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Floodplain Management

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Introduction to Floodplain Management

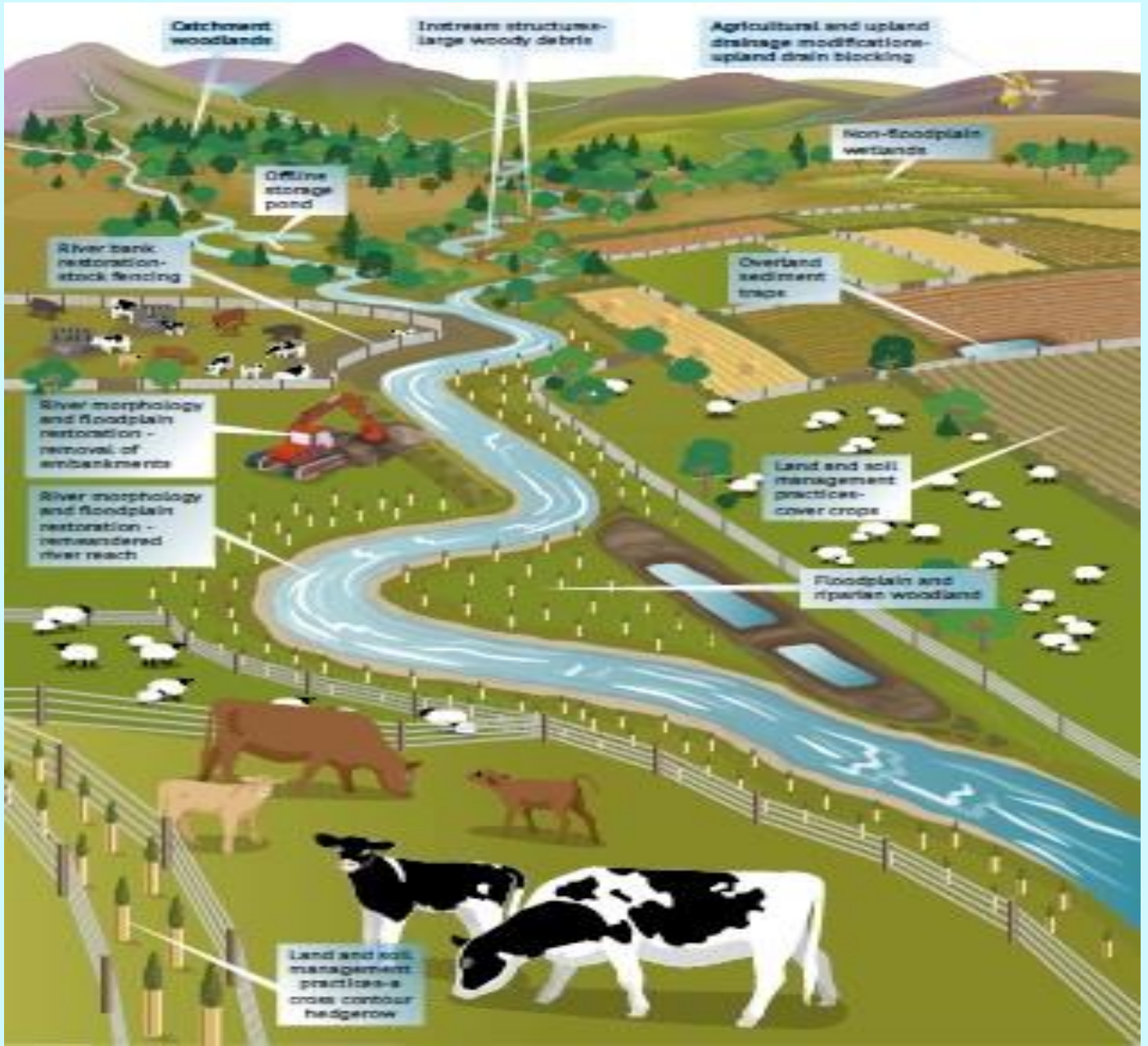
Introduction to Floodplain Management

Climate change, population growth, economics, and environmental legislation such as the Floods Directive and Water Framework Directive all necessitate a move towards a more integrated, catchment based approach to the management of land and water. Working in this way creates efficiencies in how we manage our environment by recognizing that many issues in catchments affect many different sectors and that where land and water are managed together at the catchment scale this can bring about whole catchment improvements and multiple benefits to society. A key component of this integrated, catchment based approach is the recognition that working with natural processes to manage the sources and pathways of flood waters can benefit flood risk in other parts of the catchment, including our coastline. This technique, commonly referred to as natural flood management, can help deliver more expansive landscape changes than has previously been the case, while also saving money and delivering other benefits alongside flood protection, thus benefiting the environment, society and the economy.

Introduction to Floodplain Management

Natural flood management involves techniques that aim to work with natural hydrological and morphological processes, features and characteristics to manage the sources and pathways of flood waters. These techniques include the restoration, enhancement and alteration of natural features and characteristics, but exclude traditional flood defence engineering that works against or disrupts these natural processes.

