



5 MANAGEMENT RATIONALE

5.1 Vision and Objectives

Upon completion of the field inspection and review of the relevant literature, including the Wodonga Waterways Community Consultation report, a vision was developed for the waterways of the Wodonga area by the project team. This vision being:

“To develop ecologically healthy and self-sustaining waterway environments throughout the Wodonga region, promoting community values and social utilisation of the riparian zone where applicable”.

The vision is thought of as a broad objective to be achieved through the successful management of the Wodonga waterway corridors through this Regional Waterway Action Plan. To achieve this vision, the Wodonga Urban Landcare Network and stakeholders have identified the following management objectives:

- Ensure that the values and functions of waterways and floodplains are maintained or improved.
- Recognise aesthetics values and to promote recreation and social opportunities.
- Respect community values, aspirations and priorities as they relate to the waterways of Wodonga.

The successful implementation of the Plan shall lead to the riparian zones in the priority waterways being less weedy, better connected (both in terms of people and habitat), and more stable.

5.2 Restoration and Rehabilitation

To assist with the preparation of individual project objectives we have provided the following possible target condition definitions:

- **Restoration** – Is the process of returning a damaged or disturbed system to a natural or previously undisturbed state. That is, the structure, function and process of the recovered system are the same as they were in the previously undisturbed state.
- **Rehabilitation** – Is the process of recovering a damaged or disturbed system to an improved state that does not represent the natural or previously undisturbed state of that system. In a waterway it may be judged that a return to a near natural state is not feasible. In this instance, the condition of the reach is rehabilitated towards a form that is different to what existed prior to disturbance but is considered more stable or holds more value than the existing condition.



6 MANAGEMENT RECOMMENDATIONS

6.1 Management Recommendations and Prioritisation

6.1.1 Overview

This section details priorities and recommendations for the management of the stream network across the project area. The recommendations for management (see Appendix A – Summary Sheets) consider the erosion processes, threats and values present within the project area that are discussed in preceding sections of this report. It is important to acknowledge that most on-ground actions will involve a combination of management strategies to address a threat(s) and to achieve the desired outcome.

The identified strategies and actions for each waterway contained within the project area are summarised in Table 6-1. This table also identifies the key values being protected by the proposed strategy/action and assigns a recommended implementation sequence (provided in alphabetical order).

As described in Section 2.3, numerous riparian management zones exist within the project area that influence and/or control the way the riparian zone is managed. It is important from the outset to have a clear vision for the potential use and appearance of the riparian land being improved. The riparian land vision needs to be acknowledged by all stakeholders so that the methods of management are understood and accepted. The recommended management actions relevant to the Riparian Management Zones within each reach have been identified in Table 6-1.

As previously noted, the project scope has not included a detailed site assessment of all the waterways contained within the project area. As such, the recommended management strategies and actions discussed in this section are limited in scope to the threats/opportunities either observed by the project team or brought to the attention of the project team. More specific and detailed strategies and actions could be identified through a comprehensive investigation of individual waterways within the current project area.

6.1.2 Prioritisation

Guiding principles for the determination of priority works have been developed and discussed in the following sections. These principles should be considered in the development of any future works proposal to demonstrate and/or justify the strength of any individual works proposal or funding bid.

6.1.2.1 Project Planning and Development

Project planning and development is considered key to the success of any individual project. Priority projects should include:

- The identification of clear and measurable project objectives.
- Actions/strategies that are consistent with this Plan and complementary to other relevant Plans/Strategies.
- Actions/strategies that are undertaken in accordance with Best Practice Management.

6.1.2.2 Protection of Existing Waterway Values

It is recognised to be far easier and cost effective to protect the existing ecological and structural function and values of waterways compared to rehabilitating waterways where decline has already occurred. On this basis, it is recommended that:

- Ecologically/structurally intact reaches be protected as a high priority.



- Subsequent prioritisation considers the level of investment and ongoing management intervention required to prevent further degradation or improvement to the environmental condition of the waterway. That is, reaches with a high recovery potential should be prioritised above reaches with a low recovery potential.

6.1.2.3 Erosion Management

The highest priority for erosion management is given to those actions/strategies:

- That address bed degradation. Bed degradation is the dominant fluvial erosion process occurring within the project area. Bed degradation in turn can cause bank erosion. Hence preventing the on-going bed degradation is considered a high priority. Several management interventions are available to manage bed degradation within the project area. The Department of Sustainability and Environment (2007) broadly categorise the options as:
 - Inflow and runoff management options. The potential to manage inflow and runoff within the project area through reducing peak flows (e.g. incorporating water sensitive urban design techniques such as the construction of retention basins/wetlands in future developments) is limited within existing urban developments. However, it is recommended that such techniques be employed for future developments (discussed further in Section 6.2).
 - Vegetation options (e.g. vegetation establishment).
 - In-stream interventions (e.g. rock chutes).
- That addresses erosion which is negatively impacting upon public or environmental assets.

6.1.2.4 Weed Management

There are numerous woody weeds present within the project area, however willows are the most prevalent and problematic woody weed species within the study area. Hence, **the highest priority for weed management is given to those actions/strategies that involve willow management.**

The second highest priority is weed management works (growth control, spread control or eradication) that target highly invasive weed species that are deemed to have a negative impact on environmental health. The dominant species of concern include:

- Box Elder.
- Desert Ash.
- Blackberry.
- Ivy.
- Robinia.
- Poplar.
- Gorse.
- Broom.
- Parrots Feather.

6.1.2.5 Riparian Vegetation Management

The highest priority for riparian vegetation management is given to those actions/strategies:

- That protect existing remnant vegetation and structural intactness.
- That protect large old trees that contain habitat attributes (e.g. hollows).



- That provides an important ecological link (e.g. a connection between patches, restoration of longitudinal continuity or creation of new corridors).
- Where vegetation establishment will provide multi-benefit outcomes (e.g. channel stability, aesthetic values, ecological values).

6.1.2.6 Sediment Management

Prioritisation for works associated with sediment transport and deposition are as follows:

- Highest priority is given to those actions that:
 - Involve the management of **sediment supply** at the source. This is most effectively achieved through:
 - Vegetation establishment and stock exclusion in the upper catchments.
 - Adopting suitable sediment and erosion control measures associated with land development and construction activities.
- The second highest priority is given to actions that:
 - Promote **sediment storage** in the channel or floodplain, most readily achieved through vegetation establishment and stock exclusion in the upper and mid catchment reaches.

6.1.2.7 Stakeholder Contribution

When considering stakeholder contribution for individual projects, it is recommended that projects be given highest priority where:

- There is landholder/land manager/community group willingness for the works to be undertaken and to contribute to the maintenance of the works. Where there are different landholders on each side of the channel (particularly on small waterways), it is most beneficial to the project success to have willingness from both landholders/land managers.
- There is willingness from the landholder/land manager to contribute funds to the project.



Table 6-1 Summary of Management Strategies and Actions.

