Assessment of flood risk posed by vegetation and large wood in and around waterways

Guidelines for waterway managers

VICTORIA State Government | Environment, Land, Water and Planning

Acknowledgements

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Cover photograph: Large wood trapped against a bridge on Sutherland Creek. *Source: Corangamite CMA*

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Contents

1 Introduction

These guidelines have been developed as part of the Victorian Government's response to the 2012 Inquiry into flood mitigation infrastructure in Victoria, undertaken by the Environment and Natural Resources Committee of the Victorian Parliament (ENRC 2012).

The Victorian Waterway Management Strategy (VWMS) (DEPI 2013) and the Victorian Floodplain Management Strategy (VFMS) (DELWP 2016) give high priority to management of vegetation in and around waterways, and both identify specific actions.

One of these actions was for the Department of Environment, Land, Water and Planning (DELWP) to lead the development of guidelines to assess the flood risk posed by large wood and instream vegetation. The inquiry noted that updated guidance was required, including information for the community on how to apply to a waterway management authority (catchment management authority [CMA] or Melbourne Water) for authorisation to carry out works on waterways. The guidelines were to include practical advice on how to meet requirements for environmental protection, and Indigenous and cultural heritage.

1.1 Purpose and scope of the guidelines

The purpose of the guidelines is to assist waterway managers in assessing works on waterways (WoW) applications where the applicant is proposing to manage vegetation or large wood in and around waterways for flood mitigation. The guidelines include a decision framework to support this assessment process.

The guidelines do not consider the management of vegetation and large wood for other purposes, such as recreation and public safety, beyond flood risk. They also do not consider the assessment of WoW applications that may indirectly increase or be perceived to increase flood risk, e.g. installing instream wood, rock weirs, etc.

These guidelines supersede sections 16 and 17 of the Guidelines for Assessment of Applications for Permits and Licences for Works on Waterways (SKM 2001), where the application relates to the management of vegetation and large wood for flood mitigation[1]. These waterway vegetation guidelines incorporate Victorian Government legislation, strategies and policies that have been revised since 2001. The Guidelines for Assessment of Applications for Permits and Licences for Works on Waterways (SKM 2001) may still contain relevant information where the scope of works is beyond the scope of these waterway vegetation guidelines.

Although not the specific purpose of the guidelines, the information may also be useful for:

- WoW applicants or other interested parties who have issues relating to flood risk associated with the management of vegetation and large wood
- waterway managers in reviewing proposals for works on waterways that are exempt from WoW applications
- waterway mangers in providing advice to other agencies, groups or individuals with an interest in or responsibilities associated with flood risk beyond the scope of WoW applications.

These guidelines are supported by a series of fact sheets designed to provide information about the relationship between waterway vegetation and flooding. The series includes information about best practice and approvals that may be required.

1.2 Key terms and definitions

Vegetation in and around waterways is structured into different zones that are graded from aquatic to terrestrial in response to variability in flow levels. As shown in Figure 1, the bed of the channel has submerged hydrophytes and sometimes fully submerged large wood. At the toe of the bank, emergent macrophytes (such as reeds) are present, as well as partially submerged wood, that interact with all flows. Further up the waterway bank, the plants change in response to less water, with hydrophytes and macrophytes giving way to grass, bushes and trees. Above the top of the bank, vegetation only interacts with high flows in times of flood.

1 Refer to Sections 16 – Large Woody Debris Management and Section 17 – Vegetation Management in Guidelines for Assessment of Applications for Permits and Licences for Works on Waterways (SKM 2001)

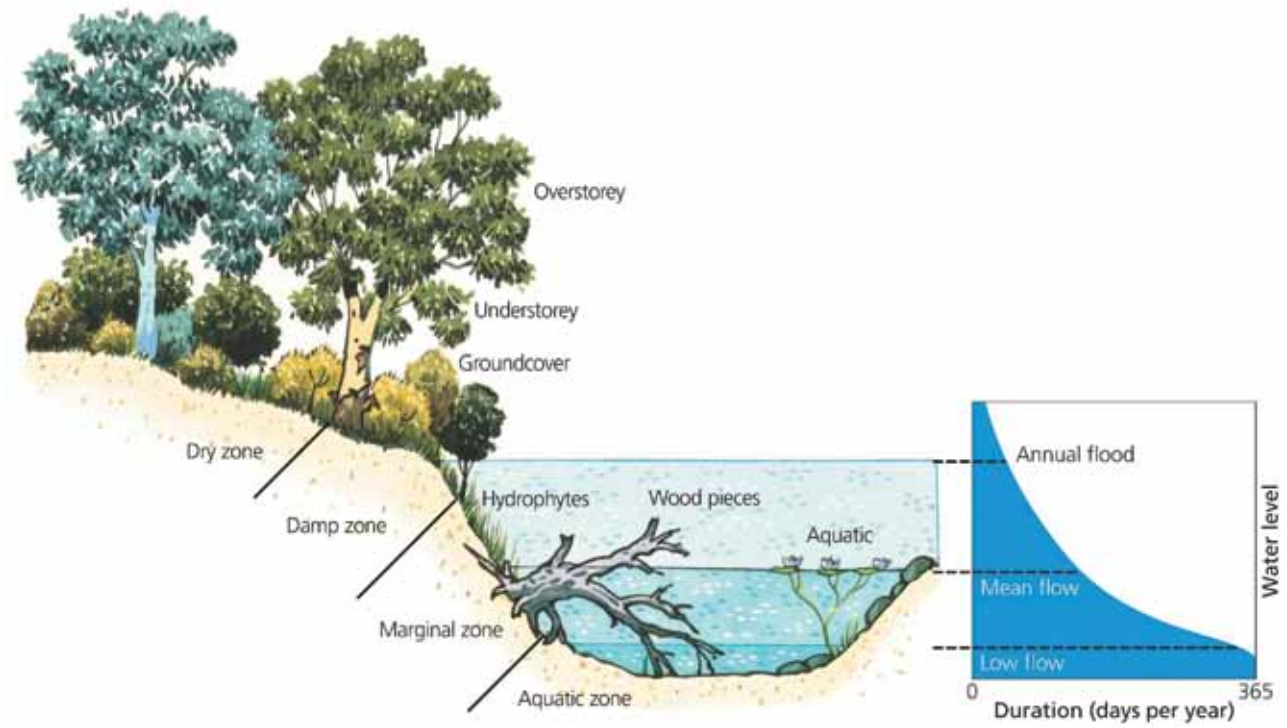

Figure 1: Structure and flow interaction of vegetation and large wood instream and on riparian land.
Source: Lovett and Price, 2007

1.2.1 Large wood

Large wood, sometimes called 'snags', includes fallen native trees, logs and branches and can be found in both instream and riparian areas.

Large wood is defined as downed wood in waterway channels greater than 10–20 cm diameter, and 1–2 m long (Gippel et al. 1996b; Fox 2004 et al. Wohl et al. 2016). This includes whole fallen trees (including roots) as well as branched pieces.

'Large wood' is the preferred term, covering material previously defined under 'large woody debris', 'coarse wood' and 'log jams'.

1.2.2 Instream vegetation

Instream vegetation grows in the water and along the lower banks of rivers, estuaries and wetlands (waterways). Some species may have roots attaching them to the bed and banks while others float on the water surface. Some of the attached plants may be completely submerged while others emerge from the water (emergent vegetation).

The width of the instream zone is defined by the waterway banks.

1.2.3 Riparian vegetation

Land that adjoins rivers, creeks, estuaries, lakes and wetlands is known as riparian land[2] (often called 'streamside' or 'frontage'). In Victoria, about 30,000 kilometres of riparian land is 'Crown frontage'. Much of this land is licensed to adjoining landholders for grazing, and increasingly for riparian management. More information about Crown frontages and licensing can be found in the fact sheets 'Crown land water frontage licensing' and 'Riparian management licences' at www.forestsandreserves.vic.gov.au/land-management/crown-land-leases-licences-and-permits.

There is no single rule for defining the width of the riparian area; it will be determined by the particular landscape and by management objectives. For example, the width of riparian land required to shade a waterway may only be a fraction of what is required for wildlife management.

2 It is the land along and that adjoins the top of the bank of the waterway, but not the bank itself. In the landscape, the riparian land and bank of the waterway grade into each other but their distinction has implications for the approvals discussed in the guidelines.

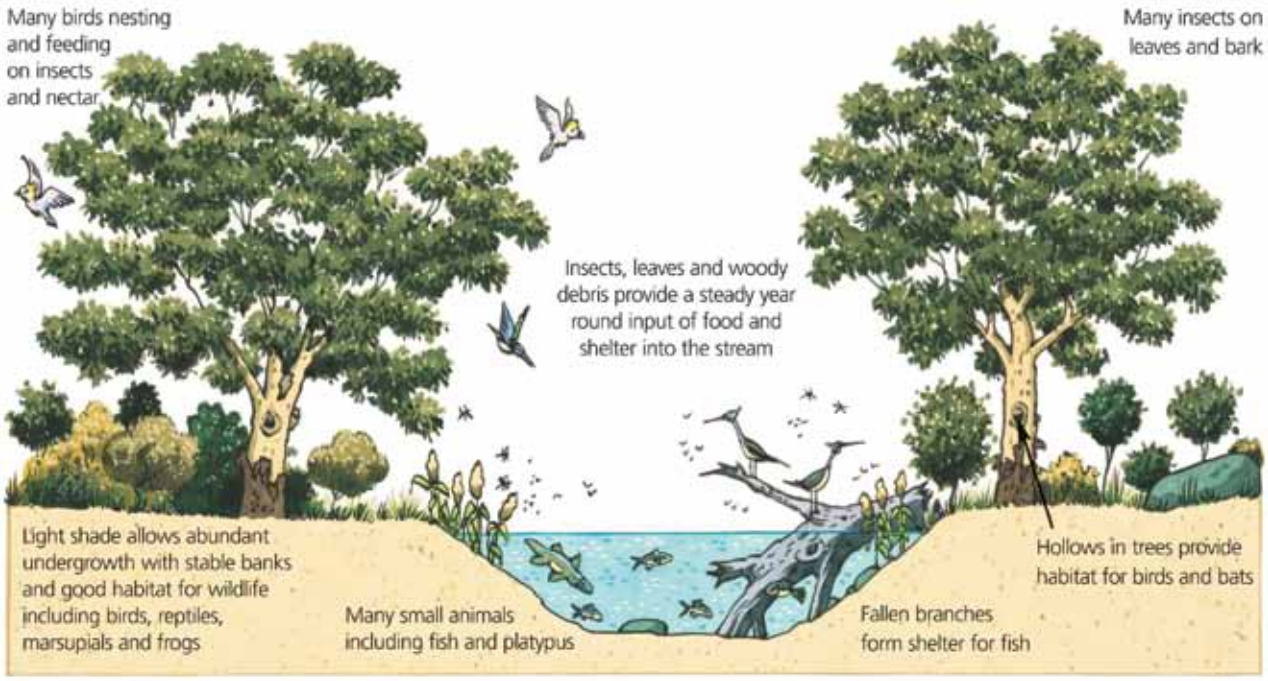

Figure 2. Ecological benefits of native instream, riparian vegetation and large wood to the condition of the waterway. *Source: Lovett and Price 2007*

1.3 The role of vegetation and large wood

Vegetation and large wood are important contributors to the condition of waterways (see Figure 2).

Waterways and riparian land are productive parts of the landscape for both natural ecosystems and human agricultural systems. Riparian land often has deeper and better-quality soils than the surrounding hillslopes due to past erosion and river deposition. They often retain moisture over a longer period because of their position lower in the landscape.

Instream zones and riparian areas are often vulnerable parts of the landscape, at risk of damage from cultivation or over-grazing as well as from natural events such as floods. This combination of productivity and vulnerability means that careful management of these zones is vital for the conservation of instream and terrestrial biodiversity, as well as for sustainable agricultural productivity. Maintaining large wood and vegetation in and around waterways protects public water supplies, improves water quality for fishing and recreation, helps reduce bars downstream (DEPI 2013) and reduces the occurrence and scale of flood-related channel change (Alluvium 2011). Riparian land is also important for the storage of carbon (Bunn and Davies 2007).

The instream zone and riparian areas generally support a higher diversity of plants and animals than the surrounding hillslopes. This is a result of their wide range of habitats and food types, proximity to water, less extreme microclimate and ability to provide refuge. Many native plants are found only, or primarily, in waterways, and these areas are also essential to many animals for all or part of their lifecycle. Waterways also provide a refuge for native plants and animals in times of stress, such as drought or fire.

Vegetation and large wood provide shelter, food sources and breeding sites for a variety of instream animals, including threatened fish species, as well as contributing to biological processes within the river channel. Large woody habitat is also an important structural component of rivers, helping form features such as scour pools and channel bars, as well as stabilising the river channel. In large lowland rivers, large woody habitat may be the only stable substrate and an important instream source of nutrients (DEPI 2013).

1.4 Impacts of removing vegetation and large wood and historical management practices

Wide-scale removal of vegetation and large wood and unmanaged grazing of domestic stock have resulted in widespread and large-scale degradation of instream zones and riparian land. The removal of large woody habitat and instream vegetation increases flow velocity, bed degradation, channel enlargement and loss of important instream habitat (DEPI 2013):

- Removing riparian trees increases the amount of light reaching waterways and, as a result, raises water temperatures. This favours the growth of nuisance algae and weeds.
- Clearing native riparian and instream plants removes the natural source of leaves, twigs, fruit and insects that underpin the aquatic food web.
- Under natural conditions, trees occasionally fall into the waterway and the large woody pieces provide important habitat for aquatic organisms. Removing instream and riparian vegetation disrupts these aquatic ecosystems.
- Continuing agriculture to the top of waterway banks by cropping or unrestricted stock access increases the delivery of sediments and nutrients to waterways. Large volumes of fine-grained sediment smother aquatic habitat, while increased nutrients stimulate weed and algal growth. Increased nutrient load also affects estuaries and marine life beyond the river mouth. Figure 3 illustrates the different impacts light, moderate and heavy grazing have on instream health and riparian vegetation.
- Removing instream and riparian vegetation destabilises waterway banks, often resulting in large increases in channel width, channel incision and gully erosion. This erosion delivers sediment to waterways, leading to downstream impacts, such as the sedimentation of pools and weirs.