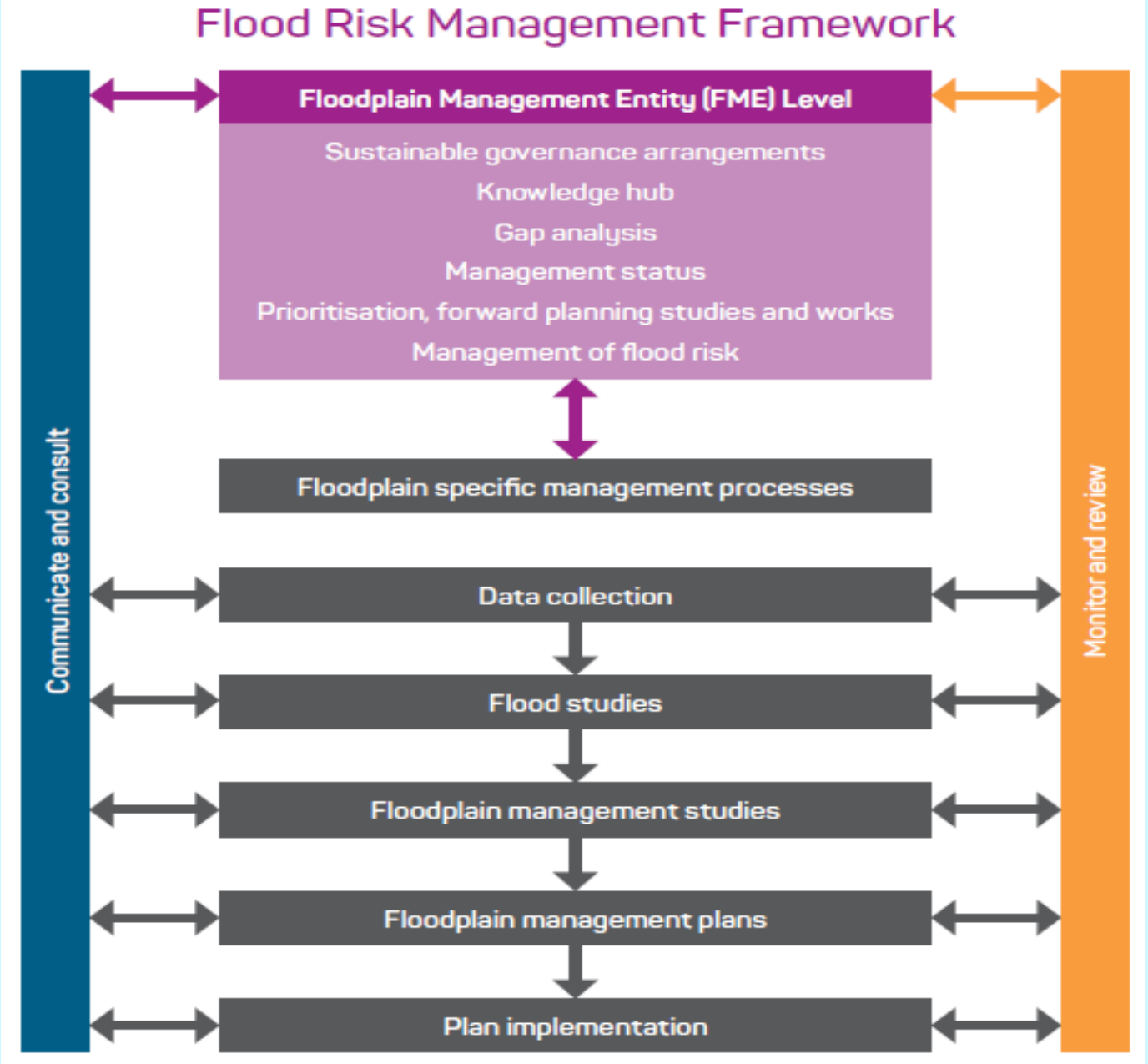
Introduction to Floodplain Management



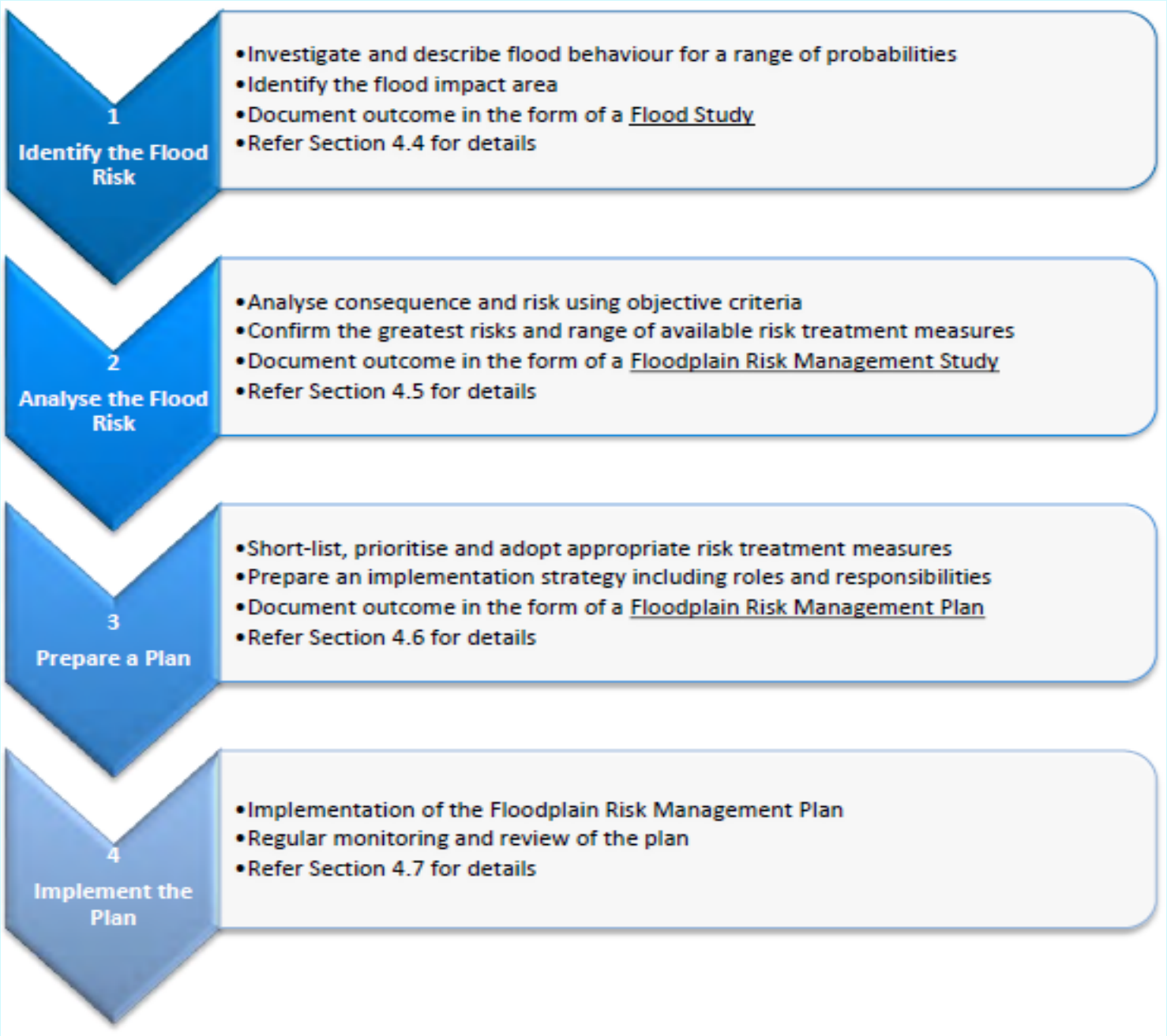
Introduction to Floodplain Management

The catchment wide approach is commonly based on measures that work with natural features and processes to manage the sources and pathways of flood waters, or what is commonly referred to as natural flood management. Natural flood management typically involves slowing or storing flood water and covers a spectrum of techniques from full-scale restoration of the course of a river or intertidal habitat to smaller scale land management measures such as upland drain blocking. In addition to benefits to flooding, these techniques can also often easily incorporate, and contribute to, improvements in biodiversity, water quality, and carbon storage which in turn can improve access to wildlife, health and wellbeing, recreation, and jobs.

Flood Risk Management Framework



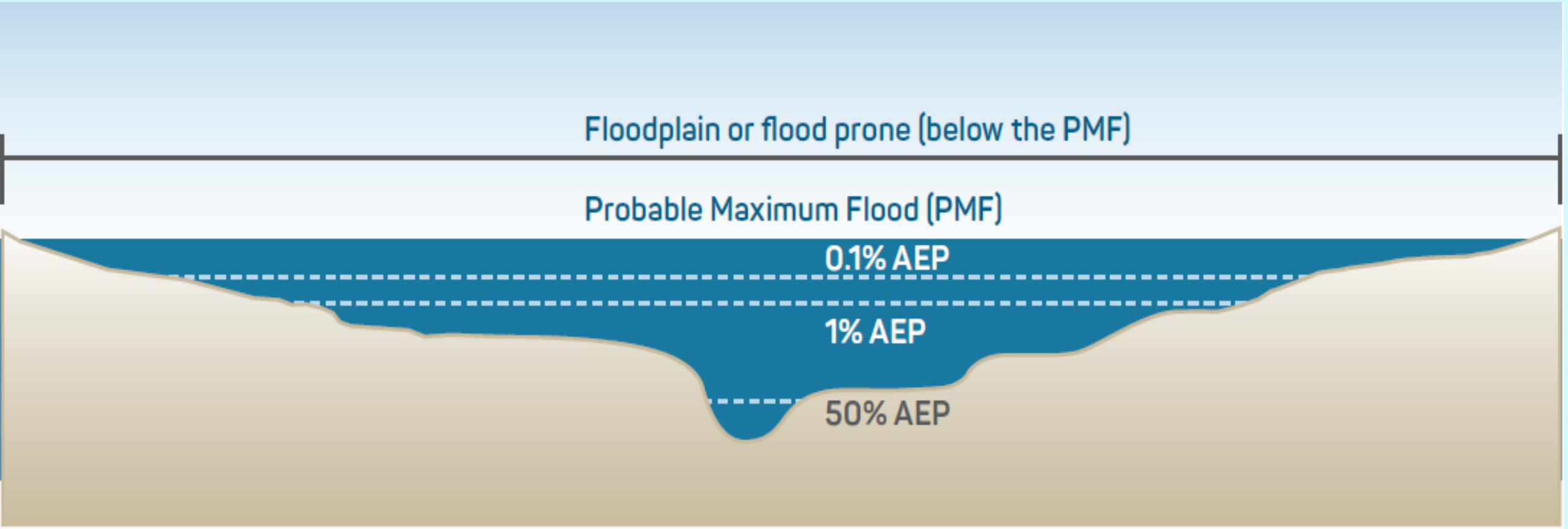
Flood Risk Management Framework



Floodplain Definition

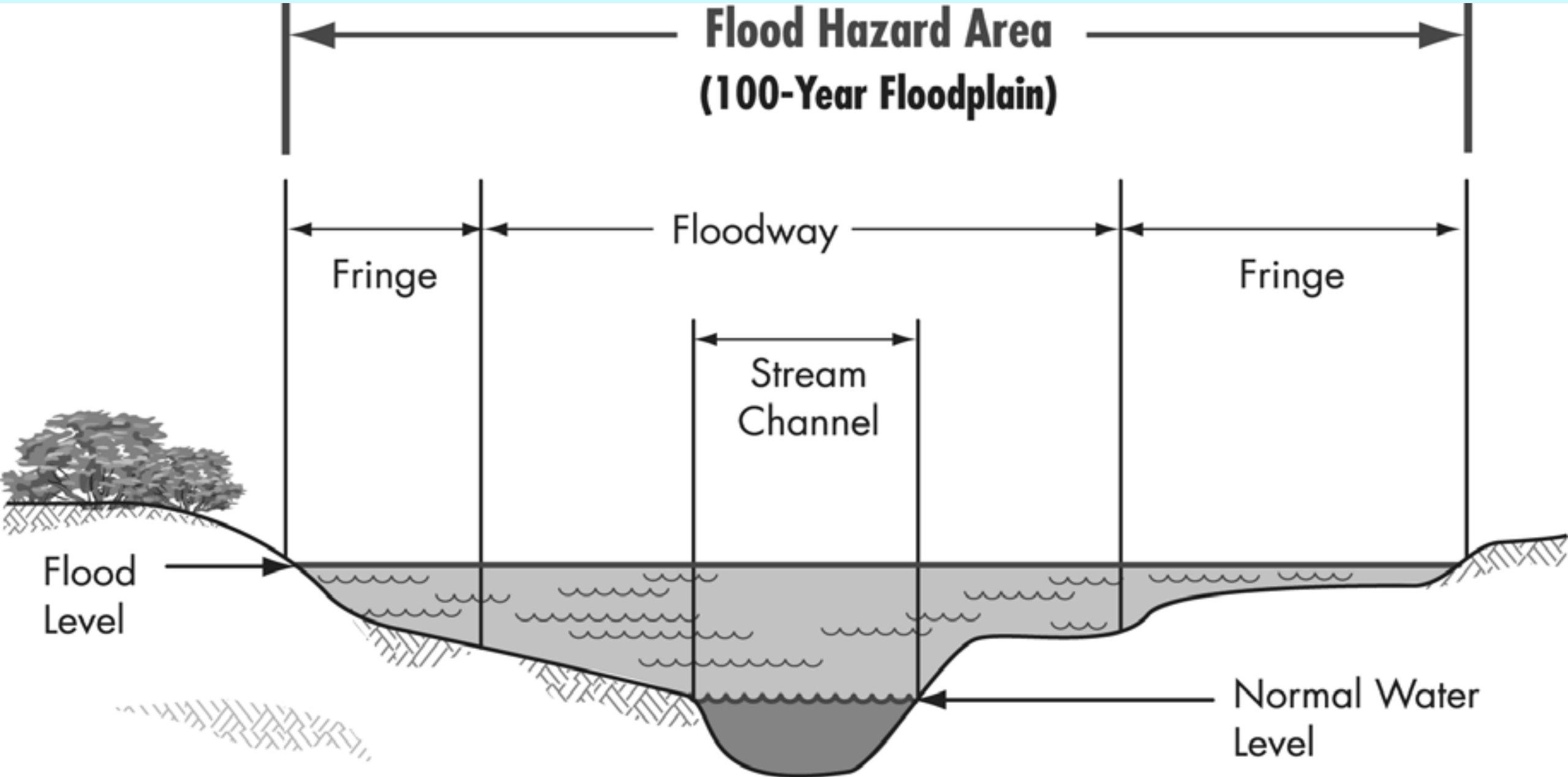
A floodplain is a flat or nearly flat lowland bordering a stream or river that experiences occasional or periodic flooding. It includes the floodway, which consists of the stream channel and adjacent areas that carry flood flows, and the flood fringe, which are areas covered by the flood, but which do not experience a strong current. The floodplain corridor acts as the “right-of-way” for a stream and functions as an integral part of the stream ecosystem. Floodplains perform important natural functions, including temporary storage of floodwaters, moderation of peak flows, maintenance of water quality, groundwater recharge, and prevention of erosion. Floodplains also provide habitat for wildlife, recreational opportunities, and aesthetic benefits.

Floodplain Definition



AEP = annual exceedance probability

Floodplain Definition



Floodplain Definition

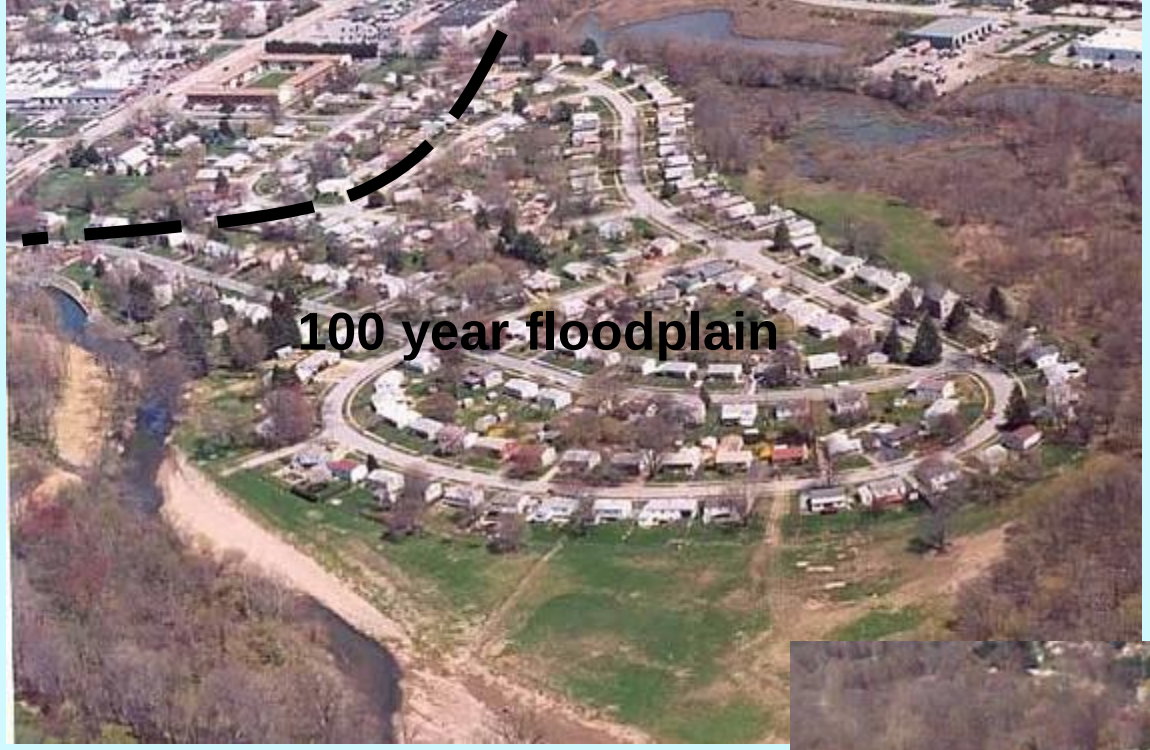
Annual exceedance probability (%)	Approximate Average recurrence interval (years)	Probability of experiencing a given-sized flood in an 80-year period	
		At least once (%)	At least twice (%)
20	5	100	100
10	10	99.9	99.8
5	20	98.4	91.4
2	50	80.1	47.7
1	100	55.3	19.1
0.5	200	33.0	6.11
0.2	500	14.8	1.14
0.1	1,000	7.69	0.30
0.01	10,000	0.80	0.003

