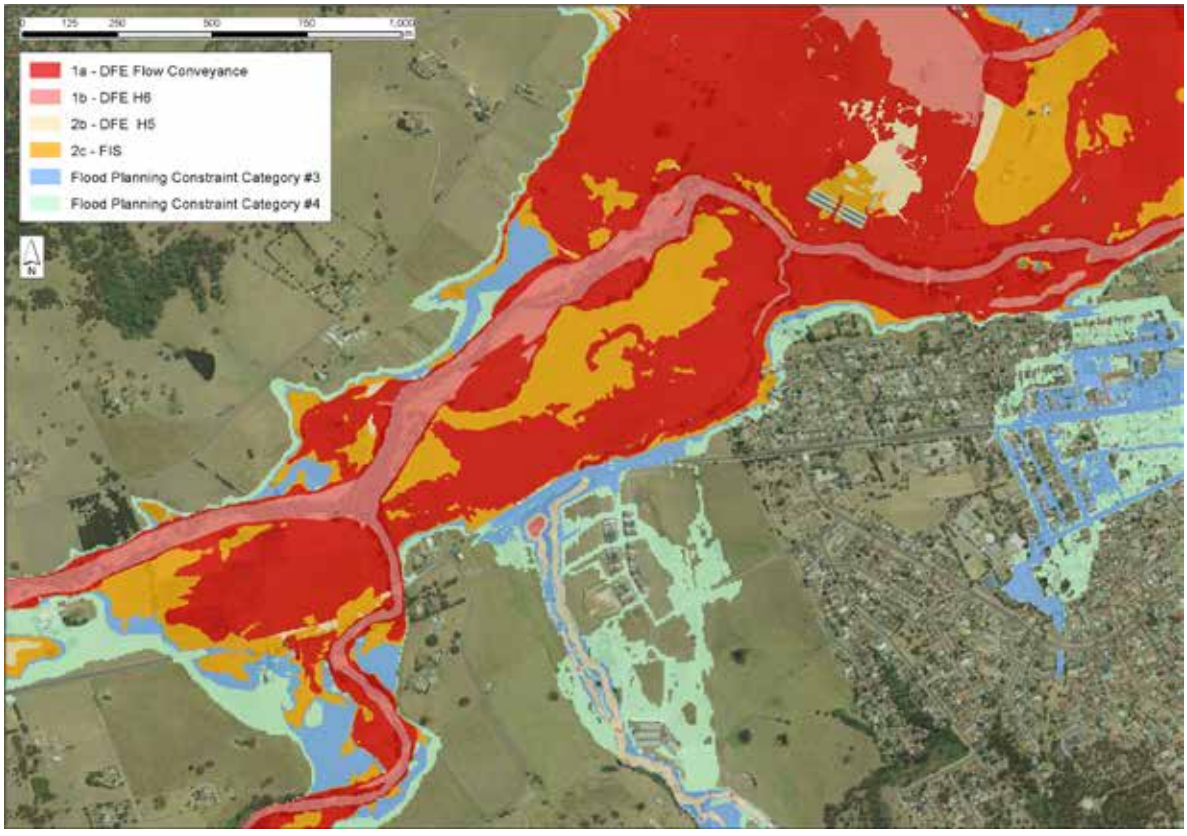


Figure 35: **Example** A4—flood planning constraint categories



DFE = defined flood event; FIS = Flooded Isolated Submerged

Figure 36: Example A4—flood planning constraint subcategories

Appendix B
Reporting example

This appendix outlines the minimum information that should be provided in a report based on full consideration of this guideline. It assumes that a general description of flooding and all technical flood analyses are contained in other sections of the report.

This example is based on Example A1 from Appendix A. It refers to figures and tables in other sections of the guideline to avoid reproduction here. In a study report, the chapter should include flood planning constraint category (FPCC) mapping and relevant tables so it can be a stand-alone reference for land-use planning activities. Maps that make up the FPCCs may be provided in other sections of the report.

B.1 Flood information to support land-use planning activities

B.1.1 Introduction

This section of the report provides information on flooding and its management to support land-use planning activities. It has been developed in accordance with the *ADR Guideline 7-5 Flood Information to Support Land-use Planning* (AIDR 2017) and relevant jurisdictional guidance. It should be read in conjunction with the guideline.

The information provided in this section is not designed to be directly used in land-use planning systems. It is meant to be considered during broader land-use planning activities, and aims to inform decision-making and, thereby, limit the growth in flood risk because of changing land uses and new development.

B.1.2 Why is it important to consider flood risk?

Floods create hazardous conditions within the floodplain. A flood risk is created when people and the built environment interact with flooding. Therefore, introducing new or intensifying existing land uses in the floodplain creates a flood risk to these developments and their users. It can also affect flood behaviour, which can affect the flood risk of the existing community and built environment. These effects will vary depending on how the floodplain is developed. Decisions on directions on preferred locations for development, and how to distribute different land uses to support community growth can all influence the growth of flood risk to both existing and future development.

Once a decision is made to develop an area of the floodplain, opportunities to reduce flood risk through planning and building conditions are limited. Therefore, understanding the varying types and severities of constraints is important, to provide a sound basis for deciding how to develop the floodplain to support community growth.

FPCCs and supporting information provide advice on where flood-related constraints exist and the issues to be considered before identifying areas for development or developing different areas of the floodplain. This information can help to determine the best locations for community facilities that need to operate in a flood emergency, and for facilities that have users who are particularly vulnerable in response to flood events.