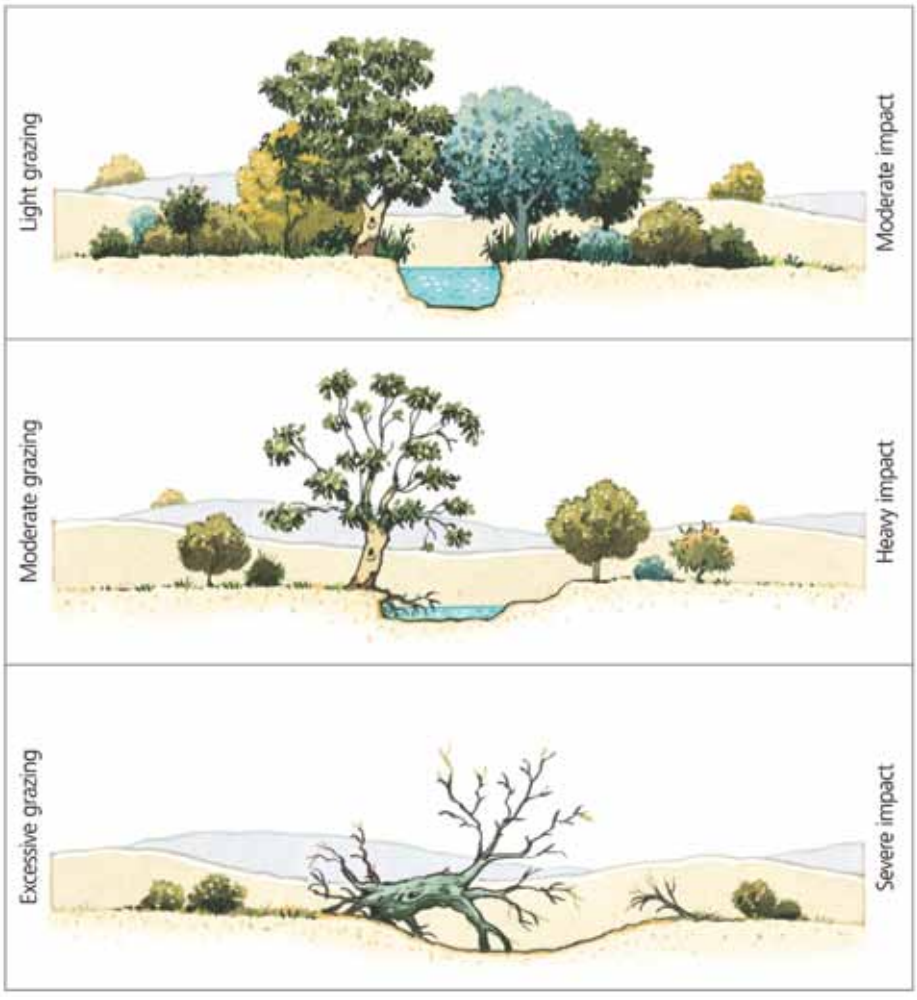

Figure 3: Grazing impacts on instream and riparian areas.
Source: Lovett and Price, 2007

- Removing instream and riparian vegetation and wood enables water to travel downstream at a faster rate, sometimes contributing to increased flooding and erosion of lowlands.
- Removing vegetation throughout the catchment can lead to raised water tables and the salinisation of land and, ultimately, waterways.
- Desnagging removes aquatic habitat and is a major cause of decline in native fish and crayfish species populations.
- Historically, the removal of vegetation and large wood, and planting of exotic vegetation was supported by legislation, government funding and institutional arrangements (Erskine and Webb 2003). From the late 1800s to late 1990s extensive removal of large wood and instream vegetation clearing in Victoria aimed to increase conveyance of flood water. However, while large wood can locally elevate water levels, at the catchment scale the roughness of large wood slows floods, and therefore reduces the height of the downstream flood peak (Anderson 2005a; Anderson et al. 2005; Anderson et al. 2006; Dixon 2013; Dixon et al. 2015).

The detrimental impacts of these disturbances are not just cumulative; they often exacerbate each other. For example, clearing riparian and instream vegetation from upland waterways multiplies, many times, the impact of increased nutrients from surrounding land use because clearing also reduces shade and, as a result, increases water temperatures. These conditions enable nuisance weeds and algae to flourish, as well as creating instream environments that favour exotic species such as carp.

2 Strategies and policies

The improved understanding of the role of vegetation and large wood in and around waterways has changed the focus from the previous approach of removal to protection and re-establishment. Many of the arguments for clearing and removing vegetation and large wood have been discounted through research and demonstration sites.

Removing vegetation and large wood from in and around waterways has become less common and there are legislative controls on these activities in Victoria.

The Victorian Government and regional agencies have developed strategies and policies to manage and protect waterway and floodplain habitats, including vegetation and large wood in and around waterways.

2.1 Victorian strategies and policies

Victorian Waterway Management Strategy

The Victorian Waterway Management Strategy (VWMS) provides the framework for government, in partnership with the community, to maintain or improve the condition of waterways, rivers, estuaries and wetlands so they can continue to provide environmental, social, cultural and economic benefits.

The strategy outlines the Victorian Government's policy on regional decision making, investment and management activities. It includes specific management issues for waterways relating to large wood and vegetation.

The VWMS states that large wood or native vegetation will not be removed from waterway channels unless it poses a serious risk to public safety or public infrastructure. Where feasible, large woody habitat is to be realigned or anchored rather than removed. The management of large wood and native vegetation in waterways to reduce flood risk is to be in accordance with the Victorian Government's response to recommendations of the Environment and Natural Resources Committee inquiry into flood mitigation infrastructure in Victoria. Where programs to reinstate instream large wood or vegetation are planned, the benefits and risks are to be assessed in consultation with the community (VWMS Policy 11.3).

The VWMS notes that there may be instances where the removal of instream large wood or vegetation is warranted to maintain the social or economic values of a waterway, reduce an immediate threat to public infrastructure or reduce public risk. In such cases, waterway managers need to balance the benefits to habitat against the level of risk – cognisant of statutory requirements for protection.

Victorian Floodplain Management Strategy

The Victorian Floodplain Management Strategy sets the proposed direction for floodplain management in Victoria. The strategy aligns with the Victorian Government's response to the Victorian Floods Review and the Environmental and Natural Resources Committee inquiry into flood mitigation infrastructure. It also aligns with the broader emergency management framework set out in the *Emergency Management Act 2013*. It integrates floodplain management with the VWMS and the Victorian Coastal Strategy 2014.

The strategy outlines government policy as it relates to large-scale flood mitigation activities on waterways that typically benefit communities as well as small-scale activities that may benefit individual landholders. Current government policy on large-scale flood mitigation activities is:

- Where flood studies demonstrate that flood risks can be materially reduced by large-scale mitigation activities on waterways, individuals or local government authorities (LGAs) may be able to carry out those activities, subject to CMA or Melbourne Water authorisation.
- If a waterway is to be modified or an activity undertaken on or adjacent to a waterway for flood mitigation purposes, and these activities are to be implemented as Water Management Schemes, the relevant LGA will be responsible for undertaking the activity/work (in compliance with any relevant conditions) and for all ongoing maintenance.
- Large-scale flood mitigation activities or works on waterways must be demonstrated, through a flood study, to be cost effective, i.e. have demonstrable benefits in terms of reduced average annual damage (AAD) that are greater than any combined costs of construction and maintenance, and any impacts on waterway health.

Individuals or groups of landholders, infrastructure managers, LGAs or other authorities (unless formally exempt) proposing small-scale activities to remove debris or sediment, or to remove or realign vegetation or large wood in a waterway, must obtain authorisation from their relevant CMA or Melbourne Water. The relevant authority will consider potential risks to waterway health and may require the proponent to undertake alternative activities to avoid or minimise any risks (VFMS Policy 18c).

2.2 Regional strategies

Regional Catchment Strategies, Waterway Strategies and Floodplain Strategies

CMAs are responsible for developing Regional Catchment Strategies (RCSs), Regional Waterway Strategies (RWSs) and Regional Floodplain Strategies (RFSs), as well as coordinating and monitoring their implementation. In the Port Phillip and Westernport region, Melbourne Water is responsible for the development of a Healthy Waterways Strategy and a Flood Management Strategy, and the Port Phillip and Westernport CMA is responsible for the development of the region's RCS. These strategies provide long-term objectives and priorities that relate to land and water resource management, including the management of vegetation and large wood in and around waterways. They inform priority actions undertaken in accordance with annual implementation programs funded through external sources, as well as related on-ground works by partner government agencies, LGAs and the community.

3 Legislation and roles and responsibilities

The legislative arrangements covering the management of vegetation and large wood in and around waterways are complex and several authorities administer legislation with influence in the area.

3.1 Works on waterways permits

Waterway managers (CMAs and Melbourne Water) are responsible for approving works that impact on vegetation and large wood in waterways.

3.1.1 The role of catchment management authorities and Melbourne Water

CMAs are regional statutory authorities established by the *Catchment and Land Protection Act 1994* to coordinate the development and implementation of regional catchment strategies. These strategies outline regional goals, developed in consultation with local communities, that aim for sustainable development of natural resource-based industries, protection of land and water resources, and conservation of natural and cultural heritage.

The CMAs and Melbourne Water have statutory responsibilities for waterway, regional drainage and floodplain management under the *Water Act 1989*. This includes coordinating the development and implementation of regional waterway strategies and related waterway works programs. They also have a regulatory role in authorising individuals and organisations to carry out works and activities on waterways. This authorisation is via a by-law under the provisions of Sections 160, 219 and 287ZC of the Act. CMAs can also license works on waterways under Section 67 of the Act[1]. A model by-law is presented in Appendix A.

The by-law applies to the waterways that the CMAs and Melbourne Water have declared to be designated waterways, or designated land or works, under Section 188 of the Act.

CMAs and Melbourne Water also have emergency response roles, as identified in the Emergency Management Manual Victoria (State of Victoria, 2015), in prevention/mitigation/risk reduction, response and relief/recovery. The main focus of these activities is to help people affected by flooding by working in partnership with local government, other authorities and communities to provide advice and assistance based on the information collected, maintained and enhanced before, during and after significant flood events.

3.1.2 Exemptions to works on waterways permits

There are a number of circumstances where a person may be exempt from requiring a permit to undertake works on a waterway. Waterway managers should refer to clauses 8 and 9 of the model by-law (see Appendix A) to identify those persons who do not require permits and any requirements applicable to those persons.

3.2 Other permits and requirements

The granting of a WoW permit does not exempt an applicant from the need to comply with other legislation.

Works and activities in and around waterways can require a number of different statutory approvals in addition to the WoW permit.

Responsible authorities that may need to be consulted include:

- local government
- Department of Environment, Land, Water and Planning
- Department of Jobs, Precincts and Regions
- Parks Victoria
- Commonwealth Department of Environment
- Office of Aboriginal Affairs Victoria
- registered Aboriginal parties
- Heritage Victoria
- Department of Justice and Community Safety
- committees of management
- Transport Safety Victoria.

1 The Glenelg Hopkins CMA does not issue works on waterways permits however, this framework may still be relevant for issuing a licence under the *Water Act 1989*.

The extent of involvement of each authority will largely be determined by the issue to be addressed (e.g. flood mitigation, navigation or pest plant management), location of activities, environmental values and floodplain management objectives. Appendix B – Approvals and agency consultation summarises the relevant legislation and agencies that may need to be consulted in relation to approvals for works that impact on vegetation and large wood in and around waterways. Some of these approvals include:

- **Crown land** – Most beds and banks of Victorian waterways and nearly 30,000 kilometres of riparian land are Crown land. Consent will be required to carry out works or activities on Crown land. Before submitting a WoW application, applicants should contact DELWP for further information on the land status, and the appropriate agency or committee of management (e.g. DELWP, local government or Parks Victoria, etc) from which approval may be required. If the proposed works and activities will occur on Crown land, written consent from DELWP should be submitted with the application.
- **Planning permits** – The *Planning and Environment Act 1987* provides for the preparation of planning schemes that are administered by local government. The planning objectives of a municipality (and for Victoria) are implemented through the application of zones, overlays and specific provisions. Planning schemes require planning permits to be issued to allow for certain land uses, buildings, works and the removal of native vegetation.
- **Cultural heritage management plans and cultural heritage permit** – The *Aboriginal Heritage Act 2006* established cultural heritage management plans and cultural heritage permit processes to manage activities that may harm Aboriginal cultural heritage.
- **Permits for flora and fauna** – The *Flora and Fauna Guarantee Act 1988* provides for the conservation of threatened species and communities and to manage potentially threatening processes. Critical habitat of flora and fauna listed under the Act can be subject to an order specifying measures for its conservation, protection or management and will need a permit under the Act for removal.
- **Approval to proceed under the EPBC Act** – The *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places. Before undertaking a management action, applicants need to determine whether an action may have significant impact on matters of national environmental significance.

The requirement for other permits is ultimately the responsibility of the applicant and should not prevent the waterway manager from considering and approving a WoW application or exemption. However, applicants will often assume that the waterway manager will be able to advise them on other permits that might be required. If the waterway manager believes that an additional permit is/may be required, it can indicate this to the applicant with the WoW permit approval (e.g. within the cover letter). However, a CMA is not required to provide this advice.

4 Decision framework for the assessment of works on waterways applications

The Guidelines for Assessment of Applications for Permits and Licences for Works on Waterways (WoW) (SKM 2001) were developed to help waterway managers assess applications for permits and licences for a range of common works on waterways in Victoria. The 2001 guidelines were designed to help assess and evaluate the hydraulic and environmental impacts of proposed works and ensure they conform with best management practice.

This section provides a decision framework to assist waterway managers in the assessment of WoW applications[1] where the applicant is proposing to manage large wood or vegetation in and around waterways for flood mitigation.

4.1 Context of the decision framework

The decision framework relates to the stage of the WoW application process where the waterway manager is assessing a completed WoW application. The framework does not discuss the processes pre- and post-assessment, such as preliminary consultation, application procedures, site inspection, monitoring, etc.

Where a WoW application relates to the management of large wood or vegetation in and around waterways for flood mitigation, the framework – and the information in Section 5 of these guidelines – supersedes the following sections of the 2001 guidelines:

- Section 16 – Large woody debris management
- Section 17 – Vegetation management

However, other sections of the 2001 guidelines are still relevant for guidance on the works on waterways application process, e.g. general application procedures, enforcement procedures, etc.

4.2 Application of the decision framework

The decision framework has the following five steps:

- Step 1 – Determine the flood risk issue and relevance of the guidelines
- Step 2 – Identify agency stakeholders
- Step 3 – Assess potential impacts of proposed works
- Step 4 – Identify options to mitigate negative impacts
- Step 5 – Assess benefits

Figure 4 provides an overview of the five steps of the decision framework and the questions proposed at each step. The following section provides a description of how to apply each of these steps and provides reference to the relevant information in Section 5 of these guidelines – Flood risk issues and approaches to management.

Step 1 – Determine flood risk issue and relevance of guidelines

The guidelines are only relevant to WoW applications that seek to mitigate flood risks by implementing works related to vegetation or large wood within the bed and banks of designated waterways.