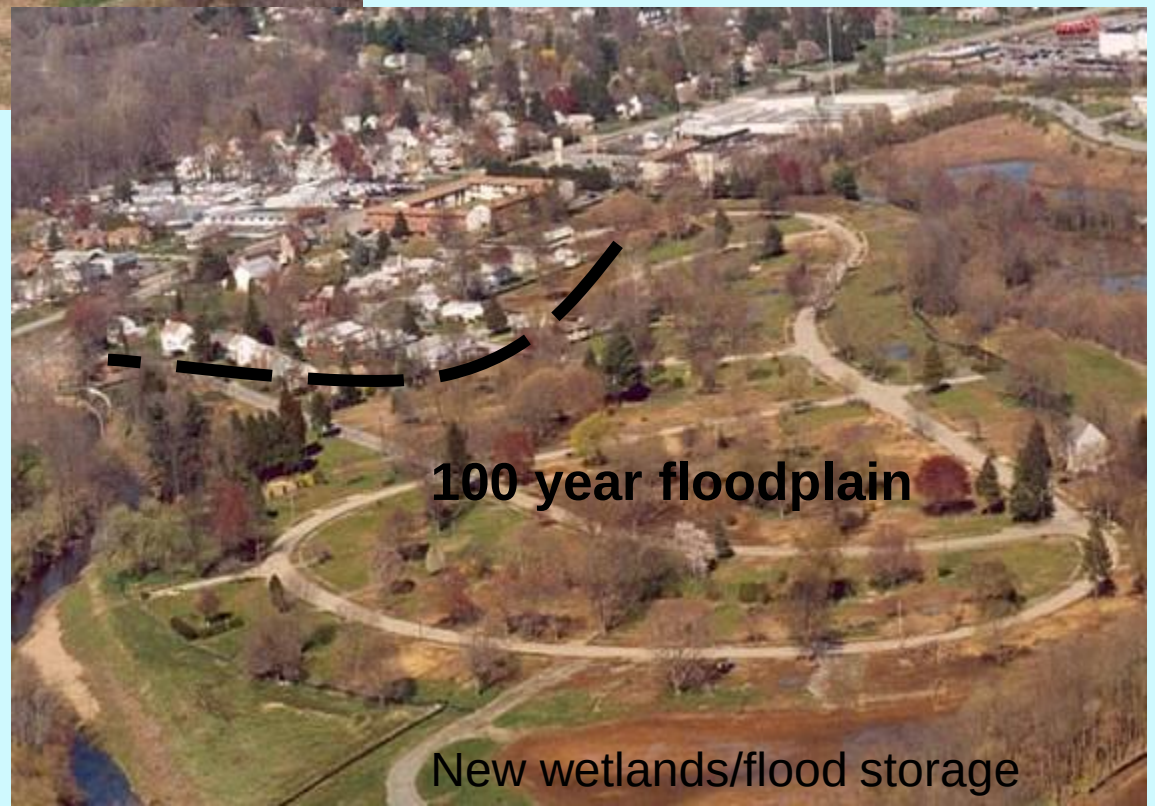

100-year flood elevation = 89
25-year flood elevation = 87
10-year flood elevation = 85
Ground Elevation = 84

Simple elevation of a flood prone house

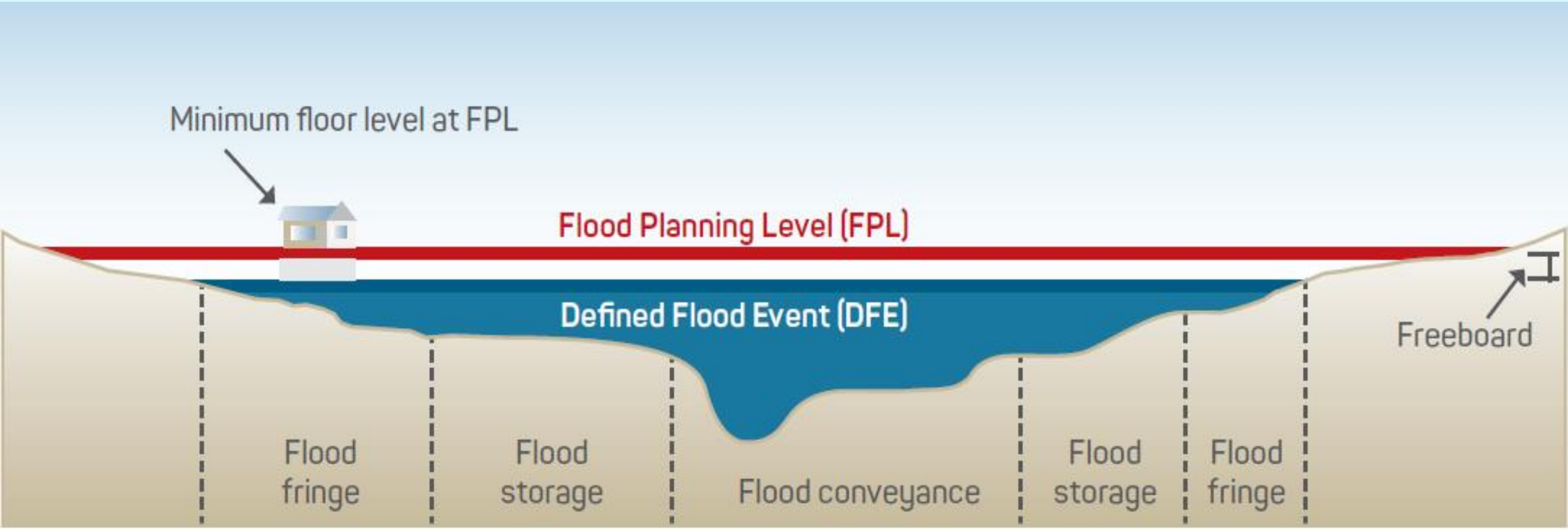

Flood Level


Flood Level


100 year floodplain


100 year floodplain
New wetlands/flood storage

Floodplain Components



Note: flood conveyance, flood storage and flood fringe areas vary with the severity of the flood event

Floodplain Classification

Primary classification	Description	Secondary classification	Description	Tertiary classification	Description	Example figures
Flooded (F)	The area is flooded in the PMF	Isolated (I)	Areas that are isolated from community evacuation facilities (located on flood-free land) by floodwater and/or impossible terrain as waters rise during a flood event up to and including the PMF. These areas are likely to lose electricity, gas, water, sewerage and telecommunications during a flood.	Submerged (FIS)	Where all the land in the isolated area will be fully submerged in a PMF after becoming isolated.	Figure 1 Figure 7 with levee Figure 8 with impassable terrain
				Elevated (FIE)	Where there is a substantial amount of land in isolated areas elevated above the PMF.	Figure 2
		Exit Route (E)	Areas that are not isolated in the PMF and have an exit route to community evacuation facilities (located on flood-free land).	Overland Escape (FEO)	Evacuation from the area relies upon overland escape routes that rise out of the floodplain.	Figure 3
				Rising Road (FER)	Evacuation routes from the area follow roads that rise out of the floodplain.	Figure 4, Figure 6 with levee
Not Flooded (N)	The area is not flooded in the PMF			Indirect Consequence (NIC)	Areas that are not flooded but may lose electricity, gas, water, sewerage, telecommunications and transport links due to flooding.	Figure 5
				Flood free	Areas that are not flood affected and are not affected by indirect consequences of flooding.	

Floodplain Classification

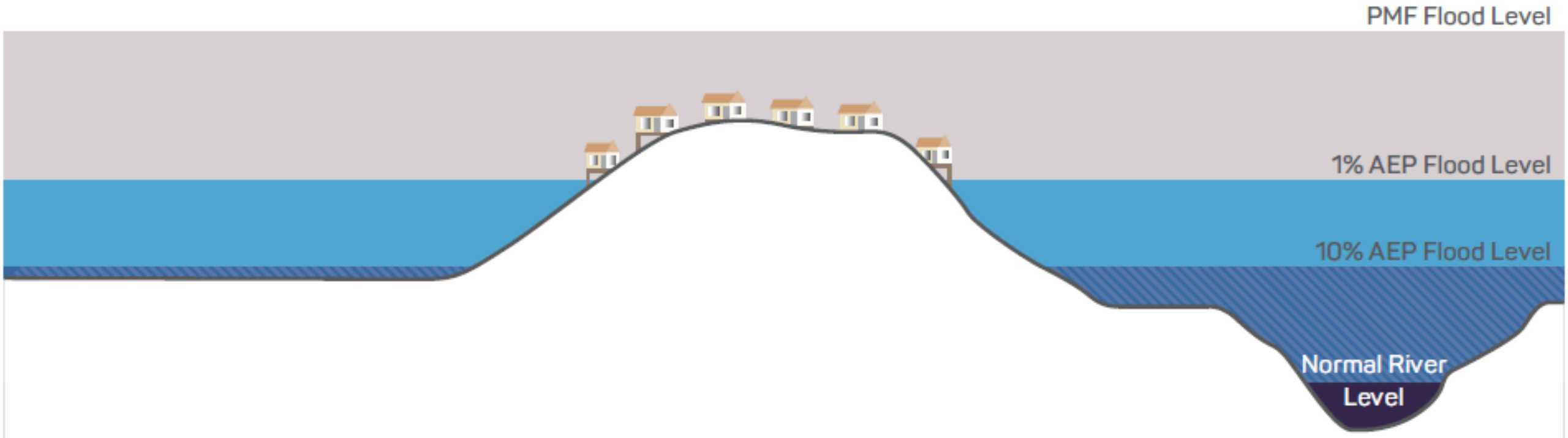


Figure 1: Example of area that is flood affected, isolated by floodwaters and fully submerged in the PMF. Category FIS.

Floodplain Classification

Figure 2: Example of area that is flood affected, isolated by floodwaters, but has some elevated area above the PMF. Category FIE.