In some cases, existing or additional treatment measures (e.g. flood-warning systems) may be integral to managing flood risk to the existing community and proposed land use or development. An example of this is documented in this section, so it can be considered in land use and development decisions. If additional treatment measures are not implemented or maintained, the land-use planning measures will be inadequate to address the floodplain management objectives for the location.

B.1.3 Short description of flood problem and study

This study is for a rural town on a major river. The town's population is approximately 2,000, with a further 1,000 living in the rural floodplain who rely on the town's services. The town is the commercial centre for the area and the base for emergency operations. The town can be affected by flooding from the river and localised flooding near drainage outlets can occur when the catchment in the town drains to the river. There are several weeks of warning of the arrival of the peak of riverine flooding, and localised flooding generally occurs because of drainage system limitations when the river is in flood. This study concentrates on flooding from the river. However, land-use planning activities must also consider the potential for localised flooding.

The majority of the town is protected by a levee system for floods up to the defined flood event (DFE).

The levee will overtop in floods larger than the DFE, and much of the town will be inundated. There are areas of the town above the probable maximum flood (PMF), with community facilities that can be used (with maintenance of utility services) for emergency response during a flood event, even if the levee overtops or fails. The town can be isolated for many days, or even weeks, and requires external support. Areas to the south of the river are isolated from the town centre during floods and are cut off from services; therefore, these areas may need additional support from the community and emergency services.

B.1.4 Floodplain management objectives

National and jurisdictional information has been considered in developing the floodplain management objectives for this location. The factors considered are outlined in Table 1.

B.1.5 Flood planning constraint categories

Four flood planning constraint categories (FPCCs) have been developed to provide advice about the relative degree and type of flood-related development constraints that apply in different areas of the floodplain. FPCC1 is the most constrained area and poses the greatest hazard to most developments and uses, whereas FPCC4 is the least constrained area and best able to support additional development. Considering development in FPCC1 and FPCC2 is likely to need further flood investigations, whereas development in FPCC3 and FPCC4 will, in most cases, not require additional flood-related investigations and have relatively few flood-related development constraints.

The development of FPCCs considers:

- **Flood extents (Figures 3 and 4 in Appendix A).** Identify areas affected by different floods, typically the defined flood event (DFE) and the PMF or a similar extreme event.
- **Flood function (Figure 5 in Appendix A).** Some areas of the floodplain are flow conveyance and flood storage areas. These areas have an important flood function and, if the floodplain is modified by development or filling, this behaviour can change. Within these areas, excluding the intensification of land use or limiting intensification to land uses compatible with these functions can limit the effects on flood behaviour and on the existing community. In this case, flow conveyance areas are important to maintain flood behaviour and are used in FPCC1. Changes to flood storage areas have limited effects on flood behaviour that can be managed by development constraints. Therefore, flood storage areas are not included in FPCC1, but would fall within FPCC2.
- **Flood hazard (Figure 7 in Appendix A).** Floods can be hazardous to people and development. Understanding how flood hazard varies for people, vehicles and buildings can assist in identifying areas that should be avoided, areas where hazard needs to be reduced to support development, and areas where standard building requirements are suitable without modifying the land.
- **Flood range (Figures 3 and 4 in Appendix A).** Floods larger than the DFE, up to and including the PMF, are examined to identify any particular areas where new flow conveyance areas operate or where flood hazard changes significantly. This provides a basis for determining areas where additional development conditions may be needed. In this case, no new flow conveyance areas develop, and changes in flood hazard are not significant and do not warrant additional development conditions.

  Examining flood range can also identify areas where flooding is likely to result in a difficult emergency response situation, so that this can be considered in decisions on changing land uses or development on the floodplain. Areas that are flooded and isolated from community emergency facilities need the most consideration. They can be broken down into areas that are then fully submerged by floodwaters (Flooded Isolated Submerged—FIS) or have some area elevated above the peak of flooding (Flooded Isolated Elevated—FIE). People who do not self-evacuate from FIS areas before they are isolated will need to be rescued or they could drown.

  FIE areas have some area of land above peak flood level that could enable retreat if evacuation failed. However, these areas are likely to have no services during a flood and people may need to be rescued for medical reasons, taken to community facilities, or provided with supplies and provisions.

  Development within FIS and FIE areas can place an additional burden on emergency services and the community.

  In this case, although there is a long evacuation time, FIS areas are isolated and inundated for extensive periods. Developing in these areas would significantly increase the burden on the community in emergency response and recovery. There are no FIE areas. FIS areas are identified in Figure 9.

Developing FPCC mapping involves combining this mapping into different FPCC categories and providing supporting information on the types of constraints that assist in addressing flood issues while considering the floodplain management objectives. The different FPCCs are shown in Figure 11, with Table 4 providing advice on the layers of information making up each FPCC category in this case.

Figure 12 provides a subconstraint category map for the FPCC1 and FPCC2 areas. This provides additional advice

on the specific constraints to address if developing in the highly constrained areas of FPCC1 and FPCC2 is being considered.

B.1.6 Typical treatment options and controls for different FPCCs

Table 2 provides general guidance on the treatment options and controls necessary to address the flood-related constraints of the different FPCCs while considering the floodplain management objectives. In this case, FIS areas may not have an issue with evacuation, but, because of isolation and inundation for extended periods, these areas will require significant community and emergency service support in, during and after a flood.

B.1.7 Relative vulnerability to flooding and community use during a flood

Understanding the relative vulnerability (compared with general residential development) of different land uses to flooding provides important information to consider in placing development in different areas of the floodplain. In addition, understanding the use of particular facilities in flood emergency management is also important, so that these can be steered towards areas that enable them to perform their community support function. Table 3 provides general guidance.