When an individual, group or organisation contacts a waterway manager it is important for the waterway manager to determine the key issues and their relationship with riparian vegetation, instream vegetation or large wood. Initial basic information on the issues, site location, proposal and relevant supporting information (e.g. photographs, maps, diagrams, etc) can assist this task. Listening to the applicant's concerns is a good way to find out their perceptions of the situation and what sort of response the waterway manager might provide.

Common vegetation and large wood concerns that waterway managers might respond to include:

- "A tree has fallen across the creek. It is diverting flow and causing bank erosion. It is also blocking the channel and I am concerned that it will hold back water and increase the risk of flooding."

1 The Glenelg Hopkins CMA does not issue works on waterways permits however, this framework may still be relevant for issuing a licence under the *Water Act 1989*.

- "There is a large log in the middle of the river that is a hazard for boating and swimming. It is a real threat, as someone could hurt themselves if they don't see it. Fishermen are always getting snagged on it."
- "The creek is choked with reeds and large logs. It's been years since the waterway had a good cleanout."
- "The creek at the park is very untidy and smells. You can't see the channel as the reeds have expanded across width of the waterway. It's full of snakes and dangerous for children to play."
- "The willows are a real problem. There used to be only a few of them but they now dominate the creek. The branches are also hanging over the waterway, partially blocking flows and causing bank erosion and widening of the channel."

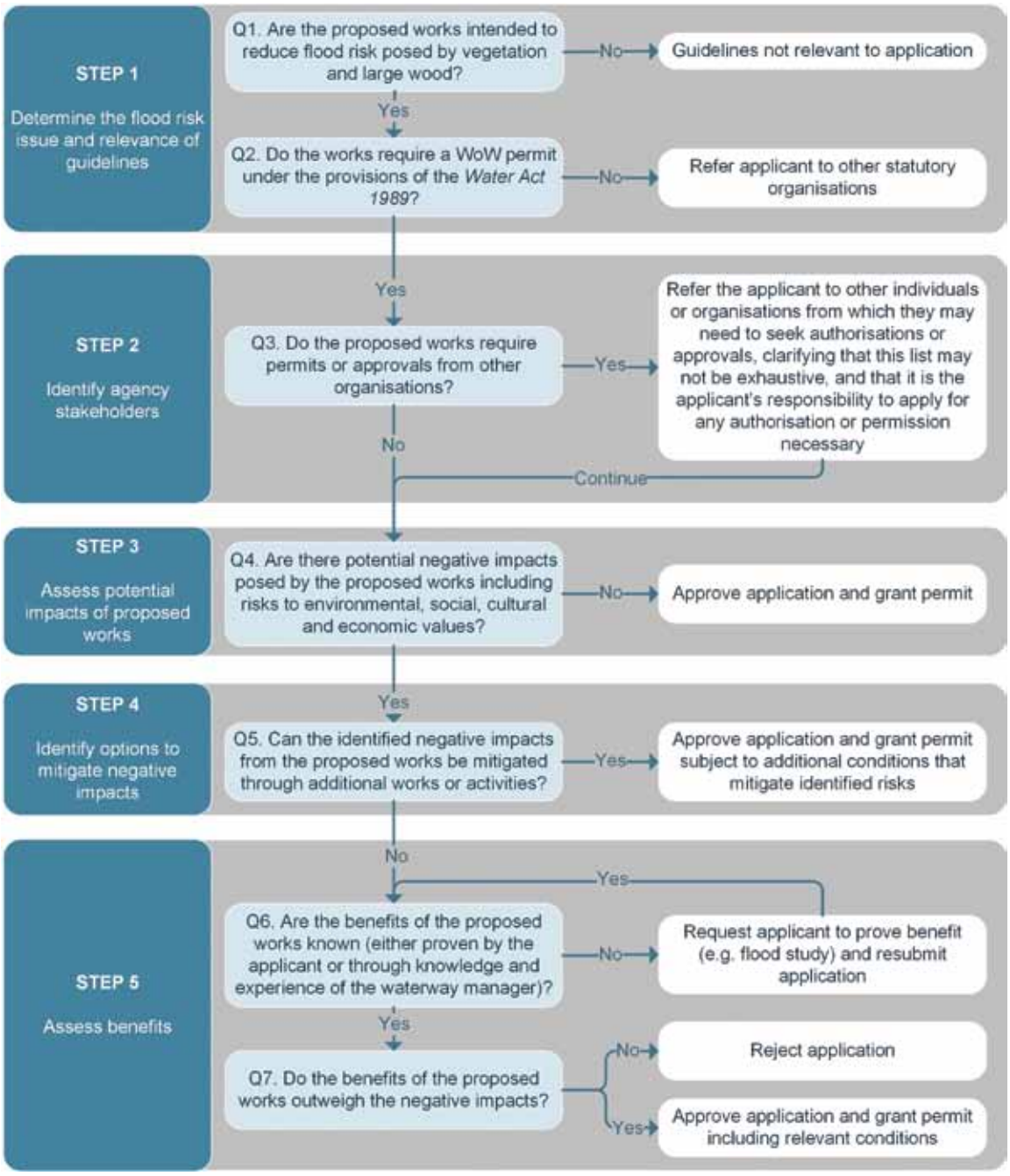

Figure 4. The five-step decision framework for assessment of WoW applications where the applicant is proposing to manage large wood or vegetation in and around waterways for flood mitigation.

- "Our community group received a grant to plant some vegetation along the creek. We were also keen to place some logs in the channel to create some fish habitat."
- "The floodwaters are just starting to recede and you can see that there is an awful lot of wood racked up against the town bridge. Someone should get down there and remove it before we get another flood."

Table 1 lists the flood risk issues included in these guidelines, with reference to further information provided in Section 5 of these guidelines.

Q1 Are the proposed works intended to reduce flood risk posed by vegetation and large wood?

YES Go to Q2.

NO Guidelines not relevant to application. Do not apply the guidelines.

The waterway manager may be asked to respond to a wide range of issues, some of which may fall outside the waterway manager's area of management. For example, the following two issues may need to be raised with council or public land manager as local drainage issues:

- "The drain at the back of my property is choked with reeds and garbage. It's been years since it had a good cleanout. It's unsightly and smelly."
- "The culverts outside my property are blocked by debris and need cleaning before they cause my property to be flooded."

Q2 Do the works require a WoW permit under the provisions of the *Water Act 1989*?

YES Go to Step 2.

NO Refer applicant to other statutory organisations.

Step 2 – Identify need for any other authorisations or permissions

The proposed works may require approval from organisations other than the waterway manager.

Works and activities in and around waterways can require a number of different statutory approvals in addition to a WoW permit. A description of the statutory approvals that may be required in and around waterways are provided in Appendix B – Approvals and agency consultation.

Section 5 of the Guidelines for Assessment of Applications for Permits and Licences for Works on Waterways (SKM 2001) requires that the completed application must be signed by the owner of the property (or if an organisation, someone authorised to do so). If the proposed works and activities will occur on Crown land, written consent from DELWP should be submitted with the application.

The requirement for other permits is ultimately the responsibility of the applicant and should not prevent the waterway manger from considering and approving a WoW application or exemption. However, applicants will often assume that the waterway manager will be able to advise them on other permits that might be required.

Table 1. Flood risk issues associated with large wood and vegetation in and around waterways included in these guidelines

Flood risk issues included in these guidelines		Further information in Section 5
Large wood	Large wood impacting flooding	Page 21
	Large wood and flood waters causing or potential to cause bank erosion	Page 23
	Mobilisation of large wood and potential to cause damage to infrastructure (e.g. bridges)	Page 23
Instream vegetation	Instream vegetation impacting flooding	Page 27
	Instream vegetation impacting on drainage	Page 27
Riparian vegetation	Riparian vegetation impacting flooding	Page 30
	Lack of riparian vegetation increasing the potential for bank erosion during flooding	Page 30

Q3 Do the proposed works require permits or approvals from other organisations?

YES Refer the applicant to other individuals or organisations from which they may need to seek authorisations or approvals, clarifying that this list may not be exhaustive and that it is the applicant's responsibility to apply for any authorisation or permission necessary.

NO Go to Step 3.

If the waterway manager believes that an additional permit is/may be required, it can indicate this to the applicant with the WoW permit approval (e.g. within the cover letter).

Step 3 – Assess potential impacts of proposed works

All works on waterways will have impacts. Some will be detrimental and some beneficial. Some will be immediately apparent and some will not be realised until long after the works are complete. Some will be short-lived, others long-lasting.

In determining whether to grant a permit, the waterway manager will first consider any potential negative impacts that the proposed works may have on any designated waterway (or land where applicable) within their region.

The interplay of the proposed works and their location will mostly determine the impacts. In its simplest form, large-scale works on small-scale waterways will have greater impacts (over longer timeframes) than small-scale works on large-scale waterways. Equally, proposed works in a reach of poor waterway health are likely to have different impacts (or a different quantum of impact) to the same works in a reach of good waterway health. Given the highly variable nature of waterway environments there is danger in reducing the impact assessment to a systematised approach that prevents the recognition and interaction of local features and processes.

In assessing an application, waterway managers could consider potential negative impacts posed by the proposed works to:

- environmental values, in particular:
  - physical form, e.g. will the proposed works initiate or increase bed/bank instabilities and what impact will this cause?
  - instream and riparian habitats, e.g. will the proposed works degrade habitats and what impact will this cause?
- social values, in particular:
  - recreation, e.g. will the proposed works impact existing recreational uses such as fishing or swimming?
  - amenity, e.g. will the proposed works reduce the attractiveness of a place?
- built assets, in particular:
  - public or private infrastructure, e.g. will the proposed works threaten bridges/ crossings or impact existing landholder access to water?

In large part, the impact assessment relies on experience and expertise and it is recommended that waterway managers consult others working in their region or state-wide counterparts, as well as investigating past works that might be similar to those that are being proposed. Table 2 lists the types of works that are often proposed for the management of large wood and instream vegetation and provides examples of the potential negative impacts that may be associated with these works. Table 2 also provides reference to further information that can be used to provide guidance on how these works should be undertaken.

The impact assessment should be set in a broader context than just the site in question. Longitudinal and lateral connectivity are important drivers of waterway health and cumulative impacts of some kinds of works might completely dwarf the individual impact of one proposal.

Additionally, waterway managers must think carefully about the proposed works at a range of immediate, short-term and long-term timeframes. Waterways are dynamic features in the landscape that change through time and respond to different forces. The community's tolerance for change varies dramatically from urban to rural settings, and their appreciation of change varies with the time elapsed since the works were complete.

In some instances, this impact assessment may also identify the need for referral to another organisation as described in step 2.

Q4 Are there potential negative impacts posed by the proposed works including impacts to environmental, social, cultural and economic values?

YES Go to Step 4.

NO Approve application and grant permit.

Step 4 – Identify options to mitigate negative impacts

In some cases, the detrimental impacts of proposed works might be avoided or mitigated by other actions at the site. For example, the impact on channel form by removing exotic vegetation might be mitigated by planting native vegetation. Potential impacts from a proposal that seeks to work in a reach of relatively good health might be mitigated by further works to expand the area of good habitat laterally or longitudinally (particularly if it can be linked to other reaches of good habitat value).

The application may have spelled out mitigation measures; where they have not, the waterway manager might require them as conditions of approval.

Importantly, impact mitigation works can be undertaken before, during or after the works to maximise their effectiveness. Project staging must properly account for the timing of mitigation works. Clause 19 of the model by-law states that "unless otherwise stated in the permit, a permit issued under this by-law is valid for one year from its date of issue unless earlier revoked by the Authority". Therefore, if required, the waterway manager can issue a permit for longer than one year, e.g. if follow-up willow treatment is required. The key is to work with the applicant to fully appreciate the ramifications of the project and to schedule works and mitigation measures appropriately.

Table 2. Management approaches, and examples of potential negative impacts, to address flood risk from vegetation and large wood in and around waterway

Management issue	Management approach/proposed works	Further information	Example of potential negative impacts
Large wood	Trim and realign wood	Page 25	Trimming – loss or reduction in bird roosting habitat Realignment (particularly to bank) – loss of channel complexity e.g. bed scour, potential to cause further issues e.g. erosion, mobilisation of wood
	Remove wood	Page 26	Loss of instream habitat, loss of channel complexity, loss of hydraulic controls, increased in-channel flood velocities
	Anchor wood	Page 26	Public safety, streambank excavation if using 'deadman' technique
Instream vegetation	Removal of native instream vegetation	Page 28	Loss of instream habitat, loss of hydraulic controls, increased in-channel flood velocities
	Removal of exotic instream vegetation	Page 28	Mobilisation of fine sediment and organic matter, bed incision, loss of pool-riffle sequences, loss of soil-binding vegetation (along banks), increased in-channel flood velocities
Riparian vegetation	Removal of native riparian vegetation	Page 32	Reduced riparian habitats, increased overbank flood velocities
	Removal of exotic riparian vegetation	Page 32	Off-target damage to remnant native vegetation, increased overbank flood velocities

Q5 Can the identified negative impacts from the proposed works be mitigated through additional works or activities?

YES Approve application and grant permit subject to additional conditions that mitigate negative impacts.

NO Go to Step 5.

Step 5 – Assess benefits

Where proposed works have identified negative impacts with no mitigation options available (or acceptable to the applicant), a permit may still be issued if the benefits of implementing the works outweigh the negative impacts. For example:

- Policies 7.6 and 11.3 in the VWMS state that large wood or native instream vegetation will not be removed from waterways unless it is demonstrated to pose a serious risk to human health, public safety or public infrastructure.
- Policy 18b in the VFMS states that large-scale flood mitigation activities on waterways must be demonstrated, through a flood study, to be cost effective, i.e. have demonstrable benefits in terms of reduced average annual damage (AAD) that are greater than the combined costs of construction and maintenance and any impacts to waterway health.

Q6 Are the benefits of the proposed works known (either proven by the applicant or through knowledge and experience of the waterway manager)?

YES Go to Q7.

NO Request applicant to prove benefit (e.g. flood study) and resubmit application.

Where the benefits of the proposed works are known, the role of the waterway manager is to account for the negative impacts and weigh the balance of environmental detriment and benefit.

Q7 Do the benefits of the proposed works outweigh the negative impacts?

YES Approve application and grant permit including relevant conditions.

NO Reject application.

5 Flood risk issues and approaches to management

The following section outlines the importance of large wood, instream vegetation and riparian vegetation and provides the following information for each of these components:

- a description of associated flood risks
- approaches for managing the flood risks.

This information can be used in the assessment of work on waterways (WoW) applications when applying the decision framework outlined in Section 4. A list of key references is also provided in Appendix C – Key references for large wood and vegetation management.

5.1 Large wood

Large wood is defined as downed wood in waterway channels greater than 10–20 cm diameter, and 1–2 m long (Gippel et al. 1996b; Fox 2004; et al. Wohl et al. 2016). This includes whole fallen trees (including roots) as well as branched pieces.

