Waterways of the North Central Region
Catchment and waterway descriptions

Loddon Catchment

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NORTH CENTRAL
Catchment Management Authority

Foreword

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A copy of 'Waterways of the North Central region – catchment and waterway descriptions' is also available on www.nccma.vic.gov.au

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The Waterways of the North Central region – catchment and waterway descriptions (Loddon catchment) has been developed by the North Central Catchment Management Authority (CMA) over several years. Major preparation contributions have been made by Angela Gladman, Greg Peters, Greg Chant and Nathan Day.

The North Central CMA would like to thank all those who contributed to its development, including the Loddon Implementation Committee and the community members who provided valuable information at the River Health Forums held in March and April 2002 at Castlemaine, Clunes Daylesford, Huntly, Kerang, Laanecoorie, Maryborough, Pyramid Hill and Serpentine.

Acronyms and abbreviations used in the Loddon catchment and waterway descriptions

AUSRIVAS	Australian River Assessment System
CMA	Catchment Management Authority
DNRE	Department of Natural Resources and Environment (formerly, now DSE/DPI)
DSE	Department of Sustainability and Environment
DPI	Department of Primary Industries
EPA	Environment Protection Authority
EVC	Ecological Vegetation Class
G-MW	Goulburn-Murray Water
IC	Implementation Committee
ISC	Index of Stream Condition
MDBC	Murray-Darling Basin Commission
ML	Megalitres
RCS	Regional Catchment Strategy
RHS	River Health Strategy
SEPP	State Environment Protection Policy
VROT	Victorian Rare or Threatened Species
VWQMN	Victorian Water Quality Monitoring Network
WoV	Waters of Victoria

See Appendix 1 for a Glossary of the key terms used.

Contents

1 Introduction

1.1 Introduction

Improving the health of Victorian rivers can only be achieved by addressing catchment issues in an integrated way. A number of State and regional strategies guide river health management in the North Central region.

In 2002, the Government released the Victorian River Health Strategy (RHS) (DNRE 2002). The Victorian RHS provides a statewide policy framework for managing the health of Victoria's rivers, floodplains and estuaries. It aims to restore stressed rivers and protect healthy waterways by treating the problems collectively.

Within this statewide context, management objectives and targets are set in regional river health strategies. The North Central River Health Strategy (RHS) (North Central CMA 2005) identifies the environmental, social and economic water services (or assets) in the North Central region, their value to the State and the region, and the issues that threaten these assets. The North Central RHS also establishes priority areas for restoration, and provides an integrated program for river restoration at the regional level.

The North Central RHS forms a key component of the North Central Regional Catchment Strategy (RCS) (North Central CMA 2003). The North Central RCS is the primary integrated planning framework for natural resource management in the North Central region. The North Central RCS identifies both 'Waterways and wetlands' and 'Water resources' as key natural resource assets in the region.

In June 2004, the Victorian Government released 'Our Water Our Future' that sets out an action plan to secure Victoria's water future over the next 50 years. Through the framework laid out in 'Our Water Our Future', the Government aims to achieve the sustainable management of water, to allow all the benefits of water to be enjoyed today, while protecting the needs of future generations.

One of the strengths of the North Central region is the extent to which plans have been developed and implemented to address many natural resources issues. These plans are acknowledged and reflected in both the North Central RCS and North Central RHS. They have been developed with considerable community and agency input. Underpinning the North Central RHS is 'Waterways of the North Central region – catchment and waterway descriptions' for the Loddon, Loddon, Avoca and Loddon catchments which provide an even greater level of detail.

The North Central RHS will guide the direction of river health management in the region, in terms of general principles, actions and targets. The catchment and waterway descriptions (referred to as River Health Plans in the North Central RHS) will provide the additional level of detail required when planning onground activities to be developed with local communities and stakeholders in Catchment Action Plans.

Catchment Action Plans aim to clarify which works are to be undertaken, by whom and its location. Development of these plans involves engaging the local community, discussing the issues and agreeing on a course of action that aligns with the principles of the North Central RHS. This gives the community the opportunity to help improve river health at the local level.

A brief summary of the relevant strategies, plans and investigations is provided in the North Central RHS.

1.2 Defining river health

The word 'health' in environmental contexts is not straightforward. People generally know what it means to be healthy; the meaning of the health of a catchment, landscape or ecosystem, however, is less clear. The concept of health was quickly expanded to include communities, social systems and landscapes.

The Victorian RHS (DNRE 2002) uses 'river health' to describe the ecological condition of a river. Health is more than what lives in a river or the quality of its water. To understand properly how healthy a river is, three aspects of the river system should be considered:

- the diversity of the habitats and biota
- the effectiveness of linkages
- the maintenance of ecological processes.

In the North Central, the CMAs role as caretakers of river health was strengthened in 'Our Water Our Future' (DSE 2004). It is responsible for a range of functions which directly impact on the environmental condition of rivers and is expected by Government to show leadership on the management of river health in the North Central region.

Health incorporates the cumulative historical impacts on catchment condition and current conditions imposed by demands on natural resources. It implies a viable condition, a self-sustaining state or series of states, which are compatible with human use and habitation.

Our water system provides a wide range of services for all Victorians. It delivers economic value by allocating water to towns, irrigation, agriculture and industry, while healthy rivers and aquifers provide environmental, cultural and recreational value.

River health in the context of the North Central RHS has been interpreted as consisting of three main themes which together dictate the health of a river or stream and which, if considered separately, can often lead to stream degradation. These themes are the environment, society and economy.

Combined, these themes are often referred to as the Triple Bottom Line. It is often argued that determining actions on a Triple-Bottom-Line basis involves compromise or trade-offs. However, informed decision-making must not only be economically sound, but environmentally and socially sound, in the short and long-term. The main focus of the North Central RHS is to protect and enhance the environmental assets of the North Central region as it considers social and economic values.

1.3 Aim of the catchment and waterway descriptions

The catchment and waterway descriptions aim to support the vision for river health set out in the North Central RHS. This vision was built on the recognition that waterways and wetlands are key environmental assets that support varied and diverse ecological communities. It was also recognised that the waterways and wetlands within the North Central region are important economically and are valued socially. We need to strike a balance between the environmental, social and economic values of our river systems, and ensure that this balance is sustainable for the long-term future.

NORTH CENTRAL RIVER HEALTH STRATEGY – VISION

Waterways and wetlands will be managed sustainably to protect and enhance their diversity and ecological function whilst supporting the uses of the regional community.

The catchment and waterway descriptions for the Loddon catchment aim to:

- provide a general picture of the major waterways in the Loddon catchment using all currently available information
- inform the general public, stakeholder groups and organisations about waterways in the Loddon catchment
- provide a education resource for students
- contribute to the background information used in funding applications by individuals, community and Landcare groups and other organisations
- link closely to the North Central RHS.

1.4 Project development

'Waterways of the North Central region – catchment and waterway descriptions (Loddon catchment)' has been developed over several years. It has involved extensive field surveys, aerial photo and map interpretation, literature reviews and community input. These are outlined in the following key steps.

- identification of major waterways
- compilation and review of relevant literature
- survey of rapid assessment points along major waterways
- aerial photo interpretation of the riparian vegetation
- completion of background investigations into aquatic life and water quality
- community, agency and Indigenous River Health Forums
- public release of draft waterway summaries and incorporation of comments
- completion of the draft Loddon River Health Plan
- review of the draft Loddon River Health Plan to reflect the North Central RHS
- renaming of the document to align with its final content
- completion, production and public release of 'Waterways of the North Central region – catchment and waterway descriptions'.

2 Catchment overview

2.1 The Loddon catchment

The Loddon River catchment, home to two-thirds of the North Central population, covers 1,531,998 hectares (approximately half of the North Central region) or about 6.8% of the area of Victoria. The catchment extends about 310km from the Great Dividing Range in the south to the River Murray. Mount Alexander is the highest point in the catchment at 741 metres on the Divide just north of Castlemaine. The northern two-thirds of the catchment are the alluvial plains of the Murray valley, with granite outcrops at Mount Terrick Terrick, Mount Hope and Pyramid Hill rising some 80 to 100 metres above the general lie of the land.

The Loddon River is the principal watercourse. It flows north from near Daylesford on the Great Divide to the River Murray near Swan Hill. Therefore, the Loddon River has a direct influence on the health of the River Murray, including salinity, flows and exchange of aquatic species, such as native migratory fish. Major tributaries of the Loddon River are Tullaroop Creek and Bet Bet Creek, in the southwest of the catchment, and Bullock Creek and Bendigo Creek, in the east. The River Murray anabranch of Gunbower Creek and Pyramid Creek flow across the northern floodplain. Barr Creek is considered one of the saltiest inland waterways in Victoria and plays an important role in salt mitigation in the Loddon-Murray region. A pump station located along the lower reaches of Barr Creek pumps water to the storage basin of Lake Tutchewop to manage flows and salinity levels in the Loddon River and River Murray. There are several high-value wetlands, including the internationally recognised Ramsar-listed Kerang Lakes and Gunbower Forest.

An important characteristic of the Loddon River catchment is that it is influenced by water imported from the Goulburn and Murray rivers. Water is diverted into the Loddon River catchment from the Campaspe, Goulburn-Broken and Murray river systems to use as potable and irrigation water. Two main supply routes exist – the Waranga Western Main Channel and the Torrumbarry Irrigation System. These systems provide relatively good quality water to the lower Loddon River. In some lower catchment waterbodies (especially in the Torrumbarry system) inflows from the Loddon River catchment only enter in times of flood.

While 80% of the catchment has been cleared for agriculture, substantial forested areas remain on the southern hillslopes. Box-ironbark forests dominate the central catchment and remnant river red gums line the northern waterways. The seven bioregions represented in the Loddon catchment as outlined in the North Central Native Vegetation Plan (draft) include the Central Victorian uplands, Victorian volcanic plain, Goldfields, Victorian Riverina, Northern inland slopes, Murray mallee and Murray fans (North Central CMA 2003).

Many native vegetation communities (or Ecological Vegetation Classes (EVCs) within the Loddon catchment are considered endangered or vulnerable. Some of these threatened riparian EVCs include creekline grassy woodland, floodplain riparian woodland and lignum wetlands. There are also many threatened flora and fauna species that are dependent upon the aquatic and terrestrial riparian environment. Flora species include pale spike-sedge, woolly waterlily, downy swainson-pea and diosma rice-flower. Threatened fauna species include the red-backed kingfisher, murray cod, silver perch, plains wanderer and white-bellied sea-eagle. The *lowland riverine fish community of the southern Murray-Darling Basin* is also listed on the *Flora and Fauna Guarantee Act 1988* (DSE website).

Bendigo is the largest population centre in the Loddon catchment, maintaining its gold rush heritage and offering a wide range of arts and culture, retail and service industries. Kerang and Swan Hill in the north are also major business centres with services in health, welfare and recreation. The catchment is well-equipped with education providers, including La Trobe and Melbourne University campuses.