Floodplain Classification

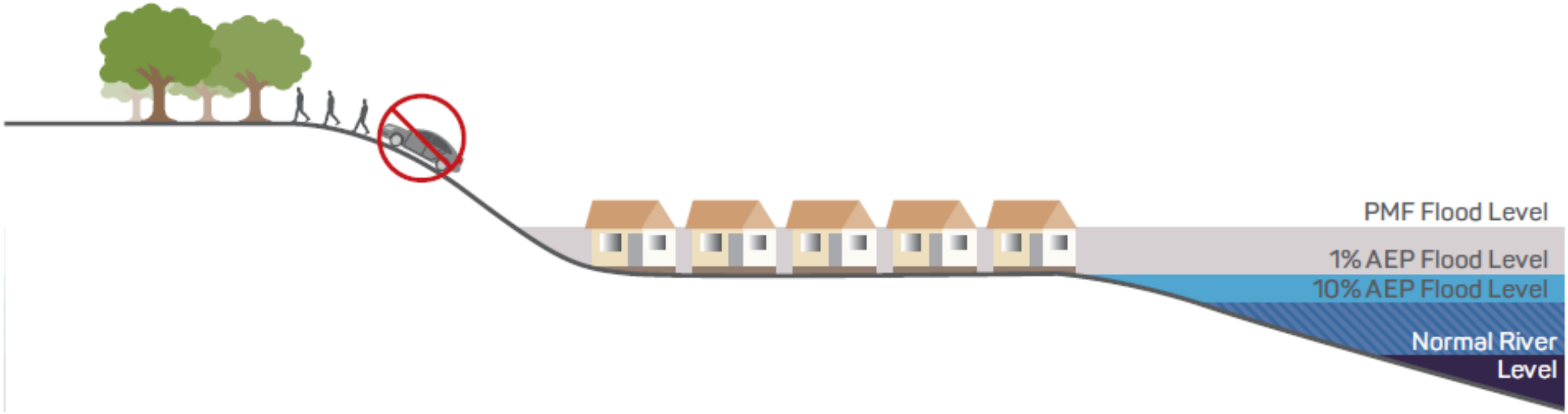


Figure 3: Example of area that is flood affected and has an exit route that relies on overland escape. Category FEO.

Floodplain Classification

Figure 4: Example of area that is flood affected and has rising road access to the road network beyond the PMF. Category FER.

Floodplain Classification

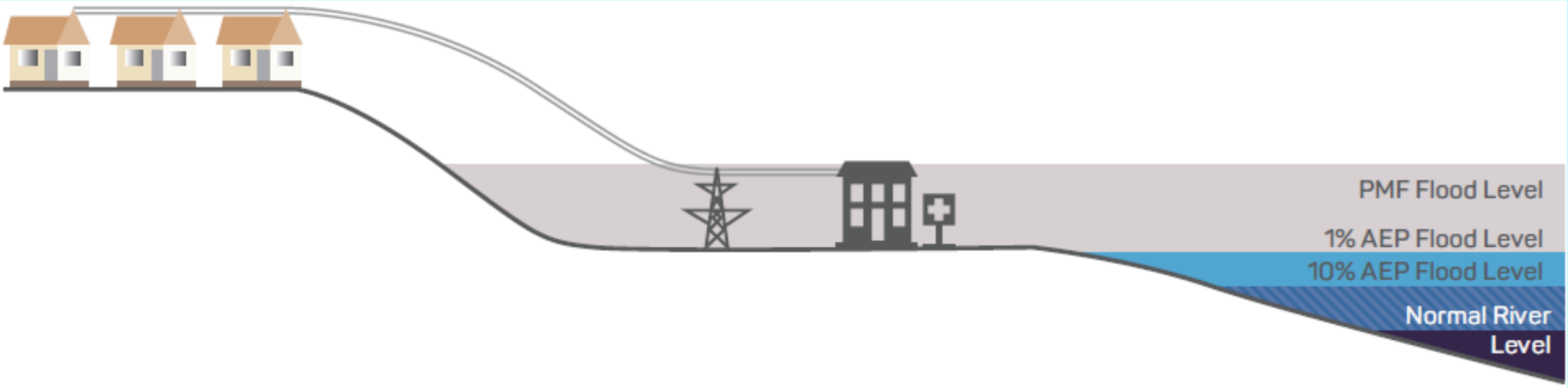


Figure 5: Example of area that is not flood affected but has indirect consequences; in this case, due to loss of power and hospital facilities. Category NIC.

Floodplain Classification

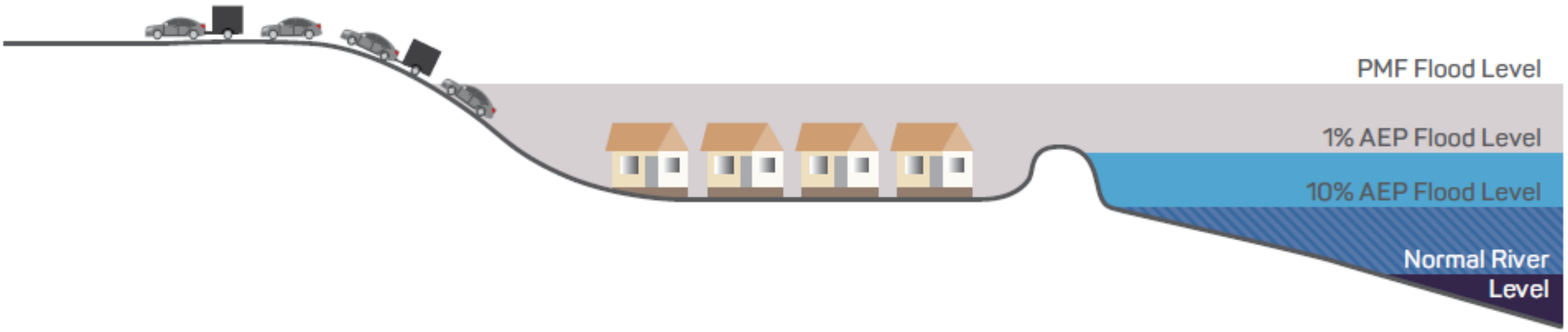


Figure 6: Example of area protected from the river by a levee designed for the 1% AEP event. In larger floods, including the PMF, the levee will overtop. The area has a rising road access to the road network beyond the PMF. Category FER.

Floodplain Classification

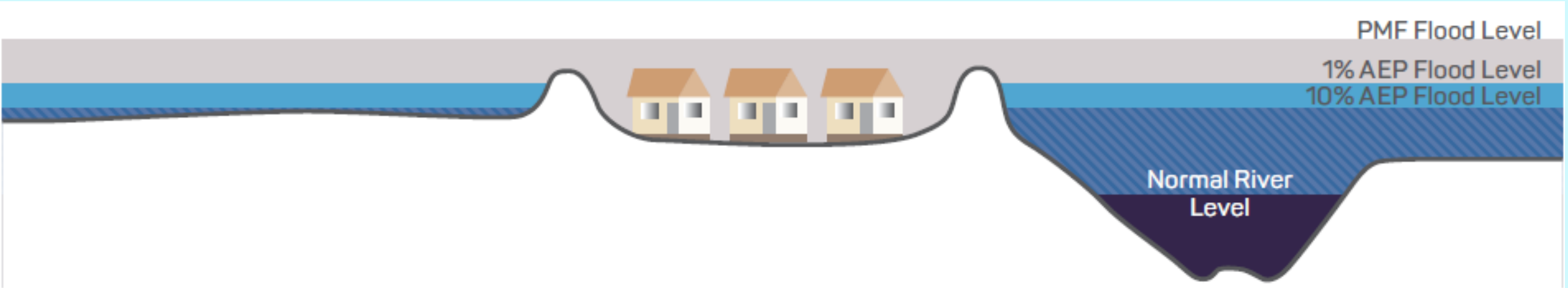


Figure 7: Example of area protected from the river by a levee designed for the 1% AEP event. In larger floods, including the PMF, the levee will overtop and fully submerge the entire area. access to the Area will be lost before overtopping. Category (FIS).

Floodplain Classification

Figure 8: Example of area that is flood affected, isolated by floodwaters, and has impassable terrain and is fully submerged in the PMF. Category FIS.

Principles of a best practice approach to flood risk management

1. A cooperative approach to manage flood risk

State and Territory governments have a shared responsibility with all levels of government for managing flood risk to local communities. This can be outlined by providing clear and continuous governance arrangements and legislative, financial, logistical and technical support to Floodplain in consideration of the full range of flood risk. Each State and Territory should develop and promote a comprehensive flood risk management policy supported by appropriate legislation, regulations, standards, guidelines and planning policies that clearly and unambiguously define the responsibilities and liabilities of all involved agencies. Decision makers at all levels need to be aware of their duty of care for decisions made with respect to the use of the floodplain, and for developing and implementing plans to manage flood risk.

Principles of a best practice approach to flood risk management

2. A risk management approach

A risk management approach enables investment to be focused on understanding and managing flood risk where it is needed most. Studies and management effort can be targeted considering the current knowledge, the scale of flood risk to existing development, and the potential for growth in flood risk through increased development within the floodplain. Plans to manage risk are ‘live documents’ and need to be regularly reviewed to ensure that they are current, able to be implemented and consider lessons that may be learnt from any recent flood events.

Principles of a best practice approach to flood risk management

3. A proactive approach

A proactive approach involves actively managing the risks of occupying the floodplain. This involves considering the full range of flood risk early in the process of developing strategic land-use plans and in managing risk to the existing community and to infrastructure.

It promotes the development and implementation of sustainable plans to manage flood risk effectively so that the existing community is more resilient to flooding. The community is encouraged to contribute to the understanding of flood behaviour and how risks are managed. Risks may be reduced by treatments where these are practical, feasible, economical and a priority within an framework service area. Community resilience may be improved by increased protection or because the community is better informed on flood risks and how to respond to the flood threat.

Principles of a best practice approach to flood risk management

4. A consultative approach

Public consultation is an important element of understanding and managing flood risk. It can facilitate:

- understanding of flood behaviour by tapping into community knowledge on historic floods
- informing the community of the flood threat they face and how and when to react to this threat
- developing sustainable floodplain management plans that have broad community support.

Principles of a best practice approach to flood risk management

5. An informed approach

Information from historic flood events can be improved using investigative techniques and more sophisticated modelling to increase understanding of these events, facilitate extrapolation to provide a greater understanding of the range of flood behaviour and risk, and enable assessment of treatment options to inform management decisions.

It is important that this knowledge be maintained – and, where necessary, improved – so that lessons from previous events and investigations can be used to manage risk into the future. The degree of knowledge required for effective management of risk varies with the:

- exposure of the community to the risk
- potential for growth in risk due to new development
- potential for change in flood behaviour
- complexity of the flood situation
- information needs of decision makers, risk managers and the community.

Principles of a best practice approach to flood risk management

6. Supporting informed decisions

It is important that flood information is readily accessible to government (including decision makers, flood risk managers, land-use planners, emergency managers), non-government entities (including infrastructure providers, insurers) and the community to provide the basis for informed decisions on investing in floodplains and managing flood risk.

Principles of a best practice approach to flood risk management

7. Recognition that all flood risk cannot be eliminated

The community and government need to recognize that living in the floodplain has an inherent risk, and a residual risk will always exist even after management measures, including mitigation and land-use planning measures, are implemented. The level of this risk will vary depend on how exposed areas of the floodplain are to flooding, the development controls that were in place when the area was developed, and the measures implemented to manage flood risk.

