Watercourse Management Plan for Mount Barker

A Report to the Mount Barker District Council

Catherine Miles

Miles Environmental Pty Ltd

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Miles Environmental Pty Ltd

E: cm@milesenvironmental.com.au

P: 0408 640 377

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1 SUMMARY

This report presents a plan for management of the watercourses within the townships of Mount Barker and a portion of Littlehampton. The objectives of the plan are:

- To prevent a decline in the condition of the watercourse, its biodiversity and other environmental values and
- To improve the condition of the watercourse, its biodiversity and other environmental values.

For the purposes of the plan, the creek is divided into management sections, each of which has been assigned a priority ranking according to its ecological values and restoration potential. Management requirements are prioritised for each section, providing a strategic approach for managing the watercourse (see Table 1-1).

The watercourse management plan describes each section and outlines the management priorities (Table 1-1). The final section highlights a number of key management issues:

- Management of Bulrush and Common Reeds
- Management of Spiny Rush and Drain Flat-sedge
- Creek widening and revegetation
- Promoting the use of local native species in revegetation
- Introduced deciduous trees
- Revegetation enhancement
- Native vegetation management skills of maintenance staff
- Follow-up weed control

Minimum monitoring requirements that are the responsibility of Council are outlined including targets and methods. Additional monitoring that would contribute towards the success of the management plan is also discussed.

A guideline for retaining and enhancing watercourses within new development areas has been prepared in conjunction with this report to ensure that additional watercourses coming into the Council's reserve system meet the objectives of this plan.

Table 1-1 Management priorities for Mt Barker watercourses

Section	Priority of Section	Management Priority			
		Very High	High	Medium	Low
1: Keith Stephenson Park	High	Remove Blackberry	Control Broom, Ash, African Daisy, Arum Lily and Fennel Revegetation to shade bulrushes	Flood mitigation Maintain and extend revegetation areas	
2: Adelaide Road to Junction with Littlehampton Creek	Low		Control Ash trees, Broom; contain Periwinkle to exotic dominated area	Erosion monitoring and management Remove Periwinkle Landscaping with local native species	Weed control Revegetation

Section	Priority of Section	Management Priority			
		Very High	High	Medium	Low
3: Willow Flat	Low	Remove Blackberry			Weed Control Revegetation
4: Anembo	Medium	Remove Gorse & Blackberry	Remove exotic trees in creek and Periwinkle Assess erosion risk and manage appropriately	Erosion management Revegetation	Rehabilitate south-eastern floodplain
5: Cornerstone College	High	Remove Blackberry, Boxthorn and Gorse	Control Desert Ash and wild Rose Maintain rabbit control	Maintain groundcover on banks for erosion control	Revegetation Improve habitat value of trees
6: Dunn Park to Junction with Western Flat Creek	Medium	Remove Blackberry, Broom, Boxthorn	Control climbing weeds in revegetation, exotic tree re-growth and contain and control Periwinkle	Revegetation in-fill	Remove remaining exotic trees Revegetation
7: Big Green	High	Remove Spiny Rush, Broom, Blackberry and exotic trees	Maintain and enhance revegetation Control Periwinkle, Ivy, Rose and other woody weeds		Plant shade trees along linear trail and creek
8: Laratinga	High	Remove Spiny Rush, Blackberry and Desert Ash	Contain and control Periwinkle Erosion monitoring and management	Maintain and enhance revegetation	
9: Railway Creek lower	Low	Remove Blackberry and Gorse	Remove exotic trees, Broom, Periwinkl and Arum Lily		Revegetate open areas
10: Railway Creek Mid	Low	Remove Desert Ash, Blackberry and Gorse	Contain and control Ivy Arborist assessment of River Red Gum	Remove other woody weeds	Revegetation
11: Eastern Creek	Medium		Control exotic trees, Ivy and Periwinkle	Revegetation	
12: Sports Hub	High	Remove Spiny Rush and Blackberry	Remove other high threat weeds Maintain channel morphology Assess erosion risk	Revegetation	Control erosion
Tributary Creeks	Low	Control very high threat weeds	Control exotic trees and remaining high threat weeds	Landscape with local native species Maintain existing revegetation areas Monitor and control erosion	Revegetation

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3 BACKGROUND

PROJECT AREA

The project area comprises the Mount Barker Creek and major tributaries within the township of Mount Barker and part of Littlehampton (see Map 1). The report addresses issues relating to the watercourse and immediate adjacent land.

The outflow of the Bremer River into Lake Alexandrina.

REGIONAL SETTING

The Mount Barker Creek is one of the major tributaries of the Bremer River, which flows into Lake Alexandrina near Milang, and hence it is part of the Murray-Darling catchment.

RELEVANT PLANS, STRATEGIES AND LEGISLATION

Plans and strategies that relate directly to parts of the Mount Barker Creek within the project area include:

- *Mount Barker, Littlehampton and Nairne Trails Plan* (Oxigen 2011)
- *Laratinga Reserve Management Plan* (EBS in prep.)
- *Mount Barker Flood Mapping Study: Draft Study Report* (Taylor et al. 2011)
- *Adelaide Road and Keith Stephenson Park Master Plan* (Hammett & Associates & Corbin 2010)
- *Draft Linear Trail Revegetation Action Plan* (Raymond 2004).

Plans, strategies and legislation relating to the Creek as part of a broader area include:

- *Mount Barker District Council Development Plan* (MBDC 2017a)
- *Biodiversity Strategy* (MBDC 2017b)
- The Natural Resources Management Act, 2004
- *The Water Allocation Plan for the Eastern Mount Lofty Ranges*
- *Regional (SAMDB) Natural Resources Management Plan: Volume A Strategic Plan*
- *Regional (SAMDB) Natural Resources Management Plan: Volume B Board Business and Operational Plan.*

This management plan should be used in conjunction with the Development Plan and Best Practice Operating Procedures – Water Affecting Activities (see Section 5.9).

MANAGEMENT TO DATE

Excluding one small section through Cornerstone College and some private land along the Railway Creek, the watercourses within the project area run through public land and are therefore primarily the responsibility of the Council.

Work carried out by the Council in recent years along various sections of watercourse has included:

- Removal of exotic trees and woody weeds and follow-up removal
- Revegetation with local native species and infill planting of older revegetation sites
- Erosion control
- Expansion of the creek bed to increase flow capacity and reduce flooding of the immediate areas
- Construction of a linear trail from Laratinga Wetland to Bollen Road and Cornerstone College, with interpretive signs.

Management to date has attempted to achieve a number of sometimes competing outcomes (due in part to its urban setting as well as the diverse expectations of the community) including:

- Maintaining amenity, cultural and heritage values
- Recreation and safety for the community
- Delivering clean water downstream
- Flood mitigation
- Reducing the negative impacts of the creek environment on the wider area (in particular with regards to the spread of weeds)
- Improving the ecological values of the creek.

This plan seeks to clearly articulate the objectives for the management of the watercourse and actions to achieve these.

4 WATERCOURSE MANAGEMENT PLAN

WATERCOURSE MANAGEMENT OBJECTIVE

The objectives of this plan are:

- To prevent a decline in the condition of the watercourse, its biodiversity and other environmental values and
- To improve the condition of the watercourse, its biodiversity and other environmental values.

These objectives are consistent with the Development Plan and Biodiversity Strategy for Mount Barker. The most relevant objectives for the watercourse management in the DC Mount Barker Development Plan (page 80; MBDC 2017a) are:

> *1. Retention, protection and restoration of the natural resources and environment.*
>
> *2. Protection of the quality and quantity of South Australia's surface waters, including inland and underground waters.*
>
> *4. Natural hydrological systems and environmental flows reinstated, and maintained and enhanced.*
>
> *8. Native flora, fauna and ecosystems protected, retained, conserved and restored.*
>
> *9. Restoration, expansion and linking of existing native vegetation to facilitate habitat corridors for ease of movement of fauna.*
>
> *10. Minimal disturbance and modification of the natural landform.*
>
> *13. Protection of the scenic qualities of natural and rural landscapes.*

Further to the above, the Mount Barker Biodiversity Strategy (MBDC 2017b) has the following relevant objectives and priority actions for habitat preservation and watercourse health:

> Objectives:
>
> - *To maintain and enhance good quality and connected habitat of flora and fauna.*
> - *Develop best practise management to optimise physical, chemical and biological state of watercourses in the district.*
>
> Priority Actions
>
> - *Prioritise weed management and integrate with existing programs and projects.*
> - *Develop conceptual linkages for fauna habitat (& potential habitat).*
> - *Develop strategic guidelines for best environmental practise of riparian planting and management.*

STRATEGIC FRAMEWORK

In order to assist the Council to most effectively allocate funds to manage and restore creek-lines within the study area, each management section has been assigned an overall priority and the management requirements within each section are prioritised.

The overall priority of the sections for management is derived from a rapid assessment of the ecological value of the sections based on:

- Naturalness (remnant vegetation, weeds, modifications to channel form, erosion)
- Diversity and richness (number of native plant species, range of habitats) (Bennett et al 2002).

More natural and more diverse sites are considered a higher priority on the basis that they require fewer resources to restore and have more to lose than highly modified and low diversity sites.

The presence of revegetation was also considered to increase the priority of an area because:

- Revegetated areas have the potential to have higher ecological value in the near future and
- The economic advantage of maintaining the original investment.

Management actions within each section were prioritised based on the following ecological criteria:

Very high – immediate action required to prevent the condition of the site and the wider catchment deteriorating

High – immediate action required to prevent the condition of the site deteriorating

Medium – action required to improve the condition of the site (relatively low level of resources required compared with the benefits)

Low – action required to improve the condition of the site (relatively high level of resources required compared with the benefit, or low cost and low level of benefit).

Combining the priority of the section and the management actions, the order of works translates into the following timeframe:

1. Implement very high management actions in the high priority section, then medium priority section then low
2. Implement the high management actions in the high priority section, then the medium priority section, then low priority section and so forth.

However, some actions may be re-prioritised as circumstances change, in particular:

- Where external funding becomes available for certain types of work
- Where flood works are carried out exotic trees are often removed in the process and revegetation should be carried out in the season following
- Where the linear trail is extended, exotic trees and woody weeds may be removed in the process and there is the opportunity to capitalise on this with further removal and revegetation.

SURVEY METHOD

The report is update to two previous surveys in 2006 (Miles 2006) and 2012 (Miles 2013a) and the Railway Creek survey in 2013 (Miles 2013b). This report includes some additional sections not previously surveyed and incorporates the watercourse assessment undertaken for the sports hub (Miles 2018)

Field surveys were undertaken in August and October 2019.

The management plan divides the creeks into distinct sections based on their natural characteristics and management requirements (Map 1). For each section, the current condition is described and the management actions determined based on the issues for the section. Priority weed species are shown were mapped using GPS and are shown on Map 1 – this map does not include weeds where they are abundant throughout the section. A shapefile of weed locations has been provided with this report

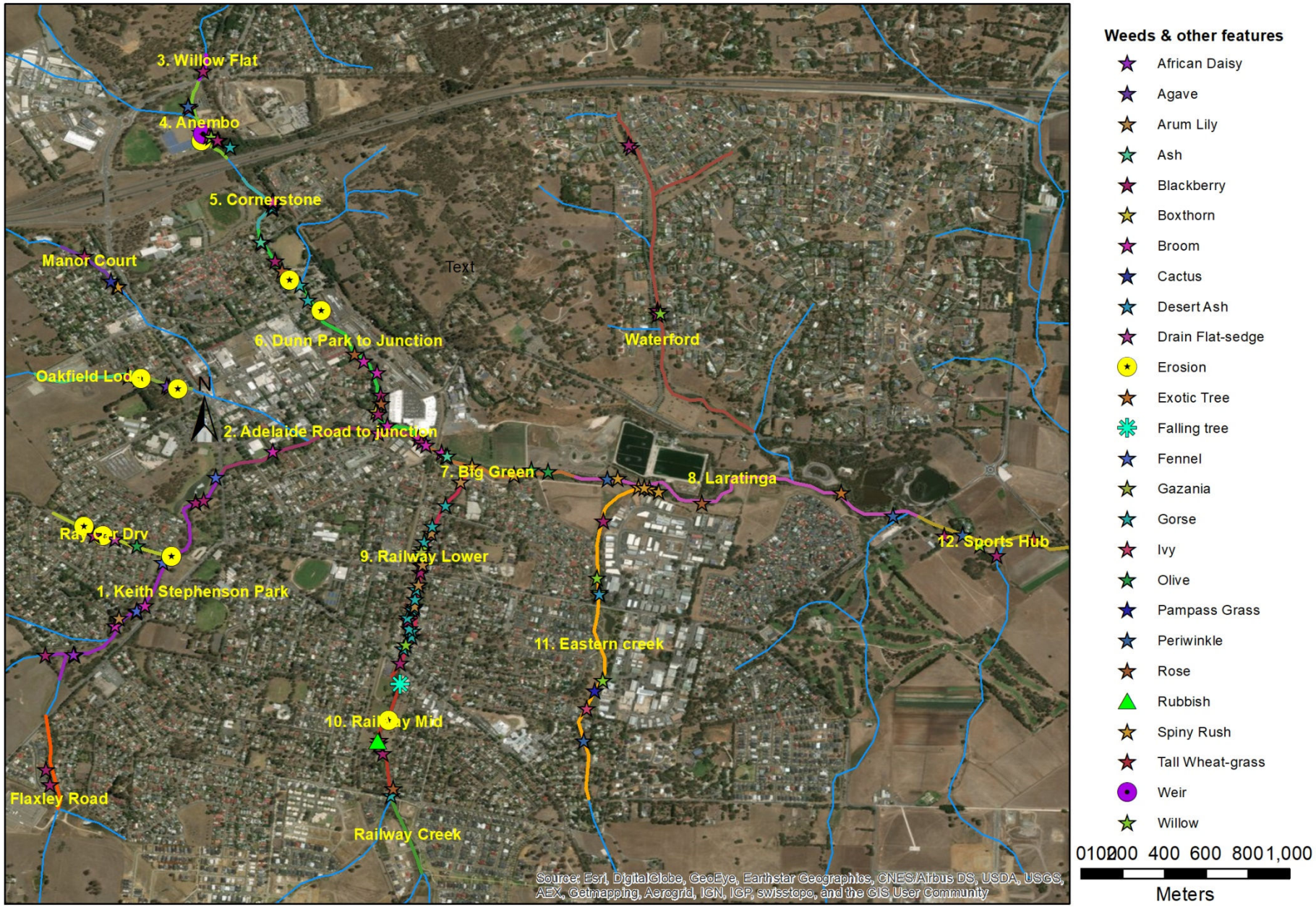
The following features were subjectively assessed to derive overall priority (this method is loosely based on the method described by Bennet et. al. 2002):

- Remnant Native Vegetation: the proportion of native vegetation covering the site, and the range of native species.
- Weed Risk: the proportion of weed cover, and the risk of those weeds spreading through the site and the wider area (Croft et. al. 2005).
- Revegetation: areas already revegetated were considered to have a higher value for biodiversity and creek health.

- Habitats: areas with a greater range and number of habitats were given a higher value, habitats included large remnant trees with hollows, shrubs, reed beds, permanent pools, large woody debris in pools, open water and submerged aquatic vegetation.
- Channel form: unmodified channel form was given a higher priority than modified channels (eg widened).
- Erosion: presence or absence.