The Loddon catchment is agriculturally diverse. There are valuable and highly productive irrigation areas in the Loddon-Murray area with extensive dairying, pasture and irrigated horticulture. Mixed farming and cereal growing dominate the mid and upper catchment. Relatively small areas of intensive horticulture in the upper catchment also generate substantial wealth.

The Loddon catchment still yields large quantities of gold, providing significant wealth for the regional economy and benefits for shareholders beyond the region, e.g. Bendigo Mining.

Photo: Rachel Hall

The Loddon River floodplain near Boort in the lower catchment.

2 Catchment overview

The waterways of the Loddon catchment are a popular location for recreational fishing, boating (e.g. canoeing and motorised), swimming and camping. The Loddon River at Bridgewater is particularly renowned for waterskiing and recreational fishing. Several towns such as Carisbrook and Kerang feature creek and riverside walking tracks. In the southern catchment, mineral springs along the Loddon River and its tributaries are popular tourist attractions.

The key issues in the Loddon catchment include:

- dryland (e.g. Bet Bet, Timor and Bulabul areas) and irrigation salinity
- biodiversity decline (i.e. remnant vegetation decline, wetland degradation, flora and fauna decline)
- soil health (i.e. soil acidification, soil erosion, soil structure decline)
- water resources (i.e. water quality and river health decline, flooding due to changed land management, flow regulation, poor drainage, groundwater management)
- pest plants and animals
- regional development (i.e. sustainable water management, land-use change).

2.2 Waterway values to the Indigenous community

An intrinsic relationship between Indigenous culture and land has endured for over 40,000 years. The Kerang Lakes area is rich in Aboriginal history and archaeological resources. Although most of the archaeological remains relate to the last 3,000 years, a population with unusually robust physical traits occupied Kow Swamp from 13,000 years ago to 9,500 years ago. Earth mounds commonly found in this region were used for cooking ovens. Other common sites that characterise wetland and floodplain occupation include freshwater shell middens, scarred trees and burials (Ross 1989).

The Mt Franklin Aboriginal Reserve dates from the earliest days of white settlement in Victoria. Assistant Protector Edward Parker, who was assigned to the Loddon District in the late 1830s, soon became convinced that a reserved area should be set aside for the Loddon tribes where they would be free to live and obtain their food without encroaching on the areas already claimed by pastoralists.

A site near Mt Franklin, known also as Lalgambook or Jim Crow Hill was eventually chosen. Housing, agricultural areas and eventually a school were established at what is now Franklinford. Despite Parker's endeavour, the number of aboriginies using the Reserve declined and the government closed the Protectorate in December 1849. Parker undertook to continue his commitment to the aborigines under his care and in 1850, he was granted a pastoral licence to the Reserve. In this way he provided a continuing home for the aboriginies, who numbered about 50 in 1856. However, the gold discoveries from 1851 onwards created great difficulties in running the property, and the demand for farmlands led to subdivision and sale of much of the Reserve from 1855 (Culvenor 1992).

The land continues to inform Indigenous identity and community today. Traditionally, Indigenous people have a strong affinity with waterways and water bodies, as a vital source of food, water and camping sites in traditional lifestyles.

Pre-European settlement streams were low energy, fine grained, small channelled systems stabilised by riparian vegetation. Channels would have been for the most part cluttered with large woody debris, narrow, characterised by deep pools and infrequent riffles formed by gravel, boulders or logs and shaded by riparian forest (Nanson and Doyle undated).

Within the North Central region, there are many areas of significance to Indigenous people. The connection may be traditional or contemporary (or both). Such sites are located along rivers and water edges and the margins of watercourses, billabongs, wetlands, floodplains and lunettes, which tend to have a high incidence of Indigenous artefacts.

Sites of significant cultural heritage can include:

- scarred trees
- artefact scatters
- mounds
- stone quarries
- middens
- rock wells
- Indigenous owned and lands
- sites of ceremonial and spiritual significance e.g. sacred sites –burial sites and birthing sites
- fishing areas – rivers and lakes
- traditional plant, animal and mineral resources
- trade and travel routes.

Protection of historical evidence of occupation sites within the region is fundamental to Indigenous cultural heritage and is required under legislation. As many sites are very specific to this area, it is essential that they be protected and honoured. It should be noted that, as these Indigenous assets are the foundation of Indigenous people's physical, spiritual and cultural existence and identity, Indigenous people within the North Central region need to be consulted regarding their protection and enhancement. Indigenous communities have also indicated a strong interest in the current condition of water and waterways and want to be informed and involved in the management of these resources (SAMLIV Project Team 2003). The Indigenous River Health Forums facilitated by the North Central CMA in 2002 were integral to a better understanding of river health in the region.

The very spots most valuable to the Indigenous community for their productiveness — the creeks, watercourses and rivers — were the first to be occupied by the European settlers, beginning in the late 1830s.

2.3 Historical impacts on river health post-European settlement

Since the arrival of the first Europeans in the Loddon catchment, the waterways have been under increasing pressure to meet the social and economic needs of the growing population. The key historical impacts include:

- the early pastoralists
- the gold rush
- the provision of domestic and irrigation water.

2.3.1 The early pastoralists

Major Thomas Mitchell was the first European to look over the great Ironbark forests, the open volcanic plains and the vast level floodplains of the Loddon catchment and deemed it ready for the 'immediate reception of civilised men'.

Mitchell crossed the Loddon River on 27 September 1836 near the present site of Newstead. Mitchell reported:

'We this day crossed several fine streams and forests of blue gum. At length we entered on a very level and extensive flat, exceedingly green and resembling an English park. It was bounded on the east by a small river flowing to the north, and abrupt but grassy slopes arose beyond its right bank. After crossing this stream we encamped. This tract was of different formation from that of the fine country through which I had recently passed. Sheltered by higher ground the spring seemed more advanced here than elsewhere and our hard wrought cattle deserved to be the first to graze on that verdant plain. The stream vanished amongst grassy hills in its course downward to water a country apparently of the most valuable and interesting character… The banks of this stream consisted of rounded acclivities and were covered with excellent grass. The bed was some eighteen to twenty feet below the level of the adjacent flats, and from its resemblance, in some respects, to the little stream in England I named it the Loddon.'

On hearing Mitchell's glowing descriptions pastoralists flocked to the area to take up runs in the southern areas and on the banks of the Murray and the Loddon rivers. Much of the better land was occupied by the 1840s forcing settlers to take up land in the less well watered country in the west of the catchment.

Joseph Parker described Campbells Creek in 1846, shortly before the onset of gold fever.

"To travel from the junction of Barkers Creek and Forest Creek, to the Bough Yards (now Guildford), was a scene of beautiful, crystal like waterholes, which sparkled in the glittering rays of the sun, every waterhole was teeming with fish, and flocks of ducks. On the slopes and hills on either side of the creek, stood evergreen trees, with such even regularity, as to lead one to believe that they had been planted by the hand of science, consisting of golden, silver and black wattle, many of them in full bloom, also blackwood, sheoak and honeysuckle."

To look at Campbells Creek today it is almost impossible to imagine the scene that Joseph Parker described.

Photo: Greg Chant

Campbells Creek today

2.3.2 The gold rush

The gold rush in the 1850s brought a massive influx of thousands of gold miners who established the townships of Castlemaine, Daylesford, Dunolly, Maryborough, Wedderburn and Bendigo. The rich alluvial deposits of gold were soon exhausted and while the population declined many gold miners remained in the region and took up land for agriculture or started businesses.

The impact that the gold rush had on the waterways of the Loddon catchment cannot be overstated. Gold mining activities fundamentally changed the nature of many of the waterways and it was not until after the momentum of gold fever had slowed that people stopped to assess the damage.

An example of this was the Government appointment in 1861 of a Sludge Select Committee to investigate claims made by property owners in the Epsom-Huntly area that their properties were being inundated and damaged by sludge from Bendigo Creek. The following is an excerpt from this inquiry:

'When you were first on Sandhurst, was there a natural channel to carry off the sludge? — There was a natural channel to carry off the water - natures own watercourse.
At the time… was it your opinion, knowing the district, that there would be any chance of being overflowed by sludge? — There was a fine creek there then.
And you did not conceive that it was possible that it would be eventually overwhelmed with sludge? — No one could have foreseen it at that time, there was a fine clear open creek when I first saw it.'

Here, 'natures own watercourse' was seen as resilient and unchanging. The ability of the Bendigo Creek to absorb and dispose of mining wastes was seen as limitless, and there was little thought as to the more direct impacts gold mining was having on the waterway.

A report by the Mines Department dated 10 August 1906 found that between the years 1900 and 1906, 49,945,465 cubic yards of material was treated under the heading of Dredge Mining and Hydraulic Sluicing by Gravitation. When we consider that this was a considerable time after the worst ravages of gold rush for which there are no figures, it gives us some insight into the extent of the soil lost from the landscape and deposited in the waterways during this period.

2.3.3 Provision of domestic and irrigation water

The discovery of gold in central Victoria in 1851 led to the rapid development of a number of substantial population centres. These towns had an urgent requirement for fresh water and for this reason the Coliban Supply System was developed (Water Victoria 1988).

The scarcity of water in the goldfields prompted the building of a reservoir in 1866 on the Coliban River in the Campaspe catchment, and the construction of a number of tunnels and several hundred kilometres of open channels and ditches to carry water by gravitational flow to the Bendigo-Castlemaine goldfields region. Malmsbury Reservoir has subsequently been enlarged twice in 1887 and 1940. Over the years increasing demand for domestic, irrigation and stock water have resulted in the construction of two more reservoirs on the Coliban River south of the original one: the Upper Coliban in 1903 and the Lauriston in 1941 (CMPS&F 1994).

This system supplies water for domestic use to towns in the Campaspe and Loddon catchments, including Bendigo, Castlemaine and Kyneton, as well as many smaller towns including Harcourt, Maldon, Chewton, Tylden, Newstead, Fryerstown, Elphinstone, Taradale, Malmsbury and Guildford.

Irrigated agriculture did not begin on a large scale until the construction of the Torrumbarry Weir in 1919 (reconstruction completed in 1996) and Laanecoorie Reservoir in 1935. Further storages were built including the Cairn Curran and the Tullaroop reservoirs in the 1950s to cater for the needs of irrigated agriculture.

Irrigation water supplies from the Murray and Goulburn river systems also supplement the Loddon catchment's surface water resources.

The irrigation area in the region is recognised as one of the most severely salt affected areas in Victoria. According to the Murray Darling Basin Commission, salinity and waterlogging is the major threat to the sustainable management of the Basin's resources. Impacts of salinity include increasing siltation and turbidity in waterways, therefore reducing water quality. Agriculture remains the main land and water user in the catchment.

Groundwater is a significant and valuable component of the North Central region's water resources. Where a groundwater aquifer is highly connected to surface water, a decline in groundwater levels will affect users of both the groundwater and the connected surface water. The groundwater contribution to river flow is also reduced. It also impacts on wetlands and other dependent ecosystems like native

vegetation. Groundwater is used extensively for stock and irrigation purposes and increasingly for town water supplies in the North Central region. In some towns, groundwater is used to augment surface water sources, while in others, it is the primary potable water source.

