ENVIRONMENT PROTECTION AUTHORITY

MYPONGA WATERCOURSE RESTORATION PROJECT FINAL REPORT 2000–07

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EPA South Australia

Myponga Watercourse Restoration Project final report 2000–07

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GLOSSARY AND ACRONYMS

AMLR NRM Board	Adelaide and Mount Lofty Ranges Natural Resources Management Board
Catchment	Myponga Reservoir catchment
DWC	Dry Weather Concentration is the pollutant concentration measured during dry weather
E2	E2 catchment modelling framework
EMC	Event Mean Concentration is the flow-weighted average pollutant concentration over a storm event
EPA	South Australian Environment Protection Authority
incentive rate	An amount of money paid to a landholder for each on-ground works activity undertaken
Project	Myponga Watercourse Restoration Project
riparian buffer zone	Riparian buffers or zones are vegetated strips of land separating runoff and pollutant-contributing land areas from surface water bodies. They provide potentially important environmental functions including maintaining waterway channel bank stability, reducing pollutant inputs to streams, and providing habitat for fauna and flora
RZMP	Riparian Zone Management Project
RPM	Riparian Particulate Model. The main function of the RPM is to quantify the particulate trapping capacity of riparian buffers through settling, infiltration and adhesion. The RPM operates as a filter (plug-in) module within the E2 catchment modelling framework.
TSS	Total Suspended Solids is a measure of the mass of fine particles suspended in water
Watershed	The Mount Lofty Ranges Watershed

SUMMARY

The Myponga Reservoir catchment on the Fleurieu Peninsula is part of the Mount Lofty Ranges Watershed and supplies mains water to approximately 50,000 people in central and southern Fleurieu Peninsula communities.

The quality of water within the Myponga Reservoir catchment became increasingly poor over many years as a result of land management practices including livestock grazing and land clearing that introduced contaminants such as pesticides and fertilisers, and increased levels of nutrients, pathogens, and suspended sediments.

The Myponga Watercourse Restoration Project was established in 2000 following a survey by the then South Australian Environment Protection Agency, which identified that unrestricted livestock access and degraded or absent riparian vegetation were having detrimental impacts on water quality within the Myponga Reservoir catchment.

To improve water quality for the reservoir raw water supply and the aquatic ecology, the current Environment Protection Authority (EPA) and landholders undertook works at 62 sites within the catchment from 2000 to 2007. Works included construction of 46 km of fencing along 24 km of watercourse, 33 stock crossings to prevent livestock from entering watercourses, and revegetation using local native plants to create vegetated riparian buffer zones.

Using the Mount Lofty Ranges E2 model, staff developed the Myponga Riparian Particulate Model to investigate the potential benefits of the works in improving water quality. The model assessed the likely effectiveness of the fenced and revegetated watercourse riparian buffer zones in reducing the amount of sediment entering the watercourse through overland surface waters. The results indicated that at the current level of fencing and revegetation of the watercourses, it is likely that the amount of sediment entering the watercourses throughout the catchment will decline by approximately 12% each year. Within certain areas of the catchment in which works were undertaken more intensely, sediment amounts are likely to be reduced by as much as 55%.

The modelling results also indicated that further riparian buffer establishment and restoration needs to be continued into the future in order to continue to improve water quality.

The project, as undertaken from 2000–07, has ceased. The Adelaide and Mount Lofty Ranges Natural Resources Management Board is now delivering a program to promote better land management across the region, including within the Myponga Reservoir Catchment.

INTRODUCTION

The Mount Lofty Ranges Watershed (the Watershed) is an area of land that is located within the Mount Lofty Ranges to the east of Adelaide and which contains a system of reservoirs that supply mains water to the greater Adelaide region, including the Fleurieu Peninsula.

The southernmost reservoir within the Watershed is the Myponga Reservoir, which supplies mains water to approximately 50,000 people in central and southern Fleurieu Peninsula communities.

As with all of the reservoir catchments within the Watershed, most of the catchment for the Myponga Reservoir is privately owned and has been developed for rural and urban land uses. The result of this development has been a change in the landscape through the removal of native vegetation; and the modification of surface and ground waters, and flow regimes. The quality of water has declined as a result of land management practices that have introduced new contaminants such as pesticides and fertilisers; and increased the existing levels of nutrients, pathogens and suspended sediments.

In 1998 the then South Australian Environment Protection Agency undertook a survey of the condition of the watercourses within the Myponga Reservoir catchment and recommended that a project be established to address the issues of unrestricted livestock access and degraded or absent riparian vegetation. In 2000 the Myponga Watercourse Restoration Project (the Project), a community supported on-ground works program, was commenced by the Agency to improve the quality of the water entering the Myponga Reservoir and to also improve ecosystem and riparian health. The Project worked with landholders to exclude livestock from watercourses and establish vegetated riparian zones.

This report reviews the work undertaken during the Project and assesses its impacts on water quality.

THE MYPONGA RESERVOIR CATCHMENT

Location

The Myponga Reservoir catchment (the Catchment) is located 40 km south of Adelaide (Figure 1) and is approximately 120 km^2 in size. In 1962 a reservoir was constructed on the Myponga River adjacent to the town of Myponga to supply mains water to approximately 50,000 people in central and southern Fleurieu Peninsula communities such as Yankalilla, Victor Harbor and Port Elliott.

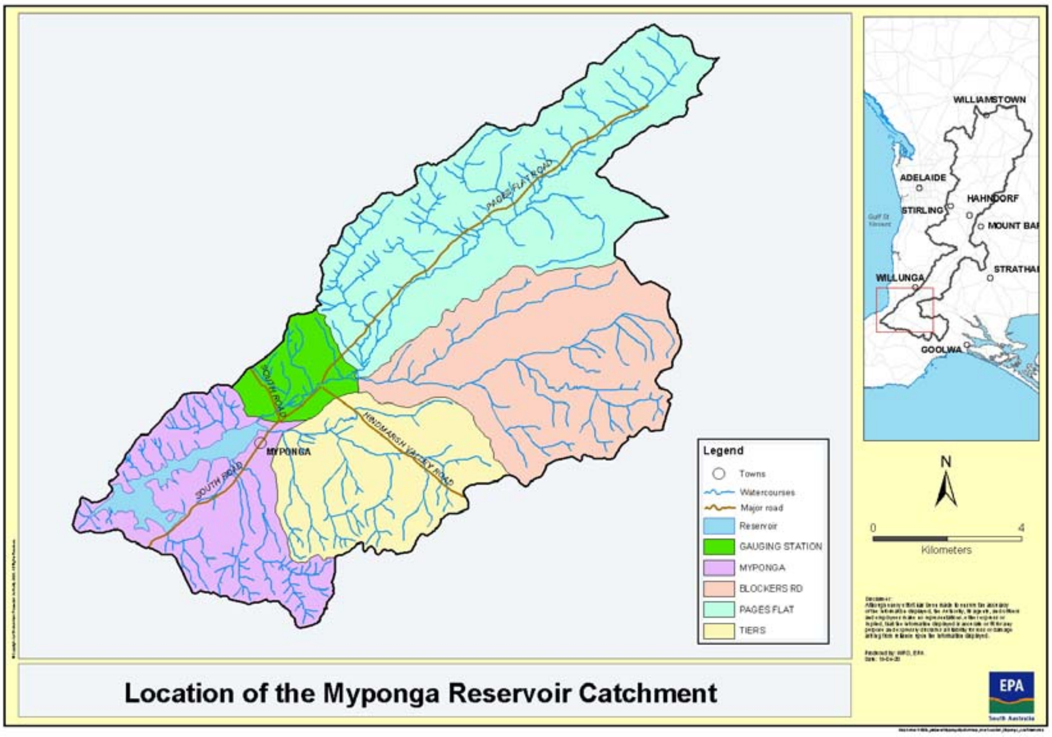

Figure 1 Location of the Myponga Reservoir catchment

Land use

The Catchment is predominantly an agricultural landscape supporting such industries as beef and sheep grazing, dairying, farm forestry, flower production and vineyards (Figure 2).

The Catchment also supports rural and urban living, and the town of Myponga and the communities of Pages Flat and Munetta are located within the catchment.

There are several protected areas, including Yulte Conservation Park, Nixon-Skinner Conservation Park and Stipiturus Conservation Park, within the catchment.