Plants are referred to by their common name throughout the report, a full list of all plant species observed is given in Appendix 2 (by common and scientific name).

The report was prepared in consultation with staff of the Mount Barker District Council.



Map 1: Mt Barker Creek, showing management sections and high threat weeds and other features

SECTION 1: KEITH STEPHENSON PARK

This includes the section of Western Flat Creek from Bollen Road to Adelaide Road through Keith Stephenson Park. The park is managed for passive recreation (e.g. walking, playground and picnics) and is highly utilised by the community.

River Red Gums are scattered along the creek and throughout the surrounding parklands and the watercourse contains native Bulrush and Common Reed as well as a small number of native herbs. Revegetation of the banks and part of the park has been undertaken progressively over a number of years (Figure 4.2, Figure 4.4).

The banks of the creek have been battered upstream of May Road for erosion and flood control and additional rock installed in some lower areas for further erosion mitigation. The prolific growth of bulrushes (Figure 4.1), particularly between Bolllen and Kay Roads is a concern for the Council due to the reduced capacity of the watercourse during flood events. The bulrushes are likely to have trapped silt from erosion upstream, further reducing the channel capacity. Bulrush management is discussed in Chapter 5.1. Shading by River Red Gums and Woolly Tea Trees appears to provide a natural control of Bulrushes (Figure 4.3).

A constructed lake near Adelaide Road was previously filled by water diverted from the creek, however, due to erosion around the structure, the structure was removed. The erosion was quite active in 2012 but now appears to have stabilised with sediment has built up and grassed-over around the area. Any future weed control or other activities at this location should be undertaken with care so as not to cause the erosion to re-activate.

The area and diversity of revegetation has increased since 2012. The weed risk was reduced from medium in 2006 to low in 2012 due to removal of woody weeds and exotic trees. In 2019 the weed threat has increased with seedlings of high threat species that could quickly spread if allowed to set seed, particularly Blackberry, Broom and Arum Lily.

Overall Priority: High

Condition

Feature	Condition	Description
Remnant Native Vegetation	Medium	Many mature River Red Gums, some regeneration. Riparian vegetation dominated by Bulrush in the watercourse. Unplanted native species present: 9
Weed Risk	2006: Medium 2012: Low 2019: Medium	Young Broom, Blackberry, Ash, African Daisy, Arum Lily and Fennel present; possible population of Drain Flat-sedge below Kay Road crossing.
Revegetation	Part	Revegetation has been undertaken in different stages over the years and most of the banks have now been planted. Woolly Tea-trees grown from locally collected seed have been planted in the watercourse at least fifteen years ago; these have regenerated providing habitat and bank protection, however some of the older plants have died and may pose a flood risk if they dislodge during high flows. Revegetation species diversity: 26 (2 regenerating)
Habitats	High	Large trees with hollows, reed beds, scattered trees, revegetation areas, deep pools, open water (lake).
Channel Form	Partly modified	Widened and battered along much of the watercourse prior to 2006.
Erosion	Low	Erosion at site of stream diversion structure has reduced

Management Priorities

Priority	Management Action
Very High	**Removal of high threat weeds:** Control Blackberry using minimal disturbance methods appropriate for a watercourse
High	**Removal of high threat weeds:** Control Broom, Ash, African Daisy, Arum Lily and Fennel. Follow-up control every two years. Re-visit possible population of Drain Flat-sedge below Kay Road crossing and remove if species is confirmed (note: it may be native Salt Club-rush) **Revegetation for shading bulrushes:** Plant River Red Gums on northern banks of areas dominated by bulrushes at 5-10m spacing.
Medium	**Flood mitigation:** Remove bulrushes and silt as per Chapter 5.1. Monitor stability and health of older Woolly Tea Trees in creek and remove where they present a hazard for flooding. **Maintain and expand revegetation areas:** In existing revegetation areas, **u**ndertake careful weed control, infill plant with understorey species are required. Extend revegetation areas, use linear planting layouts for ease of maintenance. Incorporate widely spaced River Red Gums (eg 10-30m or more apart) and other medium-sized species such as Blackwoods, Silver Banksias, Drooping Sheoaks and Wirilda throughout the park.

Figure 4.1 View from Bollen Road Bridge looking downstream 2019; revegetation of the northern (left) bank has occurred since 2012 and young River Red Gum saplings have also grown since then.

Figure 4.2 Revegetation along the watercourse in Keith Stephenson Park in 2006 (top) and 2019 (bottom) – note the successful establishment of shrubs while planted rushes have not survived

Figure 4.3 Planted and secondary regeneration of Woolly Tea Trees in the creek (2019)

Figure 4.4 New revegetation area on the near bank and older revegetation on the far side with naturally regenerated River Red Gums in the creek (2019).

SECTION 2: ADELAIDE ROAD TO JUNCTION WITH LITTLEHAMPTON CREEK

This section has historically been lined with large exotic trees and lacks native vegetation. Many of the younger exotic trees have been removed. Periwinkle, Three-corner Garlic and other weeds tolerant of the heavy seasonal shade dominate the understorey. Four large River Red Gums behind the Bowling Club are the only native overstorey. Bulrush and Common Reed are present in unshaded areas.

The upper and lower ends have had the banks battered and revegetated. A pony has been grazing various grassed sections for several years now; it has been tethered and moved regularly and has therefore not caused any damage to the banks or creek. An area of bank has eroded above the Hutchinson Road Bridge which has not previously been (Figure 4.5).

The width of the riparian reserve is generally narrow (i.e. 3 to 10 metres), limiting exotic tree removal options. Some garden establishment in the riparian reserve has been undertaken adjacent to new houses, while the majority of species appear to be local native this activity should be monitored to ensure species with weed potential are not planted.

Minimal change has occurred since the original survey, which is appropriate given this section has been rated low priority. Many smaller exotic trees have been removed; however there remains an overstorey of exotic trees along much of this section. Periwinkle appears to have spread. Revegetation on the battered banks at the lower end has established well (Figure 4.6). Blackberry has been successfully removed.

Overall Priority: Low

Condition

Feature	Condition	Description
Remnant Native Vegetation	Poor	A small number of large River Red Gums. Bulrushes, Common Reed and aquatic herbs present in creek. Unplanted native species diversity: 5
Weed Risk	High	Mid-section dominated by exotic trees and exotic groundlayer. A small number of Broom plants throughout. Periwinkle poses a risk to downstream areas.
Revegetation	2006: none 2012 & 2019: part	Two small areas of low diversity revegetation at the upper and lower ends have established. Revegetation species diversity: 8 (2 regenerating)
Habitats	Poor	Small number of large trees.
Channel Form	Modified & unmodified	The channel has been largely unmodified excepting behind the Croquet Club and immediately upstream of the junction with Littlehampton Cree, where the banks have been battered, exotic trees removed and revegetation undertaken.
Erosion	2006 & 2012: none 2019: low	Bank erosion upstream of the Hutchinson Road Bridge may pose a hazard to the path on the south bank.

Management Priorities

Priority	Management Action
High	**Remove high threat weeds:** control Ash trees, Broom; contain Periwinkle to exotic dominated area. This will be on-going every 2-3 years
Moderate	**Erosion monitoring:** monitor bank erosion risk to path and manage as required. **Weed control:** remove Periwinkle entirely. **Landscaping:** plant fast growing "attractive" local native species such as Blackwoods and Silver Banksia along the linear trail.
Low	**Weed control:** Remove remaining exotic trees on both the north and south banks, and woody weeds. Ensure Periwinkle and Ivy are controlled before revegetation begins. Follow-up and control re-growth of weeds. Remove non-local natives in revegetation (Sugar Gums and Silver/Black Wattle). Liaise with landholders planting in reserve to ensure no new weeds are introduced. **Revegetation and exotic tree removal**: In the longer term the exotic trees should be removed as they pose a weed threat and impact the watercourse condition. Fast growing, shady and attractive native species such as Blackwoods should be established in the short term on the northern side of the linear trail in anticipation of longer-term removal of exotic species. Revegetate banks following methods outlined Chapter 5.3.

Figure 4.5 Bank erosion upstream of Hutchinson Road Bridge (2019)

Figure 4.6 Downstream section where the southern bank was battered and revegetated; top photo taken in 2012 and bottom in 2019.

SECTION 3: LITTLEHAMPTON CREEK, WILLOW FLAT

This section of the Littlehampton Creek runs through a small public reserve known as Willow Flat. There are several mature River Red Gums in the park and along the creek (one of which has died since 2012), but the site otherwise lacks native vegetation (Figure 4.7). The creek is mostly lined with Plum trees and Hawthorn over exotic grasses, with some Willows in the Park. The western side of the creek is mown to the top of the banks, but the land on the eastern side between the creek and the Railway is vacant and does not appear to be maintained for any purpose.

The creek is deep, narrow and heavily shaded by deciduous trees and lacks riparian vegetation.

This section is unchanged from previous surveys, which is appropriate given its low priority.

Overall Priority: Low

Condition

Feature	Condition	Description
Remnant Native Vegetation	Poor	Lack of native vegetation other than River Red Gums. Unplanted native species diversity: 1
Weed Risk	High	Exotic species dominate, some Blackberries.
Revegetation	None	
Habitats	Poor	River Red Gums currently lack hollows, deciduous vegetation provides poor habitat for native fauna.
Channel Form	Unmodified	No obvious recent disturbance.
Erosion	None	May have been some bed-deepening in the past.

Management Priorities

Priority	Management Action
Very High	**Remove high threat weed**: Blackberry and Gorse using minimal disturbance techniques (spot spray and “cut and swab”) close to the watercourse, monitor for re-growth and control.
Low	**Weed control:** Remove exotic trees using drill and fill method for larger trees and cut and swab for smaller trees. Remove Ivy and Periwinkle by spot spraying, working from the least infested areas first. Follow-up and control re-growth; this will require control over at least two years to ensure the site is clear of Ivy and Periwinkle. Monitor for and control erosion that may occur through lack of cover. **Revegetation:** Revegetate with predominantly hardy understorey species with widely spaced overstorey. Do not revegetate areas until Periwinkle and Ivy have been cleared for at least two years to ensure they do not re-grow amongst revegetation. Plant clumps of sedges and rushes in the watercourse to prevent Bulrush becoming the dominant species.

Figure 4.7 Willow Flat section (2019) – the second gum tree on the right bank has died since the 2012 survey

SECTION 4: LITTLEHAMPTON CREEK, ANEMBO PARK

This section of creek runs through Anembo Park, which is used primarily for sport and recreation. River Red Gums are scattered along the creek and Bulrushes are growing in the creek. The riparian widths are generally very wide, however some of the site infrastructure is positioned quite close to the creek. There is an old concrete weir approximately half way down the creek positioned in a rock bar. Downstream of the weir the creek is incised and the floodplain on the eastern side is largely inaccessible and weedy, however there are many River Red Gums and there has been some regeneration of Silver Wattle since the previous survey in this area.

There is a significant amount of erosion throughout the entire section which was not observed in 2012 (e.g. Figure 4.8 and Figure 4.9). This may be as a result of increased run-off in the catchment, removal of grass cover on the banks as part of the revegetation preparation, site stormwater or a combination of factors. A stormwater drain from the new sports facilities outlets near the top of the bank at an outer bend in the creek and there is a significant amount of erosion at this point.

A small creek enters the Littlehampton Creek from the west midway through this section (Figure 4.10); the water coming from this creek was visibly clearer than water coming from Littlehampton.

Revegetation along most of the banks, except the south-eastern floodplain, has been undertaken in the last twelve months. Fennel abundance has been reduced. Area of Gorse in southeastern floodplain has increased since 2006.

Overall Priority: Medium

Condition

Feature	Condition	Description
Remnant Native Vegetation	Poor	Excepting the lower end where there is a concentration of River Red Gums and natural regeneration of Silver Wattles. Bulrush is common upstream of the weir and Common Reed downstream. Unplanted native species diversity: 7
Weed Risk	2006 & 2012: Moderate 2019: Low - Moderate	High threat weeds have been removed upstream of the weir, but are abundant downstream to the Freeway, including exotic trees, Gorse and Blackberries. Willows are recently established or re-grown downstream of the weir. A patch of Periwinkle near the softball pitch is newly established.
Revegetation	2006: none 2012: parts 2019: most	Almost the entire western bank and most of the eastern bank upstream of the carpark has recently been revegetated. Older planted trees and shrubs are also present. Revegetation species diversity: 11
Habitats	Poor	Several deep pools (probably permanent) but mainly lacking in native aquatic vegetation, few large trees except near Freeway.
Channel Form	2006 & 2012: Natural 2019: widening	Excepting the weir, which is retaining sediment upstream, the creek form appears not to have been modified intentionally, but is currently adjusting to increased flows and widening at several points.
Erosion	2006 & 2012: None 2016: throughout	There are many points of bank erosion throughout this section, with the most severe erosion where a new stormwater drain outlets. Types of erosion are predominantly slumping upstream of the weir and rilling of the upper bank downstream of the weir.

Management Priorities

Priority	Management Action
Very High	**Remove high threat weeds:** Gorse and Blackberry using minimal disturbance techniques (spot spray and "cut and swab"); some Blackberry is growing amongst reeds in the creek and will require a high level of care to prevent off-target damage. Monitor and control at least every two years.
High	**Remove exotic trees:** Willows using minimal disturbance techniques ("drill and fill" or "cut and swab") as the Willows is growing amongst reeds in the creek and will require a high level of care to prevent off-target damage. **Remove newly established weed:** remove patch of Periwinkle **Assess erosion risk at stormwater outlet:** undertake an assessment of the stormwater outlet and take appropriate action.
Medium	**Erosion management**: monitor erosion in creek and undertake appropriate action as required. When undertaking weed control works, minimise the amount of bank where groundcover is removed. **Revegetation:** maintain newly established revegetation areas through weed control and infill planting as required.
Low	**Contain spread of exotic trees:** undertake removal of outlying exotic trees on eastern bank. **Revegetate south-eastern floodplain:** Remove exotic trees growing among River Red Gums in downstream area using minimal disturbance techniques ("drill and fill" larger trees and "cut and swab" small seedlings). Revegetate with local native middle and understorey species. An open park design may make this work more manageable, with mown grass areas between the River Red Gums, and understorey planted under the gums.

Figure 4.8 Example of erosion near upstream end of Anembo Park (2019)

Figure 4.9 View towards Freeway (2019); Erosion at point where stormwater inlets (on right bank), note Blackberry growing through reeds and Gorse on left, with exotic deciduous trees on eastern floodplain.

Figure 4.10 Junction of two creeks showing old and recent revegetation (2019)

SECTION 5: LITTLEHAMPTON CREEK, CORNERSTONE COLLEGE

This section of creek starts from below the Freeway, through Cornerstone College to Cameron Road. The majority of the channel is unmodified except a short section below the College's bridge, which has been battered on both banks, and where a levee bank has been constructed above the bridge. Since 2012, the Linear Trail has been extended through the College on the eastern bank.