'Large wood' is the preferred term, covering material previously defined under 'large woody debris', 'coarse wood' and 'log jams'.

The environmental benefits of large wood in waterways (see Figure 5) and their importance to waterway health are well recognised by researchers and waterway management agencies.

Figure 5: Structurally complex wood partially submerged and providing excellent fish habitat.

Source: Jamin Forbes

Historically, wood was removed from waterways due to concerns about navigation and the perception that it aggravated the risk of floods, bank erosion and damage to infrastructure.

There is compelling evidence, however, that shows the benefits of wood in waterways far outweigh perceived negative consequences. The case for retaining wood in waterways was made around 20 years ago (e.g. Gregory and Davis 1992; Gurnell et al. 1994; Gippel 1995; Gippel et al. 1996b), with the most recent reviews continuing to deliver consistent messages about the beneficial roles large wood plays in ecosystems (e.g. Ruiz-Villanueva et al. 2014; Roni et al. 2015; Wohl et al. 2016). Many rehabilitation projects, such as the one shown in Figure 6, focus on the reinstatement of wood to provide fish habitat and flow diversity.

Table 3 summarises the ecosystem functions large wood provides and explains why removing large wood from waterways is largely prohibited, except in special circumstances.

5.1.1 Flood risk issues associated with large wood

Large wood and flood risk

It is commonly thought that the local effect of large wood is to increase channel roughness and raise water levels (called afflux), which theoretically leads to a higher likelihood of water overtopping the banks for floods of a given size and frequency. While there is some evidence for this in the literature, much of it is confounded by other changes occurring at the same time that could also have led to the change in water level (Gippel 1995). A critical aspect of this relates to the size and position of the wood in the channel. For wood to have a significant local hydraulic effect on water levels, it must act to restrict the hydraulic control (i.e. cause a significant narrowing or shallowing of the channel).

Large wood in areas where the waterway cross-section is narrow and/or shallow, are more likely to be hydraulically significant than large wood in pools. While large wood can locally elevate water levels, at the catchment scale the roughness of large wood

Figure 6: Resnagging on the Murray River, with large hollow logs being returned for fish habitat and flow diversity. *Source: Fern Hames*

Table 3. Beneficial role of large wood in ecosystem functioning.

Role of large wood	Ecosystem processes
Acts as hydraulic roughness to increase water levels and slow velocity	The presence of large wood leads to slower passage of floods and local storage of sediment and organic matter around the wood. Large accumulations of wood can increase water levels which, in turn, improve connectivity of water, sediment, nutrients and organisms between the channel and floodplain. This can facilitate storage of sediment and nutrients on floodplains, access to floodplain habitat by aquatic organisms and lateral channel movement across the floodplain.
Increases habitat diversity within channels and on floodplains	Woody habitat is the inland equivalent of coastal reefs. Large wood causes flow separation and localised scour of the bed and banks, resulting in pools and undercut banks, providing a variety of habitats for aquatic plants and animals. Large accumulations can cause upstream backwater areas of lower velocity and greater water depth. Wood can alter the type and dimensions of bedforms present along a channel.
Promotes hyporheic exchange	Wood can generate diverse hydraulic gradients within channels and between channels and groundwater, driving hyporheic exchange. This can have positive effects on water temperature moderation and reduction in contaminant concentrations. Hyporheic zones also provide habitat for a variety of macroinvertebrates.
Creates locally variable flow velocities	Reduction in flow velocity helps retain fine and coarse particulate organic matter that is a fundamental energy source in many ecosystems. Slow as well as fast water velocities created by wood provide a variety of habitats for fish and macroinvertebrates.
Stabilises waterway beds and banks	Natural loadings and distribution of large wood along a reach help decrease erosion of waterway banks and scouring of the bed by resisting and deflecting flows.
Provides fish habitat	In general, a greater variety of fish occur in waterways with large wood. The range of hydraulic habitat that large wood provides satisfies fish requirements during different stages of their life cycle and at different times of year. Wood provides shelter from high velocity flows, shade, feeding and spawning sites, nurseries for larvae and juvenile fish, territory markers for migratory fish, and refuges from predation. In lowland waterways, large wood provides important foraging sites for predators as well as hard substrates for invertebrates to colonise. Fish select locations near large wood and other structures that provide refuges from high velocities and overhead cover from competitors and predators.
Supports invertebrate life cycle	Large wood creates pools or backwaters that are preferred by some species and also hard substrate for growth of waterway algae and subsequent colonisation by invertebrates. Large wood is a hotspot for invertebrate biomass, production and diversity, with higher annual biomass generally found on wood habitats than in streambed sediments. Aquatic invertebrates that have a terrestrial adult stage use large wood that protrudes out of the water to emerge from their aquatic larval stage.
Improves water quality	Large wood oxygenates the water flowing over it during low flows.
Provides perches	Birds, reptiles (e.g. turtles and lizards) and mammals (e.g. water rats) use protruding large wood as resting, foraging and lookout sites.

slows floods, and therefore reduces the height of the downstream flood peak (Anderson 2005a; Anderson et al. 2005; Anderson et al. 2006; Dixon 2013; Dixon et al. 2015).

A rule of thumb for the effect of large wood on flood levels is that wood must block more than about 10% of the flow's cross-sectional area to produce an increase in water level large enough to be detectable in the field. This is more critical, however, where the wood lies in channels that are narrow and/or shallow). Large wood in deep pools has been found to have very little impact on water levels, causing insignificant afflux.

Large wood and bank erosion

Large wood along one bank projecting into the channel can deflect flow toward the opposite bank and may sometimes result in erosion (Rutherfurd et al. 2002; Wohl et al. 2016). In large waterways where bank materials are well consolidated with good vegetation cover, large wood has less of an erosive effect (Rutherfurd et al. 2002). Bank erosion is a natural process in alluvial waterways and does not necessarily warrant intervention (Brooks et al. 2006).

By the time erosion around a fallen tree is noticeable, there is a good chance the bank erosion from the wood is almost complete. This means that if the same-sized flood occurred on a given waterway twice in a row, the second flood would cause much less erosion around the same piece of wood than the first (Treadwell et al. 2007).

When considering the influence of wood on channel erosion, keep the following general rules in mind (Treadwell et al. 2007).

- Not all erosion is bad. Scour of the bed and undercutting of the banks are essential for producing the 'hydraulic diversity' required for habitat in a healthy waterway. Natural waterways are lined with undercut banks.
- As a rough guide, erosion around an obstruction will usually remove an amount of material equivalent to no more than one or two times the projected area of the obstruction.
- It is likely that at low flows a log will deflect flows in a different direction to that at high flows.
- The common perception that a log orientated with its tip pointing upstream will cause more scour on the adjacent bank is seldom true. In fact, at high flows it is likely that a log oriented upstream will deflect flow away from the adjacent bank. Scour of the adjacent bank is usually caused by mechanisms that are not strictly influenced by flow direction.

Large wood and infrastructure

Some (not all) large wood moves during floods. The bigger the flood, the more likely it is that large wood will move. Various studies have shown that large wood moves further and more frequently in larger waterways than smaller ones, and that smaller pieces of wood move farther than large pieces. The most mobile pieces of wood are shorter than the bankfull width.

Other characteristics that affect the movement of large wood include rootwads, piece diameter, burial depth, wood density and channel morphology. Rootwads inhibit movement by anchoring pieces to the bed or bank, and increasing drag. The diameter of the wood piece influences the depth of flow required to entrain and transport it; its density affects its buoyancy and, therefore, how easily the log is moved (Melbourne Water 2003; SKM 2009).

Large wood from Australian riparian areas are relatively immobile. Our streams tend to have a low average stream power, with high-density wood and many riparian trees having a complex branching structure that ensures they are easily anchored in position (Treadwell et al. 2007). Of particular importance for waterway management and allaying community fears is the finding that if at least 10% of large wood is buried, the piece becomes immobile in high flows (SKM 2009).

Channel morphology (form and structure) affects movement, as wood is often deposited in wide, sinuous reaches where channel curvature and alternate bar morphology promotes frequent contact between wood and channel margins (Melbourne Water 2003).

It is common for concerns to be raised about large wood racking on bridges, decks and piers during floods (see Figure 7), causing the structure or abutments to fail (Diehl 1997; Brooks et al. 2006; SKM 2009; Engineers Australia 2015). As wood begins to rack against a bridge, the cross-sectional area between the bridge abutments (or piers, if present), the bridge deck and stream bed is reduced, thus increasing the likelihood of further racking by smaller or similar material. Smaller material is unlikely to cause a full blockage of a structure without the presence of large pieces spanning the structure (Engineers Australia 2015). These situations are not unexpected, given that wood is a natural feature of our waterways, and bridge design accounts for wood loading.

Ruiz-Villanueva et al. (2014) reframed the issue by suggesting that by discarding the assumption that large wood is the problem, the approach could be redefined as the inability of bridges, to allow large wood to pass. This view was based on the assumption that most wood is stable most of the time, providing positive ecosystem benefits, and only hazardous to human infrastructure during short and infrequent high-flow events. In such cases several organisations would be involved in making the decision to remove or realign wood to protect a high value asset.

5.1.2 Management approaches for large wood

The following section provides a description of the key management approaches for managing large wood. There are several options for managing large wood in river channels, including trimming, realigning, anchoring and selective removal. The first three options should be explored before considering removal.

The VWMS states that large wood or native vegetation will not be removed from waterway channels unless it poses a serious risk to public safety or public infrastructure, e.g. large wood abutting bridges and other infrastructure after

Figure 7. Large wood trapped against a bridge on Sutherland Creek. *Source: Corangamite CMA*

floods. Where feasible, large woody habitat is to be realigned or anchored rather than removed. The management of large wood and native vegetation in waterways to reduce flood risk is to be in accordance with the Victorian Government's response to recommendations of the Environment and Natural Resources Committee inquiry into flood mitigation infrastructure in Victoria. Where programs to reinstate instream large wood or vegetation are planned, the benefits and risks are to be assessed in consultation with the community (VWMS Policy 11.3).

The VWMS notes that there may be instances where the removal of instream large wood or vegetation is warranted to maintain the social or economic values of a waterway, reduce an immediate threat to public infrastructure or reduce public risk. In such cases, waterway managers need to balance the benefits to habitat against the level of risk – cognisant of statutory requirements for its protection.

Further detailed information on methods to assess the impacts of wood and risks associated with large wood management projects are provided in Appendix D – Large wood methods.

Trimming and realigning wood

Trimming generally involves taking off a major branch that is directing flow into a bank or removing the uppermost limbs that are thought to affect flow when levels have risen during a flood peak. Lopping branches near the water surface can help prevent the trapping of smaller pieces that eventually form large accumulations (Rutherfurd et al. 2002). Where it is necessary to trim off a branch that is directing flow into an asset on a bank or remove an accumulation of smaller items that have become trapped on a bridge, culvert or other infrastructure, consider storing or relocating them for future habitat elsewhere (Rutherfurd et al. 2002).

The realignment of large wood has been found to be detrimental to many native fish species, particularly Freshwater Blackfish. They require log jams or deep holes under logs, which tend not to form if the log is realigned to the bank. From an ecological perspective, it is recommended that large wood is left undisturbed (Melbourne Water 2003). 'Let sleeping logs lie' is good advice to those who want to see wood moved.

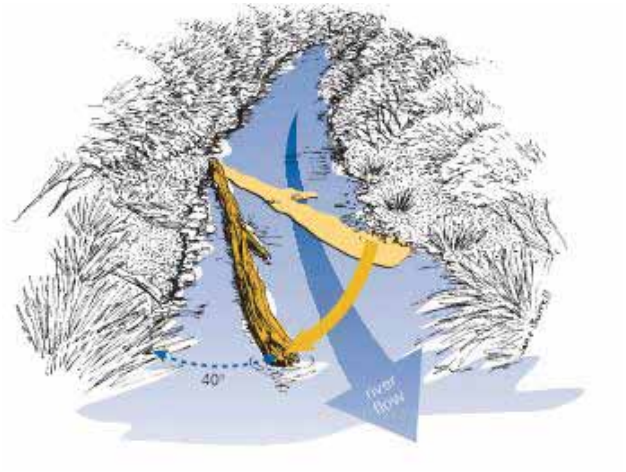

Figure 8: Realignment of large wood to reduce hydraulic effect. *Source: Rutherfurd et. al. 2002*

If large wood is to be realigned, consider the following principles:

- Large wood is often naturally angled at 20-30° to the flow, and this is the angle where it is most hydraulically efficient (Gippel et al. 1996b). Where large wood spans the entire channel, rotating large trunks from perpendicular to the flow to an angle of 20-40o to the waterway bank (see Figure 8) can improve the hydraulics of flows (Rutherfurd et al. 2002).
- To maximise both the hydraulic efficiency and the area of zero or near-zero velocity zones, large wood pieces should be two to four diameters apart from each other. Large wood clumped close together and in-line is more hydraulically efficient than widely separated, isolated items of large wood placed close together across the channel (Gippel et al. 1996b).
- For hydraulic efficiency and stability, large wood should be placed in zones of low velocity along the channel margins or on the inside of meanders (Gippel et al. 1996b).

Anchoring wood

Partial burial of a log and fixing of logs together to form structures may be an effective option where there is concern about the movement of instream wood (natural or reinstated).

Pinning logs in place with hardwood piles is essential in high energy environments to allow the timber to become saturated and/or collect sufficient sediment ('bond with the bed') and so prevent them becoming re-mobilised. Partial burial is not sufficient alone as the weakness within the bed will allow the large wood to be readily gouged out by high flows.

Removal of wood

Current best management practice is to remove large wood from a waterway only where a valuable asset is threatened by erosion or water levels associated with peak flows, or where safety is a consideration for recreational users. Realignment rather than removal is recommended, with the caveats mentioned above (Rutherfurd et al. 2002).

In some circumstances, it may be appropriate to move large wood near bridges to other areas. It may also be possible to improve the stability of the wood and limit the likelihood of it moving. Anchoring can be achieved by excavating and partly burying the large wood, or logs can be bound to boulders or trees with stainless steel wire cable. Trees felled into the waterway from the riparian land can be cabled to their stumps (Melbourne Water 2003).

A general principle is that the onus in making a case to remove large wood must lie with those wanting to make the change. If reduced local water levels and flood duration is the primary rationale for large wood removal, the case should be supported by a hydraulic analysis and evidence provided as to why action needs to be taken (Rutherfurd et al. 2002).

5.2 Instream vegetation

Instream vegetation grows within the water and along the lower banks of waterways. Some species float on the water surface, some live completely under water, others may be anchored to beds and banks and emerge from the water (emergent vegetation). Under natural conditions, instream vegetation is often restricted to the edges of waterways or scattered in isolated moist patches. Where it occurs depends on its ability to cope with drying out, flooding, shade, light, water temperature, water velocity, water quality and soil characteristics.