Strategies and Actions	Implementation Order	Key Threats Addressed	Riparian Zone Types Present					
			Formal Parkland	Informal Parkland	Riparian Reserve	Rural Riparian Reserve	Habitat Reserve	Constructed Floodway
Kookinburra Creek – Upper Reach								
<ul style="list-style-type: none"> ■ Stock Access Management <ul style="list-style-type: none"> ■ Negotiate with landholders to fence off creekline to manage stock grazing pressures. This will help protect stream banks from compaction, pugging, the development of tracks and associated sediment inputs and impacts on riparian vegetation. 	A	Stock Access Increased Bed Instability & Bank Erosion Degraded Riparian Vegetation				✓		
<ul style="list-style-type: none"> ■ Exotic Flora Management <ul style="list-style-type: none"> ■ Undertake weed management, targeting garden escapes, Blue Periwinkle, Blackberry and occasional tree weeds. 	B	Exotic Flora Degraded Riparian Vegetation				✓		
<ul style="list-style-type: none"> ■ Native Flora Management <ul style="list-style-type: none"> ■ Revegetate riparian areas that have been fenced from stock. This may only require top up revegetation using missing lifeforms (e.g. shrubs only if trees are present). This will prevent incremental vegetation loss and improve structure, continuity and width. 	B	Degraded Riparian Vegetation				✓		
Kookinburra Creek – Mid Reach								
<ul style="list-style-type: none"> ■ Stock Access Management <ul style="list-style-type: none"> ■ Negotiate with landholders to fence off creekline to manage stock grazing pressures. This will help protect stream banks from compaction, pugging, the development of tracks and associated sediment inputs and impacts on riparian vegetation. ■ Ensure fencing around the Barnawartha South Bushland Reserve is excluding stock. 	A	Stock Access Increased Bed Instability & Bank Erosion Degraded Riparian Vegetation				✓	✓	
<ul style="list-style-type: none"> ■ Exotic Flora Management <ul style="list-style-type: none"> ■ Undertake weed management, targeting garden escapes, Blue Periwinkle, Blackberry and willows, including Black Willow. 	B	Exotic Flora Degraded Riparian Vegetation				✓	✓	
<ul style="list-style-type: none"> ■ Native Flora Management <ul style="list-style-type: none"> ■ Revegetate riparian areas that have been fenced from stock. This may only require top up revegetation using missing lifeforms (e.g. shrubs only if trees are present). This will prevent incremental vegetation loss and improve structure, continuity and width. ■ Provide top up riparian revegetation to the Barnawartha South Bushland Reserve to enhance the structure of native vegetation and to help stabilise creek banks. 	B	Degraded Riparian Vegetation				✓	✓	
Felltimber Creek – Upper Reach								
<ul style="list-style-type: none"> ■ Stock Access Management <ul style="list-style-type: none"> ■ Negotiate with landholders to fence off creekline to manage stock grazing pressures. This will help protect stream banks from compaction, pugging, the development of tracks and associated sediment inputs and impacts on riparian vegetation. 	A	Stock Access Increased Bed Instability & Bank Erosion Degraded Riparian Vegetation				✓		
<ul style="list-style-type: none"> ■ Native Flora Management <ul style="list-style-type: none"> ■ Revegetate rural riparian areas that have been fenced from stock. This may only require top up revegetation using missing lifeforms (e.g. shrubs only if trees are present). This will prevent incremental vegetation loss and improve structure, continuity and width. ■ Provide top up riparian revegetation to the Felltimber Creek Conservation Reserve to enhance the structure of native vegetation and to help stabilise creek banks. ■ Revegetate along both banks of the creek within the Hunchback Mountain Bike Park. 	B	Degraded Riparian Vegetation				✓	✓	
<ul style="list-style-type: none"> ■ Exotic Flora Management <ul style="list-style-type: none"> ■ Continue weed management, particularly Blackberry, to maintain woody weeds at low levels. 	C	Exotic Flora Degraded Riparian Vegetation				✓	✓	



Strategies and Actions	Implementation Order	Key Threats Addressed	Riparian Zone Types Present					
			Formal Parkland	Informal Parkland	Riparian Reserve	Rural Riparian Reserve	Habitat Reserve	Constructed Floodway
Felltimber Creek – Mid Reach								
<ul style="list-style-type: none"> Bed Instability and Bank Erosion Management <ul style="list-style-type: none"> Undertake a stability analysis to determine the extent of active deepening, and potential for head-out initiation if large willows root masses are to be removed from instream. This may lead to the design and construction of rock chutes to manage the deepening. Review the erosion below the McGaffins Road culvert apron to determine if additional rock or redesign is required to ensure ongoing stability. 	A	Increased Bed Instability & Bank Erosion		✓	✓	✓		
<ul style="list-style-type: none"> Exotic Flora Management <ul style="list-style-type: none"> Undertake weed management, firstly targeting garden escapes and seeding woody species (e.g. Black Willow, Box Elder, Ash, Blackberry), then controlling all other species. Salvage more durable logs from tree removal for use as placed Large Woody Habitat both instream (under the direction of the NECMA) and within the revegetated riparian area. 	A	Exotic Flora Degraded Riparian Vegetation		✓	✓	✓		
<ul style="list-style-type: none"> Native Flora Management <ul style="list-style-type: none"> Undertake revegetation following weed control to re-establish native vegetation structure, continuity and width. 	B	Degraded Riparian Vegetation				✓	✓	
<ul style="list-style-type: none"> Stakeholder Engagement <ul style="list-style-type: none"> Discuss land management practices/improvement opportunities with relevant manager/authority including rubbish dumping, weed control methods, garden escapes and avoiding planting invasive garden specimens close to the waterway. 	A	Exotic Flora Urban Development		✓	✓			
Felltimber Creek – Golf Course Reach								
<ul style="list-style-type: none"> Bed Instability and Bank Erosion Management <ul style="list-style-type: none"> Undertake a stability analysis to determine the extent of active deepening, and potential for head-out initiation if large willows root masses are to be removed from instream. This may lead to the design and construction of rock chutes to manage any deepening processes. 	A	Increased Bed Instability & Bank Erosion		✓	✓			
<ul style="list-style-type: none"> Exotic Flora Management <ul style="list-style-type: none"> Undertake weed management, firstly targeting garden escapes and seeding woody species (e.g. Black Willow, Box Elder, Ash, Blackberry), then controlling all other species. Salvage more durable logs from tree removal for use as placed Large Woody Habitat both instream (under the direction of the NECMA) and within the revegetated riparian areas. 	A	Exotic Flora Degraded Riparian Vegetation		✓	✓			
<ul style="list-style-type: none"> Native Flora Management <ul style="list-style-type: none"> Undertake revegetation following weed control to improve bank stability and re-establish native vegetation structure, continuity and width. Investigate the poor tree health in Albert Terrill Reserve, monitor condition and implement appropriate health improvement actions. 	B	Degraded Riparian Vegetation		✓	✓			
<ul style="list-style-type: none"> Stakeholder Engagement <ul style="list-style-type: none"> Discuss land management practices/improvement opportunities with relevant manager/authority including rubbish dumping, weed control methods, garden escapes and avoiding planting invasive garden specimens close to the waterway. 	A	Exotic Flora Urban Development		✓	✓			
Felltimber Creek – Lower Reach								
<ul style="list-style-type: none"> Exotic Flora Management <ul style="list-style-type: none"> Undertake weed management, firstly targeting seeding woody species (e.g. Black Willow, Box Elder, Ash, Blackberry), then controlling all other species. Salvage more durable logs from tree removal for use as placed Large Woody Habitat both instream (under the direction of the NECMA) and within the revegetated riparian area. 	A	Exotic Flora Degraded Riparian Vegetation		✓	✓			
<ul style="list-style-type: none"> Native Flora Management <ul style="list-style-type: none"> Undertake revegetation following weed control to improve bank stability and re-establish native vegetation structure, continuity and width. 	B	Degraded Riparian Vegetation		✓	✓			