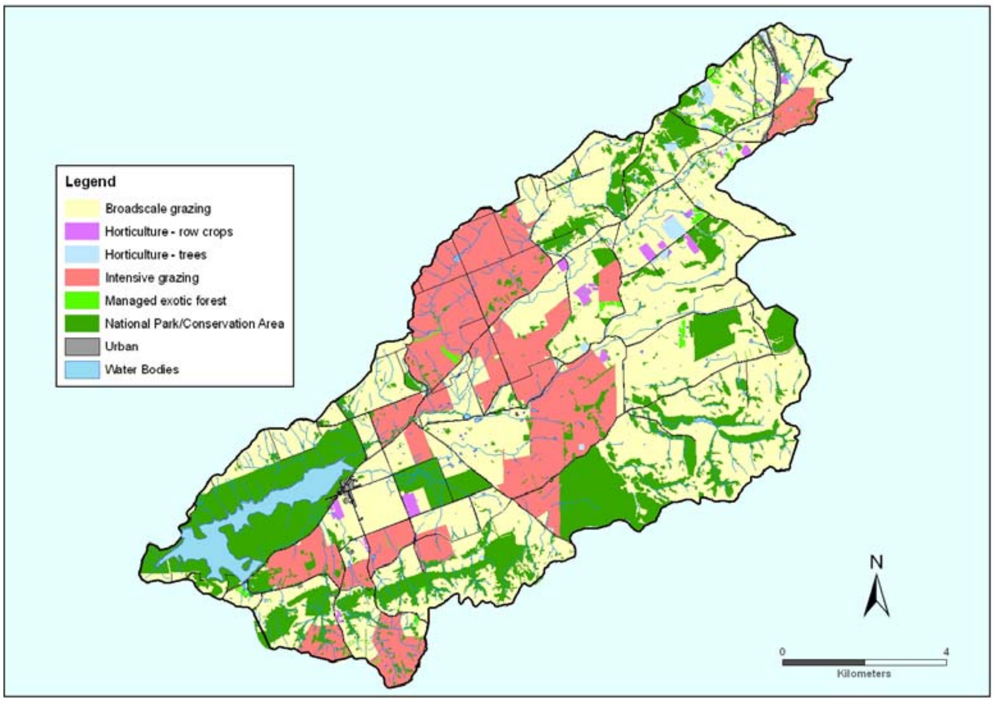

Figure 2 **Land use in the Myponga Reservoir catchment**

The watercourses and water quality

The Catchment can be hydrologically divided into five sub-catchments—Pages Flat, Blockers Road, Gauging Station, Tiers and Myponga Reservoir (Figure 1).

The Myponga River is the largest of the watercourses within the catchment and flows through the glacial valley of the Pages Flat sub-catchment. The Myponga River is the only named watercourse in the catchment, but there are substantial watercourses that flow through the other sub-catchments.

Prior to non-indigenous settlement of the Myponga region in 1843, the larger watercourses of the Catchment flowed through relatively flat landscapes following flow paths along often poorly defined channels, lined with Eucalypt woodland and swampy wetlands, which allowed the flow of water to spread across broad flood plains in periods of high rainfall and to retract to ephemeral pools in dry periods (EPA 1999). The vegetation within the Catchment, particularly riparian vegetation, served to maintain water quality by stabilising waterway channel banks, slowing the flow of water, and removing nutrients and pollutants from stormwater run-off.

Since 1843, development of the Catchment has led to modification of surface and ground waters and of flow regimes. The removal of vegetation from the Catchment and unrestricted livestock access has resulted in erosion of the landscape and watercourses, causing sedimentation of the waters and contamination with pathogens and nutrients from animal wastes and fertilisers. Flow regimes have changed so that waters are no longer slowed through long and broad swampy wetlands, but flow along incised, eroded channels, and the ephemeral pools that once formed during dry periods are uncommon (EPA 1999).

These changes to water quality and flows have resulted in the need to undertake expensive treatment processes to make water from the reservoir potable and have caused a decline in the health of aquatic ecosystems.

Remnant riparian vegetation in the Catchment

In a disturbed catchment, watercourses are often one of the last parts of the landscape in which riparian vegetation is found. Despite the clearance of vegetation from much of the Catchment, there remain areas of remnant riparian vegetation, including Eucalypt woodland and the Swamps of the Fleurieu Peninsula, which have the important function of maintaining water quality within the Catchment.

The Swamps of the Fleurieu Peninsula, which have been listed as a 'Critically Endangered Ecological Community' under the *Environment Protection and Biodiversity Conservation Act 1999* (EPBC Act), are localised wetlands that are densely vegetated with reedy or heathy vegetation growing on peat, silt, peat silt or black clay soils (EA 2003).

As well as the role that they have in maintaining water quality, remnant vegetation supports a variety of interesting and unusual plants and wildlife. The Mount Lofty Ranges Southern Emu-wren and the Southern Brown Bandicoot, both listed under the EPBC Act as being endangered, are found along the swampy watercourses of the Catchment including the Stipiturus Conservation Park and its surrounding swamps (DEH 2007).

Plate 1 The Swamps of the Fleurieu Peninsula provide habitat for a variety of wildlife and slow the flow of water along the watercourses.

PROTECTING THE WATERCOURSES OF THE CATCHMENT

Riparian Zone Management Project

In 1994 the then Environment Protection Agency commenced a series of watercourse surveys and developed management recommendations for metropolitan water supply catchments in the Mount Lofty Ranges. The aim of the Riparian Zone Management Project (RZMP) was to 'improve the water quality and ecological "health" of watercourses in the Mount Lofty Ranges through better management of their riparian zones' (EPA 1999).

A survey of the Myponga River catchment was undertaken in 1998 resulting in the publication of the report, *Watercourse Survey and Management Recommendations for the Myponga River Catchment* (EPA 1999). The report concluded that the surrounding land uses had impacts on the watercourses of the Catchment over many years. Unrestricted livestock access, introduced plants and absent or degraded riparian vegetation, were identified as the most significant issues threatening watercourse condition within the Catchment.

Myponga Watercourse Restoration Project

The Project was established in 2000 to implement the recommendations of the RZMP report.

The objectives of the Project were to:

- protect and enhance the quality of the source water supply to the Myponga Reservoir, which provides mains water for central and southern Fleurieu Peninsula communities
- increase overall health of aquatic and riparian ecosystems within the Catchment
- improve riparian zone condition and biodiversity value along the whole of watercourse.

In order to meet these objectives, on-ground works were undertaken with landholders to:

- fence watercourses to exclude livestock that degrade water quality through erosion and sedimentation, and the introduction of pathogens and nutrients
- fence watercourses to create a vegetated buffer zone that will filter stormwater runoff prior to it entering the watercourse
- construct livestock crossings to enable livestock to cross watercourses without walking through them
- install off-stream watering points to enable livestock to drink after access to watercourses has been prevented
- revegetate riparian zone buffers to create a vegetation filter and increase biodiversity
- control woody weeds and exotic trees
- construct structures to control stream bank erosion.

Plate 2 **The support of the community was vital for the Project's success.**

Funding sources and incentive rates

During the term of the Project a total of $496,116 was provided by various funding sources including the National Action Plan for Salinity and Water Quality and Natural Heritage Trust ($335,371), the EPA ($80,000), AMLR NRM Board ($60,745), and SA Water ($20,000). Landholders have also contributed significantly to the Project through labour and materials.

In order to encourage voluntary participation in the Project and in recognition of the wider community benefits of the on-ground works, funds were used to provide financial incentives to landholders who partook in the Project. The financial incentives varied from year to year as did the activities for which funding was provided. Table 1 contains the incentive rates for 2007. Landholders contributed to the on-ground works by paying for materials, undertaking the work themselves, or by paying for the work to be undertaken by contractors.

Table 1 **Landholder incentive rates in 2007**

Activity	Incentive rate
Fencing	$4,000/km
Construction of culvert-style livestock crossing	$2,000/crossing
Establishment of off-stream watering point	$400/watering point
Weed control	$1,000 maximum
Revegetation with native plants	Free of charge

In 2006 and 2007 funds were used by the EPA to contract a project officer to liaise with landholders and organise the on-ground works.

Participants

The Project worked with a number of groups to undertake the works, including:

- Myponga Riparians Group—the group consisted of landholders upon whose land works were undertaken. The group was involved in meetings and field days with guest speakers, undertook voluntary work, and assisted with tours of the Catchment by various natural resources management organisations
- AMLR NRM Board incorporating:
  - Fleurieu Animal and Plant Control Board—the former Fleurieu Animal and Plant Control Board provided advice on the control of weeds in the Catchment

- Area D Steering Committee/Fleurieu Project Steering Committee—met regularly and provided a forum for the discussion of natural resources management issues and assisted with obtaining funding
- Land Management Program—assisted with the organisation of field days and tours, and the provision of advice on property management issues.