Native instream vegetation acts as a filter to intercept water and nutrient-bearing sediments, and remove pollutants from the water. Root systems also stabilise waterways by protecting beds and banks from erosion (DEPI 2013). It provides important food, shelter and nest sites for many terrestrial and aquatic species, and a corridor for wildlife moving between areas.

The presence and distribution of instream vegetation is closely linked to the quality of the riparian vegetation. Riparian areas create a micro-climate along the waterway, with vegetation shading the waterway, and reducing temperatures and evaporation (see Figure 9). This is important as low water temperatures can help prevent excessive growth of instream vegetation, algae blooms and the spread of invasive exotic species.

The distribution of instream vegetation along waterways is affected by broader changes to the landscape and flow management. Higher light and water temperature levels associated with removal of riparian vegetation can lead to excessive growth of macrophytes and algae in waterways, causing major changes in aquatic habitats and water quality problems (Bunn and Davies 2007). Flow regulation often reduces the magnitude and frequency of high flows, while prolonging the duration of low flows. This creates more favourable conditions for growth and expansion of emergent and submergent vegetation. Catchment clearing has increased the supply of sediments to waterways, creating shallow water flow conditions favourable for instream vegetation. Irrigation water drainage and seepage into waterways also contributes to the expansion of instream vegetation.

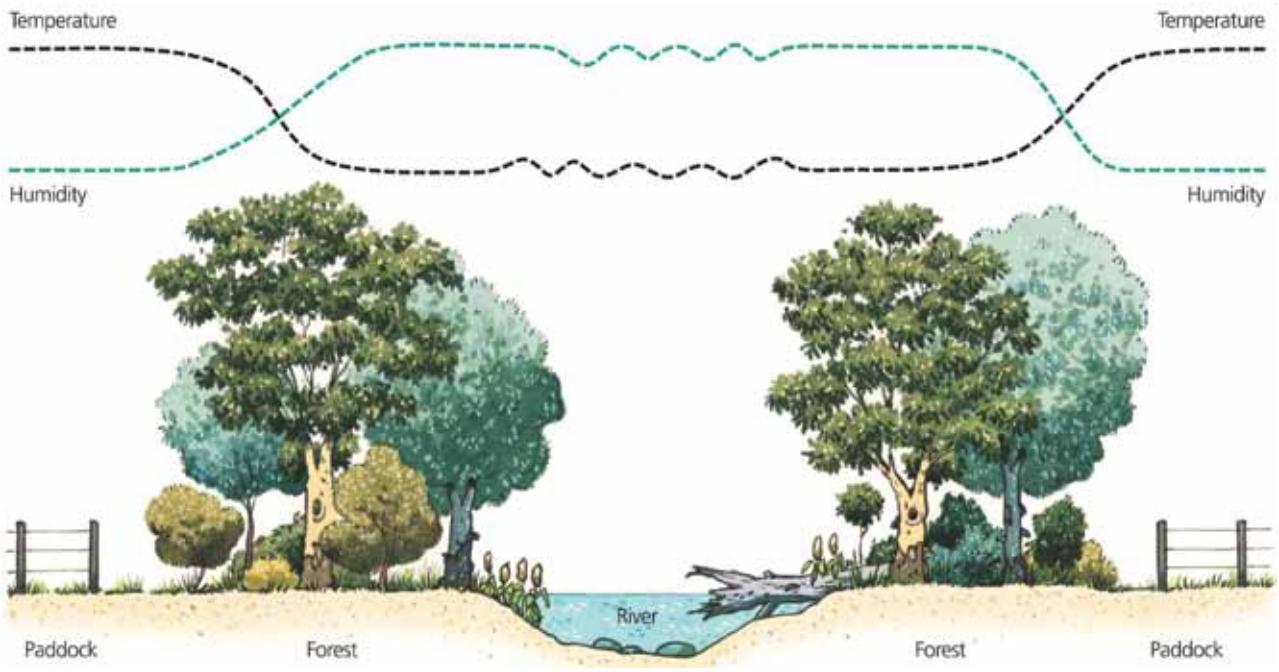

Figure 9: Riparian vegetation has a moderating effect on microclimatic parameters such as air temperature and humidity. *Source: Malanson in Lovett and Price 2007*

5.2.1 Flood risk issues associated with instream vegetation

Emergent instream vegetation and flood risk

Instream vegetation is often a cause for community concern. Where reeds have expanded across the channel, they can look like they are blocking the channel and so are perceived to be a flood risk. During low flows, the resistance of the reeds does slow water velocities, but once flows reach roughly a quarter of the height of the reeds, their resistance is significantly reduced as they are bent by the flow. During high flows, reeds actually provide lower resistance in the channel than woody vegetation, as they are swept over by the flow and lie flat on the bed.

Similarly, willows can spread their roots into the bed of a waterway. However, unlike reeds, willows are woody vegetation that can block channels, slow the flow of water and increase flood levels, or divert floodwaters if thickets are dense enough.

There is also concern that instream vegetation collects sediment, reducing the capacity of river channels to hold floodwaters. In some streams, the flow of water has been reduced because of pumping, diversions or regulation to supply water for irrigation and other purposes. The change in flow and land use has often resulted in more sediment entering waterways and reduced movement of sediment through streams. This can result in more favourable conditions for instream vegetation growth and further sediment deposition.

Rutherfurd et al. (2007) provide some rules of thumb for the effect of vegetation on flood levels:

- If vegetation does not block more than 10% of the cross-sectional area, it will probably have little effect on the flood stage. This is why vegetation has more effect on small waterways than large ones.
- Vegetation in the bed has more influence on flow than vegetation on the top of the bank.
- If the vegetation lies down during a flood, it probably has little effect on the flood stage.

Instream vegetation and drainage concerns

Management of waterways to maintain drainage in the landscape is a contentious issue. Drains (man-made) are different from waterways (naturally formed). Cumbungi and phragmites (and other emergent species) will often grow in drains and waterways and potentially provide instream health values. There can be competing management objectives to protect and maintain a waterway for its

waterway health values, or to manage the waterway as a drain as part of a broader rural drainage strategy.

A range of factors will influence drainage at a site (valley geometry, hydrology, constrictions, backwater influences from structures, levees, vegetation, etc). When all these factors are considered together, emergent vegetation is likely to have only a small influence on drainage. Emergent vegetation exists as a result of landscape and waterway characteristics that favour their establishment. Removing emergent vegetation from a waterway to improve drainage is unlikely to be an effective strategy.

The Victorian Government has developed a rural drainage strategy that provides strategic guidance for matters relating to rural drainage (DELWP 2018). This strategy retains the existing statutory requirements when considering the effects of dryland rural drainage on the environment. This includes the requirement to obtain approval from a CMA to undertake works on a waterway. There are some exceptions to this, including where a drain is not identified as a designated waterway. The role of DELWP is also retained as a referral agency to provide advice on planning permit applications that involves the removal of native vegetation.

5.2.2 Management approaches for instream vegetation

Removal of native instream vegetation

In Victoria, planning approval is usually required to remove, destroy or lop native vegetation. The permitting is governed by the native vegetation removal regulations that are implemented through local planning schemes administered by local government. If a landholder plans to remove native vegetation their first contact is local council, which can help them understand the requirements involved.

The removal of native instream vegetation from waterways is generally not recommended as it is detrimental to waterway health. The VWMS states that large wood or native vegetation will not be removed from waterway channels unless it poses a serious risk to public safety or public infrastructure. The VWMS notes that there may be instances where the removal of instream large wood or vegetation is warranted to maintain the social or economic values of a waterway, reduce an immediate threat to public infrastructure or reduce public risk. In such cases, waterway managers need to balance the benefits to habitat against the level of risk – cognisant of statutory requirements for its protection.

Where there is a proposal to modify the extent, coverage or composition of instream vegetation on a large/significant reach of waterway, the benefits and dis-benefits must be assessed. Typically, this will require, as a minimum, hydraulic modelling to investigate the pre-works and proposed post-works condition, with the change in vegetation condition represented by a change in hydraulic roughness within the model. Additional assessment in relation to the potential geomorphic impacts of vegetation removal may be required, depending on the waterway characteristics.

Partial removal of instream vegetation should only be considered where the vegetation is limiting recreational access to a waterway. It is recommended that areas at the margins of the channel are left intact to provide ecological habitat and protect the banks from erosion.

Irrigation and drainage channels are a special case. They are managed for a specific purpose: the delivery and drainage of water. Partial or complete removal of emergent vegetation from irrigation and drainage channels may be acceptable as part of a broader rural drainage strategy, noting that a permit will still be required as with any instream native vegetation removal.

Removal of exotic instream vegetation

Removal of exotic vegetation from waterways can improve the structure, diversity and extent of native vegetation and natural habitats. Waterways are particularly prone to weed infestations spread by water and stock. Unless properly managed, high-risk agricultural and environmental weeds (such as willows, bridal creeper and blackberry) will progressively transform and degrade waterways, spreading to contaminate downstream and neighbouring land.

The deliberate planting of exotic species (including ash, elm, poplar and particularly willows) for erosion control and aesthetic purposes has further degraded riparian environments. Planting exotic species on riparian land has been actively discouraged for the past decade, and activities to contain or remove weed infestations will continue through regional waterway management programs.

Most willow species are recognised as one of the worst riparian weeds in temperate Australia and are listed as a Weed of National Significance. Willows have invaded thousands of kilometres of riparian environments in south-eastern Australia. Within Victoria, most species of willows were declared as 'restricted' noxious weeds in 2005, meaning they

Figure 10: Removing willows along a creek. *Source: Milly Hobson*

cannot be bought or sold within Victoria. There is no legal obligation on landholders to manage willows on their properties.

Willow removal and replacement with indigenous vegetation is now a major waterway management activity in many areas of Victoria (see Figures 10 and 11). The highest priority for willow management is the control of seeding willows. The control of infestations of crack willow (a sterile species spread by vegetative propagation) is of lower priority. In the short term, willow removal can be aesthetically unattractive, but the downside is outweighed by the long-term benefits of re-establishing native vegetation along Victoria's waterways.

Sometimes, removing exotic vegetation can leave a channel vulnerable to rapid adjustment (see Figure 11). In these instances, works should be immediately followed by native revegetation. Where extensive works are planned, a staged approach might be considered so that long sections of bank are not left unprotected for long periods.

Figure 11: Willow removal on the Mitchell River. After removal, the site was fenced to prevent stock access and revegetated with indigenous plants. *Source: East Gippsland CMA*

5.3 Riparian vegetation

Waterway health depends on the condition of vegetation on riparian land (DEPI 2013). Trees on riparian land provide a supply of organic matter to waterways, including large wood, which supports aquatic invertebrates and nutrient cycling (Treadwell et al. 2007).

Vegetation on riparian land improves water quality in waterways. It filters sediments, nutrients and pathogens from overland flow entering the waterway (see Figure 12). This protects public water supplies, improves water quality for fishing and recreation, and helps reduce bars downstream (DEPI 2013). Shade from riparian vegetation also helps regulate water temperature, which can be important to native fish species, and helps reduce the likelihood of algal blooms (Davies et al. 2007). Riparian land is also important for the storage of carbon (Bunn and Davies 2007).

Riparian vegetation helps stabilise waterway banks and reduce erosion (Abernethy and Rutherfurd 1998a, 1999, 2000; Rutherfurd 2007). High-quality native riparian vegetation in or near natural waterways or established through revegetation programs such as those undertaken in Victoria over the past 10–20 years, reduces the occurrence and scale of flood-related channel change (Alluvium 2011). Channel change has led to nearly $80 million of direct repair costs over 20 years and much larger costs to repair damaged assets such as bridges and roads (DEPI 2013).

5.3.1 Flood risk issues associated with riparian vegetation

Riparian vegetation and flood risk

Public concerns about riparian vegetation and large wood blocking channels and slowing flood flows are common. Increasing flood heights have been used in the past to justify removing riparian vegetation and wood to reduce the perceived flood risks for adjoining land uses.

These works have often been carried out without:

- any investigation of the capacity of the channel (with or without wood)
- consideration of the impact of the works on upstream and downstream reaches
- cost-benefit analyses (Warner 1984; Zelman 1977).

In fact, the consequences of these practices are often the opposite of those intended. An example of this is the severity of flooding in the Ovens River around Wangaratta, Victoria, following riparian vegetation and large wood removal works that were designed to reduce flooding (Zelman 1977; Treadwell et al. 2007).

Vegetation can reduce flow velocities and influence the water depth. However, where active floodplains exist, the vast majority of flood flows are conveyed overland (the floodplain) and not in the waterway, so localised riparian vegetation and large wood will only have a minor to negligible influence on the depth and extent of major floods.

Research by Anderson (2005b) found that large wood and vegetation distributed throughout a waterway system, from headwaters to the outlet, attenuated flood peaks. Slight reductions in waterway system flow velocity that are associated with vegetation and large wood has a beneficial impact on downstream flood levels by slowing the pace and size of a flood peak. In contrast, past programs that sought to remove large wood and vegetation from waterway systems had a negligible impact on the depth and extent of major floods, and if undertaken through the entire length of a waterway system would increase the occurrence of floods in the downstream reaches.

It is common to find that during large floods any hydraulic effect of vegetation is drowned-out by downstream hydraulic controls, such as natural channel constrictions, road/rail embankments, bridges or culverts. Removing vegetation will have little effect on flood stage or duration. It is possible that removing vegetation could give people a false sense that they are protected from flooding.

Riparian vegetation and bank erosion

It is well acknowledged that riparian vegetation has an important role in decreasing erosion along waterways (see Figure 12). If riparian land is not well-vegetated with deep-rooted plants, bank erosion can accelerate. Replanting deep-rooted species on riparian land can help stabilise riverbanks and protect them in times of flood. Well-vegetated waterway banks are also more resistant to under-cutting and slumping.