Groundwater use is most extensive in the south of the region for irrigation of horticultural crops and pastures. Mineral springs in this area are also used which also support both the processing and tourist industries. Increasingly, deep lead aquifers in the middle and lower reaches of the Loddon and Campaspe valleys are also employed.

2.4 Community perceptions of waterway health

The ways in which the community values the waterway system, past and present, often dictates its condition. To gather current community views about the waterways of the Loddon catchment, three community River Health Forums were held in March and April 2002 at Castlemaine, Clunes Daylesford, Huntly, Kerang, Laanecoorie, Maryborough, Pyramid Hill and Serpentine.

These public meetings were widely advertised and were open to all interested citizens, including landholders who have a key interest and direct bearing on waterway health. The forums also attracted students, field naturalists, angling enthusiasts, local government councillors, Landcare members, irrigators and dryland farmers.

In relation to their local waterway, participants were asked to:

- rate a variety of waterway values
- rate the impact of a range of waterway threats
- prioritise a number of management activities for reducing the identified threats.

Attendees completed surveys that were developed prior to the finalisation of the database that was used as the basis of the North Central RHS. Therefore, the value and threat categories were not identically aligned. However, the information gathered at the River Health Forums was used as a 'reality check' of the information used to guide priorities and targets of the North Central RHS (North Central CMA 2005).

There is a summary of the information gathered for each catchment in Section 4.2.1 – 4.2.4 of the North Central RHS. The North Central CMA is committed to community involvement for future revisions of the North Central RHS.

2.4.1 Waterway values – upper Loddon

As shown in Figure 1, water quality was identified as the key value attached to waterways in the upper Loddon catchment followed by scenic appearance and native vegetation and wildlife.

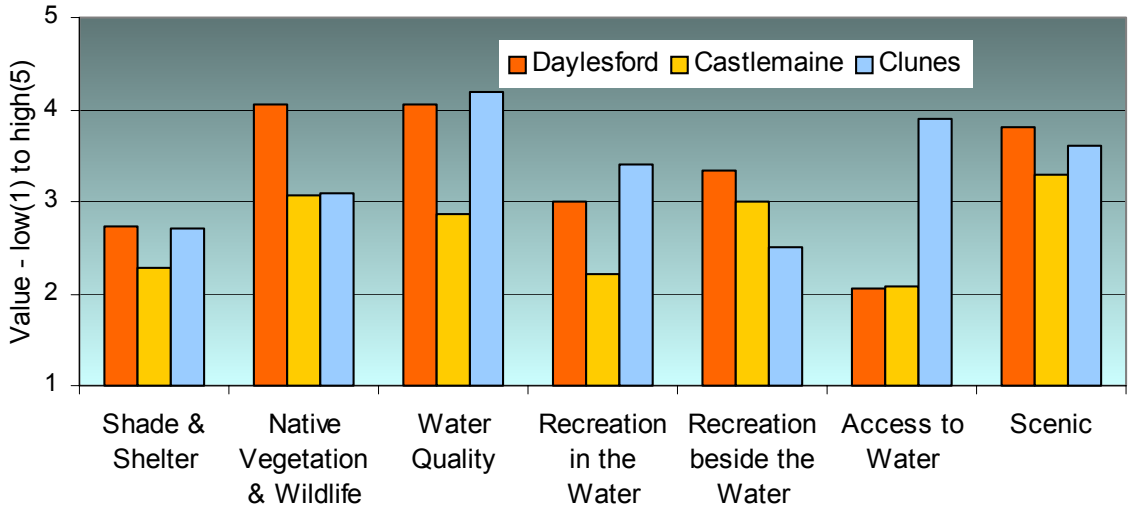

Figure 1 Perceived values attached to the waterways of the upper Loddon catchment

Water quality was valued highly at both the Daylesford and Clunes forums but not so highly at the Castlemaine forum. This may be linked to:

- the input of treated effluent to Campbells Creek (near Castlemaine)
- the degree of permanency of streams near Daylesford (e.g. Loddon River) and Clunes (e.g. Creswick Creek) as opposed to the more intermittent streams near Castlemaine.

The second point is further qualified by the high value placed on access to water at the Clunes forum.

2.4.2 Waterway values – mid Loddon

Figure 2 demonstrates that both shade and shelter, and native vegetation and wildlife were identified as the key values attached to waterways in the mid Loddon catchment.

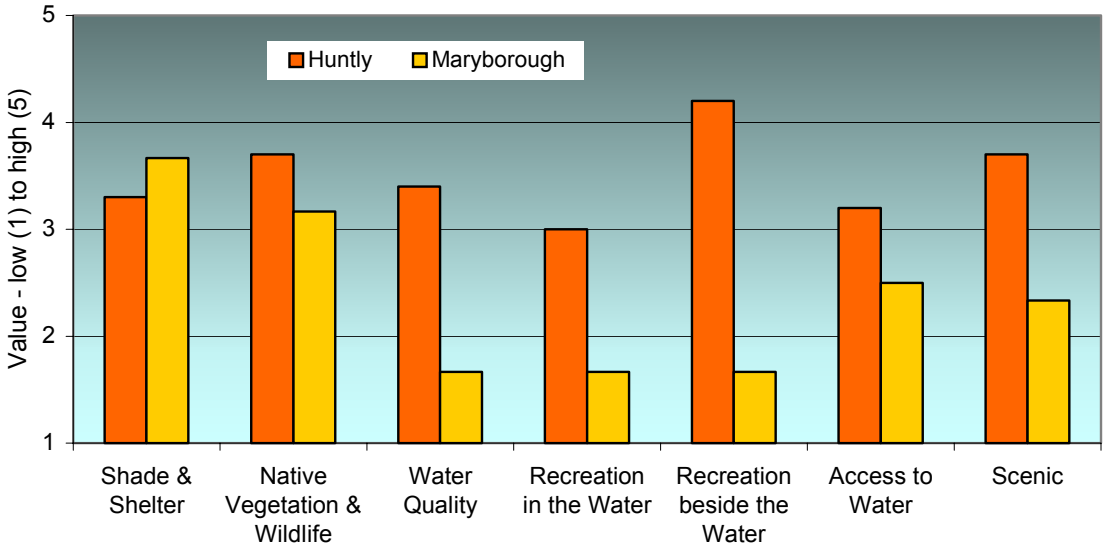

Figure 2 Perceived values attached to the waterways of the mid Loddon catchment

The Huntly forum generally placed a higher value on waterways than the Maryborough forum. This could be due to better access to creeks in the Huntly region, allowing more recreation in and beside the water. The lower value placed on water quality at Maryborough may be also be linked to the input of treated effluent to Four Mile Creek (near Maryborough).

2.4.3 Waterway values – lower Loddon

As shown in Figure 3, scenic appearance was identified as the key value attached to waterways in the lower Loddon catchment followed by native vegetation and wildlife.

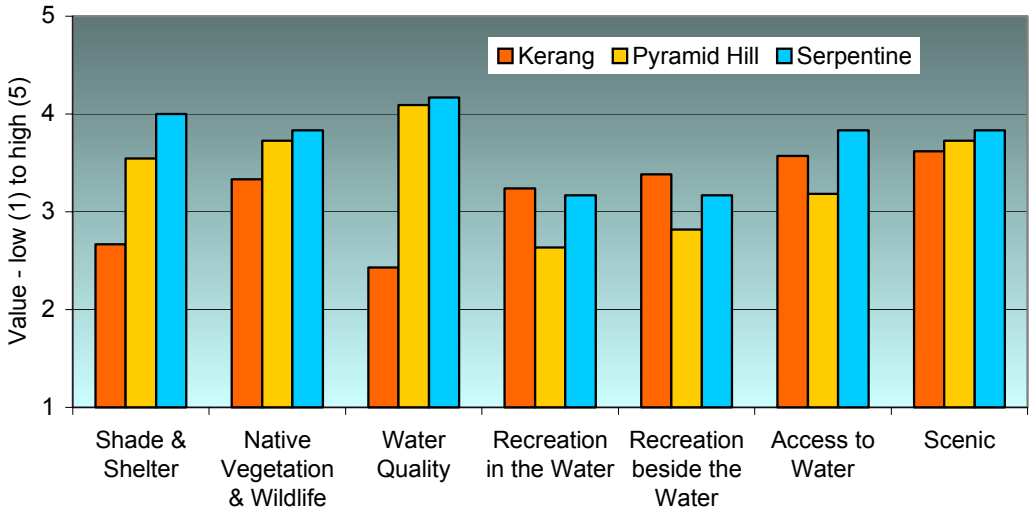

Figure 3 Perceived values attached to the waterways of the lower Loddon catchment

Water quality, native vegetation and wildlife, and shade and shelter were generally more highly valued by the Pyramid Hill and Serpentine farming communities who depend on the waterways to sustain their livestock and crops. However, recreation and access to the water was more important to the Kerang community where the Loddon River is a recreational feature through the township.

2.4.4 Waterway threats – upper Loddon

Figure 4 shows clearly that pest plants were seen as the major threat to waterways in the upper Loddon catchment.

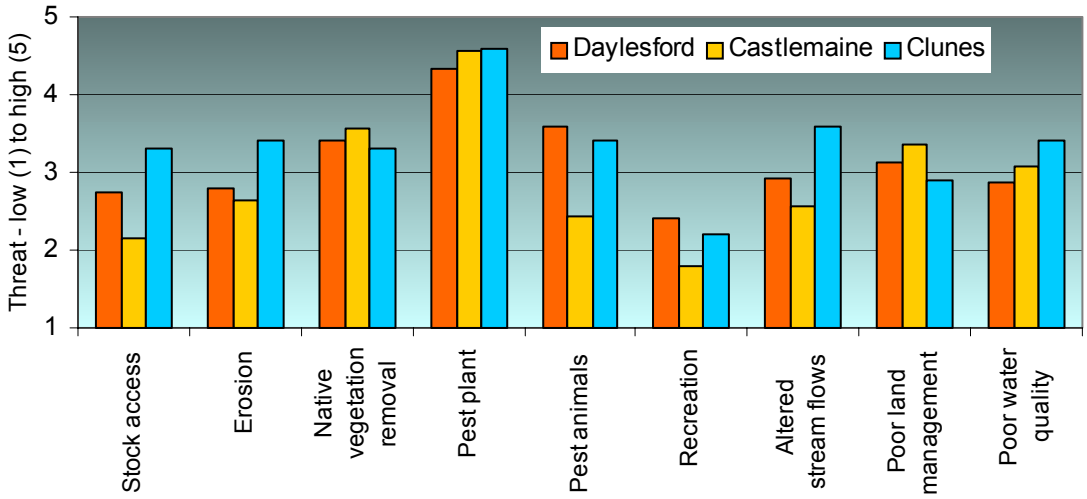

Figure 4 Perceived threats attached to the waterways of the upper Loddon catchment

A higher waterway threat was highlighted at the Clunes forum by stock access, erosion, poor water quality and altered stream flows. The latter threat may be due to the presence of numerous reservoirs and on-stream dams upstream of Clunes, including Newlyn Reservoir on Birches Creek.