THE ON-GROUND WORKS

Meeting the Project objectives

The on-ground works were implemented to meet the objectives of the Project by addressing the various issues identified in the RZMP report as having an impact on watercourse condition within the Catchment. For example, fences were constructed along watercourses to exclude livestock, which reduced erosion of the watercourse banks and entry of sediments into the waters, thereby achieving the objectives of protecting the quality of water for the Myponga Reservoir and for aquatic ecosystems. Table 2 provides the links between the factors affecting water quality and biodiversity issues, the Project objectives, the on-ground works undertaken, and their potential impacts on water quality and biodiversity.

The on-ground works implemented

On-ground works were undertaken with 40 landholders with several of them undertaking work on a number of sites within their properties, so that a total of 62 sites were established.

The type of on-ground works undertaken at each site varied, but watercourse fencing was undertaken on all but four properties. The works also included construction of livestock crossings, establishment of off-stream watering points, installation of alignment fences to control erosion points, revegetation and weed control.

Commencing in 2005, all of the sites were revisited to assess their condition and record information about the on-ground works. Table 3 contains a summary of the on-ground works undertaken during the Project. A more detailed description of the on-ground works is contained in Appendix 1.

Plate 3 A fenced and vegetated riparian buffer zone can improve water quality by filtering surface water runoff

Table 2 Meeting the Project objectives

Factors affecting water quality and biodiversity	Project objective	On-ground works to improve water quality or biodiversity	Potential impact of on-ground works on water quality or biodiversity
Livestock access to watercourses	Protect quality of reservoir source water supply Increase health of aquatic and riparian ecosystems Improve riparian zone condition and biodiversity value	Livestock-excluding watercourse fencing Livestock crossings Off-stream watering points	Reduction in nutrient and pathogen levels from livestock urine and faeces Reduction in erosion-induced suspended sediments by hard-hoofed livestock Improved wildlife habitat through reduction in damage to riparian and in-stream vegetation by livestock
Absent or degraded riparian vegetation	Protect quality of reservoir source water supply Increase health of aquatic and riparian ecosystems Improve riparian zone condition and biodiversity value	Revegetation to establish vegetated riparian buffer zone	Reduction in suspended sediments, pathogens and nutrients as a result of stormwater from paddocks filtering through a vegetated buffer zone Improved wildlife habitat
Watercourse erosion	Protect quality of reservoir source water supply Increase health of aquatic and riparian ecosystems Improve riparian zone condition and biodiversity value	Revegetation of watercourse Construction of erosion control structures	Reduction in suspended sediments through bank stabilisation
Introduced plants	Protect quality of reservoir source water supply Increase health of aquatic and riparian ecosystems Improve riparian zone condition and biodiversity value	Control of introduced plants	Reduction in nutrient input from deciduous plants Reduction in competition for native plants Improved wildlife habitat

Table 3 On-ground works undertaken for the Myponga Watercourse Restoration Project 2000−07

Landholders	Sites	Watercourse fencing	Livestock crossings	Watering points	Erosion control	Revegetation	Weed control
40	62	46 km of fencing 24 km of watercourse fenced	33 crossings	22 sites	2 alignment fences installed	34 sites Approx. 7,000 per year	23 sites

Watercourse fencing

A total of 46 km of fencing was constructed to create riparian buffer zones along 24 km of watercourses in the Catchment (refer Figure 3).

The watercourses included:

- defined watercourses such as the Myponga River
- wet gully areas that flow into defined watercourses
- intact and degraded remnant swamps.

As identified in Table 2, constructing watercourse fencing has multiple aims. The fences restrict livestock access to the watercourse, and reduce erosion and the deposition of pathogen and nutrient-containing faeces and urine. Once vegetated, the fenced riparian buffer zone can filter contaminants such as nutrients and suspended sediments from stormwater, thereby improving water quality.

The riparian buffer zones within the Catchment are naturally quite wide and in most cases it was impracticable to fence the entire riparian buffer zone. Hence, the created riparian buffer zones did not always reflect the true nature and width of the natural riparian buffer zone.

There was great variation in the width of the fenced riparian buffer zone within and between sites. For example, the riparian buffer zone width at one site ranged from 3.5 m to 155 m and the average width between sites ranged from 2.6 m up to 100 m. As a wide riparian buffer zone will have a greater ability to filter contaminants from stormwater than a narrower zone, the effectiveness of the fenced riparian buffer zones in filtering stormwater and thereby improving water quality is likely to vary from site to site.

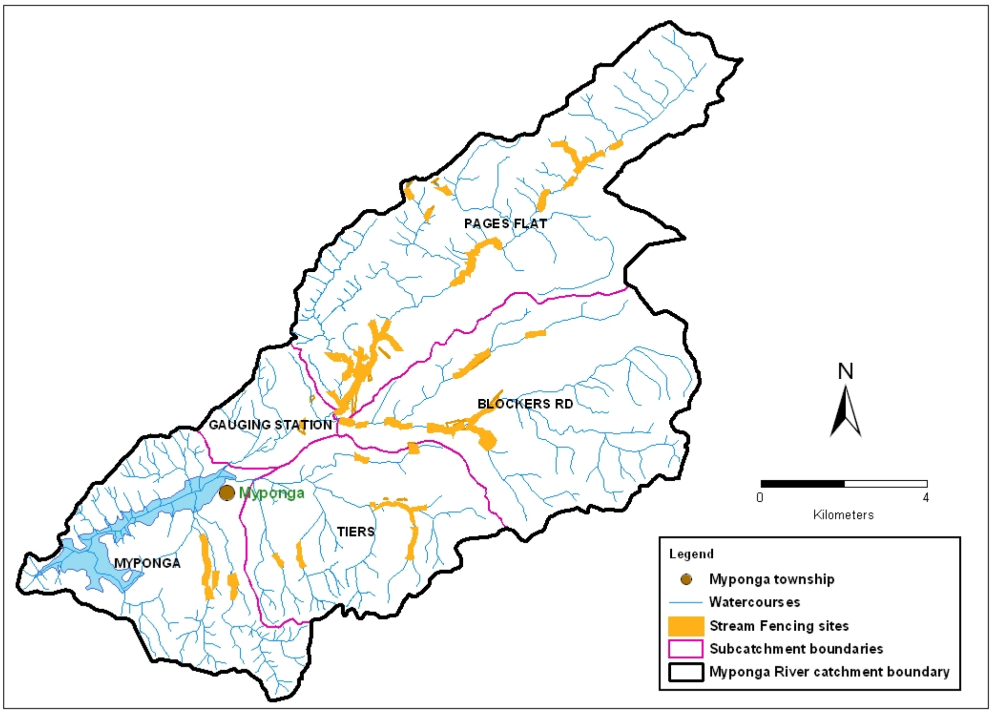

Figure 3 **Location of watercourse fencing within the Myponga Reservoir catchment**

Livestock crossings

A total of 33 livestock crossings were constructed or repaired during the course of the Project to enable the movement of livestock around properties without walking through watercourses and degrading water quality. The livestock crossings were all culvert-style crossings, which were designed to carry water during low-flow periods, but to allow water to spill over and around during high-flow periods.

Plate 4 **Crossings enable livestock to be moved around a property without needing to walk through watercourses**

Off-stream watering points

When a watercourse was fenced to exclude livestock, it was sometimes necessary to establish watering points away from the watercourse. Funding was provided to establish off-stream watering points at 22 of the 62 sites. These systems generally consisted of a pump for bringing water up to a tank to be gravity fed to troughs, with variations to suit different landholders.

Plate 5 This solar pump was installed by the landholder as part of the off-stream watering system

Watercourse erosion

Erosion of watercourse bed and banks, usually as a result of unrestricted livestock access and absent or degraded riparian vegetation, may cause sediments to enter the watercourse and have a negative impact on aquatic ecology and the source water for the Myponga Reservoir.

The watercourse bed and banks at most sites were generally stable or had limited erosion. It was expected that continued exclusion of livestock by the fences and re-establishment of vegetation would reduce erosion, but it may be necessary in the future to undertake active erosion control works at some of these sites.

Alignment fences were constructed at two sites to control erosion on bends along the Myponga River.

Plate 6 Alignment fence circa 2001

Plate 7 Alignment fence circa 2005

Revegetation

Vegetated riparian buffer zones are necessary to stabilise the banks of the watercourses and to filter contaminated stormwater.

The presence of grasses in the riparian buffer zone is essential for effective stormwater filtration and their growth, although often introduced pasture grasses rather than native grasses, was encouraged naturally through the construction of the fences, which prevented livestock grazing.

Other components of the riparian vegetation structure such as trees, shrubs and emergent plants had been removed from much of the Catchment, so revegetation of these were undertaken at 34 of the 62 sites.