There are many mature and regenerating River Red Gums, but limited "habitat trees" (containing hollows); some nest boxes have been installed to overcome this limitation. A possum could be seen in one of the trees with natural hollows (Figure 4.12). Stormwater wetlands have been constructed by the school and significant revegetation work undertaken in the wetlands and the riparian zones (Figure 4.11). Exotic perennial grasses dominate where the banks have not been sprayed. The revegetation areas were established and woody weeds removed between the 2006 and 2012 surveys. There has been some re-growth of woody weeds on the banks amongst the revegetation since 2012 however the overall the weed risk is reduced. Exotic trees growing in the creek downstream of the bridge have been removed and no Drain Flat-sedge was observed.

The level of erosion has reduced since 2012 although some minor erosion (bank slumping) is present. In past surveys, it has been noted that the banks were sprayed to reduce fuel loads but the lack of cover was contributing to bank erosion. During this survey the banks had not been sprayed and had good grass cover, which is likely to be contributing to the lower erosion levels observed.

The adjacent Freeway land and upstream areas will be an on-going source of woody weeds and therefore weed control will be an on-going activity.

Note: in previous surveys the short section of creek between Cornerstone College and Cameron Road has been included with this but, as it is not managed by the College and is more similar to Section 6 than this Section it is now included in Section 6.

Overall Priority: High

Condition

Feature	Condition	Description
Remnant Native Vegetation	Medium	Remnant River Red Gums and aquatic vegetation. Some Wallaby Grass growing on the banks may be regenerating from the revegetation areas. Unplanted species diversity: 3
Weed Risk	2006 & 2012: High 2019: Medium	Small number of wild Roses, Ash saplings, Gorse and Broom on banks amongst revegetation area within College. Area from College grounds to Cameron Road is dominated by exotic trees.
Revegetation	Most	Well established revegetation with good diversity of middle and groundlayer species. *Revegetation species diversity: 19 (1 species regenerating)
Habitats	Medium	Permanent pool, rock riffles, mature trees (but mostly lacking natural hollows), revegetation provides shrubby and grassy habitats, wetland.
Channel Form	Medium	Mostly natural, short levee bank and downstream end battered.
Erosion	2006 & 2012: Medium 2019: Low	Bank erosion areas have partially grassed over and are not currently active.

*Note: banks only; there is extensive and diverse revegetation on the floodplains and wetlands.

Management Priorities

Priority	Management Action
Very High	**Remove very high threat weeds:** Gorse and Blackberry using minimal disturbance methods. Monitor and control at least every two years.
High	**Remove high threat weeds**: Ash and Rose. Monitor for and control new weeds. Search for Drain Flat-sedge in late spring and remove if present prior to seed set. **Maintain rabbit control**
Medium	**Erosion control:** maintain groundcover on banks
Low	**Revegetate unplanted areas:** Extend revegetation area downstream using same methods and species as upstream. **Improve habitat value of trees:** Continue to install nest boxes with a range of hole sizes in River Red Gums without hollows. Note: nest boxes need to be monitored to ensure they are not taken over by introduced birds or bees.

Figure 4.11 Well established revegetation shading the creek, note absence of Bulrush or Common Reed, also small amount of erosion on left bank in foreground (2019).

Figure 4.12 Large tree with hollows (top) and possum in one hollow (bottom) (2019)

SECTION 6: LITTLEHAMPTON CREEK, DUNN PARK TO JUNCTION

Between 2006 and 2012 there was a significant amount of exotic tree removal and revegetation work undertaken along much of this section, and native aquatic species have naturally established in the creek as a result of improved light conditions (Figure 4.13). Since 2012 the revegetation has grown larger but exotic species are taking over the groundlayer and the area of Periwinkle has increased. Suckering *Robinia*s have been removed from Dunn Park.

Mature River Red Gums are sparsely scattered along the length of this section. Revegetation of tree and shrub species has been undertaken along much of the length where there is sufficient space, however in some areas exotic trees and groundcovers are still dominant. The section through Dunn Park is in the best condition (Figure 4.14), but climbing exotic species are a problem as they are growing up planted trees.

The channel is deep and narrow and is eroded in some sections (Figure 4.15). Exotic perennial grasses and Periwinkle now dominate the banks – whilst these provide groundcover they are also competing with revegetation. The overall width between the adjacent properties or roads and the top of the Creek bank is very narrow along most of the Section, with less than one metre in some parts, necessitating the construction of a boardwalk for the linear trail in one area.

One very large River Red Gum has a historical plaque (Figure 4.16); this tree is very large and could be better promoted to incorporate it's biodiversity values and both pre- and post-European heritage.

Overall Priority: Medium

Condition

Feature	Condition	Description
Remnant Native Vegetation	2006: poor 2012 & 2019: low-medium	Scattered River Red Gums and small patch of Blackwoods; aquatic species growing in watercourse. Unplanted native species diversity: 7
Weed Risk	High	High threat weeds, including Ash, Broom, Rose, Gorse, Boxthorn, Periwinkle, Cape Ivy, Ivy, Blackberry and Willows, present throughout
Revegetation	2006: none 2012 & 2019: Most	Revegetation established in most accessible areas, however weeds have re-established in many areas and some areas are quite sparse. Revegetation species diversity: 19
Habitats	2006: Poor 2012 & 2019: Moderate	Some pools, revegetation providing shrubby habitat, reed beds and one large tree with hollows.
Channel Form	Unmodified	Channel is deep and narrow along most of the length.
Erosion	Low	May have been bed deepening in past, minor bank erosion

Management Priorities

Priority	Management Action
Very High	**Remove high threat weeds:** remove Blackberry, Gorse, Broom and Boxthorn. Remove exotic tree re-growth (i.e. from revegetation areas)
High	**Control climbing weeds in revegetation areas:** Undertake careful weed control in revegetation areas to remove climbing weeds (Periwinkle and Cape Ivy) growing into planted trees. Undertake general weed control in planted areas. **Control exotic tree re-growth**: remove exotic tree seedlings at least every two years. **Contain and control Periwinkle:** Contain and control Periwinkle in areas where exotic trees have been removed by working in the least infested areas first. Robertson (2005) recommends spraying large patches in early Summer with a herbicide including a penetrant, however, the latter may not be appropriate so close to the watercourse. Follow-up control will most likely be required for two or more years, therefore revegetation should only be carried out in areas where Periwinkle has not been present or has been controlled for at least two years. Trial the use of jute matting by using this to cover selected sprayed patches to prevent re-growth. Monitor for and control any new infestations.
Medium	**Revegetation enhancement:** strategic revegetation with taller shady natives such as Blackwoods and Silver Wattle to thicken revegetation areas and shade the path. **Erosion management:** monitor erosion, particularly near swimming pool where it is close to assets, and manage appropriately.
Low	**Revegetation and exotic tree removal:** In the longer term the exotic trees should be removed as they pose a weed threat and impact the watercourse condition. Fast growing, shady and attractive native species such as Blackwoods should be established in the short term on the northern side of the linear trail in anticipation of longer-term removal of exotic species. Revegetate banks following methods outlined on Chapter 5.3. **Landscaping:** Plant fast growing “attractive” local native species such as Blackwoods and Silver Banksia along the linear trail.

Figure 4.13 Area behind shopping centre carpark in 2006 (top), vegetation is 100% exotic species, and same location in 2012 (bottom) with exotic trees removed and native species newly planted

Figure 4.14 Local native revegetation in Dunn Park (2019)

Figure 4.15 Erosion of the western bank near the swimming pool is close to trail and should be monitored (2019)

Figure 4.16 One of the few large remnant River Red gums in this section, it has a commemorative plaque (2019).

SECTION 7: MT BARKER CREEK, THE "BIG GREEN"

This Section runs from the junction of Western Flat Creek and the Littlehampton Creek downstream to just below a low pedestrian crossing. The channel was widened and the banks battered along the entire length of this section in 2004 to increase the flow capacity and reduce flooding. Exotic trees were removed in the process of modifying the banks however there has been some re-growth in the channel. Due to the abundance of exotic trees upstream, removing exotic trees in this section will be an on-going requirement.

Almost all of both banks have been revegetated since 2005. There are a small number of remnant River Red Gums on the banks as well as naturally regenerating River red Gums. Many of the older revegetated Swamp Wattles have died-off (Figure 4.17), and more are likely to die over the next few years as it is a short-lived species. Further to this, many of the native grasses and sedges that were planted have died, which may be through a combination of mis-identification during weed control activities and 'natural causes'. The only regeneration is of River Red Gums and Native Sarsparilla. There are now significant gaps in the revegetation areas and re-planting has been undertaken in some areas but more is required. The lack of natural regeneration is likely to be a combination of dense mulch being applied, use of species that require wetter conditions and misidentification during weed control. Enhancing these older revegetation areas is discussed in Chapter 5.7.

Since 2005, the watercourse vegetation shifted from being dominated by the low-growing native Sea Club-rush and introduced Water Couch to being dominated by taller Common Reed and Bulrushes (Figure 4.18). Prior to channelisation works there were three permanent pools in this section, two of which had almost completely silted-up by 2012. Only the pool beneath the railway bridge remained deep and open, probably due to the shading of the bridge and narrowness of the banks. Since 2012 the channel has started to re-form, and several pools were observable through the reeds (Figure 4.19); this development can be observed in historical imagery available through Google Earth.

The weed Spiny Rush was present in 2005 and increased in density in 2012. A Spiny Rush control program was undertaken following the 2012 survey and the numbers have reduced, however follow-up is required as several plants were observed from the Railway Creek junction downstream. European Olives were recorded for the first time; these were growing under large Wattles and have probably been brought in by birds. No Gorse was found in 2019.

Overall Priority: High

Condition

Feature	Condition	Description
Remnant Native Vegetation	Medium	Native reeds and rushes present in watercourse, a few remnant River Red Gums as well as regeneration. Unplanted species diversity: 7
Weed Risk	2006 & 2012: High 2019: Medium	A smaller number of high threat weeds than previous surveys: Spiny Rush, European Olive, exotic trees, Broom, Blackberry, Wild Rose and Ivy present in low abundance.
Revegetation	2006 & 2012: Part 2019: All	Both banks revegetated throughout. Revegetation species diversity: 17 (2 regenerating)
Habitats	Moderate	Reed beds, permanent deep pools, shallow pools, occasional large trees, revegetated shrubs and fallen small timber.
Channel Form	Modified	Channel widened and banks battered; meandering flow path and pools are now re-establishing.
Erosion	None	None observed.

Management Priorities

Priority	Management Action
Very high	**Remove high threat weeds:** Spiny Rush, exotic trees in-stream, European Olives. Only contractors or staff experienced in Spiny Rush control should be engaged for this task. Monitoring and follow-up control required.
High	**Weed control:** contain and control Periwinkle, Wild Rose and Ivy and woody weeds. Monitor and control at least every two years. **Revegetation maintenance and infill planting:** maintain weed control as required, infill plant, taking care to select appropriate species for the lower vs upper banks where there are different water regimes.
Low	**Revegetation of shade trees on north side of banks and linear trail:** River Red Gums, Wirildas and Blackwoods should be planted to shade the creek to compete with Bulrushes and Common Reed and along the linear trail to provide shade for recreational users.

Figure 4.17 Older revegetation area where Swamp Wattles have died out (2019).

Figure 4.18 View across the ford in 2006 (top), 2012 (middle) and 2019 (bottom), following channel widening, the pool silted up and Bulrush and Common Reed became the dominant watercourse vegetation; revegetation planted in 2012 is maturing.

Figure 4.19 Pool in 2019 that has formed since 2012 (note Spiny Rush on far bank), River Red Gum sapling in the foreground is from natural regeneration, the wattles on the far bank are revegetation.

SECTION 8: MT BARKER CREEK, "LARATINGA"

This section contains many large River Red Gums containing large hollows and as well as a range of other habitats including permanent pools with native aquatic vegetation and submerged logs.

There are several significant changes that have occurred in this section since the 2012 survey, both positive and negative. Positive changes are that the revegetation is maturing, natural regeneration is occurring and new plantings include a greater diversity of species, particularly groundlayer species (Figure 4.20). Revegetation has also been completed along the southern bank, and new wetlands have been established both north and south of the creek, extending the area of continuous riparian and wetland habitat in this area. The diversity of species observed in the revegetation was the highest of all sections in this survey. River Red Gums and Swamp or Silver Wattle have regenerated at the base of the banks and Water Ribbon is growing in several pools. There is also significantly less Spiny Rush, Blackberry, Watsonia and Gorse due to the Council's control program, although there has been some re-growth of Spiny Rush that requires follow-up, particularly downstream of the ford.

Negative changes are a significant amount of bank erosion and re-growth of Desert Ash. In the 2006 survey, a small number of erosion points were noted where minor drainages enter the creek and some bank erosion was observed upstream of the ford, one instance of which was due to a fallen tree diverting flow towards the bank. In 2012 the level of erosion was considered minor despite heavy rainfalls in the preceding Summer. In this survey (2019), bank erosion was observed throughout the section, despite there being no significant flow events in the last two years (Waterconnect 2019) (see for example Figure 4.21 and Figure 4.22). It is possible that the erosion was started during the major flood events that happened in 2016 and has not yet stabilised. In general, the erosion does not threaten any infrastructure assets and there are sufficient riparian buffers to allow for channel movement. However it is recommended that the erosion be regularly monitored following any significant flow events risks to assets assessed. Care should also be taken when controlling weeds to ensure banks are not left at risk of erosion. Planting seedlings of native shrubs such as Woolly Tea Tree and River Bottlebrush at the base of bank erosion points may assist to provide a 'soft engineering' solution at some locations. The relatively natural geomorphology and abundance of permanent pools should be maintained.

The Desert Ash increases in abundances towards the downstream end of this section, and includes seedlings through to small-sized trees (Figure 4.23). It is a priority to remove these in the short term as they are becoming dominant along some sections, are large enough to be reproducing and will become increasingly expensive to remove the larger they grow.

Overall Priority: High

Figure 4.20 Older revegetated eucalypts with newer plantings (2019); note the naturally maintained mulch of leaf litter and minimal grassy weeds.

Condition

Feature	Condition	Description
Remnant Native Vegetation	Good	Many River Red Gums and aquatic vegetation throughout. Unplanted species diversity: 6
Weed Risk	High	Desert Ash are abundant, Spiny Rush is abundant downstream of the ford, other high threat weeds (Blackberry, Broom, Ivy and Periwinkle) are scattered throughout.
Revegetation	2006 & 2012: Part 2019: Almost entire length	Revegetation has been undertaken along the entire length of both banks over multiple years and comprises a good diversity of species. Regeneration of three species was observed. Revegetation species diversity: 30 (3 regenerating)
Habitats	Good	Reed beds, permanent deep and shallow pools with aquatic vegetation, many large trees with habitat hollows, revegetation areas providing dense shrub habitats.
Channel Form	Modified & Unmodified	Mostly unmodified.
Erosion	2006: Moderate 2012: Minor 2019: High	Outer bank erosion and bank slumping throughout this section. Erosion is down to bedrock at two locations so bed deepening is unlikely to occur.

Management Priorities

Priority	Management Action
Very high	**Weed control:** removal of Ash Trees, Blackberry and Spiny Rush. Undertake follow-up control at least every two years.
High	**Weed control:** Control patches of Periwinkle, working from outer edges of patches, take care not to leave banks bare; control other high threat weeds (e.g. Broom, Ivy, Blackberry) **Erosion management:** undertake an assessment of erosion threat to infrastructure and undertake appropriate action as required. Plant native species at the base of banks to provide soft-engineering protection for banks. Establish protective shrubs (Woolly Tea-Tree) at the base of outer bank erosion points.
Medium	**Revegetation maintenance and enhancement:** on-going weed control and planting understorey species as required

Figure 4.21 View above ford in 2012 (top) and 2019 (bottom), note erosion of banks in 2019 photo.