Principles of a best practice approach to flood risk management

8. Recognition of individual responsibility

Individuals within the community need to recognize that they are responsible for informing themselves about flood risks and the need, availability and coverage of flood insurance; being aware of how to respond to a flood threat in consideration of community response plans; and heeding the advice of relevant government and emergency management personnel during flood events.

Key objectives for achieving best practice in flood risk management

The effort required to achieve best practice will vary depending upon the area of interest and current flood risk management practice. It begins with bringing together current knowledge of flood risk and its management, and communicating this to decision makers, risk managers and the community. Where necessary, it then identifies and fills gaps in knowledge and management practices, so that risk can be better understood and managed.

To help accomplish this, five key objectives have been identified:

Key objectives for achieving best practice in flood risk management

1. develop sustainable governance arrangements for managing flood risk, so that responsibilities for managing this risk are assigned and clearly understood.
2. make information on flood risk readily available, so that government, risk managers and community can make informed risk management and investment decisions.
3. understand flood behaviour and risk to recognize the impacts of floods on the community and enable effective decisions to be made on flood management.
4. understand and maintain the natural flood functions of flow conveyance and storage of the floodplain to enable effective flood risk management and minimize environmental impacts.
5. manage flood risk to improve community resilience to flooding, and to handle the potential growth of this risk through development and redevelopment, and future changes to floodplain topography and climate.

Floodplain Risk Management Concepts

1. Factors for Effective Floodplain Risk Management

- An authority with the primary responsibility for floodplain management policy and practice
- Appropriate and effective legislative powers for the responsible authority, with powers applied on a catchment-wide basis
- Appropriate mechanisms for coordination of land use planning and floodplain management on a catchment-wide basis
- A community awareness of the flooding problem and the planning/management process, and a willingness to become involved
- Completion of flood studies and floodplain management studies overseen by a steering committee representing all interested or affected parties
- Provision of adequate resources to undertake studies and implement measures
- Access to technical advice, standards and guidelines for the authority responsible for floodplain management
- Legal provisions ensuring that the responsible authority exercises its powers responsibly, such as legal liability for the consequences of decisions
- Provision for intercession by a central authority when necessary

Floodplain Risk Management Concepts

2. Best Practice Principles - Floodplain Risk Management

- **A Pro-Active Response**

The fundamental best practice principle of floodplain management is the adoption of a pro-active response to the flood problem, a response that first recognises the various flooding problems and then moves to address these issues and problems before they develop to or are experienced at extreme levels.

- **Community Expectations**

Floodplain management must strive to ensure that the community is:

 Able to live and work on floodplains without risk to life and safety or unacceptable risk of damage to goods, possessions and infrastructure because of flooding;

 Secure in the knowledge that effective arrangements are in place to alleviate the economic and social costs of flooding and foster recovery of the flooded area and its residents/occupants; and

 Actively involved in the floodplain management process, both in the development of a Floodplain Risk Management Plan and in meeting their obligations under that plan.

Floodplain Risk Management Concepts

Policy and Implementation

Effective policy and legislation are vital in providing a reliable social and legal foundation for floodplain management and thus it is essential that there is an integrated policy framework within all agencies that supports the management of floodplains and addresses the reduction of flood risk to life and property.

Recognize the three distinct types of Flood Problem

Current floodplain management practice recognizes three distinct types of flood problems, described below:

- The ‘existing’ problem refers to existing buildings and developments on flood prone land. Such buildings and developments, by virtue of their presence and location, are exposed to an “existing” risk of flooding.

Floodplain Risk Management Concepts

- The ‘future’ problem refers to buildings and developments that may be built on flood prone land in the future. Such buildings and developments may be exposed to a “future” flood risk, i.e. a risk that does not materialise until developments occur or that may result from climate change.
- The ‘residual’ problem refers to the risk associated with floods generally and with those floods that exceed management measures already in place. That is, unless a floodplain management measure is designed to withstand the PMF, it will be exceeded by a sufficiently large flood at some time in the future. It is not a matter of if, but of when. Unless the Defined Flood Event (DFE) used for planning controls is based on the PMF, a larger flood than that used to determine the DFE can always occur. It is not a matter of if but when. The difference in flood levels, damages, and the area of inundation and the number of dwellings to be evacuated in the PMF event relative to the event upon which the DFE is based, serves to alert a council to the upper limit of the costs and consequences of flooding.

Floodplain Risk Management Concepts

Risk Appreciation

Best practice principles to foster the community's appreciation of flood risk, exposure to flood hazard and appropriate responses include:

- Documentation of flood risk by relevant agencies in an easily understood manner on flood maps, flood searches and fact sheets to enable individuals and the community to assess flood risk.
- On-going community education by all relevant agencies in conjunction with emergency management agencies through a coordinated community education plan.

Floodplain Risk Management Concepts

The Floodplain Risk Management Plan

The implementation of a comprehensive investigative and planning process that develops a Floodplain Risk Management Plan is the most effective and equitable way to realise the multiple objectives of floodplain management.

The Flood Emergency Plan

Preparation of a flood emergency plan encompassing flood preparedness, prevention, response and recovery arrangements is the most effective way to address the residual flood risks associated with flood events.

It should be noted that flood warning should be an integral part of the flood response arrangements.

Floodplain Risk Management Concepts

Appropriate Land Uses

The careful matching of land use to flood hazard both maximises the benefits of using the floodplain and minimises the risks and consequences of flooding.

Flood Maps

Flood maps that show the extent, depth and hazard of flooding for nominated flood events are an important tool for the preparation of Floodplain Risk Management Plans and flood emergency plans.

However, there needs to be:

- Recognition that flood maps are necessarily inexact.
- Considerable care taken with the depiction and explanation of flooding features so that the map is easily understood by the local community and is not subject to misleading interpretation.

The land use planning controls that flow from flood maps should be incorporated into statutory planning instruments in a timely and expeditious manner.

Floodplain Risk Management Concepts

Floodplain Risk Management Measures

There are three generally recognised ways of managing floodplains to reduce flood losses:

- By modifying the behaviour of the flood itself (Flood Modification);
- By modifying or removing existing properties and/or by imposing controls on property and infrastructure development (Property Modification); and
- By modifying the response of the population at risk to better cope with a flood event (Response Modification).

Floodplain management measures should not be considered in isolation. Rather, they must be considered collectively on a risk management basis that allows their interactions, their suitability and effectiveness, and their social, ecological and economic impacts to be assessed on a catchment-wide, cumulative basis.

Floodplain Risk Management Concepts

Flood Behaviour

An understanding of flooding behaviour, i.e. flood discharges, flood levels, flood velocities, duration of flooding, rate of rise of floodwaters, etc. is fundamental to the preparation of effective floodplain management and flood emergency plans. It must be recognised that the behaviour of each flood will have a unique combination of these parameters and none are likely to behave across all parameters in the way predicted by design flood events used in flood models. For example, several real floods and a design flood may all have the same peak but are likely to have different rates of rise and durations.

Floodplain Risk Management Concepts

Performance Indicators and Data Collection

Flood behaviour, damage and other data should be collected expeditiously after an actual flood event has occurred, allowing an evaluation of the flood modelling and the effectiveness of floodplain management measures. Simultaneously, flood emergency operations should be reviewed in consultation with communities and, where necessary, modified.

Floodplain Risk Management Concepts

3. Legislative Imperative

There are number of significant pieces of legislation that support the establishment of a Floodplain Risk Management Framework within Council's area of responsibility. These Acts of Parliament are:

- The Sustainable Planning Act (2009); and
- The Disaster Management Act 2003 (as amended to 2010).
- Coastal Protection and Management Act (1995 as amended to 2010)
- Queensland Reconstruction Authority Act 2011

Understanding Floodplain Risk Management

There are generally three types of risk to be managed in flooding. These are:

1. Existing flood risk. This is the risk associated with current development in the floodplain. Knowing the likelihood and consequences of various scales of floods to the existing community provides the basis for determining existing risk. Understanding this risk can assist with decisions on whether to treat this risk and, if so, how.

Understanding Floodplain Risk Management

2. Future flood risk. This is the risk associated with future development of the floodplain. Knowing the likelihood and consequences of flooding can inform decisions on where not to develop (where new development may affect flood behaviour, where this may impact upon risks to existing development, or where hazards are high and cannot be managed), and where and how to develop the floodplain (to ensure risk to new development and its occupants are acceptable). This information can feed into strategic land-use planning.

Understanding Floodplain Risk Management

3. Residual flood risk. This is the risk remaining, in both existing and future development areas, after management measures such as works, land-use planning and development controls are implemented. Unless the probable maximum flood is used as the basis for development controls or works (and works do not fail), a flood risk will still remain. Residual risk can vary significantly within and between floodplains. Emergency management and recovery planning, supported by systems and infrastructure, can assist to reduce residual risk.

Strategies for Treatment Measures

Table 7.1: Treatment measures for existing development

Development scale	Type of flood risk	Treatment measures
Community or a specific area	Existing	Flood mitigation dams Retarding and detention basins Permanent levees Flow conveyance improvements Flood gates Temporary barriers Change in property zoning
	Residual	Flood prediction and warning Community-scale emergency response plans Evacuation arrangements Evacuation route upgrade Community flood readiness Community recovery plans
Property	Existing	House raising House purchase Relocation of development Flood proofing of buildings Temporary measures
	Residual	Residual risk management options listed above augmented by appropriate property based emergency management plans

Strategies for Treatment Measures

Table 7.2: Treatment measures for future development

Development scale	Type of flood risk	Treatment measures
New development and redevelopment areas	Future	Zoning Development controls Building controls
	Residual	Flood prediction and warning Flood access and evacuation routes Emergency response arrangement for new areas Update of community-scale emergency management plans Development-scale flood awareness and readiness
Infill development within existing zoned areas	Future	Development controls Building controls
	Residual	Residual risk management options listed above augmented by appropriate property based emergency management plans

Strategies for Treatment Measures

Table 7.3: Typical ability of management options to address flood risks

Option type	Existing developed areas			Future development areas		
	Existing risk		Residual risk	Future risk		Residual risk
	Safety	Damage	Safety	Safety	Damage	Safety
Measures to modify property						
Zoning and development control				High	High	Low[a]
Voluntary purchase	High	High	High			
Voluntary house raising	Low	Medium	Negative[c]			
Flood proofing of buildings	Low	Low				
Access during flood events	High	Low[e]	High	High	Low[e]	High
Measures to modify response						
Community flood awareness & readiness[b,d]	Low[b]	Low[b]	Low[b]	Low[b]	Lowb	Low[b]
Flood predictions and warnings[b]	Medium[b]	Low[b]	Medium[b]	Medium[b]	Low[b]	Medium[b]
Emergency response planning for floods[b]	Medium[b]	Low[e]	High[b]	Medium[b]	Low[e]	High[b]

Strategies for Treatment Measures

Measures to modify flood behaviour						
Levees	High	High	Negative[c]	High	High	Negative[c]
Detention/retarding basins	Medium	Medium	Negative[c]	Medium	Medium	Negative[c]
Flood mitigation dams	Medium	Medium		Medium	Medium	
Bypass flow conveyance	Medium	Medium		Medium	Medium	
Channel improvements	Medium	Medium		Medium	Medium	
Enhance environment						

Strategies for Treatment Measures

Table 8.1: Up-front, ongoing and complementary options to treat future risk

Option	Up-front work	Ongoing work	Complementary work
Zoning	Inform zonings with an understanding of flood function, hazard and emergency response limitation, and vulnerability of different development types to flooding.	Ensure intent of zonings is maintained, and development controls are reducing risk to an acceptable level. Monitor effectiveness and revisit if outcomes unsatisfactory.	Incorporate zonings intent into statutory plans. Reduce residual risk to an acceptable level with complementary development controls. Interact with flood warning and emergency response management, and ensure community awareness.
Emergency response arrangement from new development	Examine evacuation needs of new development, including flood access to site and evacuation capacity from site.	Monitor effectiveness versus expectations to inform future work.	Ensure arrangements are complementary with zonings; may require specific development controls. Interact with flood warning and emergency response management, and ensure community awareness.
Impacts on community-scale emergency response plans	Examine the impacts of development on community emergency response plans and evacuation capacity of relevant roads, etc.	Monitor effectiveness versus expectations to inform future work.	Ensure arrangements are complementary with zonings; may require specific development controls. Interact with flood warning and emergency response management, and ensure community awareness.

