Floodplain fencing – smart planning to ensure flood resilience and long-term ecological outcomes

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Key Points

- Flood damage to fencing is a major barrier to the uptake of riparian fencing projects.
- A review found that there is little systematic guidance for fencing on floodplains.
- DELWP has developed fencing guidelines for use by riparian managers.

Abstract

Major floods in Victoria in 2010, 2011 and 2012 resulted in significant damage to, or loss of, fences installed close to rivers and creeks.

Guidelines for riparian fencing in flood-prone areas have been developed to assist CMAs and other managers of riparian areas to minimise future flood damage. The guidelines help to select the most appropriate fence type, design, location and building technique.

The process of planning a fencing project in a flood-prone environment can be broken up into three main steps:

1. understanding site characteristics and floodplain behaviour
2. determining the appropriate fencing strategy for your floodplain (avoidance, resistance or resilience)
3. selecting the most appropriate fence type and location.

In isolation, use of the guidelines may still be limited by socio-economic factors. A recent survey of waterway managers indicated that the key limiting factors for uptake of flood fencing techniques were cost (78%), loss of land (69%) and time (47%). Until barriers to uptake are acknowledged and addressed, use of the guidelines may be constrained.

Keywords

Guidelines, riparian fencing, resistance, resilience, floodplain, planning

Introduction

As part of the Victorian Government's Waterway Management Program, there is substantial investment in riparian protection and improvement projects by Catchment Management Authorities (CMAs). The projects involve working collaboratively with landowners, including Crown frontage licensees, to undertake works such as fencing, revegetation, weed management and provision of infrastructure to support off-stream stock watering.

Recent Victorian floods in 2010, 2011 and 2012 caused significant damage to riparian fences. This raised issues about the type, design, construction and location of fences in active floodplains. It also caused questions about the usefulness of funding riparian works such as fencing on floodplains which may be damaged during floods.

To assist CMAs and other managers of riparian areas, the then Department of Sustainability and Environment developed statewide guidelines for choosing the best techniques to site, design and construct fences in flood prone areas. Development was divided into three key stages:

1. Literature review. This stage reviewed national and international approaches to fencing within active floodplains and the applicability of techniques described in the literature to Victorian conditions.
2. Post flood review. This stage developed an online survey and sought responses from CMAs and other managers of riparian lands about the techniques they employ when siting and constructing fences in flood prone areas. Following the survey, key respondents were interviewed to discuss their experiences. Selected regional visits were then undertaken to discuss particular sites and techniques focusing on successes and failures during flood events in 2010, 2011 and 2012.
3. Development of guidelines for riparian fencing in flood prone areas. The final stage was to translate the findings and recommendations of the earlier stages into statewide guidelines.

Literature review

While there is a serviceable amount of existing information regarding fencing in flood prone areas, much of the written material references only three sources (Staton and O'Sullivan, 2006; Kondinin Group, 1994 and Waters and Rivers Commission WA, 2000). There was very little relevant information available from International literature and few specific examples from Victoria.

Most reports refer to key principles/techniques for fencing in floodplains. These are: use the least height possible; use minimal wires and droppers; use thick posts; reduce space between posts; set posts deep in ground; drive posts into ground rather than digging holes; use strong end assemblies; and ensure that the fence line is aligned to the flow path.

From the desktop review it appeared that sufficient information already existed to guide land managers in best practice for fencing in floodplains. However, given the significant losses of riparian and floodplain fencing in the 2010, 2011 and 2012 floods it appeared that the existing tools and techniques were not being widely implemented. Anecdotal evidence indicated that many issues (both perceived and real) were restricting the uptake of appropriate techniques for fencing in flood prone areas. These included installation costs, practicality, maintenance costs, creation of flood obstructions, and reduction in farming opportunities.

Post flood review

CMAs and other managers of riparian lands were surveyed to determine why flood fencing had not been broadly applied by landholders and managers. This included an online survey, phone surveys and site visits focusing on successes and failures during the 2010-2012 flood events with selected respondents.