Poor land management was also a moderately rated threat at all three forums. This may allude to haphazard pest plant and animal control throughout the upper catchment.

2.4.5 Waterway threats – mid Loddon

Figure 5 demonstrates that poor water quality was seen as the major threat to waterways in the mid Loddon catchment, followed closely by poor land management and stock access.

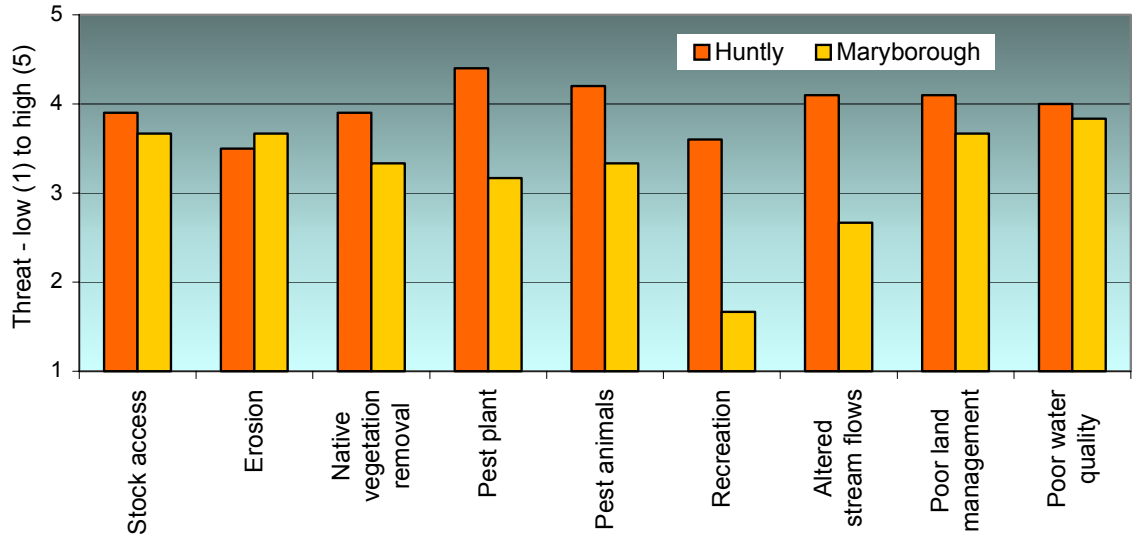

Figure 5 Perceived threats attached to the waterways of the mid Loddon catchment

The threat of poor water quality at both Huntly and Maryborough may be explained by community concerns regarding the input of treated effluent to Bendigo Creek (near Huntly) and Four Mile Creek (near Maryborough). Attendants at the Huntly forum generally rated all threats much higher than their

Maryborough counterparts, particularly the impact of recreation on waterways, which is also highly valued by the community in Huntly and surrounding districts.

2.4.6 Waterway threats – lower Loddon

As shown in Figure 6, poor water quality is also seen as the major threat to waterways in the lower Loddon catchment.

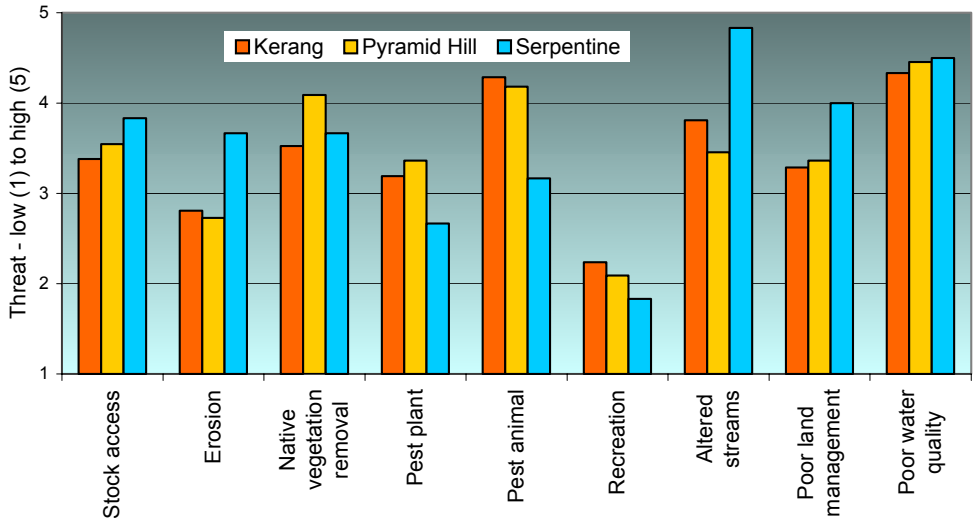

Figure 6 Perceived threats attached to the waterways of the lower Loddon catchment

Good water quality is essential for the prosperity of the Loddon Murray irrigation area. Therefore, the effects of salinity and blue green algal blooms are regarded as a high threat to both the waterways and the broader community.

Although many of the waterways act as carriers of irrigation water, this is also seen as a major threat to the health of these waterways, particularly in the Serpentine area. Erosion, stock access and poor land management was also rated as a higher threat in the Serpentine area.

The impacts of native vegetation removal on waterway health were more of a concern to the Pyramid Hill community, while pest plants and animals were rated as a higher threat in both Pyramid Hill and Kerang.

2.4.7 Community aspirations – upper Loddon

Figure 7 shows that the highest ranked recommended management activity at the three forums in the upper catchment was weed management, followed by native vegetation restoration.

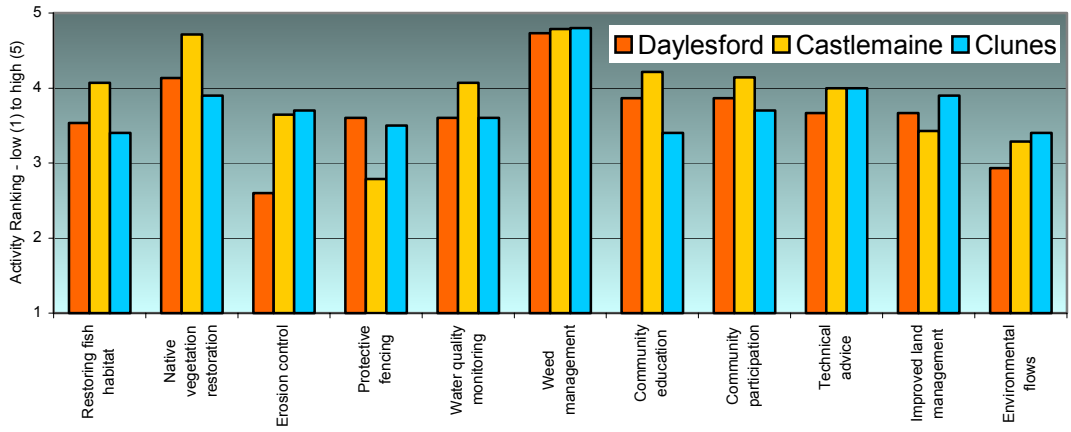

Figure 7 Suggested management activities to improve river health in the upper Loddon catchment

The restoration of fish habitat and water quality monitoring were highly rated at the Castlemaine forum. Again, this may reflect the community concern regarding the input of treated effluent to Campbells Creek (near Castlemaine). Community education and participation together with the provision of technical advice was highlighted at all three meetings.

2.4.8 Community aspirations – mid Loddon

As shown in Figure 8, all management activities were rated moderate to high, however the highest ranked activity in the mid Loddon catchment was native vegetation and fish habitat restoration.

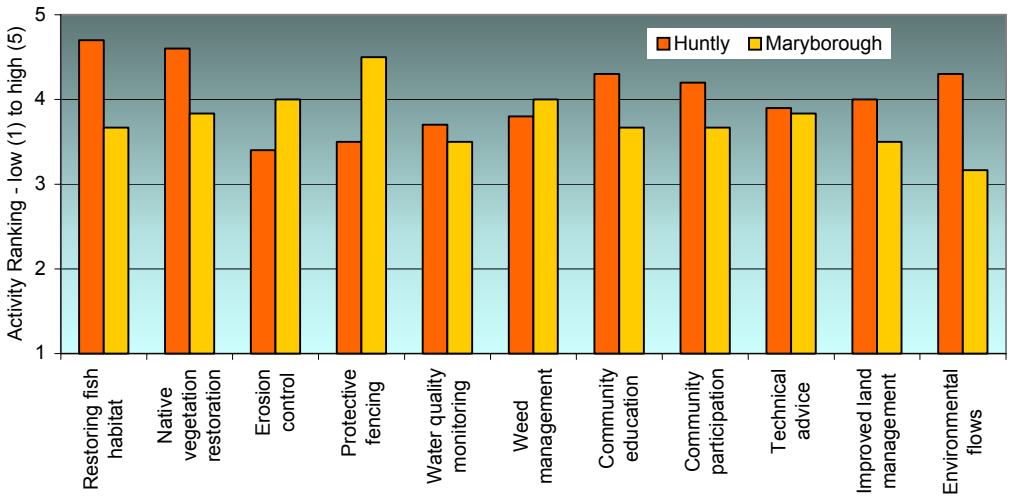

Figure 8 Suggested management activities to improve river health in the mid Loddon catchment

Protective fencing and erosion control was generally rated higher at the Maryborough forum. Environmental flows and community education and participation were also considered a higher priority at the Huntly forum (perhaps due to the proximity to the Campaspe River).

2.4.9 Community aspirations – lower Loddon

Figure 9 shows that the highest ranked recommended management activities in the lower catchment were native vegetation restoration, protective fencing and improved land management.