Figure 4.22 Erosion of the southern bank (2019), note exposed tree roots and fence that is now suspended over the eroded section; also note Ash saplings in foreground and on far bank.

Figure 4.23 Abundant Ash trees growing along the creek (2019)

SECTION 9: "RAILWAY CREEK" LOWER

The "Railway Creek" is bordered on both banks by backyards and roads and the riparian widths are mostly less than 20m, with some areas developed to the top of the bank. Unlike other watercourses in this plan, Railway Creek runs through private land in some parts. This section was previously surveyed in July 2013 (2013b).

River Red Gums are located throughout the Railway Creek section, with saplings and large remnant trees. Native Bulrush grows throughout the watercourse and is abundant in the middle section where the creek banks have been battered. The only other remnant native vegetation is Salt Club-rush, Hairy Willow-herb and some Blackwoods (the latter may have been planted). There are small areas of low diversity revegetation at the junction with the main Creek.

High threat weeds, Gorse and Blackberry, are present in low abundance throughout and have increased slightly in distribution (Figure 4.24). Large Ash trees had been removed from most of the length prior to being surveyed in 2013, however there has been significant re-growth since then (Figure 4.25) and follow-up control is required. Several large Willows are present with some regeneration. Introduced perennial grasses dominate the banks and adjacent areas. Small patches of Periwinkle at the upper end of this section were recorded in 2013; these patches have increased in area and the species has also spread in distribution. The weed Drain Flat-sedge was observed at several locations in 2013 and Spiny Rush at the junction with Mt Barker Creek, but neither were found during this survey.

A number of pools are present throughout, it is unknown if they are permanent but is likely they are groundwater supported. The middle section (from Alexandrina Road to Fletcher Road) has been widened with the banks battered back. The presence of Bulrush throughout indicates the watercourse is likely receiving base-flow year round as this species requires permanent soil moisture (Roberts & Marsten 2011).

The section is largely unchanged since the previous survey which is appropriate given it is a low priority. The control of high threat weeds is however a priority as they are becoming dominant along some sections, are a source of weeds for other areas, and will become increasingly expensive to remove as they grow. The narrow riparian width of this section means there is limited access and scope for revegetation.

Overall Priority: Low

Condition

Feature	Condition	Description
Remnant Native Vegetation	Medium	River Red Gums and Bulrush present, a small number of native herbs. Unplanted species diversity: 6
Weed Risk	High	High threat weeds (Blackberry and Gorse) present throughout in low density although some Blackberry patches are very large. Mature and juvenile exotic trees including Desert Ash and Willows abundant throughout. Large patches of Periwinkle. Exotic perennial grasses dominate banks.
Revegetation	Minimal	Small low diversity revegetation area at lower end.
Habitats	Moderate	Reed beds, shallow pools, large habitat trees.
Channel Form	Modified & Unmodified	Middle section widened and battered.
Erosion	None	None observed

Management Priorities

Priority	Management Action
Very High	**Weed control**: removal of declared weeds Blackberry and Gorse. Undertake follow-up weed control at least every two years.
High	**Weed control**: removal of exotic trees (e.g. Desert Ash, Willows). Control patches of Periwinkle, working from outer edges of patches, take care not to leave banks bare. Control other high threat weeds (e.g. Broom, Arum Lily). Undertake follow-up weed control at least every two years.
Low	**Revegetate open areas:** revegetate banks and associated floodplain where there is sufficient space and in consultation with adjacent landholders.

Figure 4.24 Dense weeds (Blackberry, Periwinkle and Desert Ash) immediately downstream of the Wellington Road bridge (2019).

Figure 4.25 Railway Creek looking downstream from Alexandrina Road bridge in July 2013 (top) and October 2019 (bottom), note narrow riparian width and growth of Desert Ash trees in 2019.

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SECTION 10: "RAILWAY CREEK" MID

The Railway Creek Mid-section runs through a riparian reserve from Hurling Drive to Alexandrina Road. It has a narrow channel that has been widened and had the banks reinforced below the Hurling Drive Bridge but is otherwise unmodified. Mature River Red Gums are scattered throughout and Bulrush and other aquatic species are present in the watercourse (Figure 4.26). There is a small area of revegetation at the upstream end, the middle area is largely open while the downstream end is dominated by exotic species. A new development and supermarket on either side of the downstream end constrain the riparian width. Some woody weed control and exotic tree removal has been undertaken in adjacent to the new development. A River Red Gum next to the supermarket appears to be falling over (Figure 4.27) and should be assessed by an arborist as it may block flows and cause localised flooding if it falls.

Ash Trees are a high priority to control as they are at risk of becoming dominant and weed control works will become increasing expensive if control is delayed. There are a row of Pine Trees on the western bank at the downstream end they do not appear to have spread and may provide food for Yellow-tailed Black Cockatoos, therefore their removal is not a priority.

This section has not been surveyed in previous watercourse surveys.

Overall Priority: Low

Condition

Feature	Condition	Description
Remnant Native Vegetation	Moderate	Scattered River Red Gums and in-stream vegetation. Unplanted species diversity: 6
Weed Risk	Moderate	Ash tree saplings and larger trees throughout, Blackberries, Ivy at downstream end, Bracelet Honey-myrtle, Lucerne Tree
Revegetation	Part	Small area of low diversity revegetation at upstream end. Conifer in revegetation may have been misidentified as Native Pine or is a weed. Revegetation species diversity: 9
Habitats	Moderate	Limited number of large trees with hollows, small pools that may be permanent
Channel Form	Unmodified	Largely unmodified except for the area immediately downstream of the Hurling Road Bridge
Erosion	Minor	Erosion where stormwater enters from eastern side.

Management Priorities

Priority	Management Action
Very High	**Remove high threat weeds:** Desert Ash, Blackberry, and Gorse; monitor and follow up control of these and Ash trees
High	**Contain and control Ivy:** working from outer edges, control will be required over a number of years **Arborist assessment:** assess risk of River Red Gum near supermarket falling.
Medium	**Remove woody weeds:** Lucerne Tree, Bracelet Honey-myrtle, Cyprus pine
Low	**Revegetation:** undertake revegetation if there is community support.

Figure 4.26 Small potentially permanent pool beneath River Red Gum (2019); note Blackberry and Ash saplings on left bank.

Figure 4.27 River Red Gum which appears to be falling over (2019).

SECTION 11: "EASTERN CREEK"

The "Eastern Creek" is a shallow watercourse draining a small subcatchment of Mount Barker Creek. The most downstream part of this watercourse floods out, forming a natural meadow wetland of exotic grasses and Common Spike-rush, before entering the Mt Baker Creek.

There are scattered large River Red Gums throughout and some plantings of native trees and shrubs in some sections, but no areas of significant revegetation. Sedges and rushes are present at some locations. The Eastern Creek vegetation is dominated by exotic perennial grasses but has few other high threat weeds. Control of these weeds now will prevent them becoming established in this section.

An artificial lake upstream of the Alexandrina Road crossing has been planted with native sedges and rushes which have spread downstream of this site. Above the pond the creek is piped underground for some distance.

The creek mostly has a wide riparian corridor (approximately 50 m), but it runs through three adjacent private properties for 100 m. Erosion is limited to bed deepening between Acacia Street and Duffield Avenue.

There is scope to improve the biodiversity values of this section through revegetation, particularly focusing around the remnant River Red Gums.

Overall Priority: Medium

Condition

Feature	Condition	Description
Remnant Native Vegetation	Medium	Large River Red Gums throughout and occasional sedges and rushes. Unplanted species diversity: 6
Weed Risk	Low	Small number and density of high threat weeds including Desert Ash, Periwinkle and Ivy.
Revegetation	Minimal	Sedges and rushes planted in lake; occasional trees and large shrubs planted
Habitats	Low	Large trees with hollows, artificial lake, reed beds
Channel Form	Natural and unnatural	Piped underground in one section and formed into concrete lined lake.
Erosion	Low	Small narrow section of bed deepening

Management Priorities

Priority	Management Action
High	**Control high threat weeds**: Desert Ash and other exotic trees, Ivy and Periwinkle.
Medium	**Revegetation:** undertake revegetation, focussing on establishing understorey in areas with large remnant trees.

SECTION 12: SPORTS HUB

The following section was prepared as part of the Regional Sports Hub Environmental Impacts Study (Miles 2018).

The Mt Barker Creek within the Sports Hub site is in moderate to poor condition but is typical of creeks in the region on grazing properties with stock access. The vegetation is dominated by exotic pasture grasses, exotic trees and woody weeds with an open overstorey of native River Red Gums. The water is noticeably turbid, however no water quality measurements were collected.

Ten native plant species occur along the watercourse. The most common native species are the River Red Gums, which range from small saplings through to very large trees, and bulrushes that grow on the perimeter of pools that have steep banks. Other native sedges, rushes and herbs are present in low abundance along the entire length of the watercourse.

Hawthorn trees (*Crataegus monogyna*), Desert Ash (*Fraxinus rotundifolia ssp. rotundifolia*), Blackberries (*Rubus fructicosus*) and Spiny Rush (*Juncus acutus*) are problem weeds that are moderately abundant along the entire length of the creek. There are isolated occurrences of Periwinkle (*Vinca major*), Weeping Willow (*Salix babylonica*), Spear Thistle (*Cirsium vulgare*) and Dog Rose (*Rosa canina*).

Rock is exposed in the channel bed at a number of points and some roots of very large remnant trees are exposed, indicating the creek bed is probably deeper now than it was under pre-European conditions. Sediment layers exposed in eroded banks also indicate the creek and floodplain have undergone periods of movement and deposition. Deposits of loose rock and debris in the channel bed show the morphology of the creek bed changes in response to flow events.

The creek banks are eroding on the outer bends at several locations, nearly all of which are downstream of the discharge point for the drainage depression. While most of the erosion is relatively minor, the first erosion point below the drainage discharge appears to be quite active, is approximately 40 m in length and is eroding towards a stobie pole.

Near the barns, two River Red Gums growing close together on either side of the banks have cause a “choke” of branches and debris which probably contributes flows to a small “flood-runner” which transfers some high flows around this point.

Key issues for the site are:

- A number of declared and high threat weeds, particularly Blackberry, Spiny Rush, Desert Ash and Periwinkle;
- Outer bank erosion at a number of points;
- An abundance of perennial pasture grasses growing on the banks that are likely to flourish when stock are removed; and
- A relatively natural channel form including permanent and near-permanent pools which are vulnerable to fill with sediment due to upstream erosion and creek widening works.

The objectives for this section should be to reduce the weed threat to the site, enhance the existing habitat through revegetation and careful engineering works and provide an area for passive recreation. Control of high threat weeds will be an on-going task that will be required annually for the first 1 to three years and at least every two years thereafter in conjunction with monitoring for outbreaks of new weeds.

Management Priorities

Priority	Management Action
Very High	**Remove very high threat weeds: Spiny Rush and Blackberry** Spiny Rush is a highly invasive weed of watercourses and wetlands that is difficult to control. Only contractors or staff experienced in Spiny Rush control should be engaged for this task. Remove Blackberries using cut and swab techniques.
High	**Remove high threat weeds: Desert Ash, Hawthorn, Dog Rose, Weeping Willow, Periwinkle, Tall Wheat-grass and Spear Thistle:** Remove woody weeds and exotic trees using drill and fill for larger plants and cut-and-swab for smaller plants. There was only one Tall Wheat-grass plant which could be dug out or spot sprayed when actively growing. Robertson (2005) recommends spraying large patches of Periwinkle in early Summer with a herbicide including a penetrant, however, the latter should not be included close to the watercourse. Follow-up control will most likely be required for two or more years, therefore revegetation should only be carried out in areas where Periwinkle has not been present or has been controlled for at least two years. **Maintain Channel Morphology:** All works in the watercourse to have minimal impact on the overall morphology. In particularly watercourse widening and battering banks should be avoided. **Assess Erosion Risk to Infrastructure:** The risk to infrastructure assets from in-stream erosion should be assessed, particularly the Stobie pole close to the creek; depending on the outcome of the assessment, relocating infrastructure or controlling high risk erosion may be required as a high priority.
Medium	**Undertake Revegetation:** Undertake revegetation of the watercourse and adjacent riparian zones as per the methods and species provided in Miles (2018).
Low	**Control Erosion:** Monitor side gully erosion and control if necessary. Establish protective shrubs (e.g. Woolly Tea-Tree, River Bottlebrush) at the base of outer bank erosion points.

Figure 4.28 Outer bank erosion (2018).

TRIBUTARY CREEKS

A sample of tributary watercourses and drainages were surveyed that have not previously been surveyed. They are typical of the minor drainages within the township and are all regarded as low priority in the context of the major watercourses within the township. They do however have local biodiversity, social and amenity values and may also be a source of weeds if not managed.

Most contain scattered remnant mature and immature River Red Gums with Bulrush and other native sedges and rushes present in the channel where channels are seasonally damp. Semi-permanent pools are found in most although not in high numbers, and many also contain dams or deeper excavated areas that pre-date the housing developments and provide permanent to semi-permanent aquatic habitats. Small areas of revegetation have been established in most, however further revegetation is not a high priority unless there is commitment from local residents to establish and maintain the areas.

There are occasional erosion points, however these are generally low risk.

In most cases these creeks run through reserve with good riparian widths, however some reserves are narrow and garden encroachment has occurred at some locations.

Overall Priority: Low

General Condition

Feature	General Condition	General Description
Remnant Native Vegetation	Low – moderate	Scattered River Red Gums, Bulrush commonly present, occasional other native sedge and rush species. Dams and excavated pools are often present and may contain aquatic vegetation.
Weed Risk	Moderate	Occasional high threat weeds such as Blackberry, Desert Ash, Ivy, Periwinkle, Broom, Spiny Rush and Willows
Revegetation	Patches	Patches of revegetation, generally low diversity and dominated by middle storey species.
Habitats	Low	Large old gums with small number of hollows, occasional semi-permanent pools, reed beds, dams/pools
Channel Form	Various	Some are channelised stormwater drainages while others follow the natural drainage line; dams and excavated pools may be present
Erosion	Minor	Occasional minor erosion e.g. from side entry stormwater.

Management Priorities

Priority	Management Action
Very High	**Control very high threat weeds:** E.g. Spiny Rush, Drain Flat-sedge and Blackberry
High	**Control high threat weeds:** E.g. Broom, Periwinkle, Cape Ivy, Gorse **Control exotic trees:** Remove young Desert Ash, Willows and other exotic trees, however removal of larger trees should only be undertaken if there is support from the local community as these are often used for recreation.
Medium	**Landscaping with local native trees:** plant a combination of small and large local native trees (e.g. Blackwoods, Drooping Sheoaks, Silver Banksias, Silver Wattle, Cup Gums, River Red Gums, Rough-barked Manna Gum) to provide habitat for common native fauna and shade whilst not increasing maintenance requirements. **Maintain existing revegetation areas:** undertake regular weed control in existing revegetation areas. **Monitor and control erosion where required**
Low	**Revegetate with local native groundcovers and shrubs:** undertake complex revegetation where there is a commitment from local residents to establish and maintain sites; begin with small areas and expand depending on levels of commitment.