The responses showed that all of the techniques identified in the literature review had been applied by land managers. However, not all of the techniques were consistently recommended to landholders and even fewer were required as part of funding agreements. The three most used techniques were fence lines aligned to river flow; high risk sections being independent from main fence; and reduced space between posts.

The greatest limiting factor for the uptake of fencing techniques was seen to be cost (78%), followed by loss of land (69%) and time (47%).

The techniques/principles for fencing in flood prone areas that were considered most successful in the recent floods were:

- Fence well back or above flood zone (73% respondents).
- Avoid fencing across waterways (60% respondents).
- Posts driven into the ground (59% respondents).
- Fence wires secured on downstream side (54% respondents).
- Isolating high risk sections of fence (52% respondents).
- Lay down or fold up fences (47% respondents).
- Stronger end assemblies (45% respondents).
- Fence aligned with flow path (41% respondents).
- Low tensile wire to attach fence to posts (41% respondents).

Guidelines for riparian fencing in flood prone areas

Based on the findings from the literature review, online surveys, field visits and phone interviews, the *Guidelines for riparian fencing in flood prone areas* (the guidelines) were developed to assist CMAs and other managers of riparian areas in Victoria to choose the best techniques for the siting, design and construction of fences in flood prone areas.

It is not possible to design a fence that will withstand the force of a major flood (Staton and O'Sullivan 2006). Therefore, the guidelines have been developed to reduce and, where possible, minimise the risks and costs of flood damage to fences. This involves a three step process that:

1. Identifies the specific floodplain type for a project area.
2. Determines the most appropriate fencing option/s for that floodplain type.
3. Provides specific guidance relevant to that fencing option/s under three main themes:
    - avoiding flood damage.
    - making fences more resistant to flood damage.
    - making fences more resilient to flood.

Step 1 - Identifying the floodplain type

In the guidelines, the first step in planning fencing in flood prone areas is identifying the floodplain type. Nanson and Croke (1992) used the planform, available energy (gauged using specific stream power), and sedimentology of floodplains to describe 15 floodplain types. Six of these floodplain types were considered relevant to Victoria (refer to Table 1). Using the classifications in Table 1, a key to identifying floodplain type was developed (refer to Figure 1). This key is used to determine the floodplain type for a project area.

Table 1. A classification of floodplain types for Victoria (based on Nanson and Croke (1992))

State/ substate	Type	Stream Power	Sediment	Erosional/ Depositional Processes	Landforms	Channel Planform	Environment	Examples within Victoria
A1	Confined coarse textured floodplain	>1000	Poorly sorted boulders and gravel; buried soils	Catastrophic floodplain erosion and overbank vertical accretion; abandoned channel accretion; minor lateral accretion	Boulder levees; sand and gravel splays; back channels abandoned channels, scour holes	Single-thread straight/ irregular	Steep upland head-water valleys	Restricted to the upper valleys of rivers in the North East and East Gippsland. Examples: Upper cleared reaches of the Wonnangatta, Kiewa East and West branches, and the Upper Snowy River.
A3	Unconfined vertical accretion sandy floodplains	300-600	Sandy-strata inter-bedded muds	Catastrophic channel widening; overbank vertical accretion; island deposition and abandoned-channel accretion. Minor lateral accretion	Flat floodplain surface	Single-thread meandering	Semi-arid open valleys	Rare in Victoria. Example: Bet Bet Creek
A4	Cut and fill floodplains	~300	Sands, silts and organics	Catastrophic gullying, overbank vertical accretion; abandoned-channel accretion	Flat floodplain surface; channel fills; swampy meadows	Straight/ irregular	Upland dells and semi-arid alluvial filled valleys	Common in the steep, cleared floodplains of small to medium sized streams throughout the state. Floodplains tend to be narrow (hundreds of metres wide rather than kilometres). Streams in these floodplains can be deeply eroded. Examples can be found in most catchments of the state.
B3	Meandering river, lateral-migration floodplains	10-60	Gravels, sands and silts	Cut-bank erosion; lateral pint bar accretion; overbank vertical and abandoned-channel accretion. Counterpoint accretion; minor oblique accretion	Flat to undulating floodplain surface; oxbows; backswamps	Meandering	Usually middle to lower valley reaches	The most common stream type in the middle reaches of Victorian rivers. These floodplains also have anabranches. In Victoria these often grade downstream into floodplain type C2. Examples: Mid Kiewa River, River Murray, Lower Goulburn River, Lower Ovens River and Latrobe River.
C1	Laterally stable, single-channel floodplains	<10	Abundant silts and clays with organics	Overbank vertical accretion	Flat floodplains with low levees; backswamps	Single-thread straight / meandering	Abundant fine sediment load middle – lower reaches	Typical of the floodplains in the north west of the state. Examples: Avoca River, Mid Loddon River and Wimmera River.
C2	Anastomosing river floodplains	<10	Gravel and sands with abundant silts and clays	Overbank vertical accretion; island deposition	Flat floodplains with extensive levees, islands and flood-basins crevasse-channels and splays.	Anastomosing	Very low gradient with wide floodplains	Downstream or middle reaches of rivers in northern Victoria and Gippsland. Examples: lower end of Thomson, Latrobe, Macalister, King and Ovens rivers.