The plants used in the revegetation program were grown from seed that had been collected in the local area and included trees, shrubs, sedges and rushes. Approximately 7,000 plants were planted each year. Revegetation was generally readily established, but grazing by kangaroos was a problem on properties that had nearby remnant native vegetation. In the later years of the Project, there had to be drought establishment of revegetation.

Plate 8 Revegetation of the Myponga River with local plant species has created habitat for wildlife, which will increase biodiversity

Weed control

Deciduous plants have the potential to pollute watercourses with nutrients from sudden inputs of large amounts of fallen leaves and to reduce biodiversity in the riparian zone, so control of woody weeds and exotic trees was undertaken on 23 of the sites, either by the landholder or by contractors employed through the Project.

Blackberry was a very common weed along watercourses in the Catchment and was removed as part of the Project. Willows were removed from some properties, particularly in the early stages of the Project.

Plate 9 The removal of exotic plants such as willows decreases intense nutrient input from deciduous leaves and allow local native plants to be planted in their place

ASSESSING THE IMPACT OF THE WORKS

Following completion of the on-ground works in 2007, the EPA used computer modelling to investigate the potential impact of the riparian buffer zones on water quality.

As only 9% of the watercourses in the catchment were fenced off and that fencing was distributed unevenly throughout the catchment, a conventional water quality monitoring program would not be able to reliably link changes in water quality across the catchment to the on-ground works without being overly complex. Therefore, it was decided to use a computer model that could indicate the potential improvements in water quality that may have occurred as a result of the creation of riparian buffer zones.

The Riparian Particulate Model or RPM) (Newham *et al* 2005) was used to assess the amount of total suspended sediment (TSS) carried in surface water runoff that the on-ground works were likely to have prevented from entering the watercourses. The RPM operates as a filter (plug-in) module within the E2 catchment modelling framework (Argent 2004) and quantified the particulate trapping capacity of the riparian buffer zones through settling, infiltration and adhesion.

There are numerous water quality parameters that could be used to assess the potential water quality impacts of the riparian buffer zones, but the RPM's use of TSS can be seen as an indicator of likely changes in other water quality parameters. Thus, a reduction in TSS entering the Reservoir is likely to indicate that parameters such as nitrogen and phosphorous have also decreased.

The Myponga RPM assessed two scenarios; an 'existing' scenario that examined the likely impact on TSS removal of the riparian buffer zones created during the Project, and a 'future' scenario that compared the improvements in TSS removal that would result from increasing the width and length of riparian buffer zones.

Assessment of the existing scenario showed that at the current level of fencing and revegetation of the watercourses, it is likely that the amount of TSS entering the watercourses throughout the catchment will be reduced by approximately 12% each year into the future. However, as the riparian buffer zones were not spread evenly throughout the catchment there were large variations between sub-catchments with the future annual reduction in TSS likely to be as high as 55% where riparian buffer zones were more intensely applied.

Results from the future scenario assessment indicate that the establishment of riparian buffer zones needs to be continued into the future in order to greatly improve water quality.

Whilst the Myponga RPM indicated a reduction in the amount of TSS entering the reservoir through surface water runoff, it is likely that excluding livestock from entering a watercourse would also result in a decrease in nutrient input from faeces and urine thereby further improving water quality.

There may also be improvements to biodiversity as a result of excluding livestock from the watercourses and creating vegetated riparian zones. However, these have not been assessed as part of the Project.

The beneficial impacts of the Project are likely to extend beyond the simple changes in TSS that were indicated by the RPM.

Appendix 2 contains a detailed report on the computer modelling process and its findings.

DISCUSSION

The Myponga Watercourse Restoration Project has ended. The Adelaide and Mount Lofty Ranges Natural Resources Management Board is now delivering a program to promote better land management across the region, including within the Myponga Reservoir Catchment.

Computer modelling indicated that the creation of riparian buffer zones within the catchment decreased the amount of TSS entering the watercourses and it is likely that it will also reduce other parameters such as nutrients and pathogens.

Excluding livestock from watercourses, creating vegetated riparian buffer zones, and removing introduced plants such as willows and blackberry over a seven year period may have also improved biodiversity, although that was not assessed as part of the Project.

The Project had a focus that, whilst incorporating aspects of biodiversity, was primarily on water quality and on the watercourse itself. Management of the catchment, indeed any catchment, needs to be holistic; focussing not just on water quality, but also management of soils and biodiversity, and working across the landscape, not just along its watercourses.

The field of natural resources management has a greater scope for managing issues at a landscape scale, whereas the EPA, which is primarily a regulator, has a much more limited scope. Therefore, it is appropriate that the Project is now managed by the AMLR NRM Board.

There are lessons to be learnt from the Project, which may be applied to the future management of the catchment, and quite equally, to all on-ground works projects. These are discussed below.

- Develop a strategic approach to management of the catchment

Management of a major catchment cannot be undertaken without a carefully considered community and government-developed strategy that expresses the wishes of the community, assesses the risks to the resource, sets targets and develops management actions.

The Project was one of numerous activities that have taken place within the catchment. Much of this work was undertaken in an isolated and opportunistic manner.

A strategic whole-of-catchment approach should be developed to enable a coordinated approach for, not just the works of the Project, but all of the activities that may take place within the catchment. The application of a comprehensive strategy would be of great benefit, as it will enable the development of a carefully considered water quality improvement plan for the entire catchment. This may also make it easier to engage the community from the outset and enable on-ground works to be more readily undertaken, as the community would be aware of its agreed role in the strategy and have a focus for its works.

- Impact on water quality

The focus of the Project was on undertaking on-ground works directly along the watercourses in order to protect and improve the quality of the water for the Myponga Reservoir and the aquatic ecology.

Although it was intended that this approach would benefit water quality and biodiversity, it would be of greater benefit for the Project to be more focussed on whole-of-property management. It is possible that the impacts on water quality of land management activities that are occurring away from watercourses are significant enough that fencing and revegetation of the watercourses may not be sufficient to counteract these broader scale impacts. It is also likely that land holders who do not graze livestock may still be having an impact on water quality through their particular land use. Such land holders were not part of the Project, so expanding it into broader land management issues should capture a wider variety of activities and land uses and would manage the causes and not just the symptoms.

- Better decision-making tools for allocation of resources

It is recommended that decision-making tools, particularly computer modelling, be used to assist with the allocation of resources through more considered decisions on which properties to undertake works.

Decision-making tools could be used to compare the benefits or otherwise of undertaking works in one sub-catchment or property rather than in another. Such property identification would allow greater targeting of landholders, and more effective use of funds and time.

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APPENDIX 1 DETAILED DESCRIPTION OF ON-GROUND WORKS

Survey method

In order to obtain an accurate record of the on-ground works that were undertaken during the Project, each site was revisited so that data on the works could be collected.

Sites 1–48 were visited and the on-ground works assessed between June and December 2005. On-ground works continued to be undertaken and the more recent Sites 49–62 were visited in October and November 2007.

Information on fencing, livestock crossings, off-stream watering points, watercourse erosion, existing vegetation and revegetation works, and weed management were recorded for each site.

Data gathering at each site commenced with the measurement of fencing. The length of fencing on each side of the watercourse was measured with a measuring wheel. At intervals of 50 m, or 30 m when the fencing length was shorter, the width of the riparian buffer zone was measured. At some sites access to the watercourse was restricted by dense vegetation, so riparian buffer zone widths were estimated or measured using a Geographic Information System (GIS). An average width of the riparian buffer zone was determined for each property. At selected locations along the fence Global Positioning System (GPS) readings were taken to enable the location of fencing to be plotted using GIS. The length of watercourse fenced off was measured using the measuring wheel, although as access to the watercourse at some sites was restricted by dense vegetation, watercourse lengths were sometimes measured using GIS.

Livestock crossings were noted and their condition recorded.

The presence of off-stream watering points was identified.

In order to ensure consistency with Australian standards, watercourse bed and bank stability was assessed using criteria derived from the Australian River Assessment System (AUSRIVAS). Notes were made on whether any erosion control had been undertaken and whether there were erosion problems on the property or upstream property that might have an impact on water quality.

Vegetation that would have been present prior to works being undertaken was assessed using criterium derived from the AUSRIVAS. The state of revegetation was assessed and the presence of weeds recorded.

The on-ground works

Watercourse fencing

A total of 46 km of fencing was constructed to exclude livestock from 24 km of watercourse and drainage lines in the catchment. This length of fencing included nearly 1.5 km of fencing that existed prior to the Project commencing, either as internal property fencing to which the Project fencing was connected, or fencing that had already been constructed along sections of a watercourse by landholders. This latter fencing is particularly important as it showed the commitment of some of the landholders to protecting watercourses, with one landholder having fenced off and revegetated part of his watercourse more than 15 years ago.