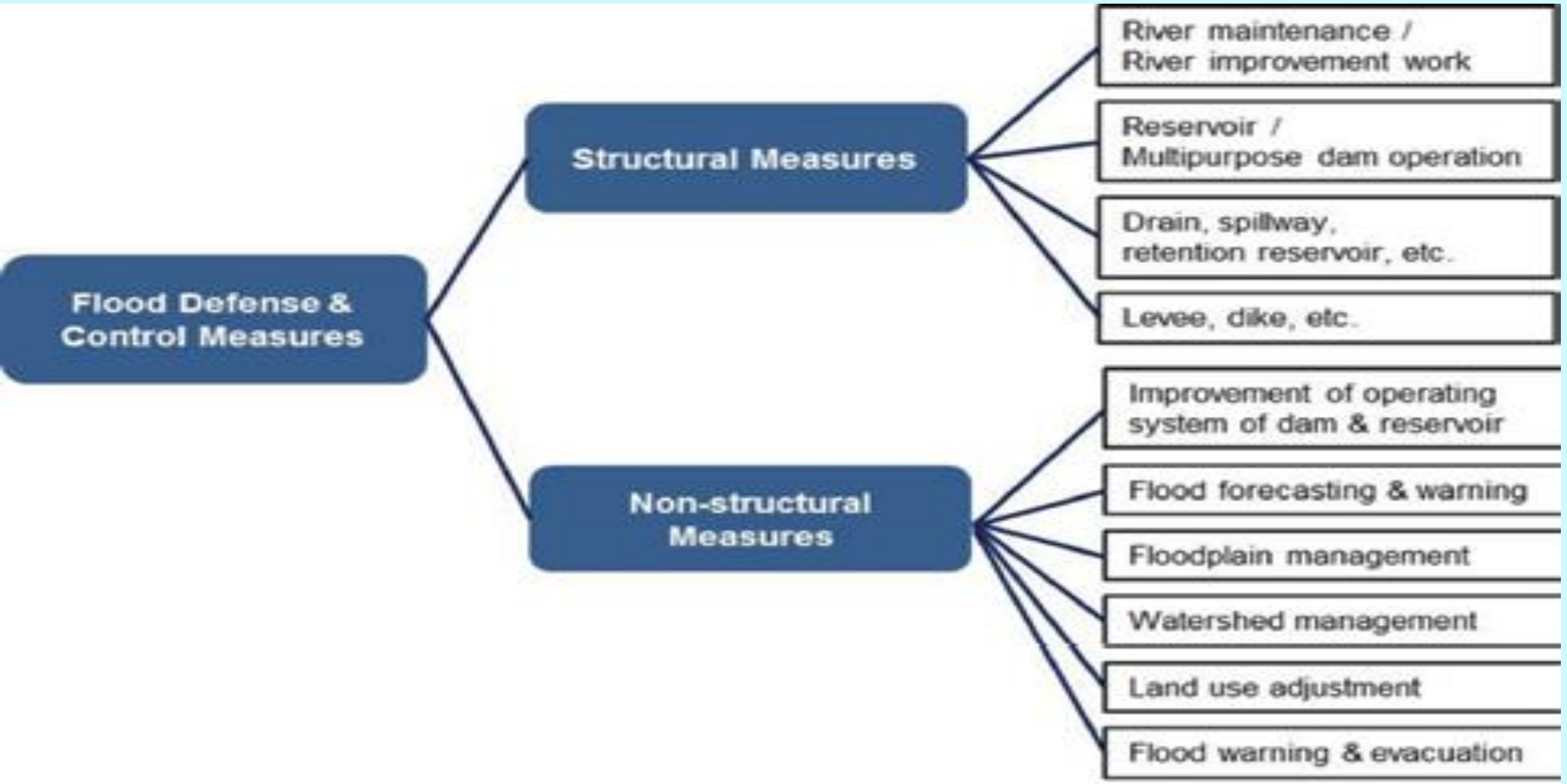
Strategies for Treatment Measures

Flood access to site	Examine appropriateness of access point to development given flood behaviour and risks.	Monitor maintenance of any special (non-road or not in public ownership) evacuation paths so these are maintained and available as necessary.	Ensure arrangements are complementary with zonings; may require specific development controls. Interact with flood warning and emergency response management, and ensure community awareness.
Development and building controls	Understand purpose and desired outcome in supporting zonings.	Ensure intent of zonings is maintained and development controls are reducing risk to an acceptable level. Monitor effectiveness and adjust if outcomes unsatisfactory.	Ensure arrangements are complementary with zonings. Place development controls into statutory planning instruments and development control plans and/or policies. Interact with flood warning, emergency response management, and ensure community awareness.

Strategies for Flood Control

Pre-flood activities	*"During-flood" activities*	*Post-flood activities*
Flood risk management for all causes of flooding and disaster contingency planning.	Detection of the likelihood of a flood forming (hydro-meteorology).	Relief for the immediate needs of those affected by the disaster.
Construction of physical flood defense infrastructure and implementation of forecasting and warning systems.	Forecasting of future river flow conditions from the hydro-meteorological observations.	Reconstruction of damaged buildings, infrastructure and flood defenses.
Land-use planning and management within the whole catchment.	Warning issued to the appropriate authorities and the public on the extent, severity and timing of the flood.	Recovery and regeneration of the environment and the economic activities in the flooded area.
Discouragement of inappropriate development within the flood plains.	Response by the public and the authorities.	Review of the flood management activities to improve the process and planning for future events in the area affected and more generally, elsewhere.
Public communication and education of flood risk and actions to take in a flood emergency.		

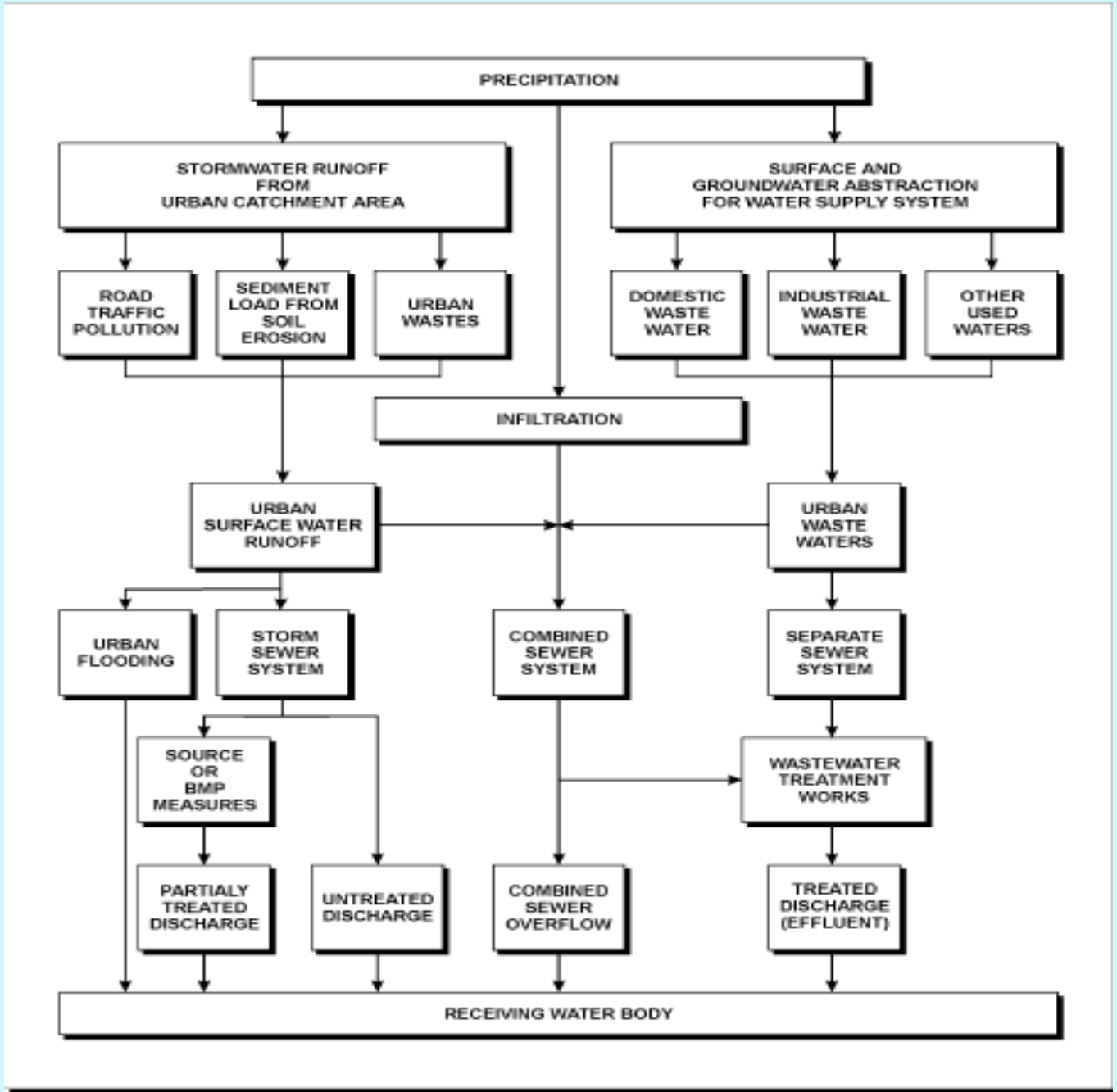
Flood Control Measures



Flood Control Measures

STRUCTURAL MEASURES (Section 3.2)			Catchment-wide interventions (agriculture and forestry actions and water control works) River training interventions Other flood control interventions (passive control, water retention basins and river corridor enhancement, rehabilitation and restoration)
NON-STRUCTURAL MEASURES* (Section 3.3)	**RISK ACCEPTANCE**	Tolerance strategies	Toleration Emergency response systems Insurance
	RISK REDUCTION	Prevention strategies	Delimitation of flood areas and securing of flood plains Implementation of flood areas regulation Application of financial measures
		Mitigation strategies	Reduction of discharge through natural retention Emergency actions based on Monitoring, Warning and Response Systems (MWRS) Public information and education*

Floodplain Non-Structural Control Measures



Floodplain Non-Structural Control Measures

Non-structural controls can be defined into five principal categories:

1. Town planning controls - such as the use of town planning instruments to promote water sensitive urban design features in new developments.