Manor Court Reserve to Hill Street

A small creek through a wide reserve off Manor Court that then narrows with houses either side. Many exotic trees planted along the creek. A small weir. Some garden encroachment. Used for passive recreation.

Figure 4.29 Tributary creek in reserve adjacent Manor Court (2019).

Oakfield Lodge

The watercourse between the new residential care facility and Mount Barker Primary provides a good example of high diversity watercourse revegetation. The use of plastic tree guards will require regular checks to ensure they are not washed or blown away. The drainage line has been shallow excavated and there is minor in-stream erosion.

Figure 4.30 Revegetation of watercourse behind Oakfield Lodge Residential Care (2019).

Mount Barker Primary School

Downstream of the aged care facility the creek floods out and then reforms again north of Mount Barker Primary School. This section of creek is very weedy with Blackberry, Ivy, Desert Ash and wild plums. There is some erosion around the footbridge where overland run-off enters the creek, and bed deepening downstream of a small pond. There has been extensive revegetation of the adjacent Primary School land; restoring this section of creek could link to the existing revegetation.

Figure 4.31 Creek adjacent to Mount Barker Primary School revegetation block (2019); note abundant Ash saplings as well as other exotic trees and Arum Lily growing in creek.

Ray Orr Drive to Peake Court

This section lacks large remnant trees but has several small areas of revegetation. A dam midway along the creek has abundant Bulrush. Several patches of Blackberry have been sprayed but there is some that is growing into the dam – it may be possible to control this patch if water levels drop over Summer but care will need to be taken to avoid off-target damage. There is some erosion immediately above and below the dam. The creek is probably entirely constructed for stormwater.

Figure 4.32 Drainage line upstream of Peake Court with revegetated native shrubs on the eastern bank (2019).

Donoghue Road to Flaxley Road

This short section of creek drains a salty sub-catchment. There are some large remnant, regenerated and planted River Red Gums as well as Bulrush growing in the creek and dam and planted Blackwoods. There is a large dam that pre-dates the housing development.

Figure 4.33 Dam in creek upstream of Flaxley Road (2019).

Railway Creek upstream

Upstream of Hurling Drive, Railway Creek has been revegetated with a mix of local and non-local Australian native species, including Bracelet Honey-myrtle which can become a weed. There are a small number of Desert Ash and Willows. There are scattered young and old River Red Gums throughout.

Figure 4.34 Wester bank of creek upstream of Hurling Drive with remnant River Red Gums and planted Bracelet Honey-myrtle (2019)

Waterford creek

Creeks in the Waterford Estate are protected in wide riparian reserves and lined with remnant and regenerated River Red Gums with native sedges and rushes are present in the creek. The banks and adjacent riparian zone are lawned. Weed levels are generally low, but there is one occurrence of Drain Flat Sedge, some Blackberries and occasional Willows, Desert Ash and Box Elder saplings; the latter two species are probably sourced from street tree plantings. Pre-existing dams have been incorporated into the estate's stormwater management but have silted up. Rock riffles and bank battering have been used throughout to prevent erosion and there are some recently constructed ponds.

Figure 4.35 Creek in Waterford Estate with regenerated River Red Gums and Bulrush in the creek (2019).

5 MANAGEMENT ISSUES

5.1 MANAGEMENT OF BULRUSH, COMMON REEDS AND SEDIMENTATION

Bulrushes (*Typha domingensis*, also known as Cumbungi) and Common Reed (*Phragmites australis,* Reeds) are large emergent aquatic species (growing to 2-3m) with cosmopolitan distributions (native to Australia but also naturally occurring in other parts of the world) (Roberts & Marston 2011). Both species increased in abundance in the Mt Barker Creek between the first (Miles 2006) and second (Miles 2013a) surveys (Figure 4.18, Figure 5.2); they do not appear to have changed since. Bulrushes in particular are abundant in most areas with permanent soil moisture and have formed thick monocultures where the channel has been widened. Reeds dominate in the Big Green section where they have completely overtaken the channel.

Growth & Habitat

Bulrushes and Reeds reproduce by seed and spread via rhizomes (underground tubers). They can grow underwater because they are able to aerate the rhizome by pressurised ventilation in the leaves and stems. They are summer-active species that die back each winter and re-sprout from the rhizomes in spring (Roberts & Marston 2011).

Bulrushes prefer permanently flooded, non-clayey soils and can grow to depths of 2.7m. They grow well under high nutrient conditions (particularly high Phosphorous) and warm temperatures (Roberts & Marston 2011) and are therefore common in disturbed, un-vegetated watercourses affected by sedimentation and increased nutrients from catchment erosion and run-off (Clarke & Flannery 2007). Reeds are able to grow to depths of 1.5m and are more tolerant of seasonal drying than Bulrushes (Roberts & Marston 2007).

Impacts: positive and negative

Bulrush and Reeds are naturally occurring in the Mt Barker area and provide habitat for aquatic life, substrate for algae to grow and habitat for riparian birds such as Reed Warblers and Purple Swamp Hens. They are able to trap sediments and utilise nutrients and therefore provide a role in improving downstream water quality. They also slow the flow of water and therefore reduce the velocity of downstream flows, reducing the likelihood of erosion and flooding (Clarke & Flannery 2007).

However, because of their capacity to grow well in disturbed watercourses, both species are known to have a number of negative impacts including:

- Excluding other native species and forming monocultures;
- Blocking channels; and
- Contributing to flooding.

The effect of in-stream vegetation on flooding is to increase flooding immediately upstream of the vegetation whilst reducing flow downstream (Rutherford et al. 2007). In the Mt Barker Creek, flood risk is a major concern, particularly in the upper Western Flat Creek where the channel is relatively shallow and flooding occurs frequently. Comparison of photos taken in 2005 (Figure 5.1) and in 2012 (Figure 5.2) show how Bulrush has increased in density and surface water is no longer visible because the channel has filled in (note that the photographs were taken at different times of the year, however the differences are apparent in the stem density and lack of open water). Sedimentation of the channel is further responsible for increasing the flood risk by reducing channel depth. Sedimentation has also resulted in some waterholes filling in, including two in the Big Green that were previously permanent open water holes (e.g. Figure 4.18). However, only one native fish species has been found in Mt Barker Creek (Hammer 2004) and the ecological value of these waterholes is probably insufficient to justify artificially re-instating them unless this is being done as part of a larger channel modification program.

Smaller native watercourse plant species have been displaced by Bulrushes and Reeds, but weed species including Spiny Rush and Water Couch have also been displaced and overall the impact may be a neutral to positive outcome for native plant species diversity.

Figure 5.1 Western Flat Creek, looking downstream from Bollen Road bridge, photo taken in September 2006; note: open water visible between Bulrush stems.

Figure 5.2 Same view as above in December 2012; note: increased density of Bulrush (larger size of plants is due to differences in time of year), lack of open water. The Ash Tree saplings to the left of the photo above have been removed.

Causes

The main causes of the increased Bulrush growth are:

- Increased light leading to increased temperatures,
- Increased soil erosion leading to sedimentation and
- Increased nutrients and changes in the catchment characteristics and channel form altering the hydrology and morphology (Figure 5.3).

The growth of Bulrushes and Reeds is part of a natural response to these changes and, if left alone, would most likely lead to the watercourse reaching a new steady state.

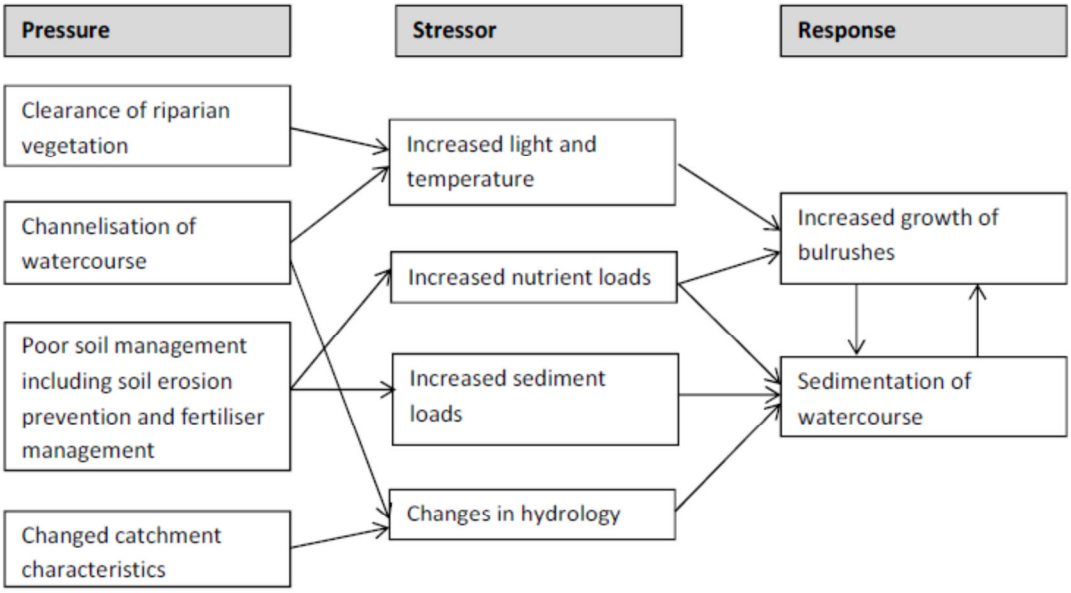


Figure 5.3 Pressure – stressor – response model showing likley causes of prolific Bulrush growth in Mt Barker Creek

Management Approach

Mechanical removal of the bulrushes and dredging of silt will be the most cost effective solution in the short term but will need to be repeated every few years. Several sapling River Red Gums growing close to the watercourse will need to be avoided or application made for a native vegetation clearance permit. Throughout the survey are it is noticeable that Bulrush and Common Reed are only abundant in open, unshaded areas. Revegetation of the banks, particularly the northern bank, will provide a longer term solution whilst still allowing access from the southern bank for bulrush removal.

The management of Bulrushes and Reeds requires a combination of short and long-term solutions. The upper Western Flat Creek has been identified by Council as a priority due to the existing flood risk and the recommendations below should be applied to this section.

There is a trade-off between reducing flooding, sedimentation and nutrient enrichment in the vicinity of where the actions are carried out and increasing flows and sediment and nutrient loads downstream of the site. It is recommended that the Council accept that Bulrush and Common Reed proliferation is a consequence of the pressures and stressors shown in Figure 5.3 and should only be managed through excavation works where there is a flood risk. Where there is not a flood risk, longer term management approaches outlined below are recommended for Bulrush management.

Short-term techniques known to successfully remove Bulrushes and Reeds are:

- Cutting 20-30cm below the water level
- Herbicides
- Physical removal of the entire plants by hand or excavation (Clarke & Flannery 2007).

Cutting below the water level is labour intensive and would only be suitable where there is sufficient water depth but could be trialled where Bulrushes are invading pools such as the one at the ford in the Big Green. Herbicide use is difficult because of the risk of off-target damage and limitations posed by the watercourse. Therefore physical removal is the most practical option for most areas. Because of the visual amenity and habitat values of the Bulrushes, complete removal of the Bulrushes in one operation is not recommended.

The techniques above will only remove Bulrushes and Reeds in the short term because they do not address the causes of their proliferation. Longer term techniques focus on the causes and include:

- Revegetation to shade the watercourse
- Re-establishment of smaller native watercourse species for competition
- Improved catchment management to reduce sediment and nutrient loads (Clarke & Flannery 2007).

The action plan outlined below may be applied where there is a flood risk. In addition to these actions, wider catchment nutrient and sediment inputs need to be addressed and the DC Mt Barker should work with:

- Developers to reduce sediment inputs from new housing estates and
- Private landholders, the Goolwa – Wellington LAP and the SAMDB NRMB to improve agricultural land management.

Staged Action Plan for Reducing Flood Risk

Stage	Season	Details
1	NA	• Undertake detailed site assessment and obtain necessary approvals (see following section).
2	Winter prior or earlier	• Order/propagate watercourse plant seedlings, see table below • Order/propagate shade tree seedlings, see table below.

3	Summer - autumn	• Excavate centre of channel to previous profile, opening out to larger pools (like a tear-drop shape with the narrow end extending upstream), removing Bulrush and Reeds. Take care to:
		  ○ Ensure rhizomes are removed
		  ○ Avoid the spread of weeds, especially if working in areas with high threat weeds, through appropriate soil hygiene
		  ○ Avoid damaging other native vegetation such as Red Gum saplings growing adjacent to the watercourse
		  ○ Prevent sediments washing downstream through careful timing and use of short term sediment traps.
		• Lay down matting (as used in other sections) around pools to prevent watercourse erosion and minimise weeds, Bulrushes and Reeds re-establishing.
		• Monitor for erosion and provide additional bank protection if required.

Stage	Season	Details
		• If available, watercourse seedlings can be planted in summer to early Autumn immediately following excavation works provided there is permanent moisture and warm temperatures, otherwise delay planting until spring.
4	Winter	• Spray-out top of northern banks with an appropriate knockdown herbicide: blanket spay if mulching, spot spray if area to be maintained through slashing. • Plant shade tree seedlings on top of northern banks. • Mulch: if area is to be maintained through slashing, only mulch around seedlings, otherwise mulch the entire area.
5	Spring	• Plant watercourse seedlings in channel and on lower banks to provide medium-term competition to slow Bulrush and Reed re-establishment (upper banks can be maintained through slashing).
6	Spring – Summer	• Follow-up spot weed control around revegetation with an appropriate herbicide.

For more detailed information on techniques see Clarke & Flannery (2007) and *Working in Waterways* (AMLR NRMB). It will take some years for the longer-term solutions (planting shade trees and catchment management) have a significant impact, therefore the excavation and watercourse planting works (stages 1-3 and 5) may need to be repeated every 5 to 10 years.

Table 5-1 Revegetation species (use some or all)

Common Name	Scientific Name	Purpose (notes)
River Red Gum	*Eucalyptus camaldulensis ssp. camaldulensis*	Shade; 1000 plants/m^2 or 2-3 rows 2-3m apart with plants at average 3m spacing; plant on upper banks.
Wirilda	*Acacia retinodes*	
Blackwood	*Acacia melanoxylon*	
Sea Club-rush	*Bolboschoenus caldwellii*	Watercourse margins, i.e. areas seasonally flooded and exposed; note some of these species may be difficult to obtain but can be propagated through division (except Water Ribbons and some Rushes); 10,000 plants/m^2, average 1x1m spacings.
Common Spike-rush	*Eleocharis acuta*	
Slender Knotweed	*Persicaria decipiens*	
River Buttercup	*Ranaunculus amphitricus*	
Flat-sedge	*Cyperus vaginatus*	
Tall Sedge	*Carex appressa*	
Tassel Sedge	*Carex fascicularis*	
Cutting Grass*	*Gahnia trifida*	
Small Rushes	e.g. *Juncus planifolius, J. pauciflorus, J. subsecundus*	
Water Ribbons**	*Triglochin procerum*	

*sturdy species that grows to 1m, consult with engineer / hydrologist as may be too large

** deeper water

Policies relevant to removal of Bulrush and Common Reed

The following is a summary of policies relevant to the actions outlined above. In addition, the *Working in Waterways* (AMLR NRMB) document outlines best practice operating procedures.