B.1.8 Need for additional treatment to manage risk

The treatment options suggested in Table 2 were examined to see if they, in isolation, could manage flood risk for, and because of, new development. This was done by assessing their ability to meet the floodplain management objectives outlined in Section 3.1 of the guide. The following treatment measures are already in place for the community:

- flood-warning system for riverine flooding
- emergency management arrangements and associated facilities
- levee protecting certain areas of the town from flooding by the DFE.

These treatment measures are unlikely to be significantly affected by the level of growth predicted for the community. However, they are integral to floodplain management in the township, including for new land uses and development. Therefore, they need to be maintained, operated and upgraded, as necessary over time, to ensure that they remain fit for purpose. Consideration was also given to the need for additional treatments to manage flood risk. As the flood range between the DFE and the PMF is relatively low, it is unlikely that additional flood-related development controls would be necessary.

However, where the levee overtops, areas protected by it can fill with water relatively quickly during a flood, and the effects of the flood can last for weeks. Overtopping of the levee can also result in relatively high-velocity waters near the levee. Development controls to reduce the flood impacts near the levee because of levee overtopping or failure could be considered. These could include limiting the ability to increase development density close to the levee, having setbacks from the levee to structures, and having additional building controls in place to reduce impacts on structures.

In addition, areas near drainage outlets through the levee can also experience flooding from ponding or backwater in internal drainage systems while the river is in flood. In this case, these areas are within FPCC3. Consideration should be given to having minimum floor levels of new developments above the ponding levels for local drainage issues inside the levee, as well as any requirements for riverine flooding, and deciding whether these areas are appropriate for more intense development.

Maintaining flood function by having land uses that are compatible with flow conveyance in FPCC1 reduces the potential for substantial changes in flood behaviour for minor flow changes due to climate change or catchment development. Therefore, FPCCs are unlikely to change substantially.

B.1.9 Future catchment conditions

In this case, the upstream catchment is very large and the scale of increasing development within the catchment relative to the scale of the catchment is unlikely to change flooding of the town.

However, changes to upstream flow distribution are important. There are several major transport links with waterway structures that maintain natural flow distribution upstream from the town. Changes to these major transport links that alter this distribution could adversely affect flood behaviour in the town. This issue is well understood by transport authorities and is being monitored. Therefore, no significant impacts of development are expected.

In addition, climate change effects on flooding are not significant. This location is not influenced by ocean levels and increases in rainfall are expected to result in only a minor change to flood behaviour, as evidenced by the limited change in flood levels between design floods. At this stage, this change does not warrant any changes to FPCC mapping or proposed development conditions.

B.1.10 Conclusions

Although the town is protected by a levee in the DFE, the levee will overtop in floods larger than the DFE, with the largest scale of impact in a PMF. There are areas of land that are flood-free in a PMF event. Given the relatively modest community growth expected,

further development would ideally concentrate in areas outside the floodplain, or in FPCC3 and FPCC4. The level of demand for new development is unlikely to require more intense land use or development within FPCC2 and FPCC1 areas. Where community facilities for emergency response are being considered, these should be located outside the floodplain wherever possible, or in FPCC4 with consideration of operation and access. Developments whose users are vulnerable in emergency response should be ideally located outside the floodplain or in FPCC4.

Figure 10 (FPCC mapping) and Table 2 provide information on the flood-related planning constraints recommended for different FPCCs. In addition, specific controls need to be considered to manage development near the levee, and to manage flooding from internal ponding of stormwater within the levee.

The FPCCs and associated development conditions are only valid where supported by the levee, flood-warning system and emergency management arrangements for the town. This community infrastructure needs to be maintained, operated and upgraded to ensure that it is fit for its intended purpose; otherwise, the FPCCs and associated controls need to be reviewed.

The FPCCs are unlikely to change substantially as a result of development or climate change if land uses within FPCC1, where not consistent with maintaining flow conveyance, are not intensified.

Appendix C
Using constraint categories in land-use planning activities

Land-use planning activities balance the needs of the community, with many different constraints, including flooding to help direct future community growth.

Flooding is an important constraint to consider up front or as early as possible in planning activities, because development in some areas may not be feasible. This may be because of the impacts of development on the flood risk of the existing community, or the flood risks that may be posed to the new development and its users. If decisions are made to locate development in some more severely flood affected areas it may be difficult and expensive to mitigate the consequences of this decision to the existing community and to the new development and its users.

Therefore, it is important to consider flood-related constraints in decisions about where development may be appropriate.

Flood planning constraint categorisation and the other information in this guideline can help inform land-use planning activities, such as identifying:

- areas that are unsuitable or less suitable for more intense development
- areas that are more suitable for development
- the types of land uses that are more suitable for different areas of the floodplain
- the right development conditions and supporting treatment measures needed to address growth in risk due to development.

This advice needs to be considered in the context of the relevant jurisdictional legislation, regulation, policies and land-use planning systems.

This information can reduce the growth in flood risk to both the existing community and future development.

Flood planning constraint category (FPCC) mapping is interpreted directly from modelling results and analysis, and may need to be simplified to suit different land-use planning activities.

Examples of how to use the information developed in this guideline are provided below. These are based upon the examples provided in Appendixes A and B.

C.1 Example C1—moderate expansion of an existing flood-affected community

This example is based on the flood situation outlined in Example A1 and discussed further in Appendix B. The FPCCs are shown in Figure 37 and the broader flooding in Figure 38.