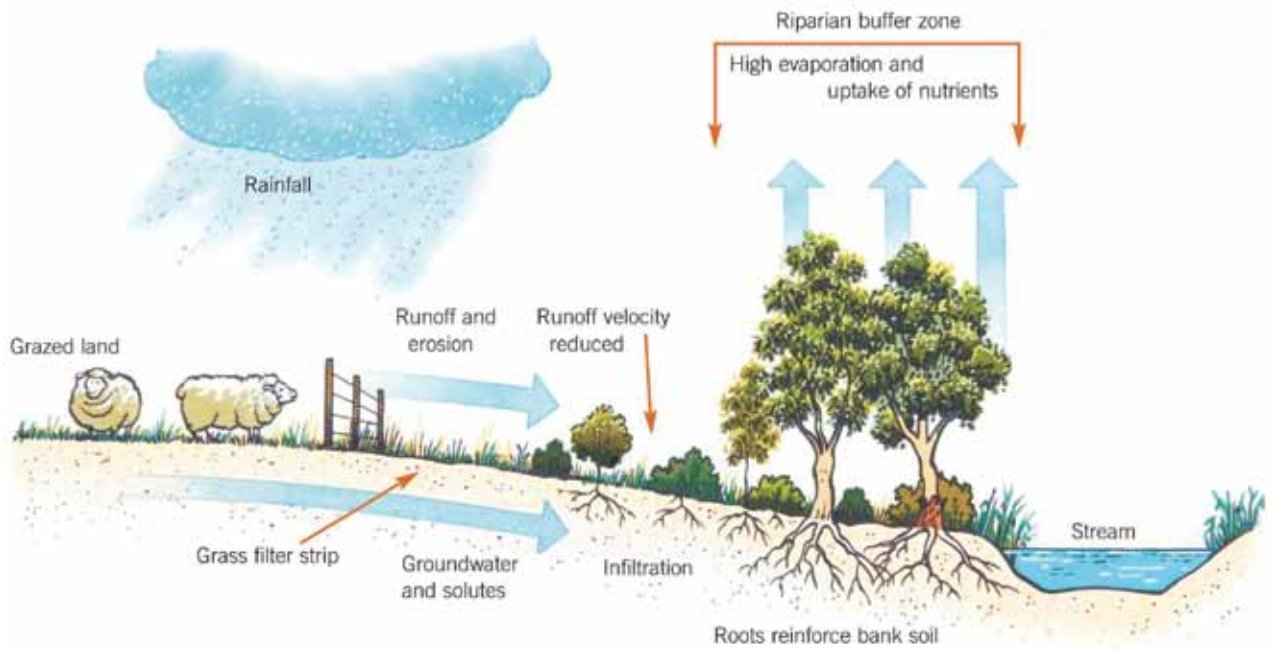

Figure 12: Filtering function provided by riparian land. *Source: Flanery, Price and Lovett, 2007*

A study by Alluvium (2011) on the impact of revegetation on waterway erosion during floods in Victoria found the absence of native riparian vegetation increases the occurrence and scale of flood-related channel change in waterways, and associated flood related recovery costs. This study found that to increase the resistance to flood-related change, riparian vegetation needs to be:

- structurally diverse
- of an appropriate width from the edge of the waterway bank to ensure it is ecologically and physically functional
- largely continuous along the waterway.

The study also found that, while native riparian vegetation corridors will increase the resistance and resilience to flood-related channel change, additional structural works for river bed and bank stabilisation may be required where there is significant public infrastructure near waterways.

Figure 13: Riparian replanting to mitigate erosion, part of the Glenelg River Restoration Program. *Source: Glenelg Hopkins CMA*

5.3.2 Management approaches for riparian vegetation

Removal of native vegetation

In Victoria, planning approval is usually required to remove, destroy or lop native vegetation. The permitting is governed by the native vegetation removal regulations that are implemented through local planning schemes administered by local government. If a landholder plans to remove native vegetation their first contact is local council which can help them understand the requirements involved.

The removal of riparian vegetation from waterways is generally not recommended as it is detrimental to waterway health.

Removal of native vegetation should only be considered where it forms part of a local waterway or floodplain management strategy. Removal of native vegetation may be justified:

- in response to large-scale flood mitigation activities, where it has been demonstrated through a flood study that removal of native vegetation will have benefits in terms of reduced average annual damage and that these benefits are greater than any costs to waterway health
- as part of ongoing maintenance works to protect the integrity of levees or other engineered structures (i.e. rock chute, flow regulator and bridges)
- as part of a broader waterway management strategy where the CMA is aiming to maintain the capacity of a reach, such as in the case of a developing anabranch.

Where there is a proposal to modify the extent, coverage or composition of riparian vegetation on a large/significant reach of waterway, the benefits and dis-benefits must be assessed. Typically, this will require, as a minimum, hydraulic modelling to investigate the pre-works and proposed post-works conditions, with the change in vegetation represented by a change in hydraulic roughness within the model. Additional assessment in relation to the potential geomorphic impacts of vegetation removal may also be required, depending on the characteristics of the waterway.

Removal of exotic vegetation

Weeds are a key threat to the condition of riparian land. Riparian land is particularly prone to weeds spread by water and from stock access. Unless properly managed, high-risk agricultural and environmental weeds (such as willows, bridal creeper and blackberry) will progressively degrade riparian land and spread downstream and into neighbouring farmland.

The deliberate planting of exotic species (including ash, elm, poplar and particularly willows) for erosion control and aesthetic purposes has led to degradation of riparian environments. Planting exotic species on riparian land has been actively discouraged for the last decade or more and activities to contain or remove weed infestations will continue to be implemented through regional waterway management programs.

Landholders are required to manage certain weeds (and pest animals) under the *Catchment and Land Protection Act 1994* for private riparian land and through licence conditions for Crown frontages.

A works on waterways permit is typically not required to remove riparian weeds. However, a permit may be required if the weed removal occurs on both the riparian land and on the slope of the bank of the waterway. For example, willows often occur on the banks of the waterway and on the riparian land. Their removal carries significant risks of transferring willow fragments downstream if not carried out appropriately. Therefore, willow removal will likely trigger the requirement for a works on waterways permit in most cases.

A permit may also be required, depending on the method of removal of the weeds. For example, large-scale weed removal with heavy machinery on riparian land may require a permit because the removal may also be affecting the bank of the waterway.

Spraying weeds on riparian land with approved herbicides would not require a permit.

Refer to section 5.2.2 for further specific discussion on the management of willows.

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Appendices

Appendix A – Model by-law

WATER ACT 1989

The ***[insert name]*** Catchment Management Authority makes the following by-law –

Dated

The Common Seal of the ***[insert name]*** Catchment Management authority was hereunto affixed in the presence of:

……. Chairman

……Member

……Chief Executive Officer

By-law No *[insert number]* Waterways Protection 2014
[insert name] Catchment Management Authority

Part 1 - PRELIMINARY

Title:

30. This by-law may be cited as by-law No. ***[insert number]*** Waterways Protection 2014.

Objectives:

31. The objectives of this by-law are to make provision for -

(d) the control, management and authorisation of works and activities in, under, on or over designated waterways and designated land or works;
(e) the protection and care of designated waterways and designated land or works;
(f) conservation and preservation of flora, fauna and habitat in designated waterways and designated land or works.

Authorising provisions:

32. This by-law is made under sections 160, 219 and 287ZC of the Act.

Application:

33. This by-law applies to the ***[name]*** Management District ***[if more than one waterway management district, add names of additional districts].***

Definitions:

34. In this by-law -

"Act" means the *Water Act 1989*.

"Authority" means the ***[insert name]*** Catchment Management Authority.

"Charge unit" is the unit of monetary value set by the Authority under section 160(4) of the Act for the purposes of calculating the value of fees set under a by-law.

"Designated land or works" means any land or any works or any part of any works which the Authority has declared to be designated land or works under section 188 of the Act.

"Designated waterway" means any waterway or any part of any waterway which the Authority has declared to be a designated waterway under section 188 of the Act.

"Emergency" has the same meaning as under section 4 of the **Emergency Management Act 1986**;

"Government agency" means –

(d) any body corporate or unincorporated constituted by or under any Act for a public purpose; and
(e) any member or officer of such a body; and
(f) any person in the services of the Crown in the right of the State of Victoria upon whom any function, power, duty or responsibility is conferred by or under any Act;

"Penalty unit" has the meaning provided for under section 110 of the **Sentencing Act 1991.**

Explanatory note: A penalty unit is a unit of monetary value that is used to calculate penalties for offences under legislation. The value of a penalty unit is set each year by the Treasurer under the Monetary Units Act 2004.

"Person" means an individual, a body or association (corporate or incorporated) or a partnership.

"Rubbish" includes any solid or liquid domestic or commercial waste refuse or debris and without limiting the generality of the above includes abandoned vehicles or vehicle parts, clippings and vegetation, concrete, stone and bricks and any part of an animal carcass.

"Water Corporation" has the same meaning as in section 3 of the Act.

"Waterway" has the same meaning as in section 3 of the Act.

"Works" has the same meaning as in section 3 of the Act.

Part 2 - WATERWAY PROTECTION

Prohibited works and activities

35. A person must not -

(d) deposit any rubbish in a designated waterway or on any designated land or works;
(e) erode or damage the surrounds of a designated waterway or any designated land or works; or
(f) cause or permit any designated waterway or any designated land or works to be polluted.

Penalty: 20 penalty units
Penalty for continuing offence: 5 additional penalty units for each day on which the offence continues.

36. A person must not do any of the following unless in accordance with a permit issued under this by-law -

(f) construct, alter, remove, obstruct or interfere with any structures or works in, under, on or over a designated waterway or any designated land or works; or
(g) construct or carry out any works that deviate or are likely to deviate a designated waterway.
(h) obstruct or interfere with a designated waterway or any designated land or works;
(i) cut down, interfere with or take any tree or other vegetation within or from a designated waterway or any designated land or works;
(j) interfere with or take any soil, earth, sand, gravel or other material within or from a designated waterway or designated land or works.

Penalty: 20 penalty units
Penalty for continuing offence: 5 additional penalty units for each day on which the offence continues.

Persons who do not require permits

37. Despite anything to the contrary in this by-law, the following persons do not require a permit –

(i) a person acting in the course of his or her duties as –

(iv) an officer, employee or contractor of the Authority;
(v) an authorised officer appointed in writing by the Authority for the purpose of this by-law;
(vi) a member of the Police force;

(j) any of the following bodies, or officer within such body, taking action that is required to respond to or prepare for an emergency –

(vi) the Country Fire Authority established under the **Country Fire Authority Act 1958**;
(vii) the Metropolitan Fire and Emergency Services Board established under the **Metropolitan Fire Brigades Act 1958**;
(viii) the Victoria State Emergency Service Authority established under the **Victoria State Emergency Service Act 2005**;
(ix) local council, water corporation or other government agency;
(x) telecommunications, gas, electricity or other utility.

(k) a person undertaking works, other than a deviation of a waterway, associated with –

(iv) a licence to take and use water from a designated waterway issued under Division 2 of Part 4 of the Act;
(v) a right to water from a designated waterway under section 8(1) of Division 1 of Part 2 of the Act;
(vi) a dam or weir situated on a designated waterway, a licence for which has been issued under Division 2 of Part 5 of the Act;

(l) a telecommunications, gas, electricity or other utility company constructing a pipeline or underground cable that crosses a designated waterway;
(m) a water corporation constructing water supply, sewerage or irrigation works in, under, on or over a designated waterway;
(n) a local council constructing a public bridge or access crossing on a designated waterway;
(o) a person authorised under an Act to undertake the works or activities, in relation to the relevant designated waterway, land or works, that would otherwise be prohibited under clause 7;
(p) a person undertaking routine maintenance of existing previously authorised works or works under paragraphs (d), (e), (f) or (g) being low impact, minor, maintenance of such works, including but not limited to re-planting, vegetation clearing, cleaning, or minor structural repairs.

Requirements applicable to person who does not require a permit

38. A person who does not require a permit due to the operation of clause 8(d), (e), (f), (g) or (h) in undertaking works of the kind described in those clauses, must –

(d) do so in accordance with any guidelines issued by the Authority;
(e) submit a works proposal to the Authority prior to commencing the works;
(f) notify the Authority when commencing the works.

Penalty: 20 penalty units
Penalty for continuing offence: 5 additional penalty units for each day on which the offence continues.

Permits

39. For the purposes of clause 7 of this by-law a person may apply to the Authority for a permit.

40. After assessing the application and the risk of degradation to the designated waterway or its surrounds, the Authority may issue or refuse to issue a permit.

41. On making decision to issue or refuse to issue a permit, the Authority must –

(c) in the case of a permit being issued, advise the applicant of that approval and any conditions that apply to the permit; or
(d) in the case of a permit being refused, advise the applicant of that refusal.

42. Where a permit is issued under this by-law, the holder of the permit must act in accordance with –

(c) conditions (if any) determined by the Authority as being applicable to the permit; and
(d) guidelines issued by the Authority.

Part 3 – PROCEDURAL REQUIREMENTS APPLYING TO PERMITS

Application for a permit

43. An application for a permit shall be -

(c) in the form (if any) approved from time to time by the Authority; and
(d) accompanied by -

(i) the relevant fee as determined under Part 4 of this by-law; and
(ii) such plans, specifications or other documents necessary for the Authority to determine the application to grant the permit.

44. A person applying for a permit may request the Authority to issue a single permit for multiple similar or related works or activities.

45. If required to do so by the Authority a person applying for a permit must –

(c) supply such additional information, plans, specifications or other documentation that the Authority considers necessary to determine the application; and
(d) give public notice of the application or give notice of the application to such persons the Authority considers may be affected by the application, at such times and in such manner as determined by the Authority.

Amendment or transfer of a permit

46. The holder of a permit issued under this by-law may apply to the Authority to –

(d) amend the permit (with or without conditions);
(e) renew the permit; or
(f) transfer the permit.

Notification of commencement and completion of works or activities

47. Any person, who carries out any works or activities for which a permit has been issued by the Authority must –

(c) notify the Authority at least seven days before commencing the works or activities; and
(d) notify the Authority upon completion of the works or activities.

Validity of permit

48. Unless otherwise stated in the permit, a permit issued under this by-law is valid for one year from its date of issue unless earlier revoked by the Authority.

49. The Authority may renew a permit for a period of up to 12 months with additional or varied conditions as necessary.

Revocation of permit

50. The Authority may revoke a permit if in the opinion of the Authority there has been a failure to comply with this by-law or the permit or its conditions, provided –

(d) a notice of contravention has been provided to the permit holder; and
(e) there has been a failure to comply with the notice of contravention; and

(f) the failure to comply continues for a period of 7 days or any longer period allowed by the Authority, after the date specified in the notice.

Application of other requirements

51. A permit issued under this by-law does not remove the requirement for the person to whom the permit has been issued to apply for any authorisation or permission necessary under any other Act with respect to anything authorised by the permit.

Part 4 - FEES AND CHARGES

Fees

52. The fee payable for an application for a permit is –

(c) a base fee of 1.5 charge units; and
(d) any additional amount as determined by the Authority in accordance with clause 25.

53. The fee payable for the amendment, renewal or transfer of a permit is 1 charge unit.

54. For the purposes of clause 23(b) –

(c) the Authority shall estimate any additional time likely to be required to assess the application; and
(d) advise the applicant of the estimated additional cost of considering the permit application on the basis of an hourly charge of 1 charge unit.

55. Upon payment of the estimated additional hourly charges the Authority shall process the application.

56. Upon completion of processing the application the Authority shall -

(c) advise the applicant of the actual additional amount; and
(d) either refund to the applicant any amount paid in excess of the actual additional amount or advise the applicant of the further amount payable being the difference between the estimated additional hourly charges and the actual additional hourly charges.