SAMDB NRM Plan:

Section 4.5 (Removal or destruction of vegetation) of the Best Practice Operating Procedure (BPOP) for water affecting activities (WAA) within the Mount Barker District Council outlines the Councils requirements relating to vegetation removal and WAA permits.

Native Vegetation Act

Provides for some exemptions for clearance of Common Reed and Bulrush (*Typha domingensis* only) however recent changes under Regulation 8(16) of the Native Vegetation Regulations 2017 do not include clearance in a natural watercourse. Clearance approval is therefore required and Native Vegetation Branch should be contacted.

Environment Protection Act

May come into effect depending on the scale of the dredging as it may affect water quality.

5.2 MANAGEMENT OF SPINY RUSH AND DRAIN FLAT-SEDGE

Background

Spiny Rush (*Juncus acutus*) and Drain Flat-sedge (*Cyperus eragrostis,* also known as Umbrella Sedge) are two highly invasive watercourse weeds found during the course of the field survey.

Spiny Rush is native to North Africa, Europe and America and is established throughout southern Australia, generally in seasonally damp sites and often under semi-saline conditions in pastures, wetlands and watercourses. It is a perennial species that matures within two years and produces numerous fine seeds in Summer. The tips of the leaves and stems are extremely sharp, making it unpalatable to stock, impenetrable and a hazard to humans. Spiny Rush can displace native vegetation, forming dense monocultures. It may be mistaken for native species such as Sea Rush (*J. kraussii*). For more information about the impacts and identification of Spiny Rush see Miles (2009).

Figure 5.4 The weed Spiny Rush (*Juncus acutus*)

Figure 5.5 The weed Drain Flat-sedge (*Cyperus eragrostis*)

Drain Flat-sedge is native to South America and, although not common in the Mt Lofty Ranges, is well established in some wetlands and channels in the northern Adelaide Plains. It is found throughout Australia and is particularly a common weed in drains and rice crops in NSW and Queensland. It is a perennial species with short rhizomes from which it regrows after dry periods. It also produces numerous small seeds. It may be mistaken for native sedges such as Flat-sedge (*C. vaginatus*).

Distribution

Spiny Rush was found in Mt Barker Creek in 2006 in the Big Green section below the entry of Railway Creek and in Laratinga section (Miles 2006). It has increased in density in some areas and has now spread upstream into the lower end of Railway and Littlehampton Creeks, into the newer wetlands on the southern side of the Laratinga section and downstream into agricultural lands. Whilst increasing in density on the margins of the watercourse, it has been displaced in some areas where it was previously growing in the middle of the channel by Common Reed and Bulrush.

Spiny Rush is found in throughout the Bremer Barker Catchment and around the Lower Lakes. Drain Flat-sedge was not found during the previous study (Miles 2006) but has been found in the Cornerstone College wetlands and adjacent section of watercourse since at least 2010. During this survey, several plants were found in Railway Creek and the Cornerstone College sections, and one plant in Dunn Park and one near the Adelaide Road Bridge. A thorough examination of all watercourses and wetlands in other parks should be undertaken to identify all populations.

Management

Approach

It is recommended that an intensive program be implemented by the Council targeting both these weeds as they are currently in sufficiently low numbers to be eradicated from the Mt Barker Creek. A two year control program that incorporates populations outside the plan area should be able to control most plants after which annual monitoring and follow-up control will still be required but will require fewer resources.

There is likely to be some re-growth where plants have been removed, so the sites should be GPS'd and revisited the following year and any re-growth removed. Prior to control works, all Spiny Rushes and Drain Flat-sedges should be clearly identified with paint or tape to prevent accidental removal of local native species.

Timing

Ideally, control works should be undertaken in November – December when the plants are actively growing and prior to seed set. However, in situations where the plants are partially submerged in early Summer, it may be more appropriate to wait until water levels have dropped in mid-late Summer and it is safe to use herbicides.

Hygiene

Whatever the timing of control works, great care should be taken to avoid the spread of seeds around the site and via soil attached to the machinery, Spiny Rush in particular may carry seeds in the nuts on the plant all year. Also take care to minimise the amount of soil disturbance. All removed plants should preferably be burnt to destroy the seeds.

Spiny Rush Control Methods

Control methods for Spiny rush are 1) physical removal and 2) spot spraying with herbicide. Where Spiny Rushes occur in the watercourse, only use herbicides approved for use in a watercourse. Physical removal should be used along the watercourse where access permits. Small plants may be removed using a spade, however, because of the size of the mature plants and the sharpness of the spines, a small backhoe will be required for most plants. Follow-up monitoring and control is essential as soil disturbance generally allows more weeds to germinate, however this results in the seed bank being depleted. Spot spraying should be used for less accessible areas and where there is not open water, such as in the upper Big Green section and the wetlands to the south of the creek. For more information on control methods see Miles (2009) and DEC (2013).

Drain Flat-sedge Control Methods

Physical removal and herbicides are also recommended for Drain Flat-sedge, however, because this species commonly grows in wetter situations and is also smaller and not spiny, removal by hand is the preferred option. Ensure all rhizomes are removed, follow-up with monitoring and control new growth. Herbicide application by spot spraying, wick wiping or hand application to leaves and stems will reduce off-target damage in situations where hand removal is not practical. For more information on control methods, see DEC (2013).

5.3 CREEK WIDENING AND REVEGETATION

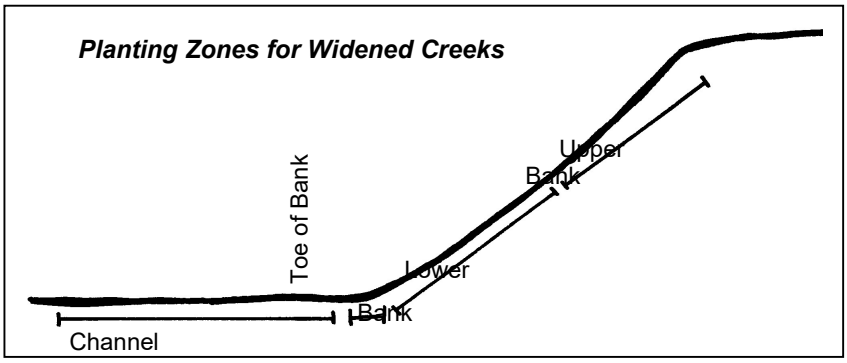
The Mount Barker District Council has undertaken a program of widening sections of creeks within the boundaries of the Mount Barker Township in order to reduce the incidence and extent of flooding in the town. It should be noted that these activities need to be compliant with the Mount Barker District Council Development Plan (MBDC 2017a) and Water Affectivities Best Practice Operating Procedure (MBDC 2015), as discussed in Section 5.9.

While the excavation work involves a high level of disturbance to the creek, there are opportunities to capitalise on the work for environmental gains. Exotic trees and large woody weeds are usually removed prior to the excavation works being undertaken. Without active revegetation and follow-up weed control, widened channels are likely to be re-colonised by exotic trees, with an understorey of the grass weed Phalaris on the banks and Bulrushes proliferating in the channel.

In order to shift the vegetation to a community dominated by local native species, revegetation should follow excavation works in the winter after, with particular care taken as to the number of plants, species used and their location:

- The number of shrubs planted on the banks should be determined in consultation with Council engineers to maintain the channel's roughness coefficient;

- Establish closely planted “colonies” of native sedges and rushes in late Summer/early Autumn before water levels rise, or Spring as water levels lower, to prevent Bulrush taking over (see table);
- Plant trees on the north and/or western banks of deeper and/or permanent pools to provide dappled shade to reduce water temperatures (Davies et al 2004).



The use of jute matting may be of assistance in preventing the banks being re-colonised by weeds. Jute matting is a biodegradable mat that is commonly used to prevent erosion in the initial phases following bank excavation works. Plants are established in holes in the matting. In the case of the Mt Barker Creek, adequately securing the matting to prevent it lifting and washing away during high flow periods will be critical, especially in the first season. As with the selection of plants, jute matting should be used in consultation with Council engineers, as it is likely to decrease the channel’s roughness coefficient in the short term, which may result in downstream erosion.

A major negative environmental outcome that may occur as a result of channel widening is the potential slowing of flows resulting in sediment accumulation (Brierley & Fryirs 2005). The two main impacts of sedimentation are:

1. That the channel becomes shallower and the surrounding areas may again be at risk of flooding, so the channel will have to be re-excavated,
2. That the deeper pools will fill with sediment, becoming shallower and will dry out for longer periods.

Deep permanent pools are important refuges for fish[1] and other native aquatic species during dry seasons and need to be maintained in order for these species to survive. Strategic planting with native vegetation may be an option to increase flows where permanent pools exist to reduce sedimentation, but specialist advice from an expert in geomorphology would need to be sought.

[1] Native Mountain galaxias (fish) have been found at four sites in Mount Barker (Hammer 2004)

Table 5-2 Revegetation species for watercourses

Scientific Name	Common Name	Channel	Toe of bank	Lower bank	Upper bank	Comments
Acacia melanoxylon	Blackwood				✓	Small tree, shade
Acacia retinodes	Wirilda				✓	Small tree, shade
Banksia marginata	Silver Banksia					
Bolboschoenus caldwellii	Salt Club-rush	✓				Tolerates submersion
Callistemon tereticaulis	River Bottlebrush		✓			Shrub
Carex appressa	Tall Sedge		✓	✓		
Carex tereticaulis	Rush Sedge		✓	✓		
Eleocharis acuta	Common Spike-rush	✓				Tolerates submersion
Eucalyptus camaldulensis	River Red Gum				✓	Large tree, shade
Goodenia ovata	Hop Goodenia			✓		Shrub
Hakea rostrata	Beaked Hakea				✓	Shrub
Juncus pallidus	Pale Rush	✓	✓	✓		
Juncus sarophorus	Rush		✓	✓		
Juncus subsecundus	Finger Rush		✓	✓		
Leptospermum continentale	Prickly Tea-tree			✓	✓	Shrub
Leptospermum lanigerum	Wooly Tea-tree		✓	✓		Shrub
Melaleuca brevifolia	Short-leaf Honey-myrtle			✓		Shrub
Melaleuca decussata	Totem Poles			✓	✓	Shrub
Phragmites australis	Common Reed	✓	✓			Likely to colonise naturally
Poa labillardieri	Common Tussock-grass			✓	✓	
Schoenoplectus validus	River Club-rush	✓				Tolerates submersion
Themeda triandra	Kangaroo Grass				✓	
Rytidosperma spp.	Wallaby Grass				✓	
Austrostipa spp.	Spear Grass				✓	

5.4 PROMOTE THE USE OF LOCAL NATIVE SPECIES IN LANDSCAPING

The Council has already begun using local native species in landscaping, in particular areas around bridges. Unfortunately some plants have died and need to be replaced with more drought tolerant species as they are growing in harsh situations. 'Halo' planting of understorey species around large remnant trees, as has been done at Laratinga Wetlands, is also a good way to integrate local native species into parks and reserves.

Local native species should continue to be incorporated in newly landscaped public areas, and signage to identify species may encourage the public to use local natives. The DC Mount Barker *Sustainable Landscape Design 2017 – Interactive* provides example designs incorporating native species.

Revegetation along trails should be mindful of maintaining lines of sight for the safety of path users and fauna.

Figure 5.6 Local native species use to landscape a bridge embankment along the Linear Trail

5.5 INTRODUCED DECIDUOUS TREES

Introduced deciduous trees have been widely planted throughout Mount Barker and surrounding townships and have cultural and amenity value to the residents. Deciduous trees have an important role in many parks, along walkways and in home gardens, where they provide cool shade in summer and warm sunlight in winter. However, these species present two main environmental problems:

1. Much of the annual leaf-drop lands in or is washed into watercourses, causing a sudden increase in nutrient pollution which can in turn lead to algal blooms, dominance of high-nutrient loving aquatic plants (such as Bulrushes) and a drop in oxygen levels in the water, and
2. Many spread by seed or suckers to watercourse areas where they can quickly become the dominant species, the heavy seasonal shade from deciduous trees favours introduced groundcovers such as Periwinkle and Three Corner Garlic to the exclusion of native groundcovers, and such areas provide poor habitat for native birds.

The Mount Barker District Council has been undertaking a program to remove exotic trees along the many creeks in its area, and the abundance of these species was notably reduced since the previous study (Miles 2006). However, exotic tree removal will is an on-going requirement as surrounding areas and upstream catchments contain numerous seed sources and many invasive species continue to be planted.

It is recommended that invasive species should no longer be established on Council lands (e.g. roadsides) and private landholders should be discouraged from planting them. Some species of particular concern are:

Box Elm (*Acer negundo*)

Desert Ash (*Fraxinus rotundifolia*)

Hawthorn (*Crataegus monogyna*)

Plums (*Prunus sp.*)

White Poplar (*Popularus alba*)

Options for using local native species should be trialled and promoted to the community. Some local small tree species with attractive appearance that should be investigated are:

Cup Gum (*Eucalyptus cosmophylla*)

Blackwood (*Acacia melanoxylon*)

Wirilda (*Acacia retinodes* – hill form)

Silver Banksia (*Banksia marginata*)

Additionally, exotic deciduous trees with low risk of spreading may be used provided they are not planted where the majority of leaves will fall in a drain or watercourse. Species include:

Claret Ash (*Faxinus aungustifolia ssp.*),

Honeylocust (*Gleditsia triacanthos*).

Figure 5.7 Box Elm is widely used in new development areas but has a high weed potential, producing numerous seedlings and thriving in damp situations

5.7 REVEGETATION ENHANCEMENT & MAINTENANCE

A number of revegetation areas are over five years old and the opportunity exists to increase the range of native species in these areas. Many native species that would not have been possible to establish during the first phase of revegetation due to conditions being unsuitable (e.g. too much weed competition, not enough shade) can now be planted. Additionally, other species that may not have been available at the initial planting phase can also be added.

Understorey species are often more difficult to propagate and locate seed for, however, once established in revegetation areas, planted understorey can become a source for future plantings. For example, the Woolly Tea-trees in Keith Stephenson Park and Silver Banksias at Laratinga Wetlands can be used as seed stock for future plantings. Native grasses and other groundlayer species such as Running Postman may produce greater quantities of seed in revegetation than they otherwise would in bush areas where there is more competition. When using revegetation as a future seed source, it is important to keep good records about the source and planting location of the plants.

Older revegetation along the Laratinga and Big Green sections includes a high proportion of Swamp Wattle (*Acacia provincialis* syn. *A. retinodes* "swamp form"). This is a shorter lived species than the closely related Wirilda (*A. retinodes* syn. *A. retinodes* "hill form") and more typical of wetter, higher rainfall sites. Swamp Wattle has not regenerated in older plantings whereas Wirilda has. It is recommended that future plantings use Wirilda in preference to Swamp Wattle and that Wirilda should be planted into gaps in these older revegetation sites.