Although the emphasis was on fencing defined watercourses, wet gully areas that flowed into more defined watercourses, and intact and degraded remnant swamps were also fenced off.

There were no set guidelines as to how far from the banks of the watercourse the fences should be constructed and as participation by landholders was entirely voluntary there was great variation within and between sites in relation to the width of riparian buffer zones. For example, the width of the riparian buffer zone on one site ranged from 3.5 m to 155 m. The average riparian buffer zone widths between sites ranged from 2.6 m to 100 m. The large widths were usually due to the generosity of landholders or the fencing of remnant vegetation or wet boggy areas adjacent to the main watercourse.

As a wide riparian buffer zone will have a greater ability to filter contaminants from stormwater than a narrow one, the effectiveness of the fenced riparian buffer zones in filtering stormwater and thereby improving water quality is likely to vary from site to site.

Livestock crossings

A total of 33 livestock crossings were constructed or repaired during the course of the Project. All were culvert-style crossings, which were designed to carry water during low-flow periods and to allow water to spill over and around them during high-flow periods. Crossings on the Myponga River were strengthened using cement-treated rubble to protect their integrity during floods. Most of the crossings at the sites were observed to be in good condition.

Off-stream watering points

When a watercourse was fenced off to exclude livestock, it was sometimes necessary to provide off-stream watering points away from the watercourse. Off-stream watering points were established at 22 of the 62 sites. These systems generally consisted of a pump for bringing water up to a tank to be gravity fed to troughs, with variations to suit different landholders.

Erosion

The level of watercourse bed erosion and deposition could not be assessed for most of the sites due to the amount of water in the watercourses at the time of the site visits. At those properties for which it could be assessed, bed erosion and deposition levels were generally quite low.

The watercourse banks were generally stable or had limited erosion on most of the sites possibly due to there being reasonable tree densities and the re-establishment of grasses, sedges and rushes. However, a number of sites had moderate or extensive instability along banks, with one site having extreme instability. It is hoped that continued exclusion of livestock by the fences and further re-establishment of vegetation will reduce erosion. However, at some sites it may be necessary to undertake active erosion control. Such work was undertaken at two sites along the Myponga River. At one of these sites, quite extensive bank erosion was identified adjacent to the culvert under Rogers Road, so an alignment fence was constructed by the landholder.

Existing vegetation and revegetation

All of the sites had some form of vegetation that was in existence prior to the works being undertaken, although the type and amount varied. All had continuous groundcover, primarily pasture grasses, which is vital for the filtering of stormwater. The presence of emergent vegetation varied and was mainly restricted to sites that had some form of swamp or wet boggy areas. The absence of an existing mid-story shrub layer was evident on many sites. Most of the sites had some level of existing over-storey of trees such as Red Gum, Swamp Gum, and Blackwood. Their presence tended to be sparse to patchy with no sites having a continuous over-storey. At those sites that had relatively intact swamp riparian vegetation, the patchy distribution of existing vegetation seemed to reflect a structure that would be typical of such sites.

Revegetation was undertaken at 34 of the 62 sites using plants grown from seed that had been collected in the local area. The plants were mostly trees (eg River Red Gum Swamp Gum, Pink

Gum, Blue Gum, Blackwood), shrubs (eg Swamp Wattle, Tea-trees, *Melaleuca* spp.), and emergent plants (eg *Carex tereticaulis*, *Cyperus vaginatus*, *Isolepis nodosa*, *Juncus pallidus*). Not all sites were revegetated, as they were not ready to be planted because of weed control problems, the landholder did not want vegetation planted or had their own plants, or there was sufficient vegetation at the site not to warrant further plantings.

Most of the plants were in good condition, but at a small number of sites the plants were in poor condition. This was generally due to grazing, either by livestock that had been allowed into the riparian zone to undertake 'crash grazing' or by kangaroos. Kangaroos were particularly a problem on properties that had nearby areas of remnant native vegetation. In 2007 two moveable 'kangaroo-proof' enclosures were constructed within one site to enable planted vegetation to grow without being browsed by kangaroos.

Weeds

Control of woody weeds and exotic trees was undertaken at 23 sites, either by the landholder or by contractors employed through the Project.

Blackberry (*Rubus* spp.) was a very common weed along watercourses in the Myponga Reservoir catchment. The level of control undertaken varied between landholders. At some sites landholders were quite diligent in their responsibilities, whereas on others, the landholders had made no effort and the blackberry was out of control.

Willows (*Salix* sp) have been removed from some properties, particularly in the early stages of the Project when greater funds were available for this type of work. For the most part there was no regrowth, but this was occurring at one site through shooting of stumps.

APPENDIX 2 ASSESSING THE IMPACT OF RIPARIAN BUFFER ZONES ON WATER QUALITY IN THE MYPONGA RIVER CATCHMENT USING THE RIPARIAN PARTICULATE MODEL

Introduction

Riparian buffers or zones are vegetated strips of land separating runoff and pollutant contributing land areas from surface waters. They provide potentially important environmental functions including maintaining waterway channel bank stability, reducing pollutant inputs to streams, and providing habitat for fauna and flora. In the Myponga Reservoir Catchment (the Catchment) of the Mount Lofty Ranges Watershed (the Watershed), considerable work was undertaken between 2000 and 2007 to construct and revegetate riparian buffer zones in order to mitigate pollutant loads to streams.

The South Australian Environment Protection Authority (EPA) used the Riparian Particulate Model or RPM (Newham *et al* 2005) to investigate the potential role for riparian grass buffers in the Catchment in reducing the sediment loads to streams. The main function of the RPM model is to quantify the particulate trapping capacity of riparian buffers through settling, infiltration and adhesion. The RPM operates as a filter (plug-in) module within the E2 catchment modelling framework (E2).

This report briefly describes the RPM and then illustrates the development of the Myponga RPM. The application of the model is then demonstrated in two scenarios; the existing case model and the future-development model. The existing case model has been created based on current riparian fencing. Thus it represents the riparian buffer trapping capability up to 2007 and the end of the EPA's involvement in the Myponga Watercourse Restoration Project (the Project). The future-development model assumes the same catchment and hydrological behaviour as the existing case model, but differs in that it assesses the effects of increasing the amount of future riparian buffer zone construction and restoration. The model results have indicated that riparian buffer establishment and restoration needs to be continued into the future in order to greatly improve water quality.

Background

During 1998 the then Environment Protection Agency undertook a review of the Myponga Reservoir Catchment watercourses. The review showed clearly that the greatest risk to water quality in the area was through unrestricted livestock access to watercourses and lack of riparian vegetation. As a result, the Myponga Watercourse Restoration Project began in 2000. This project aimed to fence watercourses, install livestock crossings, revegetate riparian buffer zones, implement weed and erosion control measures, and install off-stream watering points for livestock.

The EPA carried out on-ground surveys of restored riparian buffers on each property in 2005 and 2007. The survey enabled the water quality impacts of the on-ground works, implemented over the past seven years, to be investigated. The RPM was chosen to evaluate the effects of the restored riparian buffers on water quality because of its measurable parameter values, partitioning of fine and coarse particulates, as well as its ability to be incorporated within a large-scale catchment model such as the E2 model. While the RPM only simulates the trapping abilities of riparian buffers in sediment removal, the reduction of sediment by riparian buffer zones can be seen as an indicator of the reductions of nutrients to the receiving waterways (Barling and Moore 1994; Dillaha *et al* 1989).

During the survey, a range of data was collected including vegetation cover types, soil types and riparian buffer zone sizes. This data was used in conjunction with GIS (Geographic Information System) based data to construct the Myponga RPM.

Myponga River Catchment

The Catchment is located in the southern section of the Watershed and is approximately 120 km^2 in area. The Catchment consists predominantly of rural land, but also contains the township of Myponga. The Myponga River is the largest contributor of sediment and nutrient loadings to the Myponga Reservoir, which supplies mains water to over 50,000 people on the central and southern Fleurieu Peninsula. This is therefore of particular importance with regard to implementing land management practices, including establishing riparian buffer zones for the control of sediment and nutrient pollution.

There are five locally recognised sub-catchments within the Catchment. These are Gauging Station, Tiers, Myponga, Blockers Road and Pages Flat, ranging in size from 6 to 40 km^2 (Figure 2A). The average annual rainfall within these sub-catchments varies from around 670 mm in the north (Pages Flat) to 800 mm in the south (Tiers). This catchment has a large central floodplain area with low, longitudinal slopes, so particles are slow moving and drop out of the overland water flow more quickly than some other catchments in the Watershed.