2. Strategic planning and institutional controls - such as the use of strategic, regional or citywide urban stormwater management plans.

3. Pollution prevention procedures - such as maintenance practices, operational procedures and staff training at government, commercial and industrial sites to minimize the risk of stormwater pollution.

4. Education and participation programs - such as training programs and involving the community in the development and implementation of stormwater management plans.

5. Regulatory controls - such as enforcement of local laws to improve erosion and sediment control on building sites, the use of environmental licenses to help manage premises likely to contaminate stormwater or groundwater, and programs to minimize illicit discharges to stormwater management systems.

Floodplain Non-Structural Control Measures

Potential benefits of non-structural best management practices:

1. Cost
2. Coverage
3. Can be used in existing developed areas
4. Can target specific pollutants of concern
5. The polluter pays principle and economic incentives/disincentives can be applied through regulation and/or enforcement programs.
6. The high potential effectiveness of some measures
7. Community participation
8. Flexibility
9. Secondary benefits

Floodplain Non-Structural Control Measures

Non-structural best management practices grouped under the following headings:

- Construction practices
- Maintenance practices
- Educational and participatory practices
- Funding, policy, regulatory and enforcement practices
- Catchment planning practices

Floodplain Non-Structural Control Measures

1. Construction practices

1.1. Land development and construction sites

Land development and construction sites have the potential to be a major source of stormwater pollution, including litter, chemicals, sediment and harmful pollutants absorbed to sediment particles (e.g. heavy metals, nutrients and pesticides). The guideline recommends best management practices, including hazardous and nonhazardous waste management measures, and how to prepare an erosion and sediment control plan to control drainage, erosion, sediment loss and dust, and improve housekeeping practices (e.g. the washing of buildings and equipment, and litter control).

Floodplain Non-Structural Control Measures

1. Construction practices

1.2. Soil amendment for urban gardens and lawns

Urban development usually diminishes the capacity of soil to support plant growth through processes such as the removal of topsoil and soil compaction. Many areas in Western Australia have sandy soils with low ability to retain moisture, nutrients and trace elements. Soil amendment is a technique used to create fertile topsoil by increasing the soil's ability to retain moisture and nutrients, and filter some contaminants, such as heavy metals, before they infiltrate into groundwater. Soil amendment involves adding an agent, such as clay or crushed limestone, to the soil to improve its structure, porosity, water holding capacity and nutrient recycling capacity. Soil amendment in urban areas is still an experimental technique in Western Australia, but shows great potential.

Floodplain Non-Structural Control Measures

2. Maintenance practices

2.1. Street sweeping

Street sweeping is widely used in urban areas to reduce the accumulation of litter, leaves and coarse sediment from roads and footpaths. It is undertaken to improve aesthetics, public safety and stormwater quality. Street sweeping as a stormwater quality BMP is an attractive option for many local authorities, as it is already in use, and roads, car parks and footpaths account for approximately 70% of impervious urban areas. There are many types of sweeping equipment, with new technologies recently emerging that have the potential to collect a high proportion of fine sediments, unlike their predecessors. Street sweeping has most benefit in specific circumstances, such as focusing on pollution ‘hot spots’ rather than routinely sweeping all streets, and coordinating street sweeping with other maintenance activities and events, such as after a street parade.

Floodplain Non-Structural Control Measures

2. Maintenance practices

2.2. Maintenance of the stormwater network

Maintenance of the stormwater drainage network includes inspection, cleaning and repair of open and piped drains, pits, treatment devices, detention basins and outfall structures. This network needs to be regularly cleaned to maintain its performance. Drainage features such as infiltration pits/soak wells and detention basins can provide ‘hot spots’ for accumulation of gross pollutants and contaminated sediments with high concentrations of heavy metals, hydrocarbons and nutrients. Regular cleaning of the stormwater drainage network provides an opportunity to remove pollutant loads that would otherwise enter receiving water bodies after heavy rainfall. Drains with accumulated pollutants may also overflow, leading to localized flooding and erosion, as well as risks to human safety and constructed assets. Open drains and basins can provide habitat for aquatic fauna and birds. Maintenance of these areas may need to include protecting their environmental values and minimizing disturbance to vegetation.

Floodplain Non-Structural Control Measures

2. Maintenance practices

2.3. Manual litter collections

The manual collection of gross pollutants (especially litter) in locations where it may be blown or washed into the stormwater drainage network or directly into water bodies is a common management practice, particularly in urban areas and along main roads. Collections are typically undertaken by staff from government agencies (e.g. in ‘hot spots’, such as along the road corridor in commercial areas), volunteers during ‘clean-up days’, the private sector in relation to their own premises (e.g. around commercial and industrial sites) and sectors of the community that sponsor an area. This management practice is often implemented for aesthetic reasons. However, there is evidence that a regular manual litter collection program can significantly reduce the loads of pollutants entering water bodies via the stormwater drainage network. The practice can, in some circumstances, be used to provide an opportunity to raise the public's awareness of stormwater pollution.

Floodplain Non-Structural Control Measures

2. Maintenance practices

2.4. Litter bin design, positioning and cleaning

The design, location and maintenance regimes surrounding public litter bins (and accompanying recycling facilities) can facilitate litter control, particularly in public spaces in urban areas and potential litter ‘hot spots’ in non-urban locations (e.g. roadside rest areas). In remote locations however, public litter bins may attract illegal dumping of large volumes of waste (e.g. places where people camp). Caution is needed, as this management practice should not be considered in isolation from the local context in which it will be applied or from supporting measures (e.g. signage, public participation and enforcement). Strategies that are considered to be effective in reducing local littering in public places include placing bins in locations that are convenient to the public, designing bins to catch the attention of the public, keeping observable litter to a minimum (e.g. through frequent collections), providing signage, designing public open space to minimize areas that are hidden from public view and involving the community in litter management initiatives.

Floodplain Non-Structural Control Measures

2. Maintenance practices

2.5. Road / pavement repairs / resurfacing and road runoff

Activities to repair potholes and degraded footpaths and resurface roads have the potential to contaminate stormwater. Substantial amounts of pollutants are generated during daily roadway use, which can threaten the health of local water bodies by contributing heavy metals, hydrocarbons, sediment, gross pollutants and nutrients. The risks to stormwater quality include discharges of hydrocarbons during road resurfacing work (e.g. from a spill), discharge of sediments, heavy metals and hydrocarbons from road surfaces, bitumen overspray during road resurfacing activities, alkaline slurry from concrete cutting activities and wastewater from the washing of machinery and tools. Specific management practices need to be applied to minimize these risks, such as planning maintenance activities, modifying road resurfacing and footpath maintenance practices, managing spills and sweeping. Strategic planning and employing good road and bridge maintenance practices are efficient and low-cost means of minimizing contamination of stormwater runoff and reducing the risk of environmental harm to the receiving environment.

Floodplain Non-Structural Control Measures

2. Maintenance practices

2.6. Maintenance of premises typically operated by local government

This guideline briefly outlines key stormwater management practices that are often required on premises that may be operated by local government. These premises include parks, cemeteries, sports fields, nurseries, depots, buildings and road reserves. Note that BMP 2.2.7 specifically addresses stormwater management on parks, gardens and sports fields. Local governments may operate a wide range of facilities that have the potential to contaminate stormwater and/or generate large volumes of stormwater due to a high percentage of impervious surfaces. To thoroughly identify, assess, manage, monitor and continually improve the management of stormwater-related risks from these premises, it is recommended that operators implement an environmental management system (EMS).

Floodplain Non-Structural Control Measures

2. Maintenance practices

2.7. Maintenance of gardens and reserves

The maintenance practices applied to grassed areas and gardens can have a significant potential impact on stormwater and groundwater quality. Potential pollutants include nutrients, sediment, pesticides, wastewater from washing machinery (e.g. mowers), and organic matter (e.g. grass clippings). Possible impacts include eutrophication and elevated levels of turbidity in receiving waters, leading to a variety of adverse impacts on aquatic flora and fauna. This guideline focuses on best management practices related to plant selection and landscaping design, nutrient and irrigation management, lawn mowing, top dressing and pruning, and pest management. The objectives are to minimize pollutants leaving the site via stormwater or shallow groundwater, minimize adverse impacts on the site's hydrology, minimize the use of fertilizers and irrigation water, maximize water and nutrient recycling and, where possible, save time and money on maintenance practices.

Floodplain Non-Structural Control Measures

2. Maintenance practices

2.8. Maintenance of vehicles, plant and equipment (including washing)

The storage and maintenance of vehicles, plant and equipment can contaminate stormwater with pollutants such as petrol, diesel, kerosene, coolants, solvents, brake fluid, motor oils, lubricating grease, sediment and heavy metals. The washing of vehicles, plant and equipment can also produce highly contaminated wastewater. This best management practice outlines recommended guidelines for vehicle storage and equipment storage areas, cleaning plant and equipment, refuelling areas and vehicle maintenance. These management practices are applicable to maintenance activities undertaken by government agencies, construction and maintenance companies, operators of automotive maintenance premises and residents that maintain their own vehicles. Pollution prevention and good ‘housekeeping’ practices for the maintenance of vehicles, plant and equipment as addressed in this guideline can help reduce the influence of automotive maintenance practices on stormwater runoff and local water supplies. These practices include storing and maintaining vehicles, plant and equipment in covered areas, using drip pans and washing vehicles in wash bays.

Floodplain Non-Structural Control Measures

2. Maintenance practices

2.9. Building maintenance

Building maintenance practices such as washing of buildings and paved surfaces, sandblasting, painting, rendering and graffiti removal generate contaminated wastewater that is a potential threat to the stormwater system and can be acutely toxic to aquatic biota in the receiving water body. Once construction is completed, pollutants in runoff from roofed areas and paved surfaces may continue to enter stormwater after every rainfall event. These pollutants include flaking paint containing heavy metals, nitrogen from atmospheric deposition, litter from the building's footpaths, hydrocarbons and heavy metals from the building's roadways and nutrients from fertilized lawns and garden beds. Management practices can be applied during building maintenance and post-construction stages to minimize the risk of stormwater and groundwater pollution and, to a lesser extent, minimize the volume of stormwater discharge. These guidelines include procedures for the proper storage, use and disposal of hazardous and non-hazardous wastes, techniques to prevent wastewater from entering the stormwater system and recommendations for inspection and maintenance of stormwater-related structures.

Floodplain Non-Structural Control Measures

2. Maintenance practices

2.10. Stormwater management on industrial and commercial sites

Industrial and commercial premises have significant potential to pollute stormwater, for example, through poor control of industrial processes or inadequate facilities for waste disposal. The transport, handling and storage of goods and wastes can also result in the contamination of stormwater. Small to medium-sized industrial premises have been identified as representing a significant cumulative risk to the health of water resources in the Perth metropolitan area. Improving practices that potentially impact on stormwater and groundwater at these premises is a priority for water resource protection. Recommended pollution prevention practices include identifying and assessing stormwater-related risks on the site, developing management plans or procedures to manage the identified risks and training all staff to undertake their roles in relation to these management plans/procedures.