The town is cut off from other major centres. It is protected by several levees (north and south of the river) that are intended to be maintained and operated into the future. The levees create some internal flooding issues (limited to FPCC3 areas) if a local storm occurs while the river is in flood (which can be for weeks). Flooding can be limited by pumping stormwater into the river. The flood-warning system provides weeks of warning, and there is a long-term commitment to maintain this system.

Therefore, the protection provided by levees and the flood-warning systems can be factored into strategic planning and local flooding decisions.

C.1.1 Selecting areas suitable for development

In selecting areas for greenfield development for an existing community, it is recommended to avoid development in FPCC1 and FPCC2 areas.

Development in FPCC1 areas should generally be avoided to reduce its impacts on existing flood behaviour and the flood risks to the existing community. In addition, it is unlikely that treatment measures would reduce the exposure to severe flood hazards that new development in these areas would have.

FPCC2 areas are also often avoided for development because of the degree of flood hazard and emergency management issues and the associated flood risk that often exist. These issues often result in a large

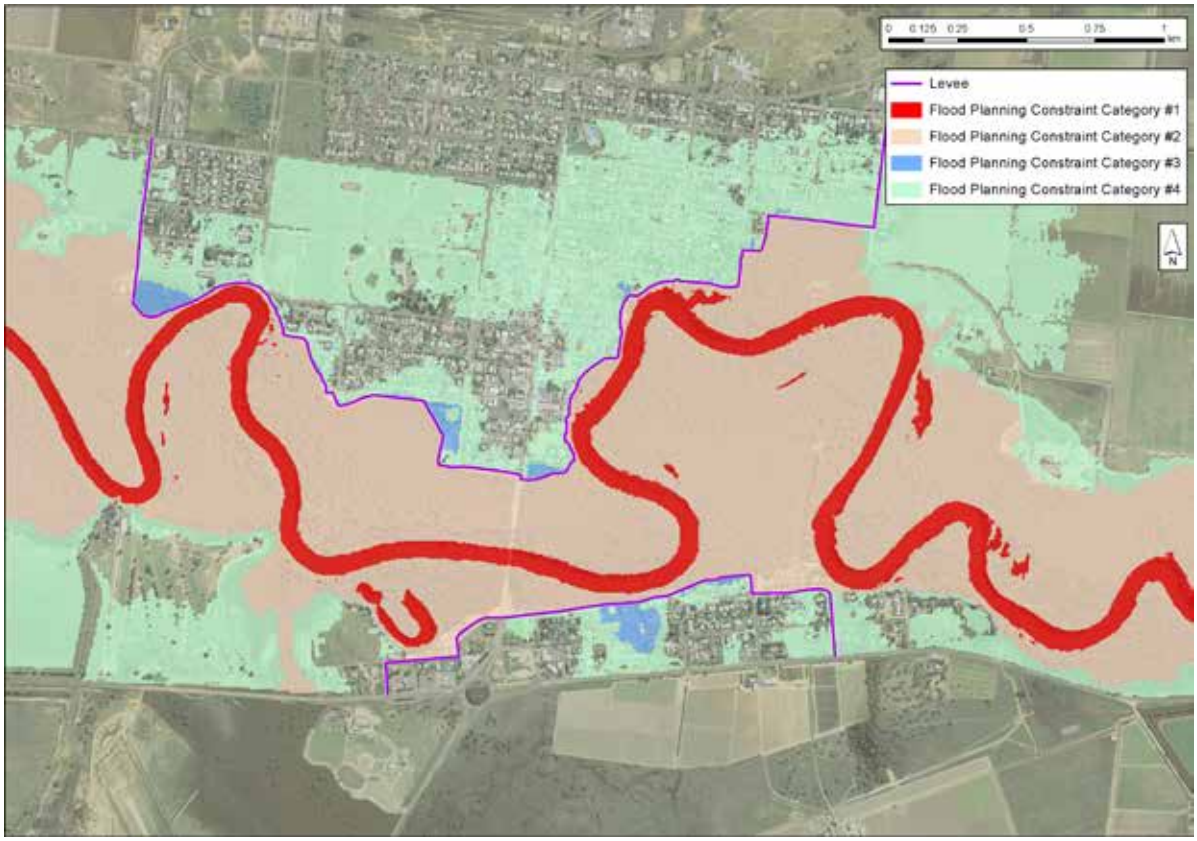


Figure 37: Example C1—flood planning constraint categories

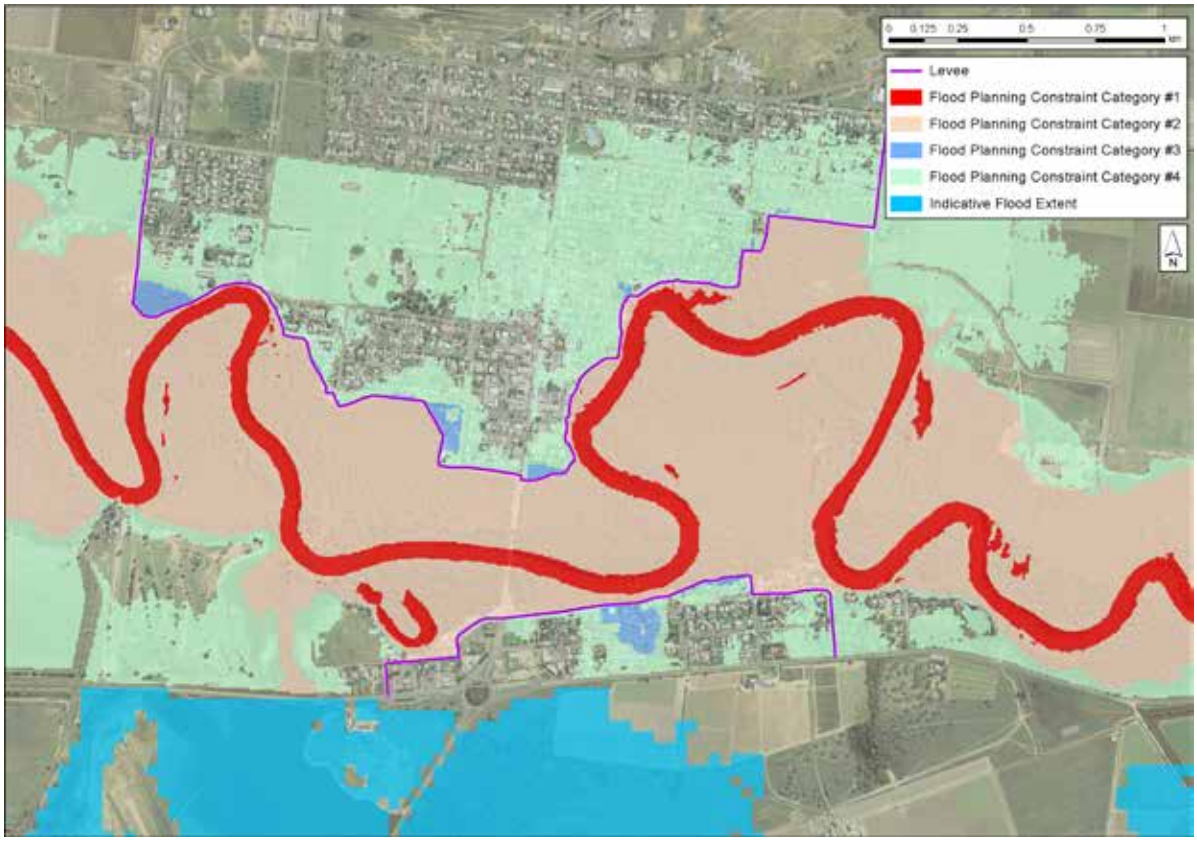


Figure 38: Example C1—indicative broader flood extents in rural areas near the town

amount of development controls and infrastructure, which affects the cost of development and the ongoing cost to government in maintaining and repairing this infrastructure, and in supporting communities in emergency response and recovery.

Greenfield urban development in FPCC3 or FPCC4 areas, or outside the floodplain is generally preferable to development in FPCC2 areas. Where development within FPCC2 areas is proposed, additional flood investigations will often be necessary to determine effective management options.

FPCC3 areas are more readily able to be developed; however, there will likely be restrictions on land use, particularly for emergency response facilities, vulnerable land uses and a range of flood-related development controls required to reduce the risk to to all future development in this area.

FPCC4 areas can generally be developed without flood-related restrictions. However, community facilities used in emergency response and land uses whose users are vulnerable in emergency response may require development conditions or may be better located outside the floodplain.

In this example, significant areas of land are outside the floodplain (not shaded in Figure 37), and in FPCC3 and FPCC4 areas north of the river and connected with the existing town. Therefore, substantial land is available for development with limited flood impacts relative to the modest anticipated growth potential of the town. Future development can be targeted to areas in FPCC3, FPCC4 and outside the floodplain.