Strategies and Actions	Implementation Order	Key Threats Addressed	Riparian Zone Types Present					
			Formal Parkland	Informal Parkland	Riparian Reserve	Rural Riparian Reserve	Habitat Reserve	Constructed Floodway
<ul style="list-style-type: none"> Stakeholder Engagement <ul style="list-style-type: none"> Discuss land management practices/improvement opportunities with relevant manager/authority including rubbish dumping, weed control methods, garden escapes and avoiding planting invasive garden specimens close to the waterway. 	A	Exotic Flora Urban Development		✓	✓			
Huon Creek – Upper Reach								
<ul style="list-style-type: none"> Stock Access Management <ul style="list-style-type: none"> Negotiate with landholders to fence off creekline to manage stock grazing pressures. This will help protect stream banks from compaction, pugging, the development of tracks and associated sediment inputs and impacts on riparian vegetation. 	A	Stock Access Increased Bed Instability & Bank Erosion Degraded Riparian Vegetation				✓		
<ul style="list-style-type: none"> Exotic Flora Management <ul style="list-style-type: none"> Undertake weed management, targeting Blackberry and Willows. 	B	Exotic Flora Degraded Riparian Vegetation				✓		
<ul style="list-style-type: none"> Native Flora Management <ul style="list-style-type: none"> Revegetate riparian areas that have been fenced from stock. This may only require top up revegetation using missing lifeforms (e.g. shrubs only if trees are present). This will prevent incremental vegetation loss and improve structure, continuity and width. 	B	Degraded Riparian Vegetation				✓		
Huon Creek – Mid Reach								
<ul style="list-style-type: none"> Stock Access Management <ul style="list-style-type: none"> Negotiate with landholders to fence off creekline to manage stock grazing pressures. This will help protect stream banks from compaction, pugging, the development of tracks and associated sediment inputs and impacts on riparian vegetation. 	A	Stock Access Increased Bed Instability & Bank Erosion Degraded Riparian Vegetation				✓		
<ul style="list-style-type: none"> Exotic Flora Management <ul style="list-style-type: none"> Undertake weed management, targeting Blackberry and Willows within the Grazed Rural Riparian Reserve and the Riparian Reserve (VREN Precinct A Site 3A). 	B	Exotic Flora Degraded Riparian Vegetation			✓	✓		
<ul style="list-style-type: none"> Native Flora Management <ul style="list-style-type: none"> Revegetate riparian areas that have been fenced from stock. This may only require top up revegetation using missing lifeforms (e.g. shrubs only if trees are present). This will prevent incremental vegetation loss and improve structure, continuity and width. 	B	Degraded Riparian Vegetation				✓		
<ul style="list-style-type: none"> Stakeholder Engagement <ul style="list-style-type: none"> Discuss land management practices/improvement opportunities with relevant manager/authority including rubbish dumping, weed control methods, garden escapes and avoiding planting invasive garden specimens close to the waterway. 	A	Exotic Flora Urban Development		✓	✓			
Huon Creek – Lower Reach								
<ul style="list-style-type: none"> Stock Access Management <ul style="list-style-type: none"> Negotiate with landholders to fence off creekline to manage stock grazing pressures. This will help protect stream banks from compaction, pugging, the development of tracks and associated sediment inputs and impacts on riparian vegetation. 	A	Stock Access Increased Bed Instability & Bank Erosion Sedimentation Degraded Riparian Vegetation				✓		
<ul style="list-style-type: none"> Exotic Flora Management <ul style="list-style-type: none"> Undertake a survey of the lower sections of this reach to identify Parrots Feather. Implement an eradication program targeting the known infestation at the confluence with Castle Creek. Undertake weed management, firstly targeting seedling woody species (e.g. Black Willow, Box Elder, Ash, Blackberry), then controlling all other species. Salvage more durable logs from tree removal for use as placed Large Woody Habitat both instream (under the direction of the NECMA) and within the revegetated riparian area. 	A	Exotic Flora Degraded Riparian Vegetation		✓	✓	✓		



Strategies and Actions	Implementation Order	Key Threats Addressed	Riparian Zone Types Present					
			Formal Parkland	Informal Parkland	Riparian Reserve	Rural Riparian Reserve	Habitat Reserve	Constructed Floodway
<ul style="list-style-type: none"> Native Flora Management <ul style="list-style-type: none"> Undertake revegetation following weed control to improve bank stability and re-establish native vegetation structure, continuity and width. Develop a Wetland Management Plan – Seek community input and develop a management plan for the Common Reed wetland at David Winterbottom Park. 	B	Degraded Riparian Vegetation		✓	✓	✓		
<ul style="list-style-type: none"> Stakeholder Engagement <ul style="list-style-type: none"> Discuss land management practices/improvement opportunities with relevant manager/authority including rubbish dumping, weed control methods, garden escapes and avoiding planting invasive garden specimens close to the waterway. 	A	Exotic Flora Urban Development		✓	✓			
Castle Creek – Upper Reach								
<ul style="list-style-type: none"> Stock Access Management <ul style="list-style-type: none"> Negotiate with landholders to fence off creekline to manage stock grazing pressures. This will help protect stream banks from compaction, pugging, the development of tracks and associated sediment inputs and impacts on riparian vegetation. 	A	Stock Access Increased Bed Instability & Bank Erosion Degraded Riparian Vegetation				✓		
<ul style="list-style-type: none"> Exotic Flora Management <ul style="list-style-type: none"> Undertake weed management, targeting Blackberry and Willows. 	B	Exotic Flora Degraded Riparian Vegetation				✓		
<ul style="list-style-type: none"> Native Flora Management <ul style="list-style-type: none"> Revegetate riparian areas that have been fenced from stock. This may only require top up revegetation using missing lifeforms (e.g. shrubs only if trees are present). This will prevent incremental vegetation loss and improve structure, continuity and width. 	B	Degraded Riparian Vegetation				✓		
Castle Creek – Mid Reach								
<ul style="list-style-type: none"> Stock Access Management <ul style="list-style-type: none"> Negotiate with landholders to fence off creekline to manage stock grazing pressures. This will help protect stream banks from compaction, pugging, the development of tracks and associated sediment inputs and impacts on riparian vegetation. 	A	Stock Access Increased Bed Instability & Bank Erosion Degraded Riparian Vegetation				✓		
<ul style="list-style-type: none"> Exotic Flora Management <ul style="list-style-type: none"> Undertake weed management, targeting Blackberry and Willows within the Grazed Rural Riparian Reserve. 	B	Exotic Flora Degraded Riparian Vegetation		✓		✓		
<ul style="list-style-type: none"> Native Flora Management <ul style="list-style-type: none"> Revegetate riparian areas that have been fenced from stock. This may only require top up revegetation using missing lifeforms (e.g. shrubs only if trees are present). This will prevent incremental vegetation loss and improve structure, continuity and width. Assist in the revegetation and management of Riparian Reserve (WREN Precinct A Site 5A). 	B	Degraded Riparian Vegetation				✓		
Castle Creek – Lower Reach								
<ul style="list-style-type: none"> Exotic Flora Management <ul style="list-style-type: none"> Undertake weed management, firstly targeting seeding woody species (e.g. Black Willow, Box Elder, Ash, Blackberry), then controlling all other species. Salvage more durable logs from tree removal for use as placed Large Woody Habitat both in stream (under the direction of the NECMA) and within the revegetated riparian area. 	A	Exotic Flora Degraded Riparian Vegetation		✓	✓	✓		
<ul style="list-style-type: none"> Native Flora Management <ul style="list-style-type: none"> Undertake revegetation following weed control to improve bank stability and re-establish native vegetation structure, continuity and width. 	B	Degraded Riparian Vegetation		✓	✓	✓		