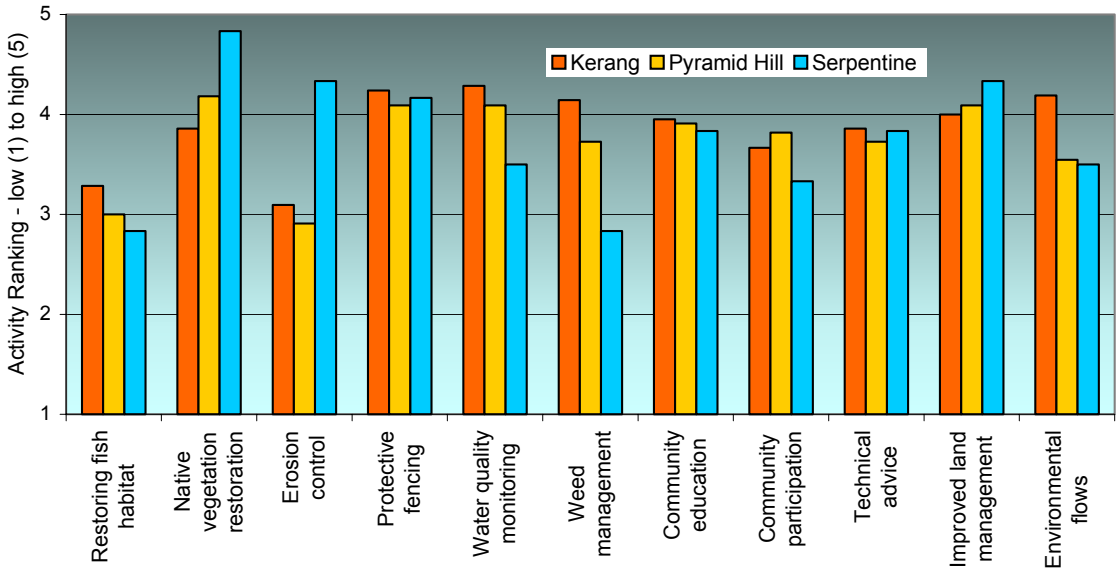

Figure 9 Suggested management activities to improve river health in the lower Loddon catchment

The provision of environmental flows was a highly ranked activity at the Kerang forum, together with water quality monitoring and weed management. Erosion control, native vegetation restoration and improved land management were seen as high priority activities at the Serpentine forum. The restoration of fish habitat was generally less of a priority in the lower catchment.

3 Waterway condition

3.1 Waterways of the Loddon catchment

River health management and planning in the North Central region occurs at several scales. As demonstrated in Figure 10, this varies from large geographic areas to individual sections of waterways.

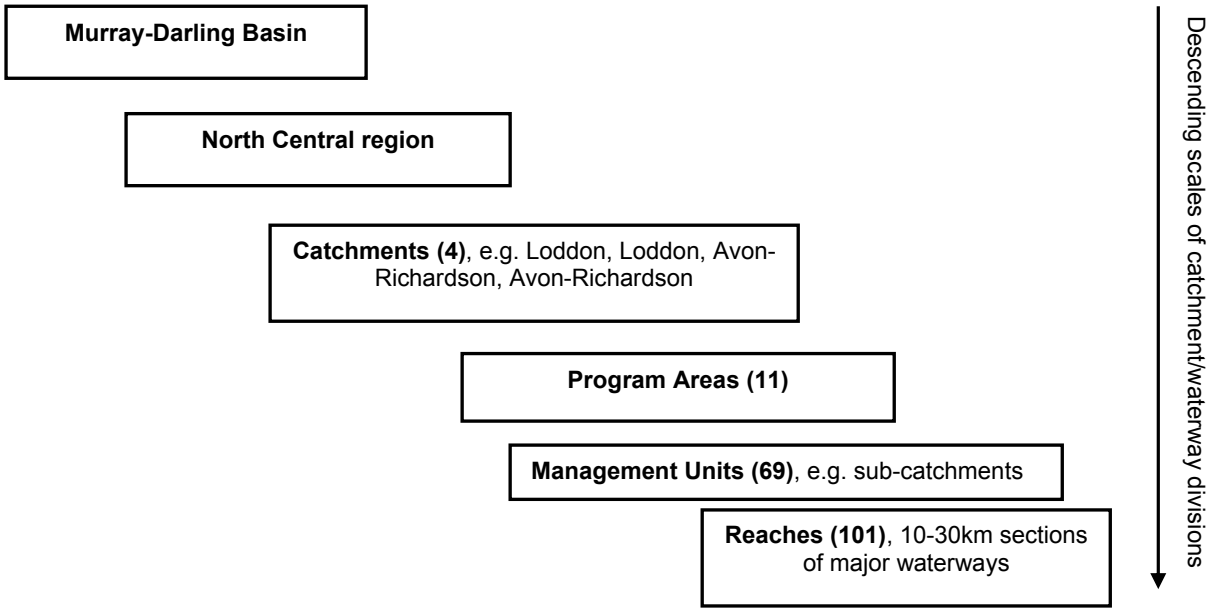

Figure 10 Means of dividing areas of catchments and waterways for management purposes.

The North Central region is an important part of the Murray-Darling Basin and therefore has a responsibility to contribute to the health of the River Murray. The region includes four major river catchments – the Loddon, Loddon, Avoca and Loddon catchments.

In recent years, several North Central CMA catchment-based plans and strategies divided the four catchments into smaller 'Management Units' (MUs) based on geographical similarities and stream management issues. Such documents include the Nutrient management strategies, Nutrient action plans and 'Waterways of the North Central region – catchment and waterway descriptions'. The MU scale is adequate for these documents to summarise waterway condition and to assign management actions. It remains a useful means of dividing individual catchments into manageable areas.

For the Loddon catchment, 192 major waterways were identified on a 1:25,000 scale topographic map. These include both named and unnamed rivers, creeks and gullies. It does not include drains, water supply channels and the margins of reservoirs.

For management purposes, the North Central CMA divided the Loddon catchment into 28 MUs. The following Table 1 and associated Figure 11, includes the major waterways and their MUs. Although most waterways are located within one MU, the Loddon River has been divided into five MUs, Tullaroop Creek flows through two MUs, Bendigo Creek is divided into five MUs and Bullock Creek two MUs.

3 Waterway condition

Table 1 Major waterways and their Management Units

MU	Stream	MU	Stream
1	Loddon River (headwaters to Cairn Curran Reservoir)	7	Unnamed Timor Creek tributary
2	Bald Hill Creek	8	Boundary Gully Creek
2	German Gully	8	Loddon River (Cairn Curran to Laanecoorie Reservoir)
2	Green Gully	8	Unnamed Loddon River tributary
2	Hunters Creek	8	Six Mile Creek
2	Jim Crow Creek	8	Unnamed Six Mile Creek tributary
2	Kangaroo Creek	9	Bradford Creek
2	Kennedys Gully	9	Unnamed Bradford Creek tributary (northern)
2	Leitches Creek	9	Unnamed Bradford Creek tributary (southern)
2	Limestone Creek	9	Little Creek
2	Middleton Creek	9	Unnamed Little Creek tributary
2	Porcupine Creek	9	McGee Creek
2	Sailors Creek	9	Murphy Creek
2	Shicer Gully	10	Bullabul Creek
2	Sailors Gully	10	Unnamed Bullabul Creek tributary
2	Sebastapol Creek	10	Dead Log Creek
2	Spring Creek	10	Kangderaar Creek
2	Tarilta Creek	10	Unnamed Kangderaar Creek tributary
2	Wallaby Creek	10	Unnamed Loddon River tributary
2	Yandoit Creek	10	Murphys Creek
3	Back Creek	10	Nuggetty Creek
3	Barkers Creek	10	Orville Creek
3	Bassett Creek	10	Simpsons Creek
3	Boundary Creek	10	Waanyarra Creek
3	Campbells Creek	11	Blind Creek
3	Chinaman Creek	11	Forbes Creek
3	Dyers Creek	11	Hope Creek
3	Forest Creek	11	Unnamed Hope Creek tributary
3	Fryers Creek	11	Kingower Creek
3	German Gully	11	Ryan Creek
3	Green Gully	11	Unnamed Ryan Creek tributary (1)
3	Hunts Creek	11	Unnamed Ryan Creek tributary (2)
3	Mia Mia Creek	12	Wandella Creek
3	Muckleford Creek	12	Sheepwash Creek South
3	Nuggetty Creek	12	Kinypaniel Creek
3	Porcupine Creek	12	Venables Creek
3	Sandy Creek	12	Sheepwash Creek North
3	Tarrengower Creek	12	Unnamed Loddon River tributary
3	Wattle Creek	12	Washpen Creek
4	Blind Creek	12	Scotts Creek
4	Carrs Creek	13	Gunbower Creek
4	Hepburn Creek	13	Yarran Creek
4	Joyces Creek	13	Taylor Creek
4	Unnamed Joyces Creek tributary	13	Deep Creek
4	Little Middle Creek	13	Longmore Lagoon
4	McLachlan Creek	14	Bullock Creek (headwaters to Waranga Western Main Channel)
4	McLeod Creek	14	Unnamed Bullock Creek tributary
4	Middle Creek	14	Dry Creek
4	Salt Creek	14	Fletcher Creek
4	Stockyard Creek	14	Ravenswood Creek
4	Tea Tree Creek	14	Spring Creek
4	White Creek	15	Bullock Creek (Waranga Western Main Channel to Pyramid/Box Creek)
5	Birches Creek	15	Welches/Seven Months Creek
5	Coghills Creek	15	Unnamed Bullock Creek tributary (1)
5	Cotty Creek	15	Pompapiel Creek
5	Creswick Creek	15	Blind Creek
5	Fleming Creek	15	Unnamed Bullock Creek tributary (2)
5	Glendaruel Creek	15	Unnamed Bullock Creek tributary (3)
5	Glendonald Creek	16	Myers Creek
5	Kilkenny Creek	16	Neilborough Creek
5	Kilkenney Creek	16	Maiden Gully Creek
5	Langdons Creek	16	Unnamed Myers Creek tributary (west)
5	Lawrence Creek	16	Unnamed Myers Creek tributary (east)
5	Petticoat Creek	16	Elysian Flat Creek

5	Pinchgut Creek	17	Bendigo Creek (headwaters to Huntly)
5	Rocky Lead Creek	17	Long Gully
5	Slattery Creek	17	Spring (Back) Creek
5	Slaty Creek	17	Back Creek
5	Splitters Creek	18	Bendigo Creek (Huntly to Goornong)
5	Tourello Creek	18	Sandy Creek
5	Tullaroop Creek	18	Yankee Creek
5	Yellow Creek	18	Crabhole Creek
6	Back Creek	18	Reedy Creek
6	Beckworth Creek	18	Unnamed Reedy Creek tributary
6	Cook Creek	19	Bendigo Creek (Goornong to Drummartin)
6	Daisy Hill Creek	19	Mosquito Creek
6	McCallum Creek	19	Round Creek
6	Mia Mia Creek	20	Bendigo Creek (Drummartin to Prairie)
6	Mt Greenock Creek	21	Bendigo Creek (Prairie to Kow Swamp)
6	Narragil Creek	22	Pennyroyal Creek
6	One Mile Creek	22	Twelve Mile Creek
6	Unnamed One Mile Creek tributary	22	Bannacher Creek
6	Sandy Creek	22	Serpentine Creek
6	Stony Creek	22	Nine Mile Creek
6	Tullaroop Creek	22	Judyong Creek
6	Unnamed Tullaroop Creek tributary	22	Unnamed Calivil Creek tributary
7	Bet Bet Creek	22	Calivil Creek
7	Burnbank Creek	22	Long Plain Creek
7	Burnt Creek	23	Pyramid/Box Creek
7	Carmanual Creek	24	Piccaninny/Barr Creek
7	Carululup Creek	24	Barr Creek
7	Doctors Creek	25	Little Murray River
7	Dunira Creek	25	Unnamed Little Murray Rivert
7	Four Mile Creek	26	Loddon River (Laanecoorie to Boort East)
7	Green Hill Creek	27	Loddon River (Boort East to Kerang)
7	Timor Creek	28	Loddon River (Kerang to Murray River)

Figure 11 The major waterways of the Loddon catchment and the 28 Management Units

See Table 2 to compare the division of the Loddon catchment used in the North Central RHS. The catchment was considered three Program Areas. Thirteen waterways were assessed as part of the ISC, which were divided into 24 individual reaches.