There are approximately 260 km of watercourses in the Myponga Catchment of which the Myponga River is the largest. The watercourse restoration project has restored and established riparian buffer zones along over 23 km of the waterways prior to entering the reservoir in the catchment to date. Figure 2A illustrates the location of the riparian restoration work within the five sub-catchments and it can be seen that the majority of the riparian restoration work has been carried out in the Pages Flat sub-catchment area.

The predominant land-use is broadscale grazing (48.7%) with intensive grazing (20.7%) being the second largest. Managed forest and protected areas, recreation, water bodies, roads and others account for the remainder of the catchment area. Table 2A shows detailed land-use information derived from the EPA 2005 Myponga land use GIS data.

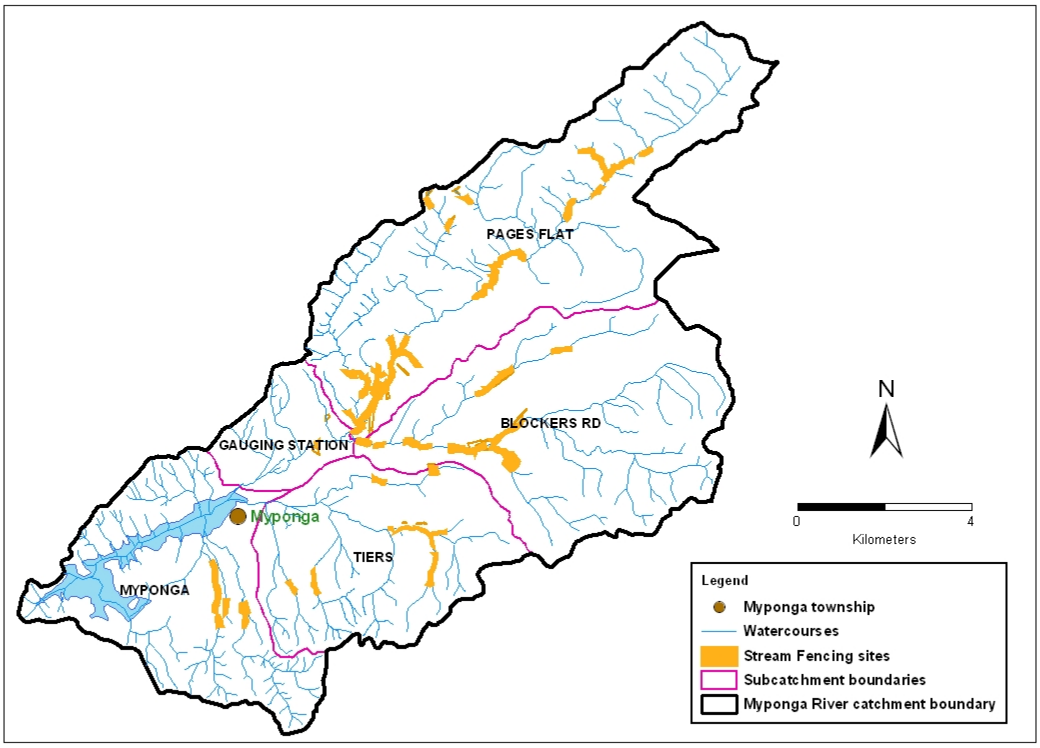

Figure 2A Location of riparian restoration work within the sub-catchments of the Myponga Reservoir Catchment

As the Catchment is mainly used for livestock grazing, the water quality impacts include increased sediment loading due to erosion of soils and damage to vegetation cover by overgrazing and trampling, and an increase of pathogens and nutrients from animal manure and fertilisers being washed into waterways from surface water runoff over livestock pastures.

Table 2A Land use in the Myponga Catchment

Landuse	Area (ha)	Percentage
Broadscale grazing	5,918.44	48.68%
Intensive grazing	2,518.96	20.72%
Managed native vegetation	2,152.71	17.71%
Protected/recreation area	700.70	5.76%
Water Bodies	324.43	2.67%
Road	276.21	2.27%
Horticulture–row crops	95.94	0.79%
Forestry	78.51	0.65%
Horticulture–trees	67.77	0.56%
Accommodation	10.33	0.09%
Manufacturing/commerce	8.34	0.07%

Landuse	Area (ha)	Percentage
Services	3.77	0.03%
Transport/storage/utilities	1.32	0.01%
Total	12,157.45	100.00%

Modelling framework

The catchment-scale application of the RPM has been designed to be implemented within the E2 catchment modelling framework developed by The Cooperative Research Centre for Catchment Hydrology and is available online at <www.toolkit.net.au>. E2 is a flexible modelling framework that allows different models to be chosen to best suit a particular problem. E2 provides the ability to simulate current catchment characteristics and responses, in addition to evaluating impacts of land use change and land management practices.

The main model structure of E2 is 'node-link', where sub-catchments feed water and materials into nodes from where they are routed along links. The smallest spatial unit is a sub-catchment. A sub-catchment can be further divided into functional units (FUs). FUs are the most fundamental representation of spatial behaviour within E2. In the Myponga E2 model the FUs are based on land uses. Each FU can have associated with it a runoff generation model, a constituent generation model and a filter model (Argent *et al* 2005). The former two components predict daily time series of overland flow and constituent loads. The filtering component is of special interest in this report. The RPM model is used as a 'plug-in' optional model to filter sediments from surface flow prior to entering streams. This section will briefly introduce the first two basic model components and their corresponding input parameters for the Myponga Catchment. Following this, the section will focus on the RPM model development for the Myponga Catchment.

Rainfall-runoff model

A 'bucket-style' rainfall-runoff model, SimHyD model, based on Chiew (2002), has been used in the Myponga E2 model. It is a daily conceptual model that estimates stream flow from daily rainfall and areal evapotranspiration. In the Myponga E2 model, rainfall data was obtained from the NRM SILO data drill database, and potential evapotranspiration data was provided by the Bureau of Meteorology. The model has three stores which include interception loss, soil moisture and groundwater. It has seven parameters for the Catchment, which are listed in Table 2B. Flow data from the Myponga gauging station in the Catchment was used for the calibration process; good agreement (E = 0.805) was obtained between the predicted and observed flow values (Webber 2006).

Table 2B SimHyd parameters from Weber (2006)

Parameter	Description	Value	Units
RK	Baseflow coefficient	0.074	none
COEFF	Infiltration coefficient (maximum infiltration loss)	234	mm
SQ	Infiltration shape	10	none
SUB	Interflow coefficient	0.092	none
INSC	Rainfall interception store capacity	0	mm
CRAK	Recharge coefficient	0.425	none

Parameter	Description	Value	Units
SMSC	Soil moisture store capacity (maximum storage)	500	mm
PF	Pervious Fraction	0.75–1	none

Constituent generation model

The Myponga E2 model uses a simple constituent generation model. This model applies two generation-processes where the rates vary with land-use: the event mean concentration (EMC) for surface flow during flood events and the dry weather concentration (DWC) for slow flow. The E2 model constituent generation and export is based on event runoff monitoring of individual land uses.

The Myponga E2 model considerers eight different land uses including intensive grazing, broadscale grazing, urban, managed exotic forest, horticulture crops, horticulture – trees, national parks and conservation areas, and water bodies. Different land uses generally have different generation rates. However, in the absence of specific water quality monitoring data to assign specific values to each land use, these land uses are broadly grouped into forest, grazing, agriculture and urban based on the nature of their similar generation mechanism. Table 2C lists the pollutant concentrations used in the Myponga E2 model. These values are the total suspended solids (TSS) values, which were sourced from work undertaken through the development of the MLR E2 model (Webber 2006).

Table 2C TSS EMC/DWC parameters for different land use

Constituent	Land use			
Total Suspended Solids	**Forest**	**Grazing**	**Agriculture**	**Urban**
DWC (mg/L)	7	10	10	10
EMC (mg/L)	20	140	140	140

Riparian Particulate Model (RPM)

Model structure

One important role of riparian buffer zones is to reduce pollutant inputs to streams. The RPM is specifically used to simulate the trapping capability of riparian buffer zones through three main mechanisms that of settling, infiltration and adhesion (Newham *et al* 2005). The trapping capacity of riparian buffer zones depends on the quantity of particulates it can store. The RPM sub-divides the total particulate load into two size classes of coarse and fine. As a result, the RPM has two trapping storages, one for coarse material and one for fine material (Newham *et al* 2005). Figure 2B illustrates the storage structures of the RPM.

In the RPM, coarse particulates are assumed to be trapped via settling, while fine particulates can be trapped through infiltration into a fixed volume corresponding to soil macropores. It can be seen in Figure 2B that the coarse material storage consists of the vegetated region and the 'backwater wedge' (the area upslope of the riparian strip), while the fine material storage equals the infiltration volume of the soil volume of the riparian buffer zone.