Strategies and Actions	Implementation Order	Key Threats Addressed	Riparian Zone Types Present						
			Formal Parkland	Informal Parkland	Riparian Reserve	Rural Riparian Reserve	Habitat Reserve	Constructed Floodway	
<ul style="list-style-type: none"> ■ Bed Instability and Bank Erosion Management <ul style="list-style-type: none"> ■ Undertake a stability analysis to determine the extent of active deepening, and potential for head-out initiation if large willows root masses are to be removed from instream. This may lead to the design and construction of rock chutes to manage the deepening. ■ Review the integrity of the informal rock chute immediately upstream of the House Creek confluence 	A	Increased Bed Instability & Bank Erosion		✓	✓	✓			
House Creek – Upper Reach									
<ul style="list-style-type: none"> ■ Exotic Flora Management <ul style="list-style-type: none"> ■ Engage key stakeholders, including the community, to ensure cooperation in the development of a detailed and coordinated weed management plan for the entire House Creek riparian corridor. A coordinated approach is required as there are seeding tree weeds throughout. Consult with freehold property owners on right bank. ■ Undertake weed management, firstly targeting seeding woody species (e.g. Black Willow, Box Elder, Ash, Blackberry), then controlling all other species. Salvage more durable logs from tree removal for use as placed Large Woody Habitat both instream (under the direction of the NECMA) and within the revegetated riparian area. 	A	Exotic Flora Degraded Riparian Vegetation	✓	✓	✓				
<ul style="list-style-type: none"> ■ Native Flora Management <ul style="list-style-type: none"> ■ Undertake revegetation following weed control to improve bank stability and re-establish native vegetation structure, continuity and width. 	B	Degraded Riparian Vegetation	✓	✓	✓				
<ul style="list-style-type: none"> ■ Bed Instability and Bank Erosion Management <ul style="list-style-type: none"> ■ Undertake a stability analysis of the House Creek to determine the extent of potential deepening and bank erosion. This may lead to the design and construction of rock chutes to manage the deepening or rock beaching and/or revegetation to manage bank erosion. ■ Review the bank erosion identified in this reach, particularly along the right bank adjacent to freehold land. Negotiate revegetation on freehold riparian land adjacent to identified instabilities. ■ Review the impacts of sedimentation and support efforts to reduce sediment generation in the upstream catchments of the Huon and Castle Creeks 	B	Increased Bed Instability & Bank Erosion	✓	✓	✓				
House Creek – Mid Reach									
<ul style="list-style-type: none"> ■ Exotic Flora Management <ul style="list-style-type: none"> ■ Undertake a survey of the entire length of House Creek to identify Parrots Feather infestations. Implement an eradication program on identified infestations (e.g. immediately upstream of Lawrence Street, within Les Stone Park). ■ Undertake weed management, firstly targeting seeding woody species (e.g. Black Willow, Box Elder, Ash, Blackberry), then controlling all other species. Salvage more durable logs from tree removal for use as placed Large Woody Habitat both instream (under the direction of the NECMA) and within the revegetated riparian area. 	A	Exotic Flora Degraded Riparian Vegetation	✓	✓					
<ul style="list-style-type: none"> ■ Native Flora Management <ul style="list-style-type: none"> ■ Maintain existing revegetation Undertake revegetation following weed control to improve bank stability and re-establish native vegetation structure, continuity and width. 	B	Degraded Riparian Vegetation	✓	✓					
<ul style="list-style-type: none"> ■ Bed Instability and Bank Erosion Management <ul style="list-style-type: none"> ■ Undertake a stability analysis to determine the potential for head-out initiation if large willows root masses are to be removed from instream during woody weed control. This may lead to the design and construction of rock chutes to manage any deepening processes. 	A	Increased Bed Instability & Bank Erosion	✓	✓					



Strategies and Actions	Implementation Order	Key Threats Addressed	Riparian Zone Types Present					
			Formal Parkland	Informal Parkland	Riparian Reserve	Rural Riparian Reserve	Habitat Reserve	Constructed Floodway
House Creek – Lower Reach								
<ul style="list-style-type: none"> Exotic Flora Management <ul style="list-style-type: none"> Undertake weed management, firstly targeting seeding woody species (e.g. Black Willow, Box Elder, Ash, Blackberry), then controlling all other species. Salvage more durable logs from tree removal for use as placed Large Woody Habitat both in stream (under the direction of the NECMA) and within the revegetated riparian area. Investigate the potential risks associated with removing vegetation (weeds) adjacent to the abattoir. Woody weeds may be performing important nutrient stripping roles and therefore well planned, phased replacement of weeds with natives may be required. 	A	Exotic Flora Degraded Riparian Vegetation	✓	✓	✓			
<ul style="list-style-type: none"> Native Flora Management <ul style="list-style-type: none"> Undertake revegetation following weed control to improve bank stability and re-establish native vegetation structure, continuity and width. 	B	Degraded Riparian Vegetation	✓	✓	✓			
<ul style="list-style-type: none"> Bed Instability and Bank Erosion Management <ul style="list-style-type: none"> Undertake a stability analysis to determine the potential for head-cut initiation if large willows root masses are to be removed from in stream during woody weed control. This may lead to the design and construction of rock chutes to manage any deepening processes. 	A	Increased Bed Instability & Bank Erosion	✓	✓	✓			
Jack-in-the-Box Creek – White Box Rise Reach								
<ul style="list-style-type: none"> Exotic Flora Management <ul style="list-style-type: none"> Continue to control weeds at low levels within Jack Perry Reserve to protect high quality native vegetation (i.e. protect the best vegetation within the reach). Survey the creekline within the industrial area between Victoria Cross Parade and Thomas Mitchell Drive and control high threat weeds. 	B	Exotic Flora Degraded Riparian Vegetation			✓			
<ul style="list-style-type: none"> Bed Instability and Bank Erosion Management <ul style="list-style-type: none"> Address the local erosion that has been identified in the Jack Perry Reserve immediately upstream of Victoria Cross Parade. 	A	Increased Bed Instability & Bank Erosion			✓			
<ul style="list-style-type: none"> Manage Sediment Inputs <ul style="list-style-type: none"> Investigate the sources of sediment (including the White Box Rise Development) and implement sediment mitigation actions to limit the movement of sediment into the stormwater and creek systems. 	A	Increased Bed Instability & Bank Erosion Reduced Water Quality			✓			
Jack-in-the-Box Creek – Piped Reach								
<ul style="list-style-type: none"> Water Quality Management <ul style="list-style-type: none"> Investigate water quality and consider the design and installation of gross pollutant traps at the junction pit at Osburn Street. 	A	Reduced Water Quality						✓
<ul style="list-style-type: none"> Native Flora Management <ul style="list-style-type: none"> Undertake additional revegetation in patches if there is sufficient clearance available between the floodway and adjacent housing. 	B	Degraded Riparian Vegetation						✓
Jack-in-the-Box Creek – Lower Reach								
<ul style="list-style-type: none"> Exotic Flora Management <ul style="list-style-type: none"> A weed control program should be implemented, firstly controlling weeds amongst remnant Red Gums around the old railway line and freeway, then undertaking staged removal of weeds along the remainder of the reach. 	B	Exotic Flora Degraded Riparian Vegetation			✓			
<ul style="list-style-type: none"> Sediment Management <ul style="list-style-type: none"> Sediment extraction has the potential to contribute to channel instabilities and increase sediment transport rates within this reach. Undertake an investigation to determine the impacts associated with the periodic sediment extraction activities. 	A	Increased Bed Instability & Bank Erosion Reduced Water Quality			✓			



Strategies and Actions	Implementation Order	Key Threats Addressed	Riparian Zone Types Present					
			Formal Parkland	Informal Parkland	Riparian Reserve	Rural Riparian Reserve	Habitat Reserve	Constructed Floodway
<ul style="list-style-type: none"> ■ Native Flora Management <ul style="list-style-type: none"> ■ Undertake revegetation following weed control to improve bank stability and re-establish native vegetation structure, continuity and width. ■ The presence and abundance of the rare Wallaby Grass at the downstream end of the reach (Vivid Consulting, 2015), should be confirmed and suitable protection and enhancement measures implemented. 	B A	Degraded Riparian Vegetation			✓			
Middle Creek – Upper Reach								
<ul style="list-style-type: none"> ■ Stock Access Management <ul style="list-style-type: none"> ■ Negotiate with landholders to fence off creekline to manage stock grazing pressures. This will help protect stream banks from compaction, pugging, the development of tracks and associated sediment inputs and impacts on riparian vegetation. 	A	Stock Access Increased Bed Instability & Bank Erosion Degraded Riparian Vegetation				✓		
<ul style="list-style-type: none"> ■ Bed Instability and Bank Erosion Management <ul style="list-style-type: none"> ■ Undertake a stability analysis to determine the extent of active deepening, and potential for head-cut initiation if large willows root masses are to be removed from instream. This may lead to the design and construction of rock chutes to manage the deepening. 	A	Increased Bed Instability & Bank Erosion				✓		
<ul style="list-style-type: none"> ■ Exotic Flora Management <ul style="list-style-type: none"> ■ Undertake weed management, targeting Blackberry and Willows. 	B	Exotic Flora Degraded Riparian Vegetation				✓		
<ul style="list-style-type: none"> ■ Native Flora Management <ul style="list-style-type: none"> ■ Undertake revegetation following weed control to improve bank stability and re-establish native vegetation structure, continuity and width. 	B	Degraded Riparian Vegetation				✓		
Middle Creek – Mid Reach								
<ul style="list-style-type: none"> ■ Bed Instability and Bank Erosion Management <ul style="list-style-type: none"> ■ A series of rock chutes (bed grade control structures) are present downstream of Frederic Street Road. These rock chutes provide an important function in maintaining channel stability within this reach, particularly as further development is planned within this reach. The structures should be regularly monitored and maintained as necessary. 	A	Increased Bed Instability & Bank Erosion				✓		
<ul style="list-style-type: none"> ■ Stock Access Management <ul style="list-style-type: none"> ■ Negotiate with landholders to fence off creekline to manage stock grazing pressures. This will help protect stream banks from compaction, pugging, the development of tracks and associated sediment inputs and impacts on riparian vegetation. 	A	Stock Access Increased Bed Instability & Bank Erosion Degraded Riparian Vegetation				✓		
<ul style="list-style-type: none"> ■ Exotic Flora Management <ul style="list-style-type: none"> ■ Undertake weed management, targeting Blackberry and Willows and any other woody exotics. 	B	Exotic Flora Degraded Riparian Vegetation				✓		
<ul style="list-style-type: none"> ■ Native Flora Management <ul style="list-style-type: none"> ■ Revegetate riparian areas that have been fenced from stock, or where grazing is absent. There are large sections of creekline without riparian vegetation despite there being planted native woodlands nearby. This revegetation will help to stabilise banks and improve structure, continuity and width of the vegetation corridor. ■ Wodonga Council have developed a Waterway Masterplan for the N1 tributary (an unnamed tributary of Middle Creek) which is contained within one of the proposed development areas. Waterway management recommendations for this tributary in context of the proposed development and the existing waterway condition are provided in the Waterway Masterplan. 	B	Degraded Riparian Vegetation				✓		