Waiver or reduction of fees

57. The Authority may waive, reduce or alter any fee or charge with or without conditions.

Payment of fees

58. The Authority will not issue a permit until all required fees are paid.

Appendix B – Approvals and agency consultation

Table 4 provides a summary of approvals, relevant legislation and agencies that may need to be consulted in relation to approval for works on a waterway. The waterway manager is not required to ensure or enforce the applicant's compliance with these approvals. However, it is best practice for waterway managers to ensure applicants (and potential applicants) are aware of these requirements and to provide guidance where possible.

Table 4. Summary of approvals, relevant legislation and agencies that may need to be consulted in relation to works on a waterway (unless otherwise noted, all acts are Victorian).

Approval	Legislation	Comments
Work on waterways	*Water Act 1989*	This relates to a licence, permit or exemption issued by a CMA or Melbourne Water. Typically, they are for constructing a crossing or connecting a drain to a waterway. The CMA or Melbourne Water assesses the impact of works on the bed and banks (stability) of the waterway. They also consider aspects such as removal of vegetation and large wood, and the ecological health of the waterway such as fish passage and water quality. Permits are not always required where exemptions apply and for some low-risk situations. In such cases, guidelines are provided to help the landholder or agency deliver the works using best practice. Where a permit is required, an administration fee may apply.
Planning permits	*Planning and Environment Act 1987*	The *Planning and Environment Act 1987* provides for the preparation of planning schemes that are administered by local government. The planning objectives of a municipality (and for Victoria) are implemented through the application of zones, overlays and specific provisions. Planning schemes require planning permits to be issued to allow for certain types of land use or development, including, buildings, works and the removal of native vegetation. Applicants should be advised to check with the local council whether a planning permit is required for their proposed management action, particularly if it involves works that could affect flood behaviour.
Planning permit – native vegetation	*Planning and Environment Act 1987*	In Victoria, planning approval is usually required to remove, destroy or lop native vegetation. This includes a standing dead tree with a trunk diameter of 40 centimetres or more at a height of 1.3 metres above ground level. The permitting is governed by the native vegetation removal regulations which are implemented through local planning schemes administered by local government. If a landholder plans to remove native vegetation their first contact is local council which can help them understand the requirements involved. Information is also available at https://www.environment.vic.gov.au/native-vegetation/native-vegetation
Significant environmental effects	*Environment Effects Act 1978*	The *Environment Effects Act 1978* should be considered when proposed activities are capable of having a significant environmental effect. Such actions should be referred to the Victorian Minister for Planning, who decides if an Environmental Effects Statement (EES) is required. Contact the Impact Assessment Unit of DELWP for further information.

Approval	Legislation	Comments
Permits for wildlife, fish or flora and fauna	*Wildlife Act 1975* *Flora and Fauna Guarantee Act 1988* *Fisheries Act 1995* *Conservation Forests and Lands Act 1987*	A permit may be required for activities that could harm wildlife, fish or flora. *Flora and Fauna Guarantee Act 1988* Action Statement 194 'Removal of woody debris from Victorian rivers and streams' provides further information and guidance. A permit may also be required to take protected flora from public land. Contact DELWP for further information or to apply for a permit. The *Flora and Fauna Guarantee Act 1988* is administered by DELWP to conserve threatened species and communities and to manage potentially threatening processes. Critical habitat of flora and fauna listed under the Act can be subject to an order specifying measures for its conservation, protection or management and will need a permit under the Act for removal. Importantly, the removal of large wood from waterways is listed as a threatening process under the Act (see *Flora and Fauna Guarantee Act 1988* Action Statement 194). Applicants proposing work that might impact on species or communities listed in the Act need to consult with DELWP.
Prohibition of certain works and activities	*Heritage Rivers Act 1992*	Certain activities may be prohibited near heritage rivers. Contact DELWP for further information on details of banned activities and the obligations on land managers to manage heritage rivers to achieve particular outcomes.
Matters of national environmental significance	*Environment Protection Biodiversity and Conservation Act 1999 (Cth)*	If an action may have significant impact on matters of National Environmental Significance (NES) it must be referred to the Commonwealth Department of Environment (DoE). DoE approval will be required if it decides it is a 'controlled action'. Contact DoE for further information, including guidelines for matters of national environmental significance and details of the approvals process. The *Commonwealth Environment Protection and Biodiversity Conservation Act 1999* provides a legal framework to protect and manage nationally and internationally important flora, fauna, ecological communities and heritage places. The Act is administered by the Department of Environment (DoE). Before undertaking a management action, applicants need to determine whether an action may have significant impact on matters of national environmental significance. These matters include species listed under the Act. A referral to the relevant authority for further guidance must be made for actions that are likely to have a significant impact on the following matters protected by Part 3 of the Act: • National Heritage places (sections 15B and 15C) • wetlands of international importance (sections 16 and 17B) • listed threatened species and communities (sections 18 and 18a) • listed migratory species (sections 20 and 20a) • a water resource, in relation to coal seam gas development and large coal mining development (sections 24D and 24E) • the environment, if the action involves Commonwealth land (sections 26 and 27A). A referral may still be made if it is believed the action will not have a significant impact or if it is not clear. The policy statement Significant Impact Guidelines 1.1 – Matters of National Environmental Significance provides guidance on Commonwealth assessment requirements. If matters of national environmental significance are likely to be impacted, proposed actions should be referred to the DoE for a determination as to whether the matter is a 'controlled action' and require DoE approval.

Approval	Legislation	Comments
Aboriginal heritage	*Aboriginal Heritage Act 2006*	Many sites of cultural importance for Traditional Owners are on, or close to, waterways. Traditional Owners are the custodians of their cultural heritage, and the rightful decision makers for cultural heritage management. The *Aboriginal Heritage Act 2006* established cultural heritage management plans and cultural heritage permit processes to manage activities that may harm aboriginal cultural heritage. It also established the Victorian Aboriginal Heritage Council and Registered Aboriginal Parties to ensure that Traditional Owners throughout Victoria play a central role in the protection and management of their heritage. Waterway managers and applicants for works on waterways are required to consider Aboriginal cultural heritage values and how they may be impacted by any proposed works. A Cultural Heritage Management Plan (CHMP) is written by a cultural heritage adviser to document the potential impact of the proposed activity on Aboriginal cultural heritage. It outlines measures to be taken before, during and after the activity to manage and protect Aboriginal cultural heritage in the activity area. Applicants should refer to the online reference tool (http://www.dpc.vic.gov.au/index.php/aboriginal-affairs/heritage-tools/25-aboriginal-affairs/452-aboriginal-heritage-planning-tool) to determine whether a cultural heritage management plan is required for the works. A CHMP must be approved by the relevant Registered Aboriginal Party. Where no registered Aboriginal party exists, the Secretary of the Department of Premier and Cabinet, on the advice of the Office of Aboriginal Affairs Victoria, may approve the plan. If the proposed management works would result in significant ground disturbance preparation of a CHMP may be required. The regulations under the Act state that a "waterway or land within 200m of a waterway is an area of cultural heritage sensitivity". If required, a CHMP will be prepared in consultation with and assessed by the Registered Aboriginal Party (RAP) for the area. If no RAP has been established the CHMP will be assessed by Aboriginal Affairs Victoria. Contact the relevant RAP or Aboriginal Affairs Victoria for further information. Further information about Aboriginal cultural heritage requirements can be found here.
Protection of catchments and pest plant and animal control	*Catchment and Land Protection Act 1994*	The *Catchment and Land Protection Act 1994* defines requirements to: • avoid land degradation • conserve soil • protect water resources • eradicate and prevent the spread and establishment of noxious weed and pest animal species. Contact the relevant CMA or the Department of Jobs, Precincts and Regions for further information.
Heritage places or objects	*Heritage Act 1995*	If the proposed activity requires excavation or involves works to registered trees and gardens, a permit may be required. Contact Heritage Victoria for further information.
Native title	*Native Title Act 1993 (Cth)* *Land Titles Validation Act 1994* *Traditional Owner Settlement Act 2010*	Native title rights will need to be considered and an agreement may need to be entered into with any person holding native title over the land upon which the works are proposed to be carried out. Contact the Department of Justice and Community Safety for further information.

Approval	Legislation	Comments
Consent for works on Crown land	*Land Act 1958* *Crown Land Reserves Act 1978* *Forests Act 1958* *National Parks Act 1975* *Coastal Management Act 1995*	Consent may be required to carry out works or activities on Crown land. Most beds and banks of Victorian waterways and nearly 30,000 kilometres of riparian land are Crown land. The type of consent depends on the status of the relevant Crown land. **Unreserved Crown land:** a licence or lease under the Land Act (if appropriate) or a formal agreement with the land manager if the works are to be carried out on behalf of the land manager. **Reserved Crown land:** a licence or lease under the Crown Land (Reserves) Act (if appropriate) or a formal agreement with the land manager if the works are to be carried out on behalf of the land manager. **State forest, national parks, state parks, nature reserves:** The Forests Act (lease/licence/section 52 permit/agreement providing works are on behalf of land manager)/National Parks Act (licence/lease/section 23 approval/section 21 permit/agreement providing works are on behalf of land manager, as appropriate)/ Wildlife Act (agreement providing works are on behalf of land manager). **Coastal Crown land:** consent under the Coastal Management Act. Contact DELWP for further information on the status of Crown land, and the appropriate agency or committee of management (e.g. DELWP, local government or Parks Victoria, etc) from which approval may be required for the subject works.
Marine safety (navigational responsibilities)	*Marine Safety Act 2010*	Transport Safety Victoria (TSV) is the waterway manager for a number of Victoria's waterways. TSV also has oversight for waterways in Victoria that do not have a waterway manager and where special rules have not been introduced to regulate vessel activity. Waterway managers are declared by the responsible Minister (Minister of Ports) and are responsible for the safety of boating activity on waterways under their control. Waterway managers oversee: • management of vessel activities on waters under their control • allocation and management of moorings and berths • provision and maintenance of navigation aids, appropriate signage of water levels, hazards, and rules applying to the waters • control of navigation and vessel movement • designation of areas in which anchorage of vessels is or is not permitted • altering or dredging of channels for navigation • removal or marking of obstructions. Contact Transport Safety Victoria or the relevant declared waterway manager for further information.

Appendix C – Key references for large wood and vegetation management

Large wood

General principles

Technical guidelines for waterway management – Department of Sustainability and Environment, 2007

Principles for riparian lands management – Lovett, S. and Price, P. 2007.

Management of large wood

Standard work procedure: large woody debris management – Melbourne Water, 2003

Managing woody debris in rivers – Rutherfurd, I., N. Marsh, P. Price and S. Lovett 2002

Australian rainfall and runoff: Blockage guidelines for culverts and small bridges – Engineers Australia 2015

Reintroduction of large wood

Design guidelines for the reintroduction of wood into Australian streams – Brooks, A., T. Abbe, S. Mika, A. Boulten, T. Broderick, D. Borg and I. Rutherfurd, 2006

Managing woody debris in rivers – Rutherfurd, I., N. Marsh, P. Price and S. Lovett 2002

Management of large woody debris – Gippel, C. J. and K. White 2000

Methods of assessment of the impacts of large wood and risks

Hydraulic guidelines for the re-introduction and management of large woody debris in lowland rivers – Gippel, C. J., I. C. O'Neill, B. L. Finlayson and I. Schnatz, 1996

Large wood stability analysis tool – Raffety, M. 2013

Management of large wood in streams: an overview and proposed framework for hazard evaluation – Wohl, E., K. Bestgen, B. Bledsoe, K. Fausch, M. Goosef and N. Kramer, 2016

Investigation into risk of Large Wood reinstatement in the Glenelg River, SW Victoria – SKM, 2009

Instream vegetation

General principles

Technical guidelines for waterway management – Department of Sustainability and Environment, 2007

Principles for riparian lands management – Lovett, S. and Price, P. 2007

Flooding

On the impact of riparian vegetation on catchment scale flooding characteristics – Anderson, B. 2005

Fire

Riparian land and bushfire risk – Country Fire Authority, 2014

Stream erosion

Guidelines for stabilising streambanks with riparian vegetation – Abernethy, B. and Rutherfurd, I. 1999

Riparian vegetation

General principles

Technical guidelines for waterway management – Department of Sustainability and Environment, 2007

Principles for riparian lands management – Lovett, S. and Price, P. 2007.

Riparian widths

Minimum width requirements for riparian zones to protect flowing waters and to conserve biodiversity: a review and recommendations – Hansen, B., Reich, P., Lake, S. and Cavagnaro, T. 2010.

Flooding

On the impact of riparian vegetation on catchment scale flooding characteristics – Anderson, B. 2005

Willows

Managing willows in Victoria – DELWP 2016. https://www.water.vic.gov.au/__data/assets/pdf_file/0028/52678/DELWP-willows-fact-sheet-FINAL-October-2016.pdf

Weeds of National Significance Website – www.weeds.org.au/WoNS/willows

Controlling willows along Australian rivers, River and Riparian Technical Guidelines, No 6, Land & Water Australia (www.arrc.com.au/managingrivers)

Stream erosion

Guidelines for stabilising streambanks with riparian vegetation – Abernethy, B. and Rutherfurd, I. 1999

An assessment of the impact of riparian vegetation on stream erosion during floods in Victoria – Alluvium 2011.

Appendix D – Large wood methods

Methods of assessment of impacts of wood

Assessing the impacts of large wood depends on the nature of the problem. Single items of large wood would be assessed differently from many items in a waterway reach. The basic aspects that need to be considered are measuring the wood, assessing its stability, hydraulic impact, and possibly its hydrological and ecological impacts. The main findings of the literature are summarised in Table 5.

Assessment	Potential approaches
Measuring large wood	Fallen trees are irregular-shaped objects, which makes absolute measurement difficult. Various approaches are described in the literature, ranging from counting the numbers of items of wood, statistically sampling across waterway transects, or conducting a census of the geometry and location of each item in a channel reach (Gippel et al. 1996a). In general, local-scale or individual site issues will involve measuring the dimension of the large wood, while reach-scale issues are more likely to involve sampling or a census of items of wood, with basic measurements of diameter and length. Aerial photography assists this procedure, provided the channel and large wood are visible.
Rules of thumb for hydraulic assessment	Under most lowland river situations, wood must block more than about 10% of the flow cross-sectional area to produce an afflux large enough to be detectable in the field (Gippel et al. 1996a). This is more critical where the wood of interest lies at a point of morphological hydraulic control (i.e. narrow and/or shallow section). Large wood in deep pools contributes insignificant afflux. Samuels (1989) outlines a rule of thumb to calculate the length of channel affected by a backwater. The equation is 0.7 D/s, where 'D' is the bankfull depth and 's' is the average slope of the river bed. This equation could provide an upper limit to the length of waterway where water levels may be affected by clearing of wood. If you are outside the backwater limit then there will be no effect, if you are inside the limit, complete more detailed hydraulic calculations.
Rules of thumb for modelling stability of large wood	In a waterway in the UK, Dixon and Sear (2015) observed high mobility of large wood. They concluded that only very large pieces of wood (longer than 2.5 channel widths) could be considered functionally immobile. In general, wood is likely to be more stable in Victorian streams than in northern hemisphere streams. In Victorian rivers, the fallen trees tend to be multi-branched rather than cylindrical, and the wood is denser. For example, Koehn et.al. (2004) found that out of more than 2000 logs in the Murray River, only 3.5% moved in a large flood, and then less than a few metres. SKM (2009) completed an analysis of the mobility of reintroduced River Red Gum structures in the Glenelg River. Log size was not found to be an important determinant of log stability. Of more importance is the log's density. River Red Gums when dry are less dense than water and can float when fully desiccated (Brooks et al. 2006). The density of the wood increases as it is saturated, rendering the wood less mobile. They found that partial burial of single logs (10%) and multiple log structures (0.5 m of the structure buried) would be an effective treatment option in eliminating the risks of their movement, with structures remaining stable under the highest flow velocities likely to be experienced in the reach.