Newham *et al* (2007) have highlighted two critical factors influencing the capacity of the coarse storage, that is, the storage volume and the density of particulates that can be packed in it. The storage volume depends on the length and width of the riparian buffer zone, the effective height to which particulates may accumulate, as well as the ground slope. Also the trapping ability of fine sediment storage depends on soil macroporosity and depth of unsaturated porous soil layer.

In the catchment-scale application of the RPM, there are two approaches to modelling coarse and fine particulates; one applies different EMC/DWC values for coarse and fine particulates separately, and the other uses the proportion of coarse particulates entering streams. The difference between the two approaches is that the second approach can not generate output loads for coarse and fine particulates separately. As a result, the first one is highly recommended (Newham *et al* 2005). However, the Myponga RPM has used the second approach, because it is not able to derive the EMC/DWC values for coarse and fine particulates separately in the absence of water quality sampling data.

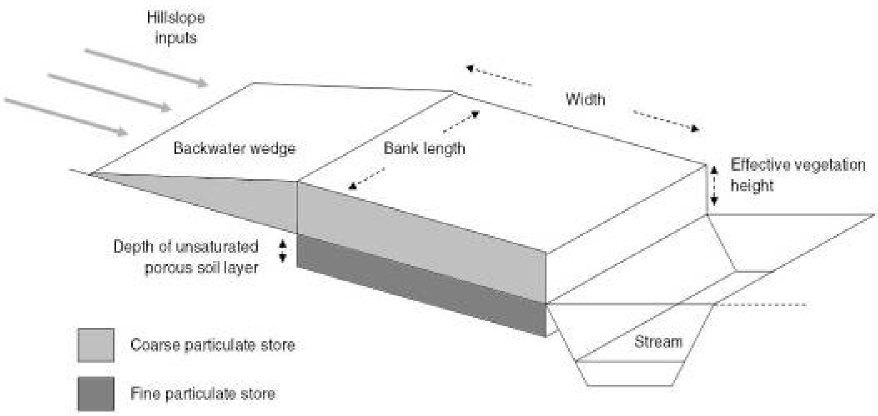

Figure 2B Coarse and fine particulates storage structure of the RPM (source: Newham *et al* 2007)

Input data

The RPM model has considerable data required to be collected from the field. This input data includes soils, vegetation cover, riparian buffer zone sizes and hydrologic characteristics in addition to the E2 data input. Table 2D lists the main input data of the RPM.

For the development of the Myponga RPM, data was collected from over 20 sample sites throughout the project area. These sample sites are covered by the range of vegetation types and densities. The vegetation cover types were classified into three main groups; grasses, reeds and rushes, and trees and shrubs. However, due to the RPM model structure it has been necessary to concentrate on ground cover (grasses) only. The average vegetation growth rate in the project area was estimated and was based on local climatic conditions and growth rates of different species, including anecdotal evidence.

Data pertaining to soils was derived from the Department of Water Land Biodiversity Conservation Soil Mapping GIS data (DWLBC 2006). In the Myponga Catchment area there are three main soil groups; that of 'loam over brown clay', 'thic k sand over clay', and 'acidic loam over clay and rock' with soil depths (depth of the *A*-soil horizon) varying from 33 cm to 66 cm. The soils in the restoration areas are predominantly loams and sands that have varying particle sizes ranging from 0.0002 mm to 2 mm. Due to lack of *in-situ* soil sample data, several model parameters such as *coarse particulate percentage* were estimated based on the DWLBC soil mapping data and local knowledge.

There were varying widths of riparian buffer zones constructed and restored during the restoration project. The current RPM model only supports up to four different buffer widths and as a result, the restored buffer zones were grouped into four different classifications; that of 5 m, 15 m, 30 m and 50 m on either side of the stream channels. This information plus the location of each riparian buffer zone has been used to generate a buffer map (E2 raster) to show where on the stream network each stream has had riparian restoration work undertaken and what the size of the riparian buffer zones are. Table 2D shows the main RPM parameter values used for the Myponga RPM.

Table 2D The main RPM parameter and values used for the Myponga Watercourse Restoration Project

Parameter	Description	Value	Unit
Initial effective vegetation height	Effective vegetation height at commencement of simulation run	0.35–0.75	m
Stem density	Stem density of riparian vegetation	875–910	stems/m^2
Stem radius	Average stem radius of riparian vegetation	0.002–0.003	m
Daily vegetation growth rate	Daily growth rate of riparian vegetation	0.001	m
Soil depth	Depth of unsaturated, porous surface layer present in the riparian zone	0.33–0.66	m
Slope	Mean slope of specific buffer size type	0.8–1.5	degrees
Surface bypass percentage	Percentage of surface runoff which bypasses riparian filtering processes	5–100	%
Coarse particulate bulk density	In-situ bulk density of trapped coarse particulates	0.73	t/m^3
Coarse particulate percentage	Percentage of coarse particular entering riparian buffers	48%–52%	none
Fine particulate bulk density	Bulk density of fine particular adhered to riparian vegetation	1.2	t/m3

Pre-processor

A RPM pre-processor has been developed for the E2 model and it is specifically designed to ease the input of the spatial data necessary to run the model. This pre-processor requires a digital elevation model (DEM), land use map and a riparian buffer area map. Stream threshold is also required for further breaking down the E2 sub-catchments into sub-sub-catchments. The pre-processor automatically generates the length of buffered streams and the average buffer slopes for different buffer types for each particular land use (FU) where a riparian buffer exists.

For the current project, a DEM with a 25-m cell size has been used to generate the E2 sub-catchments and stream network. A stream threshold of 2.5 km^2 was chosen as being appropriate for building the RPM model. This has resulted in a total of 32 sub-catchments being automatically generated in the Myponga Catchment. For the RPM processor, the stream threshold was set at 0.25 km^2 as the sub-catchments are required to be further divided into sub-sub-catchments in the RPM.

Results and discussions

The current Myponga E2 model has three scenarios including base (pass-through), existing and future-development (the latter two are described in detail below). The pass-through scenario was constructed to simulate sediment loads from 2000–07, based on the assumption that surface water flows to streams without any riparian restoration buffer zones. This scenario has not incorporated the RPM filter model. The latter two scenarios were developed using the Myponga RPM based on the parameter values shown in Table 2D. The existing scenario was then developed to represent the riparian buffer zone restoration works implemented over the past seven years. The future-development scenario assumes the same catchment and hydrological behaviour as the existing case model but differs in that it includes the likely riparian buffer zone construction and restoration in the future. This enables comparisons to be made between these scenarios.

As discussed previously, the RPM acts to filter sediments from surface flows before entering streams. The primary outputs from the Myponga RPM Model are a daily time-series of flow and TSS, and an estimate of overall riparian buffer zone trapping efficiency by comparing different scenarios.

Existing scenario

Annual average loads of TSS were calculated from eight land use activities within the 32 E2 sub-catchments for the period 2000–07 during the riparian restoration work. Figure 2C shows the TSS percentage reduction within the E2 sub-catchments. These values are the difference between the pass-through scenario (no riparian buffers) and the exiting scenario (riparian restoration work undertaken to 2007). As illustrated in Figure 2C, the TSS trapping capabilities vary among sub-catchments. There are several sub-catchments, such as Sub-catchment 16, 17 and 30, which had a relatively high proportion of TSS reduction with more than 30%. In the case of Sub-catchment 17, there was up to 55% sediment reduction. This is because these sub-catchments have the highest proportion of stream buffer fencing undertaken in the area. However, there are a few sub-catchments having zero TSS percentage reduction due to no restoration work being undertaken in these areas. This has demonstrated that the capacity of sub-catchments to reduce sediments is strongly related to the total stream network length that have had riparian restoration work undertaken, as more riparian buffer zones mean larger storage trapping capacities.