1	**Where is the project site located?**	
	a. Upper reaches	(Go to 5)
	b. Middle to lower reaches	(Go to 2)
2	**Is the channel anastomosing (multiple channels, anabranches)?**	
	a. Yes	C2
	b. No	(Go to 3)
3	**Is the dominant riverbank sediment silt/clay?**	
	a. Yes	C1
	b. No	(Go to 4)
4	**What is the sinuosity of the stream?**	
	a. Less than 1.3	B3
	b. Greater than 1.3	(Go to 5)
5	**Does the stream abut the hill slope for greater than 90% of its length?**	
	a. Yes	A1
	b. No	(Go to 6)
6	**Is the stream in a fairly narrow valley and could be described as a swampy meadow?**	
	a. Yes	A4
	b. No	A3

Figure 1. Key to identifying floodplain types

Step 2 - Choosing fencing options based on floodplain type

Once the floodplain type has been determined (using Figure 1), floodplain type-specific preferred fencing options are provided, including decision trees where required (summarised in Table 2).

A1 - confined coarse textured floodplain

This floodplain type is likely to be a zone of high sediment and debris deposition. As such, the possibility of fence damage/loss is high. The preference is to avoid flood damage. However, a fence can be considered if it can be located behind the floodplain levee, making the fence more resistant to flood damage. This is not feasible if the floodplain is within a gorge.

A3 - unconfined vertical accretion sandy floodplain

This type aligns with high energy ephemeral channels. There is a high likelihood for fence destruction (from erosion, racking and deposition) for this floodplain type during flash flood events. The key variable is how far away can a fence be installed from the waterway e.g. outside the 10% AEP[1] flood zone) (refer to Figure 2).

A4 - cut and fill floodplain

This floodplain type is typically described as a swampy meadow. The potential for gullying is often high making fencing problematic. Additionally, fence destruction in floods is highly likely. The preference is to avoid flood damage. Alternatively, fencing well back from the channel edge with a well-vegetated riparian buffer could be possible.

[1] AEP - annual exceedance probability, which is the statistical likelihood of a flood of a given size or larger occurring in any one year, usually expressed as a percentage.

B3 - lateral migration floodplains

These floodplain types are likely to be inundated frequently, unless incision has taken place. The key variable is whether the fence can be installed parallel to the flood flow (refer to Figure 3). As the channel is also likely to migrate laterally, running fences parallel to flood flows will assist in fence longevity.