Figure 5.8 Revegetation dominated by Swamp Wattle and lacking understorey (2012)

It is noted that the range of species used by the Council in more recent revegetation projects has increased and a much higher proportion of grasses and rushes are used than trees and shrubs (although some have been lost, as discussed below). This type of revegetation mix more accurately reflects the pre-European vegetation association. Revegetation at Cornerstone College provides an excellent example of what can be achieved with diverse planting and follow-up maintenance. It is important to ensure that tree guards are removed from plantings once plants are established to ensure survival of the plants, prevent litter and for visual amenity.

The following is a list of species that could be incorporated as understorey riparian River Red Gum woodland revegetation sites:

Species Name	**Common Name**	**Propagation Method**
Wahlenbergia spp.	Blue-bell	TS
Acaena nova-zelandiea	Sheep's Burr	Seed, TS or HDS
Allocasuarina verticillata	Drooping Sheoak	Seed, TS or HDS
Arthropodium spp.	Chocolate Lily	TS
Rytidosperma caespitosa	Common Wallaby-grass	Seed, TS or HDS
Rytidosperma spp.	Wallaby-grass	Seed, TS or HDS
Austrostipa mollis	Tall Spear-grass	Seed, TS or HDS
Austrostipa sp.	Spear-grass	Seed, TS or HDS
Banksia marginata	Silver Banksia	TS
Bulbine bulbosa	Bulbine Lily	TS
Carex tereticaulis	Tall Sedge	Seed or division, TS
Hakea rostrata	Beaked Hakea	Seed, TS
Hardenbergia violaceae	Native Sarsparilla	Seed, TS or HDS
Hibbertia sericea var. sericea	Silky Guinea-flower	Seed or cuttings, TS
Juncus pallidus	Pale Rush	Seed, TS
Juncus sarophorus	Rush	Seed, TS
Juncus subsecundus	Finger Rush	Seed, TS
Leptospermum myrsinoides	Heath Tea-tree	Seed, TS
Microlaena stipoides var. stipoides	Weeping Rice-grass	Seed, TS or HDS
Olearia ramulosa	Twiggy Daisy-bush	TS
Poa labillardieri	Tussock-grass	Seed, TS
Senecio quadridentatus	Cotton Groundsel	Seed, TS
Themeda triandra	Kangaroo Grass	Seed, TS or HDS
Clematis microphylla	Old Man’s Beard	TS
Scaevola albida	Pale Fanflower	TS
Chrysocephalum apiculatum	Common Everlasting	TS
Lomandra densifolia	Soft Tussock Mat-rush	TS
Dianella revolute	Black-anther Flax-lily	TS
Kennedia prostrata	Running Postman	TS

TS = tubestock, HDS = hand direct seed

Skills of Staff and Contractors

The author and others have observed several examples of understorey plantings being sprayed during revegetation maintenance. In order to prevent accidental damage to native remnant and revegetated vegetation, it is important that any personnel working along the creeks have adequate plant identification skills. This will require staff training otherwise Council will be reliant on contractors to obtain the necessary skills to manage the planted areas. Staff training should include:

- Plant identification,
- Recognition of secondary regeneration of native species,
- Bushland weed control methods appropriate for use in bushland areas,
- Appropriate management techniques to use in and around watercourses,
- Relevant legislation, policies and procedures.

To further reduce the risk of mis-identification, species such as native grasses and rushes could be marked with a bamboo stake when planted to help identify that they are not weeds.

Ultimately, these recommendations support the implementation of the Biodiversity Strategy priority action: "Dedicated specialist on-ground team that are trained and have experience in land conservation and management" (MBDC 2017b).

5.8 FOLLOW-UP WEED CONTROL

Follow-up control of all weeds that are removed is essential otherwise cleared areas will quickly return to their former weed-dominated state. This should be seen as a higher priority than clearing new areas as the cost of maintaining areas in a weed-free state[2] is much less than removing dense weeds. For most exotic trees and woody weeds, follow-up control should be carried out every two to three years before any re-growth has an opportunity to set seed, but Spiny Rush and Drain Flatsedge should be followed-up annually.

A suggested approach would be to incorporate a follow-up control year into the Council's work plan. For example, carryout follow-up weed control and clearing of new areas in alternate years:

- Year 1: follow-up weed control all sections previously cleared, including Spiny Rush;
- Year 2: remove exotic trees and revegetate new section, control Spiny Rush;
- Year 3: follow-up weed control all sections previously cleared, including Spiny Rush;
- Year 4: remove exotic trees and revegetate new section, control Spiny Rush.

If one year is insufficient to carry out follow-up in all cleared areas, then clearing of new areas in the following year should be postponed in favour of completing the follow-up. However, where funding opportunities arise, the weed strategy may occasionally be altered.

It can be assumed that the majority of weed re-growth in the first few years will be from the soil seed-bank of the original plants, and therefore the level of re-growth should reduce over time. However, there are numerous sources of seeds throughout the catchment, so it is unlikely the need for follow-up control will be on-going.

[2] An area free of high threat weeds such as deciduous trees, Gorse and Spiny Rush.

5.9 APPROVALS AND PROCEDURES

Council is required to obtain regulatory approvals for certain activities in and around watercourses. Requirements under the *Development Act 1993* and *Natural Resource Management Act 2004* are summarised below. Other approvals may also apply, including (but not limited to) under the *Environment Protection and Biodiversity Conservation Act (*Commonwealth)*, Environment Protection Act 1993* and *Native Vegetation Act 1991*.

Water Affecting Activities

The following text is taken from the Council's Best Practice Operating Procedure – Water Affecting Activities (MBDC 2015). For further guidance, staff should refer to the BPOP.

The Natural Resources Management Act, 2004 outlines provisions for the control of water affecting activities. Water affecting activities are defined in Section 127(5) of the Act and are activities that can have an impact on water resources and dependant ecosystems,

The Act defines these activities as:

(a) the erection, construction or enlargement of a dam, wall or other structure that will collect or divert water flowing in a watercourse that is not in the Mount Lofty Ranges Watershed and that is not prescribed or flowing over any other land that is not in a surface water prescribed area or in the Mount Lofty Ranges Watershed;

(b) draining or discharging water directly or indirectly into a watercourse or lake;

(c) depositing or placing an object or solid material in a watercourse or lake;

(d) obstructing a watercourse or lake in any other manner;

(e) depositing or placing an object or solid material on the floodplain of a watercourse or near the bank or shore of a lake to control flooding from the watercourse or lake;

(f) destroying vegetation growing in a watercourse or lake or growing on the floodplain of a watercourse;

(g) excavating or removing rock, sand or soil from
- *a watercourse or lake or the floodplain of a watercourse; or*
- *an area near to the banks of a lake so as to damage, or create the likelihood of damage to, the banks of the lake;*

(h) using water in the course of carrying on a business in an NRM region at a rate that exceeds the rate prescribed by an NRM plan if the water has been brought into the region by means of a pipe or other channel;

(i) using effluent in the course of carrying on a business in an NRM region at a rate that exceeds a rate prescribed by an NRM plan;

(j) an activity prescribed by the regulations.

The Mount Barker Council operates under a Best Practice Operating Procedure (BPOP) for water affecting activities within the of Mount Barker District Council. This document conforms to the requirements of parts of Section 8.1.1 of the South Australian Murray Darling Basin Natural Resource Management Plan and forms a series of best practice operating procedures (BPOP) for Mount Barker Council's works and its contactors to follow under the Natural Resource Management Plans for the SA Murray-Darling Basin NRM Board.

Under this BPOP it is agreed that the following will apply to activities undertaken by the Mount Barker Council staff and contractors:

- *For proposed Water Affecting Activities to be undertaken in NRM Board area this Best Practice Operating Procedures will cover all minor and low risk activities undertaken by the Council. Where an activity is low risk and the procedures in this BPOP are followed, no separate Water Affecting Activity Permit will be required. Routine maintenance activities and replacement of existing pipes and culverts do not require separate permits where a matrix score of <13 is achieved.*
- *The following Water Affecting Activity Permit determination process will be used to determine whether projects and activities require a separate Water Affecting Activity Permit. Where an activity has the potential to have a high impact, i.e. a score greater than 13 in the following risk assessment template, a separate Water Affecting Activity Permit must be obtained.*

There is a 2 step process for determining if a Water Affecting Activity Permit is needed:

Step 1. Check relevant NRM plan or Water Allocation Plan for activities that require a permit and for any possible exclusions for the activity to be undertaken. (note: tables of exclusions from the NRM plan and links to Water Allocation Plans are attached in appendix A)

Step 2. Undertake the Water Affecting Activity Risk Assessment.

Development Approval Procedures

The Mount Barker District Council Development Plan details the requirements for development under the *Development Act 1993.* The Principles of Development Control establish the development standards that apply to all forms of development and provide a yardstick against which the suitability of development proposals is measured (MBDC 2017a). Principles of Development Control of particular relevance to the management of watercourses are presented in the following sections:

- Natural Resources (pp. 80 - 88) including water sensitive urban design, biodiversity and native vegetation and water catchment areas,
- Open Space and Recreation (pp. 89 – 91)
- Landscaping, Fences and Walls (pp. 74 – 75)

Other sections also have principles that may apply.

6 MONITORING PLAN

This section provides recommendations for monitoring the objectives of the management plan.

Monitoring can be resource intensive but is important to guide future management and to report on investment. Hence, monitoring is divided into:

- Minimum requirements for which the Council should be responsible, and
- Additional monitoring that would be beneficial.

Targets, timing and methods are specified for the minimum monitoring requirements, whilst additional monitoring methods and targets would need to be developed in conjunction with the participants. It is recommended that:

- A template for monitoring and reporting be developed,
- All monitoring results are collated and reported annually by the Council and
- The report includes analysis of the data and trends and outlines management responses where targets fail to be met.

MINIMUM MONITORING REQUIREMENTS

Table 6-1 outlines the minimum monitoring requirements to demonstrate progress towards the management objectives. These activities are the responsibility of Council and may be undertaken by staff with moderate levels of expertise, but staff will require some basic training.

Table 6-1 Minimum monitoring requirements

Target	Timing & frequency	Method	Area
1. A steady decrease in the distribution of high threat weeds as mapped by this project	October, annually	Walk through and GPS all high threat weeds, compare with previous year using GIS	Entire project area
2. No increase in the density of exotic trees, woody and other perennial weeds in each section compared with 2012 levels	October, annually	Walk through and record densities in each section as per categories used in this report, compare with previous year	Entire project area
3. Increased native plant cover and diversity	Ideally in spring, once before works, then 1, 2 and 5 years after works	Photopoint and plant species list (native and non-native) for a 100m section of bank (from the centre of the watercourse to the edge of the managed riparian zone)*, compare native and non-native species diversity and cover	One site per works area
4. Vegetation removal works do not contribute significantly to watercourse turbidity	Monthly intervals, ≥ once before and on-going after works until banks are covered	Water turbidity sampling using turbidity tube	2 sites per works area, one within 200m upstream, one within 200m downstream

*Bushland Condition Monitoring method may be used as an alternative but is more labour intensive.

ADDITIONAL MONITORING

The following outlines additional monitoring that could measure progress towards the management objectives and help guide management future actions. These monitoring activities could be largely undertaken by volunteers, however, volunteer monitoring still requires training, support and coordination.

Community Monitoring

Community-based water quality monitoring is coordinated by the SAMDB NRM Board and monitoring is undertaken on an irregular basis at five sites in the management plan project area. This program provides valuable data and also engages members of the community in, and educates them about, water management. It is recommended that:

1. These monitoring sites continue to be monitored, with monitoring of physical and chemical parameters undertaken at least quarterly
2. Monitoring at the Bollen Road site (WFC 030) is expanded to at least include turbidity.
3. Macroinvertebrate monitoring be undertaken at least annually at least at the sites LAR 140, KEI 300 and MOU 110.
4. More volunteers and schools are encouraged to participate in monitoring.
5. Monitoring data for the project area be collated and reported back to the community annually.

It is recognised that implementation of these recommendations is subject to volunteer participation as well as resourcing through the SAMDB NRMB.

A water quality target would need to be developed in conjunction with the SAMDB NRM community monitoring project officer and incorporate a review of historical data. The target should focus on results being within historical trends and below critical thresholds.

Bushland Condition Monitoring

Bushland Condition Monitoring (BCM) (Croft et al. 2005) is a repeatable and semi-quantitative method originally developed for monitoring the condition and habitat values of remnant vegetation. The methodology is suitable for revegetation areas, in particular it can help guide management actions by identifying busland condition indicators that could be improved through management. Revegetation sites can be compared with reference remnant sites.

BCM is more labour intensive than the method outlined above under minimum requirements for native species diversity. If doing the full suite of indicators (including tree health and habitat), monitoring a single BCM site in remnant vegetation would usually take two operators working together 2-4 hours. Revegetation sites often do not include mature trees and have relatively low species diversity so can be quicker to monitor. BCM requires moderate plant identification skills and training which is provided by the Nature Conservation Society of SA at cost.

BCM is usually performed in 30 by 30 metre quadrats, however, for linear sites such as along watercourses, the shape may be modified to achieve the same area and so 10 by 90 metres may be used. BCM method uses 10 indicators of bushland condition which ideally should all be used, however, the first three (plant species diversity, weed abundance and threat and structural diversity) can be used as a minimum.

A suggested target for this indicator is: a steady improvement in bushland condition scores.

Fauna Monitoring

Additionally, monitoring of birds, fish and frogs should be encouraged to give an indication of the biodiversity condition of the creek systems. Frogs are known to be particularly sensitive to water pollution and would be good indicators for implementation of the management plan. In the past, the frog monitoring program “Frogwatch” was coordinated by the EPA and involved volunteers recording frog calls, with the recordings analysed by the EPA. Such a program could be

developed in Mt Barker and would be useful in engaging the community, however, it may be less resource intensive to undertake the monitoring without community participation.

Bird monitoring is undertaken in the vicinity of the Laratinga Wetlands by volunteers from Birds SA. Bird monitoring requires specialist expertise and it may be difficult to expand the current monitoring beyond Laratinga. However, bird monitoring would be particularly useful for demonstrating improvements resulting from exotic tree removal and volunteers should be encouraged undertake monitoring within other management sections.

Fish monitoring also requires specialist expertise as well as a permit. A fish survey was carried out in 2004 and only one native species (Small-mouthed Hardyhead) was found (Hammer 2004). It is likely that native fish are responding to pressures beyond the scope of the management plan and are not recommended as indicators for the management plan.

No decline in fauna diversity and a steady increase in diversity is recommended as the target for fauna monitoring.

Community Support and Participation

Ideally, the Mt Barker community should be engaged in and supportive of the management plan. Numbers of participants in watercourse management related activities can be recorded and reported annually. Media and direct correspondence may also be monitored to gain an indication of non-participants support or otherwise for the management plan.