Given the length of time the river is in flood and since land supply is not limited relative to demand, no new greenfield residential land releases would be recommended south of the river. However, since this area is close to a major transport route, some light industrial or commercial development may be desirable here.

C.1.2 Locating different types of land use

The next step is to determine how to use the available land. This involves considering where different types of development would be best located in growing the town, considering demand for different development types. This should consider the use of different development types in response to a flood emergency, and the relative vulnerability of the land uses and users of the land to flooding. Table 3 in the guideline provides some advice.

An efficient way of determining how to distribute land uses within the available land is to first locate facilities required during a community emergency response. These need to operate during a flood event, so their exposure to flooding needs to be limited.

The next step is to locate the land uses with development or users that are most vulnerable to flooding where their flood exposure is limited. This process continues until the least vulnerable types of development are located. For example, locate residential aged care facilities first, and less intense development such as agricultural development typically last.

In this example, developments used in emergency response (e.g. emergency response hospitals, evacuation centres) are ideally located in the northern part of town in areas outside the influence of flooding or in the fringes of FPCC4 areas, where they can still perform their emergency response roles during a flood event.

Land uses with occupants or users who are vulnerable in emergency response (e.g. residential aged care facilities) should be located in places where the consequences of failed evacuations are limited. These would generally be in areas where flood depths are relatively shallow and evacuation routes are relatively short. Therefore, areas to the north of town—within and towards the fringes of FPCC4 areas, or outside the floodplain—would be the most suitable.

FPCC1 and FPCC2 areas are generally between the northern and southern sections of town near the river, and outside the protection provided by the levees. Given the demand for development relative to the available land the areas are not considered for further intensification of use at this time. The exception is generally for intensification of agricultural activities that are compatible with maintaining flow conveyance, and therefore unlikely to negatively affect flood behaviour near the town. Any agricultural activities and works in these areas should also consider the degree of flood hazard in the location and the limited ability to manage this hazard.