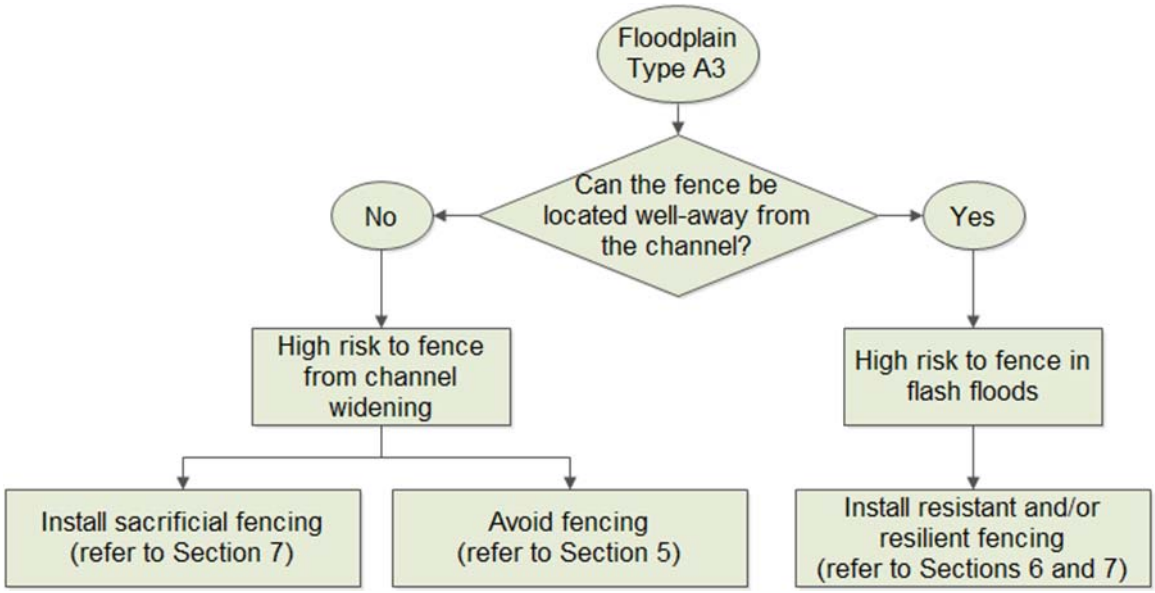

Figure 2. Fencing options for unconfined vertical accretion sandy floodplains

Care is also needed in defining the top of the point bar to match bankfull on the opposite bank so that fencing is outside of the channel. Whilst this floodplain type is relatively low energy compared to the channel, any topographical variation will increase flow velocity (such as flood runners). In these instances, sacrificial fences (fences that are cheaper and simpler to replace than conventional fencing) may be appropriate.

C1, C2 - low-energy vertical accretion floodplains

These floodplain types are low energy. However, to minimise damage, the preference is to make the fence more resistant to flood damage. Where possible, fences should be positioned behind the floodplain levee.

Summary

Table 2. Summary of floodplain type-specific preferred fencing options.

Floodplain type		Preferred fencing option		
		Avoidance	Resistance	Resilience
A1	confined coarse textured floodplain	✓		
A3	unconfined vertical accretion sandy floodplain	✓	✓	✓
A4	cut and fill floodplain	✓	✓	✓
B3	lateral migration floodplain		✓	✓
C1, C2	low-energy cohesive floodplain		✓	