Assessment	Potential approaches
Rules of thumb for assessing bank erosion potential	Treadwell et al. (2007), drawing on Rutherfurd et al. (2002), provided a number of rules of thumb regarding bank erosion related to large wood: • By the time erosion around a fallen tree is noticeable, there is a good chance the bank erosion from the wood is almost complete. • Erosion around an obstruction will usually remove an amount of material equivalent to no more than 1–2 times the projected area of the obstruction. • At high flows it is likely that a log oriented upstream will deflect flow away from the adjacent bank, not cause erosion on that bank. • In most Australian waterways the effect of wood on erosion decreases with the size of the channel (as other channel forming processes will dominate in larger waterways).
Modelling stability of large wood	Rafferty (2013a) developed a spreadsheet-based tool (Rafferty 2013b) for evaluating the stability of large wood structures proposed for waterway enhancement (Rafferty 2014). The tool can be used to evaluate wood stability and options for the design and placement of wood, based on factors including the size and species of wood, configurations and anchor requirements. Input data includes channel dimensions, discharge, streambed substrate and wood characteristics. Brooks et al. (2006) and Department of Sustainability and Environment (2007) also document methods for assessing the stability of large wood structures.
Hydrological assessment of large wood	Anderson (2005b), Anderson et al. (2005) and Anderson et al. (2006) developed a model (ROVER) that predicts the impact of riparian vegetation on flood hydrographs at the catchment scale. In principle, the same concept can be applied to large wood.
Modelling hydraulics of large wood	The simplest form of hydraulic assessment is to estimate the afflux at the local site scale. A method for this was proposed by Gippel et al. (1996b). The method involves measuring the dimensions of the wood and the channel, the depth of flow, selecting a drag coefficient based on a set of equations or graphs, calculating the Froude number and blockage ratio, and then correcting the drag coefficient. Shields and Gippel (1995) developed a method for estimating the effects of wood on flow resistance in rivers on the basis of wood density, channel geometry, mean flow velocity and blockage-dependent wood drag coefficients. Resistance due to bed material, bars and bends was also considered. More elaborate tools are available for modelling the hydraulics of channels with large wood. The simplest tools are one-dimensional, such as HEC-RAS (www.hec.usace.army.mil/software/hec-ras/), which can also be used to estimate scour. In cases where information is required at more detailed spatial scale or where floodplains are involved, two-dimensional hydraulic models can be used (Wohl et al. In press). Hydraulic models can also be used to model habitat availability under scenarios of large wood management. This requires the additional information of hydraulic habitat preferences and tolerances of the species of interest (Wohl et al. In press). Hydraulic modelling is a specialised task that requires the services of a trained professional.

Methods of risk assessment applied to large wood problems

Risk reflects the probability of an event occurring and its consequences. A risk analysis considers potential adverse consequences to the natural environment, built environment and public safety.

Deciding that a proposed action needs a risk assessment requires careful consideration of the potential for adverse consequences. Thorne et al. (2014) proposed a project risk screening matrix, called RiverRAT, for waterway management and restoration. In this model, a waterway with high response potential (which depends on factors such as waterway type, bed and bank material, and hydrological regime), and with a high expected potential impact from the proposed project, likely warrants a more thorough risk assessment than a low response waterway with a low-impact project.

Knutson and Fealko (2014) propose a 10-step approach to designing large wood management using risk-based design. Initially, this approach outlines a process to identifying the potential risks to public safety and property that the placement of large wood in a waterway may present. A level of risk is assigned to project elements and the project as a whole for both public safety risk and property damage potential. Minimal design guidelines are then given for each risk combination for a design team to follow. Details of the design process and appropriate references are provided to lead a design team through to completion, resulting in a clearly documented design for a large wood management project.

SKM (2009) documented an approach to assess the risks of large wood reinstatement in the Glenelg River. A risk assessment approach consistent with Standard AS/NZS 4360:2004 Risk Management (Standards Australia 2006) was used to assess the risks. Event tree analysis was used to analyse the likelihood and consequential impacts arising from the movement and non-movement of reintroduced wood. Consequential impacts were broken down into two main categories: those associated with damage to infrastructure (minor bridge damage, bridge failure and increased flooding) and those that cause public harm (loss of life, permanent disablement and other injury). The likelihood of these impacts is a function of a number of conditional probabilities that relate to the characteristics of the wood (density), its potential to move, and damage a particular asset.

Wohl et al (2016) propose a large wood risk assessment process that incorporates four tools. A brief overview of these tools is provided here. The reader is directed to the publication for further information on the risk assessment process and described tools.

If wood is present in a channel, a simple checklist (Tool 1) can be used for an initial assessment of whether to remove the wood or consider other options. If options other than immediate removal are considered, a hydraulic analysis tool such as Large Wood Structure Stability Analysis tool (Rafferty 2013a; 2013b; 2014) or HEC-RAS (Tool 2) can be used.

The outcome of Tool 2 can then be used with the Decision Bands (Tool 3) to qualitatively assess the alternative actions. The Decision Bands are used to assign risk to a high, medium or low category with respect to three characteristics: legal/property/infrastructure/inhabitants, recreation and the ecosystem. Wohl et al. (2016) suggested that a more quantitative approach (Tool 4) could be based on multi-criterion decision analysis (MCDA).

Tool 1. Checklist for Initial assessment of individual wood pieces or wood accumulations

1. Imminent threat to public safety

   Has a river recreation accident involving the wood been reported?

   If yes, remove.

   If no, proceed to consider retaining.

   Does the wood accumulation have crevices that can trap recreational users (i.e. is it porous) and does it completely span the active river channel in a location and season known for high recreational use?

   If yes, remove.

   If no, proceed to consider retaining.

2. Imminent threat to property and infrastructure

   Has the wood already damaged a flood district facility or public or private structure?

   If yes, remove.

   If no, proceed to consider retaining.

   Could the wood potentially create, or increase the extent of, damage to a flood district facility or public or private structure that may cause loss of function to the facility or structure?

   If yes, remove.

   If no, proceed to consider retaining.

3. Legalities

   For any reason, are you legally bound to extract the wood?

   If yes, remove

   If no, proceed to consider retaining 4.

4. Overall

   If the answer to all of the preceding questions was a clear 'no,' retain wood.

If the answers involved some qualifications, proceed to Tools 2-4 and consider retaining.

Tool 2. Large wood structure stability analysis

If options other than immediate removal are considered, a hydraulic analysis tool such as Large Wood Structure Stability Analysis tool (Rafferty 2013a; 2013b; 2014) or HEC-RAS (Tool 2) can be used to assess the likely stability of the wood during different discharges.

Tool 3. Decision bands

The outcome of Tool 2 can be used with decision bands to qualitatively evaluate the relative risk created by individual pieces of wood or wood accumulations in a channel or on a floodplain. Individual bands focus on aquatic and riparian ecosystems, recreational users, and inhabitants and infrastructure. The decision bands represent a starting point for a complicated assessment process that is very context-specific and may require inputs from relevant disciplinary experts. For further information on using decision bands to assist with decision making, refer to Wohl et al. (2016).

Tool 4. Multi-criterion decision analysis

The outcome of Tool 2 can also be used in a more quantitative approach based on a multi-criterion decision analysis (MCDA) approach. MCDA provides a flexible, rational, and transparent means to establish decision-making criteria and prioritise options. Criteria are scored on interval or ratio scales and then transformed to ensure commensurability before ranking options. Criteria scores are aggregated using weights that reflect values, preferences, and expert judgment to transparently compare and rank options. Users can also adapt the system to different decision-making situations by adjusting the criteria and weights as knowledge and preferences evolve.

Glossary

Afflux: A rise in the water level immediately upstream of and due to a natural or artificial obstruction.

Algal bloom: A rapid increase in the population of algae that can occur in waterways, often caused by excess nutrients (particularly phosphorus and nitrogen).

Aquatic invertebrate: Insects, bugs and other small animals without a backbone that live in waterways.

Anabranch: A stream that leaves a river and re-enters it further along its course.

Avulsion: An avulsion occurs when the main flow of a river rapidly and naturally shifts from one section of its channel to a new course.

Bankfull: Flows that completely fill the channel.

Catchment: The region from which all rainfall flows, other than that removed by evaporation, into waterways and then to the sea or terminal lake.

Catchment management authorities: Statutory authorities established under the *Catchment and Land Protection Act 1994* to provide co-ordinated management of land and water resources.

Connectivity: Refers to the links between different habitats and species within a landscape.

Controlled grazing: Controlling a stock grazing regime within a fenced area by managing factors such as the timing, number of stock and duration of the grazing compared to having stock graze there all the time.

Crown land: Land owned by the State. Also, often referred to as public land (although not all public land is actually Crown land).

Estuary: The area where a river meets the sea, influenced by river flows and tides and characterised by a gradient from fresh to salt water.

Fire risk: The chance (likelihood) of a bushfire igniting, spreading and causing damage to the community or the assets they value (consequences).

Fish passage: Provision for the movement or migration of fish past barriers.

Flood: A natural phenomenon that occurs when water covers land that is normally dry. It may result from coastal or catchment flooding, or a combination of both (see also catchment flooding and coastal flooding).

Flood debris: Items transported by and deposited downstream by flood waters, including vegetation, sediment, rocks, litter, broken or discarded domestic and industrial items. Flooding in urban areas may result in more human-made debris (wheelie bins, shopping trollies, etc).

Flood-runner: A small distributary or anabranch that flows only during floods.

Flood stage: The level at which a body of water's surface has risen to a sufficient level to cause sufficient inundation of areas that are not normally covered by water.

Flood study: A comprehensive technical investigation of flood behaviour. It defines the nature of flood hazard across the floodplain by providing information on the extent, depth and velocity of floodwaters, and on the distribution of flood flows. The flood study forms the basis for subsequent management studies and needs to take into account a full range of flood events up to and including the largest probable flood. Flood studies should provide new flood mapping for planning scheme inclusion, data and mapping for Municipal Flood Emergency Plans, and a preliminary assessment into possible structural and non-structural flood mitigation measures.

Floodplain: Low-lying land adjacent to a waterway with unique ecosystems dependent on overflow from the waterway channel during flood events.

Flood risk: The potential risk of flooding to people, their social setting, and their built and natural environment. The degree of risk varies with circumstances across the full range of floods. Flood risk is divided into three types – existing, future and residual. Existing flood risk is the risk a community is exposed to as a result of its location on the floodplain. Future flood risk is the risk that new development within a community is exposed to as a result of developing on the floodplain. Residual flood risk is the risk a community is exposed to after treatment measures have been implemented. For example, a town protected by a levee, the residual flood risk is the consequences of the levee being overtopped by floods larger than the design flood; for an area where flood risk is managed by land-use planning controls, the residual flood risk is the risk associated with the consequences of floods larger than the Design Flood Event on the community.

Flow regime: The range of flows experienced by a waterway throughout the seasons and years which may include base flows, low flows, high flows, overbank flow and cease to flow (drying) events.

Fragmented landscapes: Landscapes where vegetation or habitat size has been reduced or disconnected, usually by human activity.

Habitat: The natural home or environment of an animal, plant or other organism.

Hydrological regime: Changes with time in the rates of flow of rivers and in the levels and volumes of water in rivers, lakes, reservoirs, and wetlands. The hydrologic regime is closely related to seasonal changes in climate.

Hydrophyte: An aquatic plant that grows in water or very moist ground.

Instream: The part of a river within the channel, including pools, riffles, woody debris, the river bank and benches.

Large wood: A dead tree, or portion of a tree, that has fallen or been laced into a waterway. Usually considered to be greater than 0.1 m in diameter and over a metre long. Also called snags.

Levee: An embankment that is built in order to prevent a river from overflowing.

Low flow: Flows that provide a continuous flow over the bottom of the channel, but do not fill the channel to any great depth. The term is most often used in relation to baseflows that occur over the drier periods of the year that are sustained for some period (weeks to months), due to short bursts of rain.

Lowland: Lowland rivers and streams are slow flowing and found in relatively flat areas.

Macrophyte: An aquatic plant that grows in or near water and is either submerged, emergent or floating.

Overbank flows: Flows that exceed the capacity of the channel and spill onto the floodplain.

Pathogens: Disease-causing microorganisms, such as bacteria, fungi, and viruses, found commonly in sewage, hospital waste, run-off water from farms and in water used for swimming.

Peri-urban: The area of land immediately adjoining an urban area, between the suburbs and the countryside.

Reach: A length of waterway that is relatively homogenous with regard to the hydrology, physical form, water quality and aquatic life.

Registered Aboriginal Party: Registered Aboriginal Parties (RAPs) are organisations that hold decision-making responsibilities under the *Aboriginal Heritage Act 2006* for protecting Aboriginal cultural heritage in a specified geographical area. More information: www.vic.gov.au/aboriginalvictoria/heritage/registeredaboriginal- parties

Refuge: Areas where plants and animals can take refuge during times of climatic or biological stress and which support the individuals that will recolonise the surrounding landscape when conditions improve. Refuges provide conditions suitable for survival of species that may be declining elsewhere.

Riparian: Land or vegetation that adjoins a river, creek, estuary, lake or wetland.

Waterways: Rivers and streams, their associated floodplain wetlands and runners, estuaries, and non-riverine wetlands.

Waterway condition/waterway health: Waterway condition (or waterway health) is an umbrella term for the overall state of key features and processes that underpin functioning waterway ecosystems (such as species and communities, habitat, connectivity, water quality, riparian vegetation, physical form, and ecosystem processes such as nutrient cycling and carbon storage).

Wetland: Natural, modified or artificial areas subject to permanent or temporary inundation that hold static or very slow-moving water and develop, or have the potential to develop, biota adapted to inundation and the aquatic environment. They may be fresh or saline.