Table 2 List of waterways within Program Areas

Catchment	Program Area	Waterway	ISC Reach
Loddon	Upper Loddon (above Cairn Curran Reservoir)	Loddon River	9, 10
		Middle Creek	24
		Joyces Creek	25
		Muckleford Creek	26
		Jim Crow Creek	27
		Sailors Creek	28
		Campbells Creek	29
		Barkers Creek	30
	Loddon (western tributaries above Laanecoorie Reservoir)	Bet Bet Creek	14, 15, 16
		Burnt Creek	17
		Tullaroop Creek	18, 19
		Creswick Creek	20
		Birches Creek	21
		McCallum Creek	22
		Beckworth Creek	23

	Lower Loddon	Loddon River	1, 2, 3, 4, 5, 6, 7, 8
		Serpentine Creek	11
		Bulabul Creek	12
		Bradford Creek	13
		Barr Creek	31
	Mid-Loddon	Box Creek	32
		Bullock/Pyramid Creek	33
		Bullock Creek	34, 35, 36
		Spring Creek	37
		Bendigo Creek	40 ,41, 42, 43, 44
		Myers Creek	45, 46
		Back Creek	47
	Gunbower	Gunbower Creek	38, 39

You will notice the broader scale and reduced number of waterways included in the North Central RHS strategic document.

3.2 Priorities for river health management

The overall objective for managing river health in the Loddon catchment as outlined in the North Central RHS is to minimise risks to the River Murray to which it is directly linked. In doing so, the riparian vegetation along Loddon catchment waterways will be protected and enhanced creating better habitat for both terrestrial and aquatic species. Improved water quality will benefit the health of the river and the variety of social and economic uses it provides.

According to the priority-setting process detailed in the North Central RHS, a number of waterway reaches were identified as priorities for river health management in the Loddon catchment. These reaches and their corresponding priority-setting principles are listed in Table 3. Refer to Appendix 2 for a description of the priority principles objectives that guide the management actions for each priority reach.

Table 3 Priority waterway reaches in the Loddon catchment

Priority principle	Priority reach
Principle 1: Protect and enhance ecologically healthy rivers and representative rivers	Loddon River reach 10 Sailors Creek reach 28
Principle 2: Minimise risks to connected high-value assets	Loddon River reaches 1, 2, 3, 4, 5, 6, 7, 8, 9 and 10 Bendigo Creek reaches 40, 41, 42, 43 and 44 Myers Creek reaches 45 and 46 Pyramid Creek reach 33 Creswick Creek reach 20 Barkers Creek reach 30 Gunbower Creek reaches 38 and 39
Principle 3: Protect and enhance high-risk reaches	Barr Creek reach 31 Serpentine Creek reach 11 Gunbower Creek reaches 38 and 39 Loddon River reaches 1, 2, 6, 7, 8 and 10 Bet Bet Creek reach 14 Creswick Creek reach 20 Bendigo Creek reach 44 Tullaroop Creek reach 18 Barkers Creek reach 30

	Birches Creek reach 21
Principle 4: Protect reaches with high-environmental-, social- and economic-value	Loddon River reaches 2, 7, 8 and 10 Gunbower Creek reach 38
Principles 5, 6 and **7**	All waterways on a case by case basis

The desired long-term (50+ years) vision for all waterways across the Loddon catchment are defined in the following Aspirational Targets which are measurable and time bound.

- Waterways will achieve full attainment of SEPP (WoV) objectives by 2055.
- The Loddon River (reach 10) and Sailors Creek (reach 28) will meet the State-set criteria for ecologically healthy condition by 2021.
- By 2030, average annual loads of phosphorus will be reduced by approximately 35% and nitrogen loads will be reduced by about 25% in the Loddon catchment.

In addition to these are the following long-term goals for the Loddon catchment:

- Water will be shared equitably and efficiently between environment and consumptive uses.
- Water quality will match users' requirements and have no detrimental impact on aquatic life.
- Erosion and sediment transport will be managed to reduce blue green algal blooms and sedimentation of reservoirs.
- Migratory fish will breed and move freely throughout the catchment.
- Large-scale fish kills will no longer occur.
- Minimise the impacts of the Loddon River to the River Murray and significant wetlands, e.g. Kerang Lakes.
- Many areas will be targeted through the North Central Dryland Targeted Salinity Program, testing and applying emerging scientific concepts to provide farmers in the North Central region with the best available technical options to improve their viability and environmental sustainability.
- To 'cap' dryland contributions to River Murray salt loads.
- To promote, protect and restore aquatic and terrestrial biological diversity for future sustainability in the Loddon-Murray region.
- To enhance the environmental and cultural assets of the Loddon-Murray region while tripling the value generated from its natural resources within 30 years.
- To have secure long-term productive, profitable and environmentally sustainable irrigated lands in the Loddon-Murray region for the benefit of current and future generations.
- Diverse, sustainable land use in the Loddon-Murray region, matched to land capability, providing improved environmental, economic and social outcomes.
- To build community capacity in the Loddon-Murray region by developing the skills, leadership and the social environment necessary to adapt to change, and to embrace those changes to become a vibrant and thriving community.
- Populations of threatened native plant and animal species will be restored to viable levels.
- Threatened vegetation communities will expand and improve in quality to achieve a net gain.
- Reaches of high-environmental-, social- and economic-value are protected from environmental threats.
- Loddon River flows will be improved to protect aquatic habitat and improve water quality.
- Urban development will be carefully planned and managed according to local government planning controls that minimise the impact on waterways, wetlands and floodplain areas.
- Long-term water security will be achieved through the implementation of the Sustainable Water Strategy for Northern Victoria.

Many of these long-term targets and goals apply across the entire Loddon catchment. Those particularly relating to the upper catchment include the control of sediment transport to reduce blue green algal blooms and sedimentation of reservoirs as well as the protection and enhancement of 'near' ecologically healthy reaches. Those pertinent to the lower catchment include the free movement of migratory fish species upstream from the River Murray and the five long-term targets for the Loddon-Murray region (from the Loddon-Murray Land and Water Management Strategy (LMLWMS) (Loddon-Murray Forum 2002).

The Management Action (five-year) and Resource Condition (ten-year) targets set out in the North Central RHS aim to achieve the Aspirational Targets and long-term goals for river health in the Loddon catchment.

3.3 Condition of waterways

The landscape of the Loddon catchment has undergone rapid changes over the past 170 years since the first Europeans traversed the area. The current condition of the waterways reflects these changes.

3 Waterway condition

The Index of Stream Condition (ISC) was undertaken in 1999. The ISC benchmarking is a snapshot of river and stream condition looking at five indicators (or sub-indices) of river health. It provides a summary of the extent of change from natural or ideal conditions for each of the following sub-indices:

- hydrology (flow volume and seasonality of flow)
- physical form (stream bank and bed condition, presence of and access to physical habitat)
- streamside zone (quality and quantity of streamside vegetation and condition of billabongs)
- water quality (nutrient concentration, turbidity, salinity and acidity)
- aquatic life (diversity of macroinvertebrates).

Results from the ISC survey revealed that only 4% of the streams in the Loddon catchment are in good condition whilst 68% are in a poor to very poor condition (Figure 12).

3 Waterway condition

Figure 12 Waterway condition in the Loddon River catchment (and ISC reach numbers)

The condition of waterways is represented in the following Figure 13.

Figure 7 ISC condition of waterways in the Loddon catchment (in 1999)

By breaking the ISC into its various sub-indices, a better picture of the condition of the waterways in the Loddon catchment can be observed. The following sections outline and discuss each sub-index.

3.3.1 Hydrology

The harnessing of rivers to provide secure water supplies for towns and irrigation has had profound effects on the ecology of rivers and floodplains. The introduction of dams and other regulating structures, of diversions of streams, of groundwater bores and of small catchment dams have impacted on the natural flow regime of our rivers. Furthermore, water resource development is not the only activity that can impact on river hydrology. Changes in land use within catchments, such as land clearing and urbanisation, have also modified the water regimes within our rivers (NRE 2002).

This effect can be seen clearly in Figure 8 which shows that less than 20% of the waterways in the Loddon catchment have natural flow conditions (i.e. a score of 10). The altered flows are largely due to the presence and functions of storages, such as Cairn Curran, Laanecoorie and Tullaroop reservoirs.
Figure 8 Condition of the hydrology of waterways in the Loddon catchment (after ISC[1])

Rivers and streams contain a vast array of aquatic plants and animals that have evolved and adapted to the particular river conditions and its natural flow patterns. Changes to these flow patterns can affect the survival of the whole river ecosystem (NRE 2001).

Unseasonal regulated water releases from the major storages have historically been to the detriment of native fish like Murray cod and Golden perch, affecting their breeding and survival (McGuckin & Doeg 2000).

Changing flow patterns can alter the shape of river channels. Naturally occurring floods are important for maintaining river profiles through the movement and deposition of sediment. Reduced flooding causes a build-up of sediments, reducing water depth, fill in pools and smothering habitat. Without natural flooding the river channel can decrease in size, becoming incapable of containing the increased flows, which may occur in very wet years (NRE 2001).

Low flows can cause a build-up of nutrients, chemicals or saline water in stagnant pools. These pools of high temperature and low water quality can cause death of resident fish and the vegetation alongside the river bank, which helps to maintain the bank and protect it from erosion.

Reducing the frequency of floods has impacts on waterbirds, reptiles and amphibians. These groups rely on sufficient water to cover streamside and floodplain areas, which provide their habitat.

Without the regular inundation of the floodplain, those areas most valued for their agricultural productiveness lack the enrichment of nutrients and sediments provided by floodwaters.

Whilst it may be argued that we have significantly altered river flows across the North Central region in the past, many threats still remain. At the agency River Health Forum held in 2002, participants from water authorities, local government and other organisations were asked to identify and rank the major threats to water allocation and flow. The results are shown in Table 4.

Table 4 Ranked threats to water allocation and flow

Threat	Ranking
Reliability of supply for consumptive uses (blue green algae, pollution, climate change, catchment yield issues)	High +
Over-commitment of water	High
Lack of clear of environmental commitment/entitlement	High
Benchmarking (where we are now, where do we what to be)	High
Potential development (stresses on system)	High/Medium
Altered seasonality and timing (timing, quantity, dynamics, temperature)	Medium/High
Fauna management issues (temperature, timing for seasonal triggers i.e. breeding)	Medium/High
Lack of connectivity	Medium
Water Quality	Medium
Historic amenity value (community expectations)	Medium/Low
Lack of understanding of the issues (by politicians and community)	Medium/Low
Lack of reuse of wastewater in urban and irrigated agricultural areas	Medium/Low

The participants raised a number of solutions to reduce these threats. These solutions included:
- provide environmental allocation

[1] The hydrology sub-index was evaluated with regard to:
- AAPFD (Amended Annual Proportional Flow Deviation - the difference between natural and existing monthly flows)
- catchment permeability
- presence of hydroelectric power stations.