C.1.3 Development constraints in different areas of the floodplain

This advice can be used, along with other non–flood related constraints to develop strategic directions for the community. Section 3.1, Table 2 of the guideline provides advice on the typical floodplain management objectives. Table 2 provides examples of development constraints that assist in achieving these objectives in different FPCCs. These could be used in conjunction with jurisdictional advice to develop documentation to support implementation of strategic directions through land-use planning systems.

C.2 Example C2—infill development in an existing flood-affected community

Example C2 examines infill development and redevelopment of existing lots using the same flood situation as in Example C1. Development and redevelopment of existing lots at their current allowable

density would be encouraged in FPCC3 and FPCC4 areas north and south of town within the areas protected by the levees. However, there would be some specific development requirements because of flooding from the river and internal flooding issues because of the levees.

No increase in the current allowable density of residential development would be encouraged in the area south of the river, even where protected by the levee, because of the isolation of the area from the commercial centre of town during a major flood event. However, commercial and light industrial development adjoining the major east–west transport route could be considered, to provide additional services to route users.

In addition, any new development or redevelopment of lots adjacent to levees should be set back from the levees to provide room for overtopping flow to go around, rather than through, structures. Setback would also enable access for operation and maintenance of the levees, or any future levee upgrade. This should be supported by a formal mechanism (such as an easement), to allow access to the levees and to prevent any degradation to its structural integrity.

C.3 Example C3—redevelopment in an existing urban area affected by flooding

Example C3 is based on Example A2 in Appendix A. It examines intensification of existing residential development in a developed flood-affected area. When examining existing flood-affected areas, it is important to acknowledge that a degree of flood risk already exists. However, this risk can be increased purely by increasing the density of population and infrastructure within the floodplain. This potential for significant growth of flood risk needs to be managed.

The FPCC mapping (Figure 39) can be used to consider alternative mechanisms of achieving a particular development outcome, such as accommodating increased population. Table 2 of the guideline outlines the typical constraints that may apply in the different FPCCs.

Figure 40 shows the area being considered for redevelopment. The flood situation in this area provides limited flood-warning time. Also, flood warnings are limited to a general storm warning for the broader city area, rather than any catchment-specific warning. This can result in residents being exposed to hazardous flood conditions on streets and properties.

Strategic planning for the area is examining whether to allow redevelopment on a lot-by-lot basis, or to support larger-scale redevelopment by encouraging consolidation of individual house lots to facilitate large-scale higher-density redevelopment. Road and rail corridors are to remain in the current configuration.

The flow patterns in the area are complex and rely on flow within individual roads, drainage lines and a number of properties. The complexity of the different flood-related constraints in the area led to a decision to combine FPCC1 and FPCC2. This combination provides clearer delineation between areas with significant constraints (FPCC1 and FPCC 2), as shown on Figure 40, from those with lesser constraints (FPCC3 and FPCC4).

The controls applied to development in the combined FPCC1 and FPCC2 area should cover those identified in Table 2 for both of these FPCCs. FPCC3 and FPCC4 remain separate, because the different levels of constraints as per Table 2 remain valid. The lack of flood warning may mean that additional development conditions need to be considered—particularly in FPCC1 and FPCC2.

In addition, underground car parking is likely to be needed in some cases, particularly where higher-density development is being proposed; therefore, redevelopment needs to consider the potential for floodwaters to enter the car park, and manage this accordingly. This may involve:

- locating car park access in areas less affected by floodwaters where possible, reducing the potential for water to enter the car park (e.g. by raising entrances)
- having systems in place to manage water that has entered carparks (e.g. pump systems)
- addressing emergency response issues because of water entering the carpark.

This is a consideration across all FPCCs, although it is less onerous in FPCC4.

C.3.1 Lot-by-lot redevelopment

Examining the potential to apply redevelopment on a lot-by-lot basis in FPCC1 and FPCC2 areas could lead to a decision to not allow any intensification of development in these areas. Development in combined FPCC1 and FPCC2 would likely affect flood behaviour and increase the number of people exposed to hazardous flood conditions where no specific or feasible flood warning was available.

However, as these lots are already developed, and the current structures and their occupants are exposed to flood risk, redeveloping these lots at the same density and maintaining at least the same surface and underground flow capacity could be encouraged. This could provide an opportunity to reduce the effects of flooding on individual structures and their occupants without significantly affecting flood behaviour. This would involve applying the development controls of the combined FPCC1 and FPCC2 to redevelopment of individual lots. These controls would:

- reduce exposure and damage potential

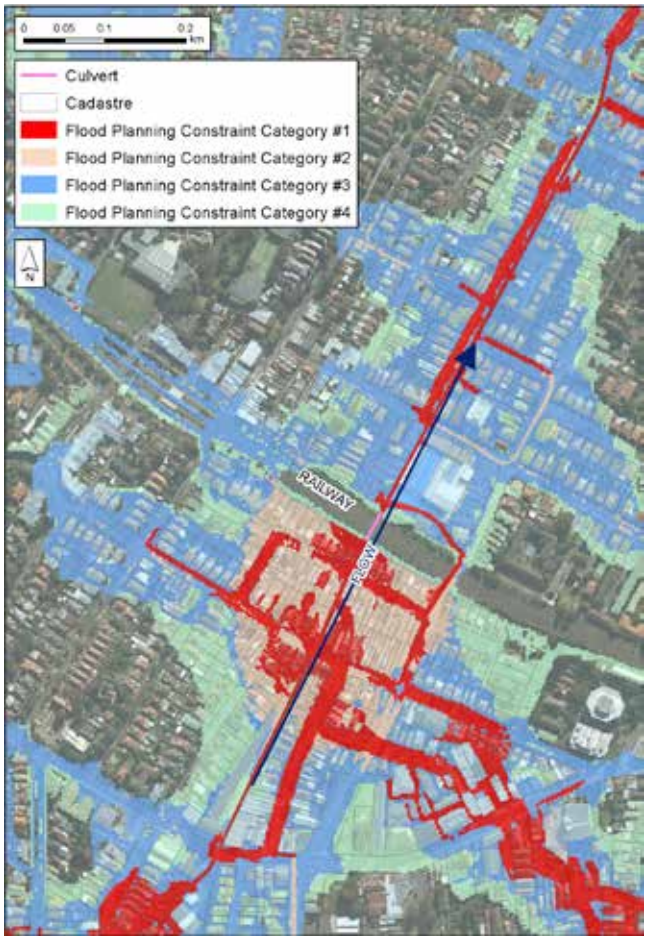


Figure 39: Example C3—flood planning constraint categories

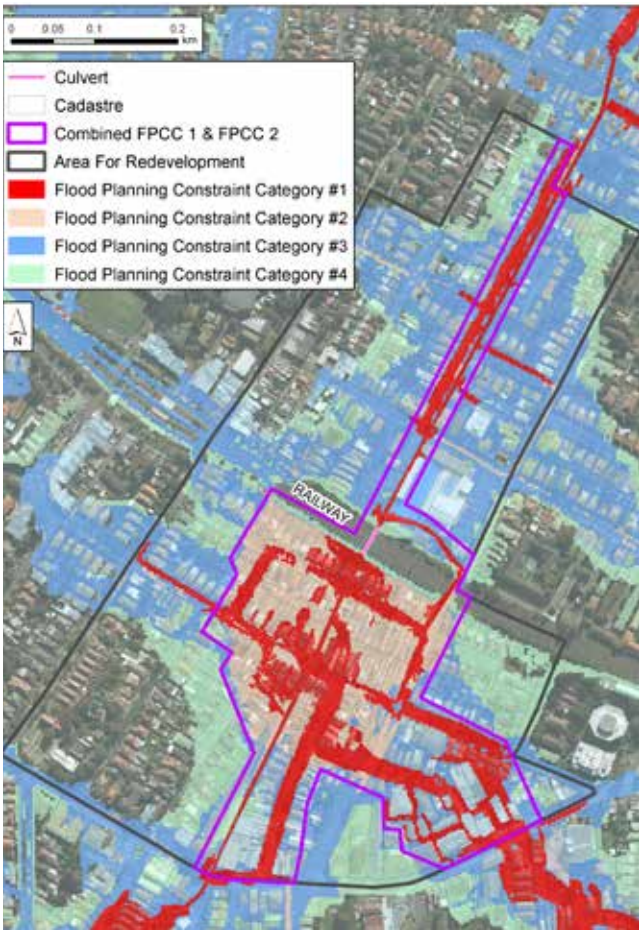


Figure 40: Example C3—combined flood planning constraint categories 1 and 2

- require flow paths to be maintained to ensure that others properties are not adversely affected by redevelopment
- consider the emergency management difficulties in this area.

Higher-density development could be encouraged in lots within FPCC3 and FPCC4 areas, and outside flood-affected areas. These areas are less constrained and would need fewer flood-related development controls than the combined FPCC1 and FPCC2 area.

C.3.2 Redevelopment based on urban blocks

If the lot-by-lot approach in Section C.3.1 does not meet additional development needs, redevelopment on a precinct or urban block basis (particularly in FPCC1 and FPCC2) could be considered. This could encourage consolidation of land ownership within an urban block (or range of adjacent lots) and enable redevelopment as a single project.

This approach has potential advantages for the areas upstream from the railway, because it could enable the disparate flow paths through the individual properties within the city blocks to be consolidated while ensuring that flood behaviour on other properties is not affected, and that the surface and underground flow capacity through the overall site is maintained. The remainder of the site could be designed to take advantage of the consolidation of flow paths while still addressing the development requirements of the combined FPCC1 and FPCC2, and the need to provide open space for the community and, where feasible, additional residential development capacity.

C.4 Example C4—key community facility in an emergency response

Example C4 examines the location and development controls required for a community facility with an important emergency response function—in this case,

a community hospital with medical emergency facilities that is required to function during a flood emergency.

C.4.1 Operational parameters for the hospital

When considering a community hospital with medical emergency facilities that is proposed to be operational during a flood emergency, several factors must be considered about how it is intended to operate. Does it need to operate normally during an emergency? Does it need to treat emergencies during a flood event? In most cases, the answer to both questions is yes. Meeting these operational parameters during a flood assumes that the hospital:

- is accessible
- has utility services
- can be resupplied
- is not flooded.

The ability to meet these requirements will depend on the flood situation, including how quickly flooding can occur, how long it will last and the likely flood depths at the location.

Shorter floods will generally mean that functions are cut off for shorter periods of time, but there will be less time to respond to the effects of a flood. Longer duration floods have more warning time, meaning that there is more time to prepare in the lead-up to a flood. However, the flood lasts longer, so the hospital needs to operate within the flooded environment for a longer time. More hazardous flooding, including higher flood water depths at the location, means that meeting these operational parameters will be more difficult.