Floodplain Non-Structural Control Measures

3. Educational and participatory practices

3.1. Capacity building programs for local governments and stormwater management industry professionals

Capacity building is a holistic approach to knowledge building and transfer, which fosters professional skill development, competency, innovation and confidence. Capacity building is also a means to facilitate network building, linkages and training for continuous improvement. Providing people with the information and skills they need to make better decisions is an essential part of promoting best practice stormwater management. This guideline outlines the steps to developing a stormwater-related capacity building program. These programs can be run at a variety of scales, from a program that covers a small local government area to one that covers an entire State. Capacity building programs may include a suite of tailored training and education packages to promote best practice in stormwater management to local government and stormwater industry professionals.

Floodplain Non-Structural Control Measures

3. Educational and participatory practices

3.2. Intensive training of landowners on aspects of stormwater management

This best management practice typically involves intensive training for volunteer residents to provide information on alternative lawn and garden care practices. These programs may focus on source controls, with the aim of minimizing stormwater pollution, particularly with respect to nutrients. Programs may address water conservation, plant selection (e.g. growing local native plants or plants that require less water and fertilizer), fertilizer use, weed and pest management, irrigation practices, stormwater and shallow groundwater reuse, composting and soil amendment. These programs are applicable to all areas, particularly areas with sandy soils that have low nutrient and moisture retention capabilities; areas draining to sensitive water bodies or water bodies that are under stress from nutrient inputs; drinking water catchments; areas with large gardens and lawns; and areas subject to erosion (e.g. due to steep slopes).

Floodplain Non-Structural Control Measures

3. Educational and participatory practices

3.3. Encouraging participation by the community in stormwater Management

Stormwater-related community participation programs seek to engage the community so that they understand the nature of the problem and can participate in the development and implementation of solutions. Community members, given support and time, can quickly build knowledge and positively contribute to the formulation of new and sustainable approaches to stormwater management. This best management practice fosters ownership of stormwater-related problems by the local community. A participatory approach can be applied to common stormwater-related activities, such as the development of a stormwater management plan or program to protect the health of a local waterway. Encouraging public participation in decision-making is a ‘bottom-up’ approach that has been shown to more effectively change people’s behaviour than traditional ‘top-down’ education methods.

Floodplain Non-Structural Control Measures

3. Educational and participatory practices

3.4. Education and participation campaigns for commercial and industrial Premises

This best management practice includes industry-specific training and environmental accreditation programs to increase the uptake of environmental management and cleaner production techniques. Many industrial and commercial premises have a significant risk of contaminating stormwater and shallow groundwater due to the type of activities they undertake (e.g. fuel and chemical storage associated with automotive repair industries). For education campaigns involving commercial or industrial premises, care must be taken to specifically tailor messages to a particular target audience. While the approach needs to be tailored, the recommended procedure of firstly surveying the target audience, designing the campaign (involving the target audience where possible), delivering the campaign and finally evaluating the campaign is generic. To maximize the effect of the campaign, the complementary use of site assessments, incentives (e.g. positive recognition, assistance) and disincentives (e.g. penalties) should also be considered.

Floodplain Non-Structural Control Measures

3. Educational and participatory practices

3.5. Focused stormwater education involving new estates

The employment of a developer-funded Stormwater Management / Environmental Officer for a large residential estate/ land development has great potential and should be considered as part of the development's overall stormwater management plan. The officer would play a role during the construction stage to ensure that best practice stormwater management techniques are implemented. This could include educating builders and sub-contractors while they are on-site and helping to maintain the integrity of structural controls, such as infiltration systems, during construction. The officer could also monitor construction practices and erosion and sediment controls. The role could be valuable in educating residents on water sensitive management practices at the building stage, when there is the greatest potential to adopt measures such as waterwise and fertilize wise gardening (e.g. through plant selection) and the reuse of shallow groundwater or roof water.

Floodplain Non-Structural Control Measures

4. Funding, policy, regulatory and enforcement practices

4.1. Funding programs for stormwater management

Effective stormwater management requires substantial resources. Resources are typically obtained from short-term grants, consolidated revenue or general rates, environmental levies and/or stormwater-related fees. Establishing a dedicated, stable source of funding is one of the key foundations for a successful stormwater management program and is required to ensure long-term viability of the program and public support. Short-term funding programs have sometimes led to poor outcomes, for example, gross pollutant traps that were hastily built with grant funds, but never maintained due to a lack of ongoing funding. Local government authorities are increasingly establishing their own dedicated funding mechanisms, usually in the form of an environmental levy or a property-based stormwater fee.

Floodplain Non-Structural Control Measures

4. Funding, policy, regulatory and enforcement practices

4.2. Point source regulation of stormwater discharges and enforcement Activities

Regulation of specific commercial and industrial premises (e.g. automotive industries, nurseries, landfills, waste recycling facilities, etc.) is a widely used and potentially highly effective technique to minimize stormwater and groundwater pollution. Such premises are typically licensed by a government agency, with their activities controlled through legally enforceable license conditions that are regularly checked by enforcement officers who audit the premises. Control of point sources of stormwater pollution is generally considered to be easier than controlling diffuse sources (e.g. runoff from roads and rural land uses), and more rewarding on a cost-benefit basis. As such, a well-managed point source regulation program should be a priority of agencies that are responsible for managing stormwater and groundwater quality.

Floodplain Non-Structural Control Measures

4. Funding, policy, regulatory and enforcement practices

4.3. Illicit discharge elimination programs

Illicit connections are defined as illegal and/or improper connections to stormwater drainage systems and receiving waters. Illicit discharge elimination programs seek to identify and remove illegal or inappropriate waste streams entering the stormwater network. The most obvious of these waste streams include trade wastes from commercial and industrial premises and wastewater from domestic premises. Illicit connections to stormwater can be surprisingly common and represent a major source of pollution. This BMP outlines the principal components of illicit discharge elimination programs and techniques to identify these discharges. To be effective, these programs need to be supported by targeted education campaigns and regulatory mechanisms that enable action to be taken to eliminate the discharge and prosecute offenders.

Floodplain Non-Structural Control Measures

5. Catchment planning practices

5.1. Risk assessments and environmental management systems

Managing stormwater at the catchment or citywide scale is a challenging task, as there are typically many sources of pollution and limited resources to manage them. Each of these sources poses a different level of risk to the health of receiving waters. One way of identifying stormwater management risks, assessing them, prioritizing them, and allocating resources to manage them is to use ‘risk assessments’ and associated ‘environmental management systems’. Risk assessment is defined as the process of risk analysis and risk evaluation. Environmental management systems provide the framework within which an organization can systematically develop its environmental policy, identify and assess its risks, develop measures to manage these risks, monitor the success of these measures, report on its environmental performance, and revise its environmental programs where necessary. The use of these tools for managing stormwater is highly applicable to local government authorities, government departments, industry and business, for example, when stormwater management plans are developed or when operations are reviewed to ensure all practicable steps are being taken to prevent or minimize stormwater pollution.

Floodplain Non-Structural Control Measures

5. Catchment planning practices

5.2. Managing the total water cycle

Increasingly, agencies responsible for stormwater management are realizing that the issue cannot be managed in isolation from other elements of the water cycle. The new approach to managing water resources in an integrated fashion is known as ‘total water cycle management’, or ‘integrated water resource management’, or ‘water sensitive urban design’. Stormwater, water supply and wastewater/effluent are all considered during the design process. The new, integrated approach to water management has significant benefits compared to the traditional approach of managing these streams in isolation, including the potential to reduce development costs, reduce water pollution, reduce the consumption of scheme water, and reduce water balance problems by minimizing changes to predevelopment hydrological regimes. Water efficiency, reuse and recycling are integral components of total water cycle management.

Hard engineering strategies

Hard engineering strategies act as a barrier between the river and the surrounding land. Artificial structures are used to change or disrupt natural processes.

Examples of hard engineering strategies include artificial embankments or levees, channelisation, diversion spillways and dredging.

Hard engineering: artificial embankments, or levees

- ✓ These are larger than natural levees and are usually made of erosion-resistant concrete.
- ✓ They allow more water to flow in the river at a greater height so flood risk is reduced.
- ✓ They allow floodplains to be built on.

Photo © David Wright.

- x Building on floodplains encourages more development, which can increase the risk of flooding.
- x If embankments fail or water overtops them then damage can be severe.

Hard engineering: channelisation

- ✓ Channelisation (straightening and deepening the channel) allows water to flow through an area more quickly, reducing flood risk.
- ✓ It makes navigation easier and quicker.

At York, the River Ouse has been lined and straightened. Photo © Robert Gamesby.

- x Constant maintenance is needed to stop the river reverting to its natural channel.
- x Areas further downstream are at greater risk of flooding because floodwaters reach them more quickly.

Hard engineering: diversion spillways

- ✓ These artificial channels divert water away from areas at particular risk of flooding, sending it back into the river further downstream.
- ✓ Spillways generally have floodgates, which control the volume of water in the spillway.

Spillway on River Wyre at Garstang, Lancashire. Photo © David Medcalf.

- x Areas close to the point where the spillway rejoins the river are at greater risk of flooding, because of increased discharge.
- x Areas further downstream are at greater risk of flooding.

Soft engineering strategies

Soft engineering is enhancing a river's natural features, its banks, to protect them from erosion.

Examples of soft engineering strategies include planting vegetation and river restoration.

Soft engineering: dredging

Dredging involves excavating the sediment at the bottom of the river bed and moving it to a different location.

Dredging on the River Usk near Newport.
Photo © Robin Drayton.

✓ Dredging increases the depth of the channel, which increases its capacity to carry water, thus reducing the risk of flooding.

x Dredging has to be carried out frequently, as sediment is continually deposited on the river bed.

x Dredging can cause disturbance to aquatic ecosystems.

Soft engineering: planting vegetation

- ✓ Planting trees and other vegetation close to the banks of the river intercepts rainwater. River discharge is lower, making the river less likely to flood.
- ✓ Plant and tree roots bind the soil together so less sediment enters the river, reducing the risk of flooding downstream.
- ✓ Planting creates new habitats and can improve water quality by filtering out pollutants.

Afforestation (tree planting) on the banks of the Afon Tywi, Carmarthenshire.

x Planting will reduce flood risk but will not eliminate it entirely.

Soft engineering: river restoration

Rivers that have previously undergone hard engineering can be restored to their original course.

This is sometimes done if the land surrounding the river no longer needs to be protected.

The River Skerne, a tributary of the River Tees at Darlington, was restored with Heritage Lottery funding. Photo © Mick Garratt.

- ✓ River restoration reduces the risk of flooding downstream.
- ✓ Maintenance costs are low.

x River restoration can be controversial as it re-introduces flooding to the area.

Floodplain Classification

There are multiple types of floodplain restoration:

- ***Hydrologic***: Reconnecting the stream to the floodplain and restoring the stream's natural hydrology.

- ***Vegetative***: Removing invasive species and replanting native plant communities appropriate to the site and conditions.

- ***Habitat Restoration***: Installing structures to improve wildlife habitat. Habitat is also gained through re-planting native plant communities.

Floodplain Components

Special Planning Zone

- In the 0-2 year flood elevations, reconstruction is prohibited
- In the 0-20 year flood elevations, any new construction is prohibited
- In the 2-20 year flood elevations, reconstruction of a home destroyed during the 2011 flood is allowed but only by the owner at that time
- Repair or reconstruction must comply with flood-proofing standards

Floodplain Components