Strategies and Actions	Implementation Order	Key Threats Addressed	Riparian Zone Types Present				
			Formal Parkland	Informal Parkland	Riparian Reserve	Rural Riparian Reserve	Habitat Reserve
Middle Creek – Lower Reach							
<ul style="list-style-type: none"> ■ Exotic Flora Management <ul style="list-style-type: none"> ■ This reach has extensive yet patchy infestations of Crack willow along the channel and across the floodplain. Develop a phased Willow management plan to ensure a complete and coordinated approach to eradication, ideally commencing from the top of the reach and working downstream. ■ Control all other weeds including Blackberry and invasive herbaceous species. 	A A	Exotic Flora Degraded Riparian Vegetation			✓	✓	
<ul style="list-style-type: none"> ■ Native Flora Management <ul style="list-style-type: none"> ■ Undertake revegetation along the creekline where woody vegetation is absent and following willow removal. This revegetation will help to stabilise banks and improve structure, continuity and width of the vegetation corridor. ■ Negotiate revegetation of the floodplain following Willow removal. A 'swampy' riparian woodland EVC may be more appropriate for revegetation in the wetter areas of the floodplain. 	B	Degraded Riparian Vegetation			✓	✓	
Yackandandah Creek – Staghorn Flat Reach							
<ul style="list-style-type: none"> ■ Stock Access Management <ul style="list-style-type: none"> ■ Negotiate with landholders to fence off creekline to manage stock grazing pressures. This will help protect stream banks from compaction, pugging, the development of tracks and associated sediment inputs and impacts on riparian vegetation. 	A	Stock Access Increased Bed Instability & Bank Erosion Degraded Riparian Vegetation				✓	✓
<ul style="list-style-type: none"> ■ Sediment Management <ul style="list-style-type: none"> ■ Support stock fencing and revegetation programs to minimise bed and bank disturbance and therefore minimise sediment input to the creek. ■ Investigate and mitigate bed deepening and widening in the Yackandandah Creek tributaries. 	A	Increased Bed Instability & Bank Erosion				✓	
<ul style="list-style-type: none"> ■ Exotic Flora Management <ul style="list-style-type: none"> ■ Survey for the presence of high threat weeds in the Baranduda Bushland Reserve and implement appropriate controls. ■ Undertake willow management activities targeting widespread and extremely invasive seeding species (i.e. Black Willow, Pussy Willow, Golden Willow and Purple Osier). ■ Undertake a phased weed management program to eradicate mature seeding poplars and control juvenile poplars. ■ Undertake a phased weed management program to eradicate Crack Willow and other less invasive willow species (e.g. Pencil, Tortured and Weeping Willow) ■ Undertake a weed management program targeting the remaining small tree (e.g. Hawthorn), shrub (e.g. Gorse, Broom) and herbaceous weed species (e.g. Bathurst Burr). 	A A B C D	Exotic Flora Degraded Riparian Vegetation				✓	✓
<ul style="list-style-type: none"> ■ Native Flora Management <ul style="list-style-type: none"> ■ Revegetate riparian areas that have been fenced from stock. This may only require top up revegetation using missing lifeforms (e.g. shrubs only if trees are present). This will prevent incremental vegetation loss and improve structure, continuity and width. 	B	Degraded Riparian Vegetation				✓	✓
Yackandandah Creek – Kiewa Reach							
<ul style="list-style-type: none"> ■ Stock Access Management <ul style="list-style-type: none"> ■ Negotiate with landholders to fence off creekline to manage stock grazing pressures. This will help protect stream banks from compaction, pugging, the development of tracks and associated sediment inputs and impacts on riparian vegetation. 	A	Stock Access Increased Bed Instability & Bank Erosion Degraded Riparian Vegetation				✓	



Strategies and Actions	Implementation Order	Key Threats Addressed	Riparian Zone Types Present					
			Formal Parkland	Informal Parkland	Riparian Reserve	Rural Riparian Reserve	Habitat Reserve	Constructed Floodway
<ul style="list-style-type: none"> ■ Sediment Management <ul style="list-style-type: none"> ■ Support stock fencing and revegetation programs to minimise bed and bank disturbance and therefore minimise sediment input to the creek. ■ Large woody debris placement within the Kiewa Reach would reduce the transport and export of sediment to the Kiewa River. 	A	Increased Bed Instability & Bank Erosion Sedimentation				✓		
<ul style="list-style-type: none"> ■ Exotic Flora Management <ul style="list-style-type: none"> ■ Undertake a woody weed eradication program, firstly targeting seeding species (e.g. Black Willow, Poplar, Box Elder), then implementing the phased removal of Crack Willow throughout the reach. 	A	Exotic Flora Degraded Riparian Vegetation				✓		
<ul style="list-style-type: none"> ■ Native Flora Management <ul style="list-style-type: none"> ■ Revegetate riparian areas that have been fenced from stock. This will prevent incremental vegetation loss of large Red Gums and improve structure, continuity and width. Revegetation of the Kiewa Reach will provide a habitat link/corridor between the Kiewa River and the upstream reaches of the Yackandandah Creek, including the Baranduda Bushland Reserve. 	B	Degraded Riparian Vegetation				✓		
Kiewa River – Lower Reach								
<ul style="list-style-type: none"> ■ Stock Access Management <ul style="list-style-type: none"> ■ Negotiate with landholders to fence off creekline to manage stock grazing pressures. This will help protect stream banks from compaction, pugging, the development of tracks and associated sediment inputs and impacts on riparian vegetation. 	A	Stock Access Increased Bed Instability & Bank Erosion Degraded Riparian Vegetation				✓		
<ul style="list-style-type: none"> ■ Bank Erosion Management <ul style="list-style-type: none"> ■ Establish broad and dense revegetation in areas aimed at controlling bank erosion. Such works will also improve riparian vegetation continuity, structure and width. 	A	Increased Bed Instability & Bank Erosion			✓	✓		
<ul style="list-style-type: none"> ■ Exotic Flora Management <ul style="list-style-type: none"> ■ Undertake willow management activities targeting willows that are not contributing to bank stability (i.e. growing in/on depositional zones such as gravel bars and inside bends). ■ Actively manage willows that are senescing, collapsing and causing bank instabilities. ■ Undertake phased willow management program to control all remaining Crack Willow and other woody weed species. 	A A B	Exotic Flora Degraded Riparian Vegetation			✓	✓		
<ul style="list-style-type: none"> ■ Native Flora Management <ul style="list-style-type: none"> ■ Revegetate riparian areas that have been fenced from stock. This may only require top up revegetation using missing lifeforms (e.g. shrubs only if trees are present). This will prevent incremental vegetation loss and improve structure, continuity and width. 	B	Degraded Riparian Vegetation			✓	✓		



6.2 Future and Existing Developments

As discussed in Section 2.2, the Wodonga City Council has been, and will be subject to future urban development and growth. Future development, including potential impacts to surrounding waterways is managed through the Planning Permit and Works on Waterways Permit process outlined in Section 2.6. General recommendations associated with future and existing developments are provided with consideration of two broad objectives for developments, consistent with Council's Sustainability Strategy, (Wodonga City Council, 2014), namely:

- Accounting for the needs of the future Growth Area and existing development.
- Sustainably accounting for the values and processes of the waterways contained within and surrounding future Growth Area and existing development.