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8 APPENDIX 1: PLANT SPECIES OBSERVED

NATIVE SPECIES

Isolated = one location or patch; P = planted L = less than 5% cover; M = approximately 5% to 50% cover; H = approximately more than 50% cover; R = regeneration present. Note: revegetation species planted in 2019 not recorded

Species Name	Common Name	1: Keith Stephenson	2: Adelaide – Hutchinson Rds	3: Willow Flat	4: Anembo Park	5: Cornerstone College	6: Dunn Park to Western Flat Crk	7: Big Green	8: Laratinga	9: Railway	10. Railway Mid	Retirement Village	Flaxley Road	Western Flat Tributary	Railway Upper	Eastern Creek	Waterford
Acacia acinacea	Wreath wattle							P			P						
Acacia melanoxylon	Blackwood	L	P		P	P	L	P	P, R	R		P	P	P		P	P
Acacia myrtifolia	Myrtle Wattle	P				P			P								
Acacia paradoxa	Kangaroo Thorn										P			P	P		
Acacia provincialis	Swamp Wattle	P	P			P	P	P	P, R	P	P		P	P	P	P	
Acacia pycnantha	Golden Wattle	P	P		P	P		P	P					P	P		
Acacia retinodes	Silver Wattle						R			P							L
Acacia retinodes/ provincialis (seedling)	Wattle				P												
Acacia rupicola	Rock Wattle	P															
Acacia sp. (argyrophylla?)	Wattle						P		P								
Acacia verniciflua	Varnish Wattle	P				P	P	P	P					P			
Acacia verticillata	Prickly Moses								P								
Allocasuaria sp. ()	Sheoak	P															
Allocasuarina verticillata	Drooping Sheoak	P	P		P			P	P					P			
Amyema preisii	Wire-leaved Mistletoe							L									
Austrostipa sp.	Spear-grass	P							P								
Austrostipa elegantissima	Elegant Spea-grass								P, R								
Banksia marginata	Silver Banksia						P		P					P			
Baumea articulata	Jointed Twig-rush															P	
Billardiera sp.	Appleberry					P	P										
Bolboschoenus caldwellii	Salt Club-rush	I	L					L	M	L						L	L
Bursaria spinosa	Christmas Bush	P			P		P	P	P					P	P		
Callistemon rugulosus	Scarlet Bottlebrush	P			P	P		P									
Callistemon sieberi	River Bottlebrush	P	P, L			P	P		P		P						
Callistemon sp.	Bottlebrush											P			P		P
*Calystegia sepium**	Greater Bindweed																
Calytrix tetragona	Common Fringe-myrtle					P											
Carex appressa	Sedge	P				P			P							L	

Species Name	Common Name	1: Keith Stephenson	2: Adelaide – Hutchinson Rds	3: Willow Flat	4: Anembo Park	5: Cornerstone College	6: Dunn Park to Western Flat Crk	7: Big Green	8: Laratinga	9: Railway	10. Railway Mid	Retirement Village	Flaxley Road	Western Flat Tributary	Railway Upper	Eastern Creek	Waterford
Carex tereticaulos	Sedge	P	P		P	P			P					P	P		
Correa glabra var. turnbullii	Rock Correa					p			P								
Correa sp.	Correa														P		
Cortaderia selloana	Pampass Grass									P							
Crassula helmsii	Swamp Crassula									I							
*Cycnogeton procerum (*Syn. *Triglochin procerum)*	Large Water Ribbons	L							L			L					
Cyperus gymnocaulos	Spiny Flat-sedge				L			L									
Cyperus vaginatus	Flat-sedge	L, P							P								
Dianella brevicaulis	Blueberry Flax-lily	P									P				P		
Dianella revulota	Black Anther Flax-lily	P					P	P	P								
Dononaea viscosa ssp. spatulata	Sticky Hop-bush	P			P		P	P	P						P		
Eleocharis acuta	Common Spikerush															I	
Eleocharis sp.	Spike Rush											L		L	L		L
Epilobium billardierianum ssp. billardierianum	Smooth Willow-herb					L		L			L			L			
Epilobium hirtigerum	Hairy Willow-herb																
Eucalyptus camaldulensis ssp. camaldulensis	River Red Gum	M	L	M	M	M	L	P, R	M	M	L	L	M	P	M	L	M
Eucalyptus cosmophylla	Cup Gum	P							P			P					
Eucalyptus fasciculosa	Pink Gum							P								P	
Eucalyptus leucoxlon ssp.	Blue Gum						P		P				L				P
Eucalyptus leucoxylon ssp. leucoxylon	SA Blue Gum						P										
Eucalyptus viminalis ssp. cygnetensis	Rough-barked Manna Gumm	P, R	P, R						P							P	
Ficinia nodosa	Knobby Clubrush	P				P	P	P	P						P		
Gahnia sieberiana	Red Fruit Cutting-grass						P										
Geranium sp.	Geranium	L			L									L			
Goodenia ovata	Hop Goodenia								P								
Grevillea lavandulacea x rosmarifolia	Grevillea hybrid					P											
Hakea carinata	Erect Hakea	P				P	P	P									
Hakea rostrata	Beaked Hakea					P	P	P	P			P					
Hardenbergia violaceae	Native Sarsparilla	P						P, R	P		P				P		
Isolepis sp.	Club-rush						I										
Juncus kraussii	Sea rush				L			L	L						P	P	
Juncus pallidus	Pale Rush				L		P		P	L		P		L	L	P	
Juncus sarophorus	Rush															P	

Species Name	Common Name	1: Keith Stephenson	2: Adelaide – Hutchinson Rds	3: Willow Flat	4: Anembo Park	5: Cornerstone College	6: Dunn Park to Western Flat Crk	7: Big Green	8: Laratinga	9: Railway	10. Railway Mid	Retirement Village	Flaxley Road	Western Flat Tributary	Railway Upper	Eastern Creek	Waterford
Juncus sp.	Rush	L			P	P		P									
Juncus subsecundus	Finger Rush								P		L			I			L
Leptospermum continentale	Prickly Tea-tree	P			P		P							L			
Leptospermum lanigerum	Woolly Tea-tree	P, R	P, R		P				P					P			
Lomandra multiflora ssp.dura	Hard Mat-rush										P				P		
Lythrum hyssopifolia	Lesser Loosestrife															L	
Melaleuca brevifolia	Swamp Honey-myrtle	P							P							P	
Melaleuca decussata	Totem Poles	P	P			P	P	P	P					P	P		P
Myriophyllum sp.*	Milfoil																
Olearia ramulosa	Twiggy Daisy-bush	P					P	P			P				P		
Patersonia sp.	Purple Flag														P		
Persicaria decipiens	Slender Knotweed	L	L				L		P		L						
Phragmites australis	Common Reed	I	L		M		L	H	M		P						
Poa labillardieri	Tussock Grass								P								
*Potamogeton crispus**	Curly Pondweed																
Rytidosperma sp.	Wallaby Grass					P, R											
Schoenoplectus pungens	Sharp-leaf Clubrush														L		
Schoenoplectus validus	River Clubrush						I				L				L	P	
Solanum sp. (laciniatum/ aviculare)*	Large Kangaroo Apple									I							
Themeda triandra	Kangaroo Grass														P		
Typha domingensis	Bulrush	H	M		L	H	M	M	M	H	M	M	M	I	H	L	M
Total Planted, no regeneration		**24**	**6**	**0**	**11**	**18**	**19**	**17**	**30**	**3**	**9**	**5**	**2**	**12**	**17**	**10**	**4**
Total planted, regenerating		**2**	**2**	**0**	**0**	**1**	**0**	**2**	**3**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Total unplanted		**9**	**5**	**1**	**7**	**3**	**7**	**7**	**6**	**6**	**6**	**4**	**3**	**7**	**6**	**6**	**6**

INTRODUCED SPECIES

I = occurs in a dense patch L = less than 5% cover M = approximately 5% to 50% cover H = approximately more than 50% cover

* indicates Winter and Spring annuals / bulbs species observed in 2005 that were not observed in 2012 but would not normally be seen in Summer

Threat	Species Name	Common Name	1: Keith Stephenson	2: Adelaide – Hutchinson Rds	3: Willow Flat	4: Anembo Park	5: Cornerstone College	6: Dunn Park to Western Flat Crk	7: Big Green	8: Laratinga	9: Railway	10. Railway Mid	Retirement Village	School	Flaxley Road	Western Flat Tributary	Railway Upper	Eastern Creek	Waterford
Medium	*Acacia iteaphylla*	Flinders Ranges Wattle						P											
Medium	*Acacia longifolia spp.*	Sydney Coastal Wattle		I															
Low	*Acacia sp.*	Wattle		I															
High	*Acer negundo**	Box Elder		L		L				L	L							L	L
Medium	*Agapanthus praecox ssp. orientalis*	Agapanthus		I										I					
Medium	*Agave americana ssp.*	Agave												I					
Medium	*Allium triquetrum*	Three-corner Garlic	L	L	M	L		L	L	L	L	L		L		L		L	
Low	*Apium graveolens*	Celery	L	L		L		L	L	L									
Medium	*Arisarum vulgare(?)*	Hooded Arum(?)	L	L				L										L	
Low	*Aster subulatus**	Wild Aster		L					L	L					L			L	
Low	*Bromus catharticus*	Prairie Grass	L			L	L	L	L	L	L								
Low	*Bromus sp.*	Brome		L							L		L						
Low	*Callitriche stagnallis*	Common Starwort				L		L			M			L					
Medium	*Casuarina sp.*	Casuarina						I											
Medium	*Cirsium vulgare*	Spear Thistle	L	L	L	L		L	L	L								L	
Medium	*Conium maculatum*	Hemlock						L											
Low	*Convolvulus arvensis**	Field Bindweed									L								
Medium	*Coprosma repens*	Mirror-bush									L								
Low	*Cortaderia sp.*	Pampas Grass									I							I	
Low	*Cotoneaster glaucophyllus*	Cottoneaster									L								
Low	*Cotula coronopifolia*	Water Buttons																L	
Medium	*Crataegus monogyna**	Hawthorn		L	L						L			L					
Low	*Cruciferae*	Wild Turnip/Mustard					L		L	L									
Low	*Cupressus sp.*	Cypress tree										L							
High	*Cyperus eragrostis**	Drain Flat-sedge	TBC													L			L
Medium	*Cytisus proliferus*	Lucerne Tree										I							
Low	*Dactylis glomerata*	Cocksfoot	M	M	M	L	L	L	L	L	M	M		M	M		H	M	
Medium	*Echium plantagineum*	Salvation Jane					L												

Threat	Species Name	Common Name	1: Keith Stephenson	2: Adelaide – Hutchinson Rds	3: Willow Flat	4: Anembo Park	5: Cornerstone College	6: Dunn Park to Western Flat Crk	7: Big Green	8: Laratinga	9: Railway	10. Railway Mid	Retirement Village	School	Flaxley Road	Western Flat Tributary	Railway Upper	Eastern Creek	Waterford
Low	*Eucalyptus cladocalyx*	Sugar Gum		L															
Low	*Festuca arundinacea*	Tall fescue	L													I		M	H
Medium	*Foeniculum vulgare*	Fennel	L	L	L	L	L	L	L	L	M			L					
High	*Fraxinus rotundifolia ssp. rotundifolia*	Desert Ash	L	L		L	L	L	L	M	H	L		L			L	L	L
Medium	*Fumaria officinalis*	Fumitory	L	L	L	L	M	L	L	L	M				L			L	
Medium	*Galium aparine*	Cleavers		L	L		L	L	L	L	L			L	L	L		L	
Medium	*Gazania sp.*	Gazania									P								
High	*Genista sp.*	Broom	L	L		L	L	L	L		L								
High	*Hedera helix ssp. helix*	Ivy		L	I	I		L	L			L		I				I	
Low	*Helminthotheca echiodes*	Ox-tongue	L	L	L	L	L	L	L	L	L							L	L
Low	*Holcus lanatus**	Yorkshire Fog						L	L		L				M	M		L	
Medium	*Ipomea indica*	Morning Glory						I											
High	*Juncus acutus*	Spiny Rush							L	L									
Low	*Lomandra longifolia*	Mat-rush						P									P		
High	*Lycium ferrocissimum*	African Boxthorn						I											
Low	*Malva*	Tree Malva																	
Low	*Malva parviflora*	Marshmallow	L	L	L	L	L	L	L	L	L								
Medium	*Melaleuca armillaris*	Bracelet Honey-myrtle										I					I	P	
Low	*Mentha sp.*	Mint		L							L	L					L		
Low	*Myoporum parvifolium var.*	Creeping boobiala															P		
High	*Olea europaea*	Olive							L	L			I						
Low	*Oxalis pes-caprae*	Soursob	M	M	H	L	L	L	L	L	L								
Medium	*Paraserianthes lophanta*	Cape Leeuwin Wattle																L	
Low	*Paspalum distichum**	Water Couch				M			L	M	L							L	
Low	*Pennisetum clandestinum*	Kikuyu	L	L				I									M		
Low	*Phalaris aquatica*	Phalaris	M	M	H	M	L	H	M	M	H			L	L	M	M	L	
Low	*Piptatherum miliaceum*	Rice Millet		L				L				L							
Low	*Plantago major*	Greater Plantain	L																
Medium	*Populus alba**	White Poplar		M				I											
Medium	*Populus nigra**	Lombardy Poplar		L														P	
Medium	*Populus sp.*														L				
Low	*Potamogeton crispus**	Curly Pondweed										L		L		L			
Medium	*Prunus sp.**	Plum		L	H	L		L	L		L							L	L

Threat	Species Name	Common Name	1: Keith Stephenson	2: Adelaide – Hutchinson Rds	3: Willow Flat	4: Anembo Park	5: Cornerstone College	6: Dunn Park to Western Flat Crk	7: Big Green	8: Laratinga	9: Railway	10. Railway Mid	Retirement Village	School	Flaxley Road	Western Flat Tributary	Railway Upper	Eastern Creek	Waterford
Low	*Quercus robur*	English Oak																	
Low	*Ranunculus sp.*	Buttercup		M				M	L										
Low	*Ranunculus sp. (trilobus)*	Three-lobed Buttercup																L	
Low	*Rhagodia sp.*	Saltbush (NLN)															P		
Medium	*Rhamnus cathartica*	Buckthorn													L				
High	*Robinia psuedoacacia*	Suckering Mop Top Robinia																	
Low	*Rorippa nasturtium-aquaticum*	Watercress	L					L		I	L				L		L		
High	*Rosa sp.*	Wild Rose					L	L	L		L	L							
High	*Rubus fruiticossus*	Blackberry	L		L	L	L	L	L	L	M					I		L	
Low	*Rumex sp.*	Dock	L	L	L	L	L	L	L	L	L	L		L	L		L	L	
High	*Salix spp.*	Willows (various species)		L	L	L		L	L	L	L			L	L		L	L	L
Low	*Scabiosa sp.**	Scabious																	
Low	*Schinus molle*	Peppercorn Tree	1																
High	*Senecio mikanioides*	Cape Ivy			M	L													
High	*Senecio pterophorus*	African Daisy	L					L		L									
Low	*Sonchus sp.*		L	L	L	L	L	L	L	L									
Medium	*Syagrus ramnzoffiana(?)*	Cocos Palm (?)																	
Low	*Thynopyrum ponticum*	Tall Wheatgrass													M				
High	*Tradescantia fluminernsis*	Wandering Jew						L											
Medium	*Tragopogon porrifolius*	Salsify																L	
High	*Ulex europaeus*	Gorse			L	I	L	L			L	I							
High	*Ulmus sp.**	Elm																	
	Unknown	Pink flowering tree		?	?			?											
High	*Vinca major*	Periwinkle		M	I	I		H	I	I	M							L	
High	*Watsonia bulbillifera*	Bulbil watsonia																	
Medium	*Yucca aloifolia*	Yucca		L														L	
High	*Zantedeschia aethiopica*	Arum Lily	L				I							I					