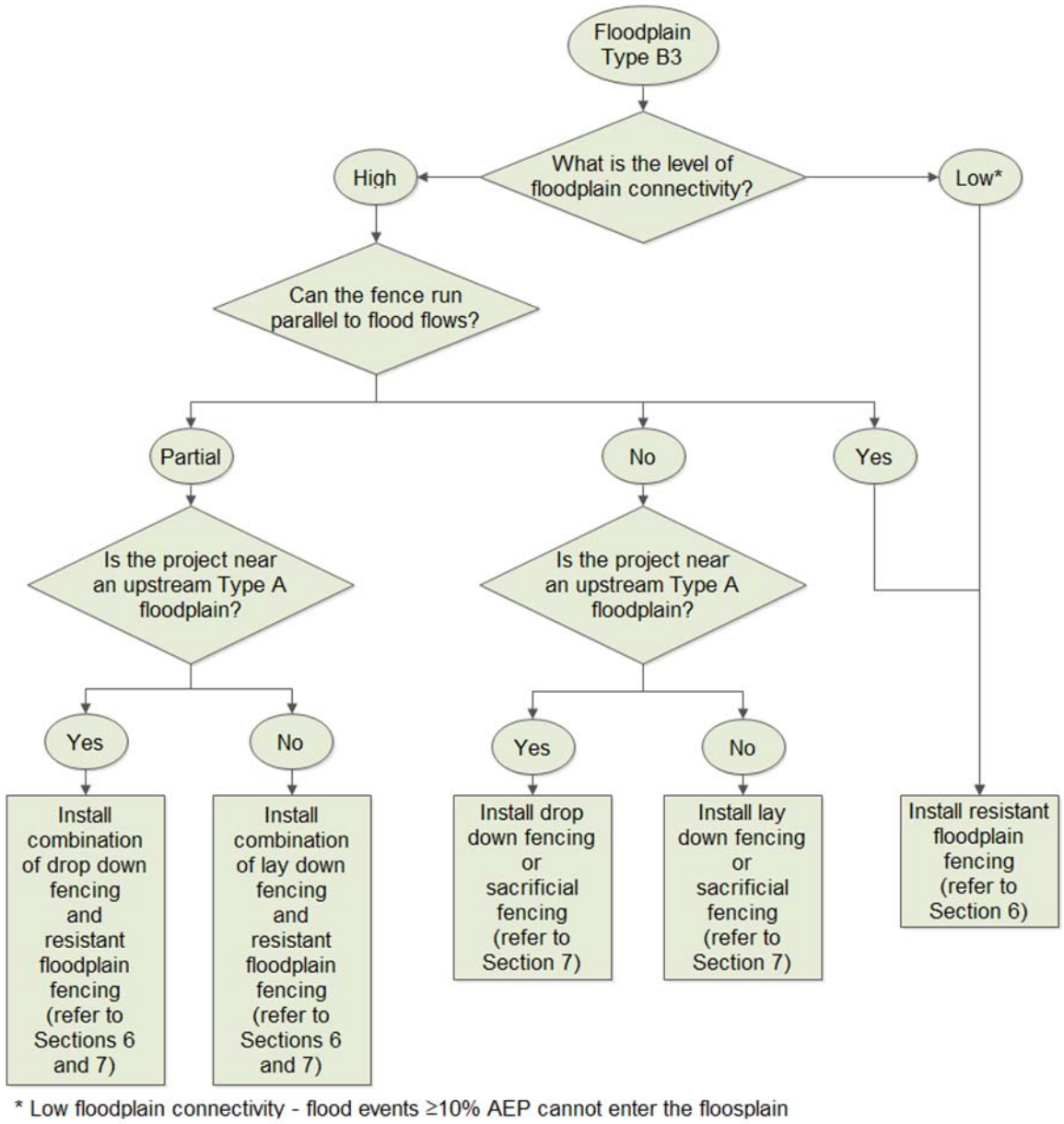

Figure 3. Fencing options for lateral migration floodplain

Step 3 – Guidance relevant to the preferred fencing option

Avoiding flood damage

Avoiding flood damage is best achieved by either:

- reducing the likelihood that the fence will encounter a flood (through appropriate location on the floodplain) i.e. avoiding floods.
- implementing alternative management options (other than conventional fencing) to control livestock on the floodplain i.e. avoiding fences. Options for managing livestock in riparian areas without fencing include: implementing a controlled livestock grazing regime (to specified times of the year, duration and grazing intensities); providing troughs with clean water away from the waterway; providing shade and shelter away from the waterway; and providing crossings in areas where livestock naturally cross water.

Making fences more resistant to flood damage

When fencing within flood prone areas cannot be avoided and alternatives to conventional fencing are not possible or acceptable, the next step is to determine if your fence can be designed to: minimise the likelihood of damage during a flood event (by withstanding the flood's impact); and maintain function post-flood with minimal repair required. This type of fencing design is known as flood resistant fencing.