- reduce over commitment of water – claim back or purchase
- manage to community expectations
- define the scope of threat
- implement the River Health Plan
- implement the Stressed Rivers Program
- undertake community education
- undertake the nutrient management approach
- increase water-use efficiency.

A number of limitations and barriers to these solutions were also identified. These included:

- community expectations
- the potential for political change
- the need for a secure water supply and its associated infrastructure
- the methodology for landuse capability and change.

3.3.2 Physical form

The extent of bank erosion and bed instabilities, presence of artificial barriers and the instream physical habitat can provide a direct measure of stream changes from naturalness.

Extensive erosion can occur under natural conditions but is generally more common and severe in streams where there has been a greater human impact (e.g. cutoff of bends, removal of snags, clearing of riparian vegetation) (NRE 1999).

An investigation by SKM (2002) using computer modelling to determine sediment transport in waterways indicated that erosion and deposition have been most active in the western parts of the catchment, particularly the Bet Bet Creek (MU 7), McCallum Creek (MU 6), Bulabul Creek (MU 10) and Kingower/Mt Hope Creek (MU 11) areas. In the east, the Muckleford Creek and Fryers Creek (MU 3) areas show similar patterns. These are sediment source areas, supplying mainly fine material to the main water storages and the lower river system. In contrast, the upper Loddon River and tributaries are predicted to be more stable, with comparatively low rates of erosion and sediment delivery to the stream network (SKM 2002).

The presence of artificial barriers (weirs, dams, culverts, etc) is a direct change from natural conditions. In addition to changes to hydrology, an artificial barrier has an important influence on a stream's physical form and aquatic life. For example, artificial barriers can change sediment and energy movement along streams and cause widespread disruption to fish spawning (NRE 1999).

Instream physical habitat is important for aquatic biota as it provides places to breed, feed, grow and shelter. For lowland reaches, the density and origin of snags is a good indicator of the level of human disturbance. There is evidence that the quality and quantity of snags have declined since settlement, through deliberate removal by desnagging and as a consequence of riparian clearing. The composition of snags has also changed and is increasingly made up of material from exotic riparian species. Debris from these species does not have the same habitat quality and features as that from indigenous vegetation (NRE 1999).

For upland reaches, snags are a less important component of physical habitat and are highly variable. An assessment of the density and stability of a number of habitat features is more appropriate, including woody debris, coarse sediment and undercut banks (NRE 1999).

Figure 9 clearly demonstrates the waterways in the Loddon catchment are generally in a moderate condition (i.e. a score of 5) with no streams currently considered to be in either excellent or very poor condition.

Figure 9 Condition of the physical form of waterways in the Loddon catchment (after ISC[2])

This rating provides no indication of whether the streams are in the process of recovery since disturbance, are further degrading or have reached a point of equilibrium. Whatever their status, it is obvious that settlement has had a significant impact upon the physical form of waterways in the Loddon catchment.

3.3.3 Riparian vegetation

Riparian Australia (2000) reasoned that the riparian vegetation of today reflected the cumulative effect of management actions since European settlement. The riparian vegetation has been affected indirectly by actions undertaken within the catchment, as well as by direct intervention. The result is the widespread degradation of a valuable natural asset.

[2] The physical form sub-index was evaluated with regard to bank stability, bed stability, artificial barriers and instream physical habitat

The effects on riparian vegetation have included:

- Narrowing and fragmentation through clearing for cropping and grazing and the extension of agricultural practices into the riparian zone.
- Isolation through the clearing and replacement of adjacent indigenous vegetation communities for agricultural production.
- Loss of indigenous species through consistent and persistent grazing over 100 years, by both vermin (i.e. rabbits) and livestock, with the most palatable of species having been rendered locally extinct over vast areas.
- Introduction of new weed species and increased weed cover and abundance through agricultural and urban expansion.
- Simplification of the riparian vegetation structure with only the retention of the tree layer, wholesale loss of the shrub layer, and the extensive replacement of the ground flora by exotic species.
- Loss of fauna and the associated loss of flora-fauna interactions, potentially affecting the fertilisation and seed distribution of indigenous species.
- Past disturbance and continuing silting caused by gold mining, particularly in the upper catchment.
- The extensive changes throughout the system by the installation of water storage, dispersal drainage and levees on the natural waterway system.

These effects are reflected in the ISC results for the Streamside Zone sub-index, shown in Figure 10.
Figure 10 Condition of the streamside zone of waterways in the Loddon catchment (after ISC[3])

Additional to this assessment, the riparian zones of all major waterways in the catchment were assessed using aerial photo interpretation.

Although canopy cover can be recognised from aerial photographs this is not necessarily an accurate indicator of vegetation quality as the nature of the understorey cover is hidden. The understorey layer is where most diversity (generally 90%) exists. In rural landscapes where vegetation has been fragmented by land clearance, and remnants are often grazed, a large proportion of these are substantially modified. Such environments are characterised by an absent understorey, compacted soil, and a lack of regeneration and weed infestation (Diez & Foreman 1997)

Subsequent ground validation of the initial results using a more detailed assessment procedure found that because of these factors ratings were consistently higher than was actually the case. Reaches rated good were actually marginal; those marginal were actually poor and so on. This is because at the vast majority of sites, there was found to be no understorey, little evidence of native species regeneration, few old trees with nesting hollows, little fallen timber, soil compaction caused by stock and significant weed infestation. Figure 11 is therefore a reflection of overstorey cover only.

Figure 11 Condition of riparian tree cover along the major waterways of the Loddon catchment (North Central CMA 2001[4])

Figure 11 clearly clearly shows that approximately 44% of the cover along the major waterways of the Loddon catchment is currently in poor condition. This vegetation generally consists of a scattered coverage of single isolated native and exotic trees along the banks. Only one quarter of the waterways are lined with a wide, continuous native tree canopy.

At the agency River Health Forum, participants listed the following significant threats to riparian land and its vegetation:

- agriculture
- inappropriate grazing management
- area: edge ratio (edge effects) and fragmentation
- exotic plants and animals
- lack of management (pest plants and animals)
- lack of structural diversity
- lack of integration between programs
- lack of landholder awareness/education
- poorly defined boundaries
- competing/conflicting interests
- levee banks
- lack of landscape approach
- poor water quality

[3] The streamside zone sub-index was evaluated with regard to:
width
- longitudinal continuity
- structural intactness
- cover of exotic vegetation
- regeneration of native species
- billabong condition.

[4] The riparian overstorey cover condition was evaluated with regard to:
- width of tree cover; types of trees present; adjoining land use; proximity of riparian vegetation to protective features/potential sources of weed infestation.

- inadequate funding of programs
- encroachment into riparian zone
- altered water regimes
- rising water tables

The participants raised a number of solutions to reduce these threats. These solutions included:

- better integration between agencies for better funding opportunities
- improved community awareness/education
- development of landscape approach
- review licensed frontages (e.g. grazing practices)
- improved land management practices (e.g. Environmental Management Systems).

A number of limitations and barriers to these solutions were also identified. These included:

- lack of strategic approach
- inter-agency bureaucracy
- conflicting interests
- land status
- lack of community awareness
- lack of clear vision
- the need for people to make money
- statutory constraints

3.3.4 Water quality

Water quality is a major environmental issue that can have significant environmental, social and economic impacts. Healthy looking waterways can potentially have significant water quality problems. For example:

- excess nutrients (nitrogen and phosphorus) can contribute to blue-green algal blooms
- suspended sediments reduce light penetration through the water column and can smother substrate
- salinisation of agricultural areas causes an increase in stream salinity
- decreasing pH can have a major influence on aquatic life (NRE 1999).

These four water quality indicators were assessed as part of the ISC benchmarking in 1999 in the Loddon catchment. The results are presented in Figure 12.

Figure 12 Current condition of the water quality of waterways in the Loddon catchment (after ISC[5])

Figure 12 demonstrates that there are no streams in the Loddon catchment with excellent water quality (i.e. a score of 10). The majority of waterways in the Loddon catchment are generally considered moderate to good (i.e. a score of 5-6).

The Loddon Nutrient Action Plan (2001) concluded that the Loddon River catchment has poor water quality by national standards. High nutrient concentrations (eutrophication), salinity, erosion, soil acidification and altered flow regimes have all contributed to water quality decline in the catchment. Frequent and severe algal blooms have been a particular concern for many of the water storages in the region. Water quality tends to deteriorate towards the downstream end of the catchment and is of particularly poor quality on the lower Loddon plains (SKM 2001).

Over 60 reservoirs and numerous wetlands are utilised for water supply in the Loddon River catchment. Significant water quality issues have been associated with these structures and with wetlands in the region, specifically algal blooms. Reservoirs can form a barrier to nutrient transport through a catchment which leads to nutrient enrichment of the dammed water. A study at Cairn Curran Reservoir for example, identified that significant reductions in nutrient concentrations occurred downstream of the reservoir. Elevated nutrient levels have been commonly recorded in reservoirs and wetlands in the catchment (SKM 2001).

Participants at the agency River Health Forum were asked to identify and rank the major threats to water quality (Table 8).

[5] The water quality sub-index was evaluated with regard to:

- Total phosphorus
- Turbidity
- Electrical conductivity
- pH

Table 8 Ranked list of the major threats to water quality

Threat	Ranking
Intensive farming industries (e.g. pigs, poultry, grapes, olives)	High
Urban development (e.g. septics, soil disturbance, stormwater)	High
Nutrients	High
Pesticides	High
Groundwater discharge/intrusion	High
Urban stormwater	High
Irrigation water	High
Vegetation clearance	Medium/High
Point sources (e.g. stormwater pipes)	Medium
Diffuse sources	Medium
Soil erosion	Medium
Fertilisers	Medium
Dams, diversions & pumping	Medium
Septic tanks	Medium
Industrial accidents	Low/Medium
Pests (plants & animals)	Low
Genetically engineered crops (e.g. pesticide use)	Low (at present)

The participants raised a number of solutions to reduce these threats. These solutions included:

- pipe stormwater to land
- involve Shire Planning Departments
- codes of Practices
- closed pipe for irrigation and reuse dams
- reuse of greywater
- more weight to Code of Practice (e.g. penalties)
- Stormwater Management Plans
- involve industry
- River Health Plans
- monitoring/assessment
- increased awareness
- planning schemes
- research

A number of limitations and barriers to these solutions were also identified. These included:

- money
- attitudes to land managers
- politics
- knowledge (databases)
- regional development
- legacy of history
- time
- corporate responsibility

3.3.5 Aquatic life

There are many types of aquatic life that are all necessary components of healthy aquatic ecosystems, including fish, platypus, invertebrates, algae, macroinvertebrates and bacteria.