For the most part, the objectives outlined in the previous points can be achieved through appropriate planning and management. General recommendations include:

- Incorporating suitable soil and water management arrangements associated with land development and construction sites (discussed in Section 3.6).
- Incorporating an open space/waterway corridor (e.g. through a Public Parks and Recreation Zone (PPRZ)) that encompasses the 100-year Average Recurrence Interval or 1% Annual Exceedance Probability flood extent.
- Placing shared recreational paths above the 10-year Average Recurrence Interval or 10% Annual Exceedance Probability flood extent in accordance with the Melbourne Water Shared Path Guidelines (Melbourne Water, 2009). This places the shared recreational path within the open space/waterway corridor.
- Providing an adequate vegetated buffer from the tributary to:
 - Minimise human activity and maximise habitat connectivity along the waterway in accordance with the recommendations of the Wodonga Retained Environment Network (WREN) Strategy (Albury-Wodonga Corporation, 2006).
 - Account for future erosion processes.

A minimum buffer of 30m is typically required.

- In general, new infrastructure should not be placed within ten metres of the top of any stream bank to account for future erosion processes. This is particularly recommended on outside bends.
- Waterway crossing positions should consider waterway processes. For instance, crossings should not be placed on outside bends.
- Similarly, future stormwater outlet locations should consider waterway process and not be positioned on outside bends.

Future urban development within catchments has the potential to increase erosive power thus causing and exacerbating erosion issues within a waterway (Section 3.2). Therefore, it is strongly recommended that inflow and runoff associated with future developments within the project area be managed through the implementation of water sensitive urban design techniques such as the construction of retention basins/wetlands in future developments such that peak flows are not in excess of the pre-development conditions. Water Sensitive Urban Design is incorporated within best practice management techniques for developments and forms a component of the Planning Permit and Works on Waterways Permit requirements.



6.3 Key Management Tools

The following on ground management techniques are considered most appropriate to achieve the vision and objectives detailed in Section 5.

6.3.1 Vegetation Establishment

Vegetation establishment is considered the key technique for meeting the vision and objectives for waterway management within the project area.

The benefits of vegetation include:

- Assisting channel stability and reducing rates of channel change.
- Improving aquatic and terrestrial ecology values of a waterway.
- Improving the social and economic values of a waterway.
- In time, revegetation will provide a source of instream logs and branches, which in turn provides complex habitat that leads to improved aquatic biodiversity.

Revegetation of the riparian zone is the most cost-effective form of erosion control in the long term. A comprehensive revegetation program should aim to plant native species on the bank face, top of bank and beyond the top of bank for as wide as can be accommodated. The revegetation offset should extend as wide as practical, **typically a minimum of ten metres** beyond top of bank.

Denser plantings are encouraged on the bank face and on outside bends. Revegetation activities must involve a mixture of indigenous species to assist bank stability. Grasses, reeds, rushes, sedges and shrubs all have a significant role in assisting bank stability and should be the primary focus of revegetation activities aimed at assisting bank stability.

Additional revegetation recommendations include:

- A vegetation survey in an adjoining or nearby stream system with riparian vegetation will assist identification of the most appropriate native species. Take note of where particular species occur in relation to the river channel (e.g. lower bank, mid bank, upper bank or floodplain).
- Preferably a range of species should be used, including trees, shrubs and ground covers.
- If overstorey trees are present, reduce or eliminate the number of trees planted.
- Utilise and protect natural recruitment of native species wherever present. These plants will have the greatest prospect for survival.
- Prior to planting seedlings, reduce weed cover as much as possible from the planting area. Ideally one full year of weed control should occur before planting.
- Avoid ripping soils in riparian areas that may be subject to flooding.
- Soil preparation, the aim is to create good tilth (loose friable soil) in which to plant your seedlings.
- Newly planted seedlings may need protection from browsing or trampling from domestic or native animals.
- Gently water new plants with a few litres of water over the first year of their life.

The North East CMA website contains further information, including relevant links to determine appropriate species selection (<http://www.necma.vic.gov.au/Solutions/Plants-Animals/Native-Plants-Animals/Vegetation-communities-revegetation>).

Riparian vegetation widths should be determined on an individual property/works site basis as part of the appropriate planning process taking into consideration:



- The works type proposed for the site.
- Ongoing management issues (e.g. weed spraying access).
- Interaction of floodplain and channel landforms.
- Property size and layout.
- Estimated meander migration direction and rate.
- Estimated erosion rate.
- Ecological benefits.
- Existing infrastructure.
- Land planning issues.
- Stock access and watering.
- Existing remnant vegetation.
- Riparian corridor links.

Concept revegetation arrangements for both vertical bank profiles and sloped bank profiles are illustrated in Figure 6-1 and Figure 6-2 respectively.