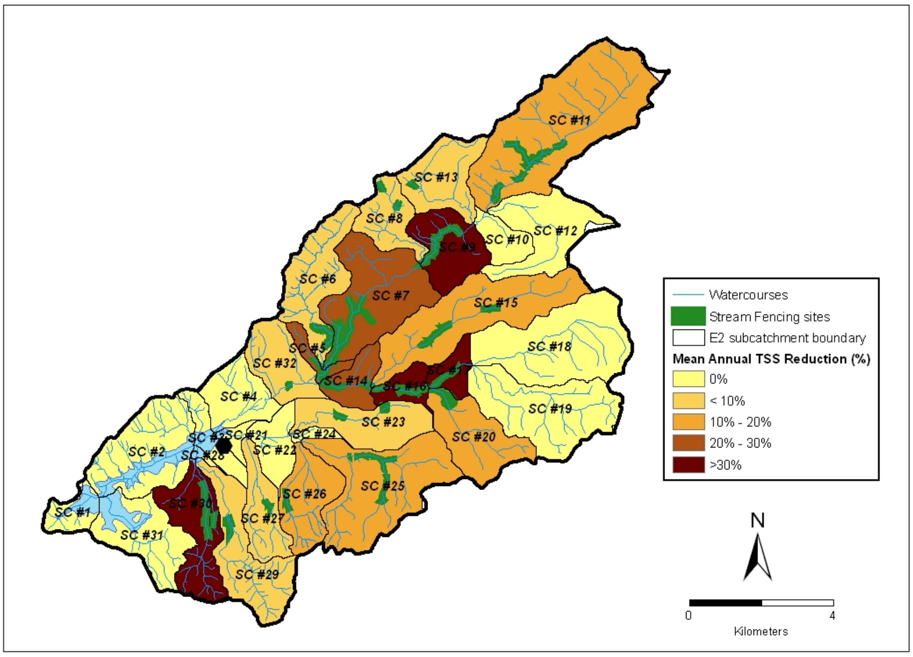

Figure 2C Average annual TSS percentage reduction for the period 2000–07

To further compare the TSS trapping efficiency between five sub-catchments, the annual average loads of TSS from 32 sub-catchments were aggregated into five sub-catchments that are locally recognised. Figure 2D presents the annual average loads from the existing scenario in five sub-catchments. The annual average loads from the pass-through scenario have also been plotted as a comparison. Table 2E further details the TSS reductions per sub-catchment in relation to the proportion of stream length that has had riparian restoration work carried out during the project. It can be seen that the Pages Flat sub-catchment has the highest reduction in TSS. This is probably linked to the highest percentage of stream length with restored riparian buffers. The trapping efficiency from the Gauging Station sub-catchment is quite small, because less than 1% of the stream length has been restored with riparian buffer zones.

According to the model results, at the current level of fencing and revegetation of the watercourses, it is likely that the amount of TSS entering the watercourses throughout the catchment will be reduced by approximately 12% each year into the future. This can be considered very positive in the light of such a small percentage (10%) of waterways having restored riparian buffer zones.

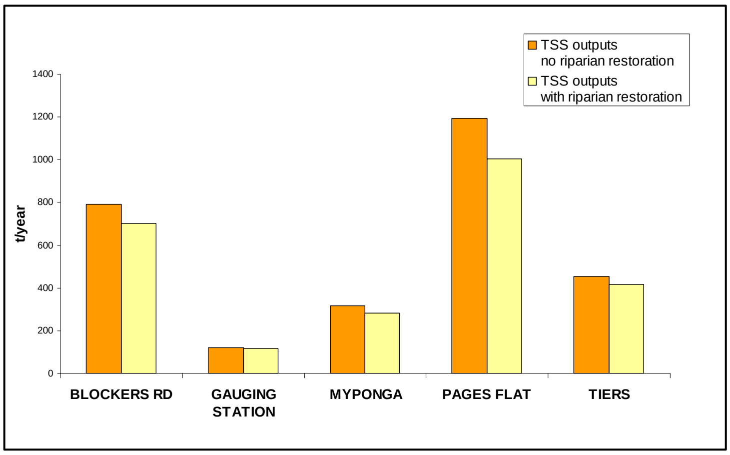

Figure 2D **Annual average reduction of TSS due to riparian restoration works in the sub-catchments of the Myponga Catchment between 2000 and 2007**

Table 2E **Characteristics of current riparian buffers and their trapping capabilities in sub-catchments between 2000 and 20007**

Sub-catchment name	**Stream length (m)**	**Fenced stream length (m)**	**Proportion of fencing**	**Average buffer width (m)**	**TSS annual average reduction**
Blockers Rd	57,599.80	4,004.53	6.95%	24.79	11.24%
Gauging Station	15,091.55	137.62	0.91%	5.00	2.90%
Myponga	67,575.94	2,589.12	3.83%	17.16	10.59%
Pages Flat	79,859.10	11,729.35	14.69%	22.19	15.91%
Tiers	45,398.75	3,397.75	7.48%	22.86	8.08%
Total	**265,525.14**	**21,858.37**	**8.23%**	**18.40**	**12.26%**

Future development scenario

Reclaiming land for development of riparian management zones is thought to improve the water quality outcomes associated with these management actions. The prevailing conditions and the size, type and make-up of the buffer zones dictate the extent of the benefits. The future-development scenario was developed to understand and compare the improvements, or otherwise, in TSS removal by increasing riparian buffer zone size. These investigations included examining the influence of increasing buffer zone widths and lengths. For example, Sub-catchments 11 and 15 were modelled based on hypothetically constructing new riparian buffer zones, thus, increasing the buffer length to an additional 3 km and width to 15 m. Table 2F shows the characteristics of both current and new riparian buffer zones and their estimated trapping performance.

Table 2F Modelled riparian buffer performances of existing and future development scenarios

SC	Stream length (m)	Current buffered stream length (m)	Current stream buffered percentage	Current riparian trapping efficiency	New buffered stream length (m)	New stream buffered percentage	New riparian trapping efficiency	Trapping additional TSS (t/y)
11	22,591	3,261	14.4%	15.65%	6,682	29.5%	32.7%	16.88
15	10,290	1,495	14.5%	13.57%	4,601	44.7%	41.7%	28.02

As illustrated in Table 2F, the modelled trapping efficiencies for Sub-catchments 11 and 15 improved by an additional 18% and 28% respectively as the stream buffer zone percentage increased by 15% and 30%. These predicted results clearly show that significant reductions in sediment export can be achieved by increasing the amount of riparian buffer zones within the catchment. Moreover, the interrogation of the modelled results demonstrated this significant difference. Consequently, considerable riparian buffer zone establishment and restoration needs to be continued in order to improve water quality in the Myponga Catchment.

Limitations

It is important to note that the Myponga RPM is only a decision-making tool and does not give the answer to the actual water quality improvements. As mentioned by Newham *et al* (2005), the RPM provides only semi-quantitative predictions about the likely effectiveness of riparian grass buffers.

Data availability is the main limitation for the Myponga RPM. Although the majority of model parameters are measurable, several model parameters are required to be estimated based on local knowledge. Furthermore, a few input data requirements were not straightforward due to the requirement of *in-situ* experiments, such as *coarse and fine particulates density*. It is always a challenging task to obtain experimental data.

The sensitivity of the Myponga RPM predictions to variations in model parameters, such as *effective vegetation height*, *daily growth rate* and *buffer size*, has been investigated. However, except for *buffer size*, the other parameters have shown very low sensitivity, which is different from the sensitivity results undertaken by Newham *et al* (2005). This could be due to the small proportion of waterways having restored riparian buffers in the catchment. Thus, the Myponga RPM may underestimate the trapping capabilities of riparian buffers in the catchment. Further testing of the model is required for more detailed predictions and results.

While the catchment-scale RPM model has proven its robustness, a simplified RPM model is required for catchment managers. The current 'plug-in' RPM model of E2 is not easy to build, especially for large catchments. Scenario testing is also difficult to implement, even for a simple question such as 'what additional sediment loads can be trapped by increasing riparian buffer zones by 25% in a particular catchment'.

Conclusions

The Myponga RPM has been applied to assess the likely effects of riparian buffer establishment in the Myponga Catchment for the period 2000–07. The model has predicted that when compared to the pass-through scenario (without any buffer zones), an annual average of approximately 12% of incoming sediments would be trapped from surface flows prior to their entry into the Myponga reservoir. This result has indicated that the Myponga Watercourse Restoration Project has made some improvements to the water quality in the catchment.

In addition, the future-development scenario has shown that the proportionate reduction in TSS is strongly related to the proportion of stream length with restored riparian buffer zones. This finding has implied that a significant improvement of water quality would be achieved given that a substantial amount of the waterways are restored and established with riparian buffer zones. Moreover, the model has shown that it can provide valuable input into the decision making process regarding prioritisation and design specifications of new buffer zones.

Further development of the Myponga RPM model would incorporate the EMC/DWC values for coarse and fine particulates separately, which enables assessment of the capabilities of riparian buffers in trapping coarse and fine particulates individually. This would help catchment managers better understand the trapping mechanisms of coarse and fine particulates for the planning of riparian buffer establishment and protection in the Myponga Catchment.

In summary, this report has provided semi-quantitative predictions at a catchment scale of potential particulate trapping by grass riparian buffers. The predictions will provide valuable information to the EPA and the AMLR NRM Board in their future riparian buffer zone establishment and restoration projects. Furthermore, development of riparian filtering models such as the RPM can be beneficial for government agencies to asses the benefits of on-ground works and to target remedial action.

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