Typically, the degree to which a fence can survive floods, particularly when floodwaters are laden with debris, will be dependent on the:

- **fence alignment in relation to flood flows**. In general, fences should be installed considering the terrain (i.e. contours) of the floodplain. As a minimum, the fence alignment should be no less than 45° to the flood flow path. However, as the risk of flooding increases, the fence alignment should be installed near-parallel to the direction of flood flows.
- **strength of strainer (end) assemblies**. During floods, debris can place additional tension on fences with many kilometers damaged or lost through end assembly failures (Wallace 2011). The key elements to consider when constructing strainer assemblies in flood prone areas are:
    - the depth of the strainer post. In flood-prone areas, longer strainer posts (e.g. 2.7m) should be used with approximately half set into the ground.
    - the method of setting the strainer post. Staton and O'Sullivan (2006) state that a driven post will be 1.5 times more secure than a post that has been placed in an oversized hole with the earth rammed back around it.
- **strength of in-line posts (to resist over-turning)**. In addition to stronger strainer assemblies, in-line posts can also be strengthened to resist over-turning during flood events by considering factors such as the:
    - type of post used. For floodplain fencing, the stronger posts (e.g. concrete, steel) are generally preferred.
    - depth of posts. As for strainer posts, in-line posts exposed to floods should be longer and set deeper into the ground than standard fence posts.
    - post spacing adopted. It is preferable to reduce post spacing, particularly in sections of fence that are more likely to encounter flood debris.
- **fence type**. Mesh fencing and barbed wire should be avoided in flood prone areas.
- **number of wires**. Keeping the number of wires to a minimum helps to limit the load carried by a fence during a flood. For this reason, electric fences which use fewer wires than other conventional fences are often the best choice in flood-prone areas.
- **placement of wire on the posts**. Fencing wire should be placed on the paddock or downstream side of posts so they pop their staples and drop rather than breaking.
- **fence height**. Fences should be constructed with the least vertical height possible to give adequate livestock control. This is generally between 1.2 m and 1.4 m.

Making fences more resilient to flood damage

When fencing cannot be aligned to flood flows, the next step is to determine if the fence can be designed to absorb the impact of a flood and restore function post-flood with limited repair required. This type of fencing design is known as flood resilient fencing.

There are two main options for fences to be re-established or repaired following a flood. The first is to install collapsible fences. These include fence designs which either: give way under the pressure of flood flows and debris to lay flat on the ground (drop-down fences) or are folded down manually, so that they can't accumulate debris and be damaged during a flood (lay-down fences). Deciding which one to choose will be dependent on: location, flood warning time and likely cost to repair post flood.

The second option is to install sacrificial fences. For areas that are susceptible to regular flood events, it is often considered more cost effective to install fences that are cheaper and simpler to replace than conventional fencing.

Conclusions

The authors acknowledge that full use of the guidelines may still be limited by socio-economic factors. This was brought out through the survey of waterway managers which indicated that the key limiting factors for uptake of flood fencing techniques were:

- **Cost**. Cost is certainly a factor influencing techniques. For example, the cost of a drop down fence used on the Glenelg was approximately 2–3 times the cost of a 'standard fence'.
- **Loss of access to land**. Aligning fences to flood flows can result in significant land being 'locked up' within the fenced-off area.

However, through recent flood experiences, landholders are becoming more aware of the benefits of appropriate fence alignment and location in minimizing fence damage. This is resulting in greater landholder/CMA partnerships, better alignment of fences to flood flow paths and an increase in riparian buffer widths.

By providing more specific advice in the selection of fencing options based on floodplain type, we believe that application of the guidelines will further these results and in turn:

- reduce the number of fences requiring replacement post flood
- reduce the time and resources required to repair fences post flood
- assist in justifying the higher up-front costs of fence installation in flood-prone areas.

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They were released in 2015 and are available through the DEPI website (http://www.depi.vic.gov.au/__data/assets/pdf_file/0007/303892/Riparian-fencing-in-flood-prone-areas-guidelines-low-res-June-2015.pdf).

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