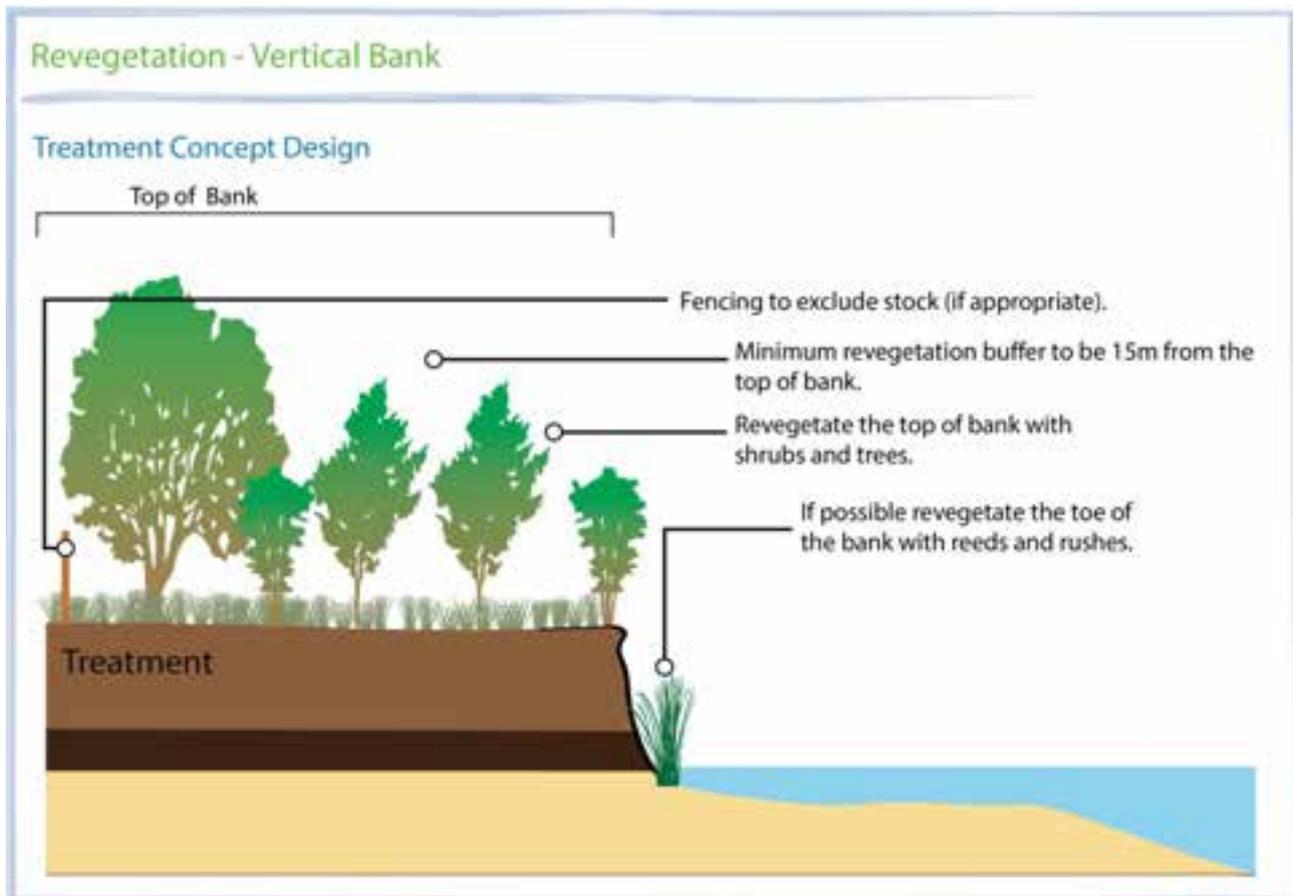


Figure 6-1 Concept vegetation arrangement involving a vertical bank profile.



Revegetation - Sloped bank

Treatment Concept Design

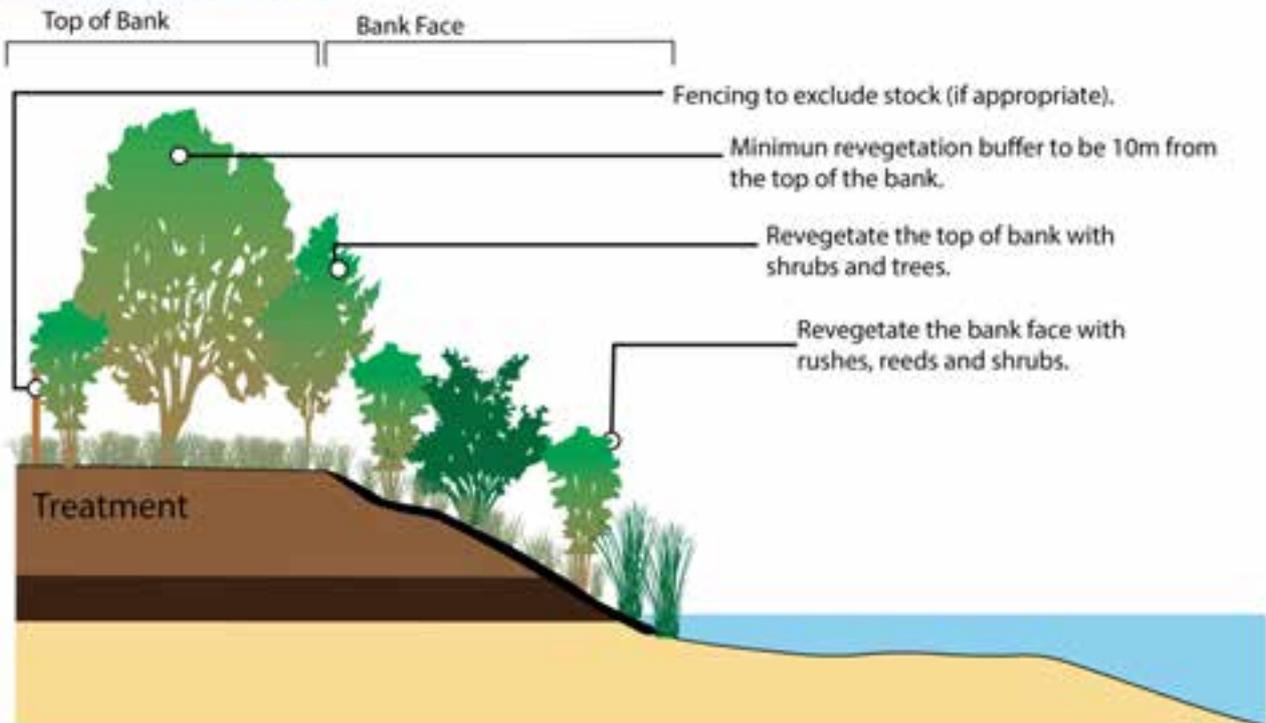


Figure 6-2 Concept revegetation arrangement for a sloped bank profile.

6.3.1.1 Managing Fire Risk

The CFA strongly encourage that fire risk be considered during the planning stage of revegetation works. Specific recommendations include:

- Consideration of the proximity of vegetation to adjoining housing and infrastructure.
- Incorporating a fire break along the edge of the revegetation.
- Incorporating a discontinuous coverage of canopy species to minimise risk and spread of canopy fires.
- Monitoring and maintenance to manage the fuel loads.

Fire risk management may conflict with environmental aims if vegetation or logs and ground litter are to be thinned or removed. Therefore, a balance needs to be found between habitat values and fire risk mitigation particularly in urban areas with a high occupancy and the proximity of infrastructure.

6.3.2 Fencing (Stock Exclusion)

Fencing is the most common approach to control stock in riparian zones. Fencing may be employed where stock exclusion will protect and/or enhance the riparian zone. This approach is particularly applicable where a healthy riparian zone (including remnant vegetation) is already present and a seed source for future natural recruitment is available. Stock exclusion can improve a riparian zone through improvements in natural regeneration and stream bank stability. Fencing also has the potential to improve the riparian zone in areas where macrophytes are currently grazed and their density is declining. Complementary revegetation may be



beneficial several years after the installation of fencing, targeting any species or structural and poor density areas not filled by natural recruitment.

Guidelines for the riparian vegetation in flood-prone areas have been prepared by the Victorian Department of Environment, Land, Water and Planning ([https://www.nrmnorth.org.au/client-assets/documents/factsheets-brochures/nrm/Flood%20Fencing%20-%20Guidelines%20\(Vic\).pdf](https://www.nrmnorth.org.au/client-assets/documents/factsheets-brochures/nrm/Flood%20Fencing%20-%20Guidelines%20(Vic).pdf)).

6.3.3 Woody Weed Management

Woody weed management involves the management (control or eradication) of all woody weeds deemed to have a negative influence on environmental health.

6.3.3.1 Willow Management

Willows are the most prevalent and problematic woody weed species within the project area. Adverse impacts associated with willows are discussed in Section 3.10.

Willow management will primarily involve the phased poisoning of all willow species. The general willow management rationale shall be as follows:

- Where the invasive willow species are assisting channel stability, willow management shall be undertaken as a staged process involving suitable alternative stabilisation works (e.g. revegetation).
- Where invasive willow species are not assisting channel stability they should be totally eradicated. Complementary revegetation activities should be undertaken as required to improve the riparian vegetation condition at the site.

Willow management activities must be undertaken with due consideration of site-specific issues and the management of stakeholder expectations. This may necessitate a staged approach to works even where willows are not assisting channel stability.

Further information regarding willow management is provided in the Managing Willows in the North East Catchment Policy Document (<http://www.necma.vic.gov.au/About-Us/Publications/Plans-and-Guides/Willow-Management-in-the-North-East>).

6.3.3.2 Other Weeds

Without intervention, invasive weed species such as Blackberry etc. will likely continue to colonise the riparian zone of the waterways within the project area. Hence a weed management program targeting highly invasive and noxious weeds is strongly recommended.

6.3.4 Structural Works

Occasionally, structural works may be required to address specific threats to waterway health or other environmental or structural assets. In these instances, specialist design advice should be sought to ensure the intended works consider the relevant waterway processes and account for the necessary design considerations. Typical best practice management techniques that may be utilised are discussed in Section 6.3.4.1 to Section 6.3.4.3.

In the planning stage of a project aimed at managing erosion, it is important to assess the implications associated with not undertaking structural works. In many circumstances, erosion processes are most effectively managed in the long term through vegetation establishment and stock exclusion.