C.4.2 Options for meeting operational parameters

To meet the operational parameters for a community hospital with medical emergency facilities, the hospital would ideally be located outside the floodplain and strategic planning would aim to achieve this. However, even if located outside the floodplain, there can be indirect flood effects, such as loss of power and other utilities. Backup services may need to be considered and are generally required for other reasons. Backup services would need to consider the length of time that the utility services they replace may be out of action. This can vary significantly depending on the length of the flood event and the ability of the service provider to get services up and running in response to the event.

It is not always feasible to locate the community hospital with medical emergency facilities outside the floodplain because of the lack of available land, or where land is already set aside for the hospital, or there are a range of other criteria that need to be met that means it cannot be located out of the floodplain. Where this is the case, additional development controls are needed to ensure that it meets these operational parameters. The alternative is to accept a compromised set of operational parameters for the facility (discussed in Section C.4.3).

Assuming the community hospital with medical emergency facilities is to remain operational for the full range of flood events, the following additional development controls may need to apply whether the hospital is located in an FPCC3 or an FPCC4 area:

- Floor levels of emergency areas and wards to be above the probable maximum flood (PMF) to ensure that these areas can operate and will not need to be evacuated.
- Backup utilities located to allow them to be operational and accessible, and, where necessary, resupplied, so they do not fail because of flooding in the PMF.
- Site design to maximise access to the emergency entry to the hospital during flooding. This may affect the location and design of the entrance. Where accessibility remains an issue, arrangements should be made to close emergency and have alternative medical emergency arrangements in place.
- When considering the PMF, the facility's design needs to enable
  - resupply of essential goods and materials during floods so it can continue to operate
  - adequate room for storage of waste products away from floodwaters.

The less flood affected the location, the easier it will be to meet these conditions. FPCC4 areas would generally need less work to meet these conditions than FPCC3 areas.

Locating this type of facility in FPCC1 and FPCC2 areas is not recommended. Where land in these areas has been specifically set aside for a community hospital, construction in this area would require significantly more investment, and would need to address, for example, the effects of the development on flooding and the flood risk to other developments, the flood hazard at the location, and access issues. Considering these factors would result in the development being even less likely to meet operational parameters.

C.4.3 Compromising operational parameters

A decision that will compromise operational parameters can affect accepting patients and admitted patients, and need to be considered.

One compromise may be to design the community hospital to only service medical emergencies during a flood of a particular magnitude or annual exceedance probability (AEP) while normal services for admitted patients are maintained. This would avoid an evacuation during a flood event that escalates beyond an initial

prediction. Utility services, patient wards and resupply would all need to meet the criteria discussed previously, so the hospital can function during all events. However, alternative arrangements would be required for medical emergencies during larger floods.

A more significant compromise with broader ramifications would be to design the hospital to only function during a flood of a particular magnitude or AEP. This would mean that the hospital would flood during a larger flood event and would not be able to accept medical emergencies. All staff and admitted patients would have to be evacuated to an alternate location.

Limitations on the ability to evacuate a hospital would depend on:

- the available flood-warning time
- the risk to patients
- evacuation logistics
- patient services available at alternate sites
- the length of time these services can be maintained, relative to when the flood recedes and the hospital can be operational again.

These factors and the associated compromises should be clearly understood, considered and documented when determining operational parameters. In addition, associated flood emergency management planning will be needed.

Acronyms and abbreviations

AEP	annual exceedance probability
DFE	defined flood event
FIE	Flooded Isolated Elevated
FIS	Flooded Isolated Submerged
FPCC	flood planning constraint category
PMF	probable maximum flood

References

Australian Disaster Resilience Handbook 7 Managing the Floodplain: A Guide to Best Practice in Flood Risk Management in Australia, AIDR 2017, Melbourne.

Australian Disaster Resilience Template 7-4 Technical Project Brief Template, AIDR 2017, Melbourne.

Australian Disaster Resilience Guideline 7-1 Using the National Generic Brief for Flood Investigations to Develop Project-specific Specifications, AIDR 2017, Melbourne.

Australian Disaster Resilience Guideline 7-3 Flood Hazard, AIDR 2017, Melbourne.

Australian Disaster Resilience Guideline 7-2 Flood Emergency Response Classification of the Floodplain, AIDR 2017, Melbourne.

Australian Disaster Resilience Practice Note 7-7 Considering Flooding in Land-use Planning Activities, AIDR 2017, Melbourne.

Ball J, Babister M, Nathan R, Weeks W, Weinmann E, Retallick M, Testoni I (eds) 2016, Australian rainfall and runoff: A guide to flood estimation, Commonwealth of Australia, Canberra.

Background information

The following references provide an explanation around the development and interrelationship of ADR Handbook 7 and the associated suite of related technical flood risk management guides and other documents that support ADR Handbook 7.

McLuckie D 2013, A guide to best practice in flood risk management in Australia, Floodplain Management Association National Conference, Tweed Heads, May.

McLuckie D 2014, Updating national best practice guidance in flood risk management, Floodplain Management Association National Conference, Deniliquin, May.

McLuckie D 2015, Improving national best practice guidance in flood risk management, Floodplain Management Association National Conference, Brisbane, 19–22 May.

McLuckie D, Toniato A 2015, Planning for flood risk, Hydrology and Water Resources Symposium, Hobart, 7–10 December.

McLuckie D, Toniato A, Askew E, Babister M, Retallick M 2016, Supporting land use planning by providing improved information from the floodplain management process, Floodplain Management Australian Conference, Nowra, 16–19 May.

Australian Institute for
Disaster Resilience

www.aidr.org.au

Australian Institute for Disaster Resilience
Knowledge Hub

www.knowledge.aidr.org.au