A variety of issues have the potential to impact upon aquatic life in the Loddon catchment, which have wider social and economic impacts. These include:

- the frequency, extent and duration of blue-green algal blooms
- the invasion of exotic fish species
- the general decline of frog and fish numbers (NRE 1999).

To establish a benchmark for the condition of aquatic life in the Loddon catchment, the ISC used macroinvertebrate species as indicators. The current condition of the aquatic life can be seen in Figure 13.

Figure 13 Condition of the aquatic life of waterways in the Loddon catchment (after ISC[6])

The condition of aquatic life is generally considered moderate to good, however no stream reaches are considered to be in excellent condition.

Of the 17 native fish species expected to occur within the Loddon catchment, three are considered threatened nationally (Australian Society for Fish Biology ASFB 1999), seven are listed as threatened in Victoria (NRE 1999) and six are listed for protection under the *Flora and Fauna Guarantee Act 1988* (McGuckin and Doeg 2000).

[6] The aquatic life sub-index was evaluated with regard to diversity of macroinvertebrates (SIGNAL and AUSRIVAS)

4 Individual waterway summaries

4.1 Waterway summary format

The current condition of each waterway is summarised in the waterway descriptions using all currently available information. For each waterway, the following information is provided:

4.1.1 Introduction

Each stream summary begins with the name of the basin, MU number and name, the name of the waterway and its unique number. The Stream and Catchment References for Environmental Data (SACRED) is a stream numbering system for Victoria, developed by the Department of Conservation and Environment (1991). This SACRED number assists in identification where waterways are known as several different names.

A photograph of a typical site along the waterway is included, together with a brief description of its location, length, flow nature (e.g. ephemeral, intermittent or permanent), flow direction and major tributaries. The waterway is roughly divided in half (referred to as upper and lower reaches) and its flow path is described in detail.

4.1.2 History and Heritage

This section attempts to provide an insight into the known history of the waterway – how the Indigenous people lived in the area and any early European descriptions of the waterway. It also provides clues into the changes that have shaped the waterway since European settlement.

Any historical information directly relevant to the waterway was derived from local history books, tourism pamphlets, websites and local residents. Relevant aboriginal heritage information including recorded archaeological sites are mentioned (without providing location details), as well as significant European sites listed on the Victorian Heritage Inventory or Register.

4.1.3 Streamform

This section examines the underlying geology through which the waterway flows. The waterway is divided into each different land type, e.g. sedimentary rises, alluvial plain. The stream assessments undertaken within each land type is summarised to provide an indication of the level of sinuosity (or meander), stream development, dominant streambed material and degree of bank erosion occurring within that land type.

4.1.4 Riparian Ecosystems

This section begins by listing the pre 1750 Ecological Vegetation Classes (EVCs) that are estimated to have occurred along each particular waterway before European settlement. This provides an indication of the range of vegetation communities originally found along the waterway and can be used as a guide for revegetation activities.

A summary of the condition of the riparian tree cover is provided. This information was derived from Aerial Photographic Interpretation (API) undertaken by the North Central CMA. The vegetation was scored based on how continuous, native and wide the tree cover appears (using 1999 aerial photography). The threats posed by the adjoining landuse and the proximity of the riparian vegetation to potential sources of weed infestation were also assessed.

Using the division of upper and lower reaches, the riparian vegetation is summarised according to the information collected in the stream assessments. This includes a description of the width of the riparian vegetation, the continuity of the tree cover, the presence of native and exotic vegetation, evidence of natural regeneration and the type of species present.

4.1.5 Aquatic Ecosystems

Using the stream assessments, the diversity of aquatic habitat is summarised in table form. The presence of native fish, macroinvertebrates, water rats and Platypus are recorded if the information is available from previous studies, investigations or local residents.

Any barriers that may restrict the passage of migratory fish are also recorded.

4.1.6 Hydrology

Average flow data is included in this section if available. Information about relevant major storages, flow regimes, cold water pollution and environmental flows is also included.

For ISC hydrology sub-index score is included, where 1 indicates a highly altered flow and 10 indicates a natural stream. This provides some indication of the level to which the natural stream flow has been affected by changed land use since European settlement.

4.1.7 Water Quality

This section incorporates the information from the catchment Nutrient action plan with regard to nutrient monitoring data and the threatening nutrient sources along the waterway, e.g. diffuse inputs, Waste Water Treatment Plants (WWTP), bank erosion, urban stormwater and septic systems.

Instream salinity levels are also included if available.

4.1.8 Principle Waterway Values

The key values directly associated with the waterway are listed, together with a brief justification and value type (e.g. environmental, social or economic).

The principle waterway values include those mentioned in the waterway summary, values gathered from the River Health Forums and the values highlighted in the North Central RHS.

4.1.9 Major Waterway Threats

The major threats to the health of the waterway are listed and a brief justification is provided. These threats include those mentioned in the waterway summary, threats raised at the River Health Forums and the threats listed in the North Central RHS.

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Appendix 1 Glossary

Anabranch – a secondary channel or river that leaves the main channel and re-joins it further downstream.

Barriers – artificial instream structures, such as dams, weirs, causeways and culverts that restrict the migration and movement of fish or other biota, and can interrupt transport of organic matter and sediment.

Catchment – the region which drains all the rainfall, other than that which is removed by evaporation, into a stream which then carries the water to the sea or a lake.

Catchment Management Authorities (CMAs) - Catchment management authorities are the caretakers of river health, responsible for regional and catchment planning and coordination, as well as waterway, floodplain, salinity and water quality management.

Effluent stream – a creek that leaves a watercourse and does not return to it (the opposite of tributary).

Environmental flow – The streamflow required downstream of a water storage to maintain appropriate environmental conditions in a waterway.

Exotics – species that are non-indigenous or outside their natural range.

Fish passage – provision for the movement or migration of fish past barriers.

Fishway – a structure that facilitates fish passage.

Floodplain – relatively flat land beside a river that is inundated when the river overflows its banks during a flood.

Flow regime – the pattern of flow in a river which can be described in terms of the quantity and variability of water flows.

Groundwater – All subsurface water, generally occupying the pores and crevices of rock and soil.

Hydrology – The science dealing with surface and groundwaters of the earth; their occurrence, circulation and distribution; their chemical and physical properties; and their reaction with the environment.

Large woody debris – large branches (> 10cm diameter) within the stream channel.

Invertebrates – animals without backbones, including zooplankton, shellfish, worms, shrimps and snails, that can be seen with the naked eye.

Management unit – an area defined at the sub-catchment planning level based upon physical feature similarities and stream management issues.

Nutrients – substances, such as phosphorous and nitrogen, that are necessary for plants (including algae) to grow.

Potable – suitable for drinking.

Program area – an area defined at the broader regional planning level based on geography, water regulation, river classes, size and relationship to key supporting strategies.

Protection – ensuring that there is no further decline in the environmental condition of a river.

Reach – a section of stream typically 10–30m long which is relatively homogeneous with regard to its physical, biological and chemical features.

Regulated systems – those where the flow of the river is regulated through the operation of large dams or weirs.

Restoration – improvement or enhancement of the environmental condition of the river toward 'ecologically healthy'.

Reticulation – The network of pipelines used to take water into areas of consumption. Includes residential districts and individual households.

Riparian zone – the area along the bank of a river or a stream that often has water-dependent vegetation.

River basin – the land into which a river and its tributaries drain.

Salinity – the total amount of water-soluble salts present in the soil or stream.

Stormwater – untreated rainfall run-off from urban areas.

Terminal lake – receives inflows from streams or rivers draining its catchment, but has no streams draining from it. It is the endpoint of a river system.

Threat – an action or process likely to cause cause harm, i.e. degrade a value.

Tributary – a river or creek that flows into a larger river or creek.

Triple-bottom-line (TBL) – Integrated approach to the achievement of environmental, social and economic outcomes.

Appendix 1 Glossary

Unregulated system – a system where no major dams or weir structures have been built to supply or extract water.

Value – something considered to be important or beneficial.

Water authorities – authorities charged with supplying water to towns and cities, for urban, industrial and commercial use. They administer the diversion of water from waterways and the extraction of groundwater.

Waterway – *The Water Act 1989* defines a waterway as: a river, creek, stream, watercourse and a natural channel where water regularly flows, whether or not the flow is continuous.

Wetlands – inland, standing, shallow bodies of water, which may be permanent or temporary, fresh or saline.

Appendix 1 Glossary

Appendix 2 Priority principles

The prioritisation principles developed in the North Central RHS (North Central CMA 2005) closely reflect the prioritisation framework outlined in the Victorian RHS (DNRE 2002). It is grounded in the notion that protection and enhancement should be directed at those reaches with the highest value. Priority shall also be given to minimise the risks to those reaches linked to high-value assets, i.e. waterways or wetlands of international or national significance. Protection and enhancement should also be directed at those reaches at high-risk of degradation.

Encouraging community capacity, protecting individual sites of significance, preventing damage and degradation of rivers from future development are also important (as reflected in the Victorian RHS (DNRE 2002a).

As such, river health priorities for the North Central region are based on the following principles. While the order of these principles generally aligns with those in the Victorian RHS, it does not necessarily mean that any one principle over-rides another as they are each legitimate reasons to undertake river health management actions. Likewise, a reach may be a priority under more than one principle although the management actions may differ according to the principle objectives.

Principle 1: Protect and enhance ecologically healthy rivers and representative rivers

Objective:

- to protect and enhance reaches considered in 'near' ecologically healthy condition
- to protect and enhance representative rivers.

Principle 2: Minimise risks to connected high-value assets

Objective:

- To reduce the risk of threats along identified waterway reaches from degrading downstream high-value assets, i.e. internationally and nationally significant waterways and wetlands.

Principle 3: Protect and enhance reaches at high-risk

Objective:

- To minimise the risk of threats degrading values along reaches at high-risk.

Principle 4: Protect reaches with high-environmental-, social- and economic-value

Objective:

- To minimise the environmental threats impacting on the values associated with each of the top five ranked environmental, social and economic reaches.

Principle 5: Maintain and enhance community capacity, awareness, motivation and involvement across the region

Objectives:

- To harness the enthusiasm of individuals or community groups across the region to improve the health of their local waterways
- To enhance the capacity of the community to become involved in improving river health by providing the information required to make informed decisions
- To enhance the awareness of the community by targeting key messages to areas of the region that relate to specific issues
- To motivate the community to care for their waterways by promoting the multiple benefits of healthy waterways from the paddock to the catchment scale
- To involve the community in detailed planning of onground, river health improvement works through local area catchment and waterway action plans
- To inform the community about how to become involved in protecting and enhancing river health through incentives and community engagement activities.

Principle 6: Protect individual sites of significance along regional waterways

Objective:

- To identify and minimise the environmental threats to individual sites of significance along regional waterways.

Principle 7: Prevent damage and degradation of our rivers from future development activities

Objective:

- To minimise the localised and catchment-scale impact of new development to ensure the 'overall improvement' in river health.