6.3.4.1 Rock Beaching

Rock beaching (also known as rock riprap or rock revetment) involves the placement of angular quarry rock against the stream bank to prevent further erosion of the bank in the medium term (Figure 6-3).

Rock beaching is a favoured erosion management technique as it is suited to addressing multiple localised mechanisms of bank erosion. The placement of rock beaching against a stream bank removes the shear stresses associated with moving water from the bank material contained. Rock beaching works are typically favoured where:

- Alternative stabilisation techniques may not address the erosion process.
- Revegetation works cannot be undertaken (e.g. camping areas).
- An asset is under imminent threat (e.g. an access track, other public infrastructure, remnant vegetation).

Revegetation establishment is strongly encouraged behind the rock beaching.

Notably, rock beaching is an expensive technique and it can have adverse waterway health outcomes in certain circumstances.

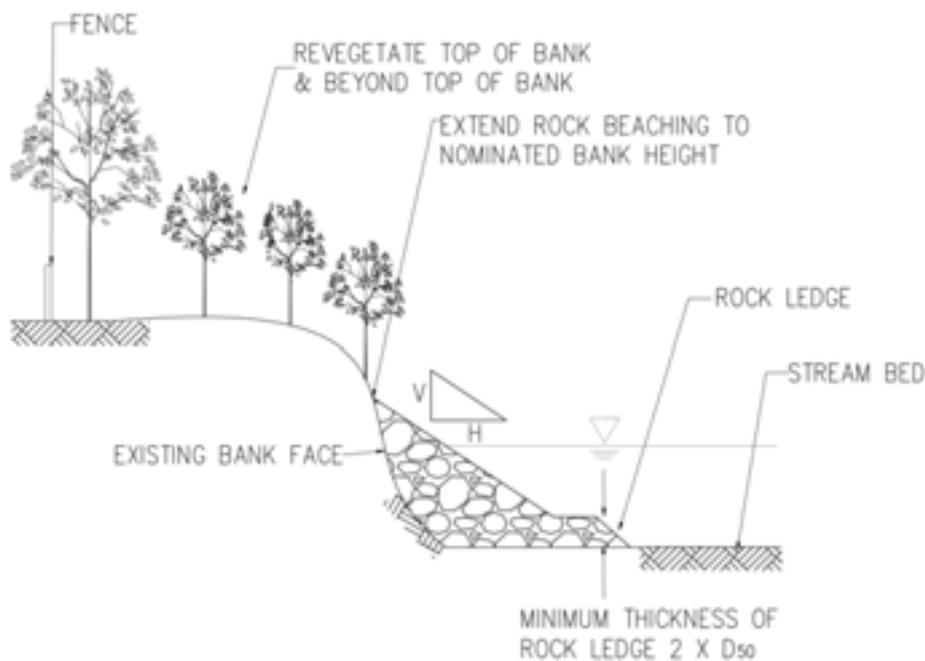


Figure 6-3 Conceptual rock beaching concept design arrangement.

6.3.4.2 Timber Revetment

Timber revetment (also known as log revetment or timber brushing) involves the placement of timber on a stream bank with the objective of preventing bank erosion over the medium term (Figure 6-4).

The treatment typically extends into the bed of the stream to deal with scour of the bed and is held onto the bank with either timber piles or cables that are anchored to stakes or piles at the top of the bank. A gravel filter layer or filter fabric can be placed under the timber to prevent flow permeating and eroding the bank material behind the timber. The application of this technique will be strongly dependent upon the availability of suitable timber and the arrangement of individual timbers.



Revegetation establishment is strongly recommended behind the timber revetment to provide long term channel stability.



Figure 6-4 An example of a timber revetment site, aimed at managing bank erosion. The application of this technique is strongly dependent upon the availability and arrangement of suitable timber.

6.3.4.3 Rock Chute

A rock chute is a relatively short, steep grade control structure that provides a stable transition from one bed gradient to a lower bed gradient through rock armouring (Figure 6-5). Rock chutes are an effective method of providing bed grade control, are commonly used across Australia and are generally considered best practice management regarding addressing bed deepening/head-cuts within waterways.

Where rock chutes are considered an option, it is recommended a longitudinal survey be undertaken to

- Defining the magnitude of the knickpoints.
- Identifying a stable bed grade in a similar section of creek nearby.
- Comparing the stable bed grade to the current bed grade where knickpoints are present.

Note that frequently stream bed deepening is not evident through discrete vertical head cuts apparent to the naked eye, but through steep bed gradients that can only be identified by analysing a longitudinal stream bed survey.



Figure 6-5 An example rock chute, aimed at providing a stable bed gradient from one bed elevation to a lower bed elevation.



7 MONITORING AND EVALUATION

Responsible investment in river restoration requires monitoring and evaluation of these projects. Monitoring and evaluation are required to:

- Ascertain the condition of the works and identify maintenance requires. The majority of erosion protection measures that fail are associated with a lack of maintenance.
- Ensure the works are not negatively impacting upon the waterway and its surrounding environments.
- Improve our understanding of the processes of degradation and our ability to prescribe efficient restoration treatments (Stewardson et al. 2004).
- Share results of the project, regardless of whether they have achieved their stated objectives or not (Cottingham et al. 2005).

Monitoring should be more frequent during the first year following any waterway disturbance and stabilisation works implementation. In general, is recommended that a visual assessment of the site be carried out weekly for the first two months following the completion of works, monthly for a further ten months and, six-monthly after that. Inspections should also be carried out immediately following high flow or rainfall events. A list of things to look for when monitoring waterway management works is provided in Table 7-1.

Monitoring of waterways can use complex methods like the Index of Stream Condition (ISC) and Works Monitoring Method (WMM), however these methods require a level skill or training, are relatively time consuming and require access to data entry tools. Therefore, these methods become costly and are unlikely to be undertaken on community-based projects. A simpler approach is more likely to be used, will provide more immediate results and will be easier to understand and communicate. Since most of the works will involve weed control and revegetation, the following simple monitoring methods might be adopted:

- **Photopoints** - Establish photopoints before works and continue photographing the site/reach over time. Photopoints can provide a visual reference of state and change over time if photographs are taken consistently and compared. Photopoints should be used as a monitoring tool regardless of the riparian land management and works type. If public participation and interest is high, the installation and use of Fluker Posts can be adopted. "People can now help monitor precious environments on their phones via a new mobile app – the Fluker Post App. This app, which was released in March 2018, is a collaboration between Victoria University and the Victorian Government to encourage the community to capture photos of the waterways and landscapes they love and use, and immediately upload their photos to the app to provide a permanent visual record of the location. The app includes an archive of historical photos and allows users to see what the location looked like under different weather or management regimes" (<http://www.flukerpost.com/>).
- **Measure weed cover** - Measure the density of weeds, either by count, percentage cover estimates or by percentage length of waterway infested by each species (i.e. chain/measure distance along the length of the waterway and record presence or absence of species of interest).
- **Measure revegetation success** - Record numbers or plants planted, record survival rate by species over time.
- **Measure native cover** – As undertaken for weeds, cover estimates and/or percentage length of waterway with overall native cover could be recorded.



Table 7-1 Key indicators to look for during ongoing monitoring.

Item	Key Indicators
Vegetation	Vegetation health (is vegetation healthy) Survival rate of revegetation Coverage (are there any exposed patches of soil) Presences of weeds
Weeds	Weed species present Extent of the weeds
Creek bed	Head-cuts Scour holes Bed level lowering Sedimentation
Creek banks	Erosion of the toe Bank slumping or collapse Channel widening
Floodplains and gullies	Erosion into the bank that is occurring through entry of overland flow Scour along the floodplain that heads back to the creek (potential avulsion)
Stormwater outlets	Scour downstream of the outlet Scour around the outlet Erosion of the bank at the entry point
Structures	Scour downstream of structure Scour or outflanking along sides of structure Integrity of structure Missing or displaced rock or concrete



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APPENDIX A – WATERWAY CONDITION MAPS AND SUMMARY SHEETS



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