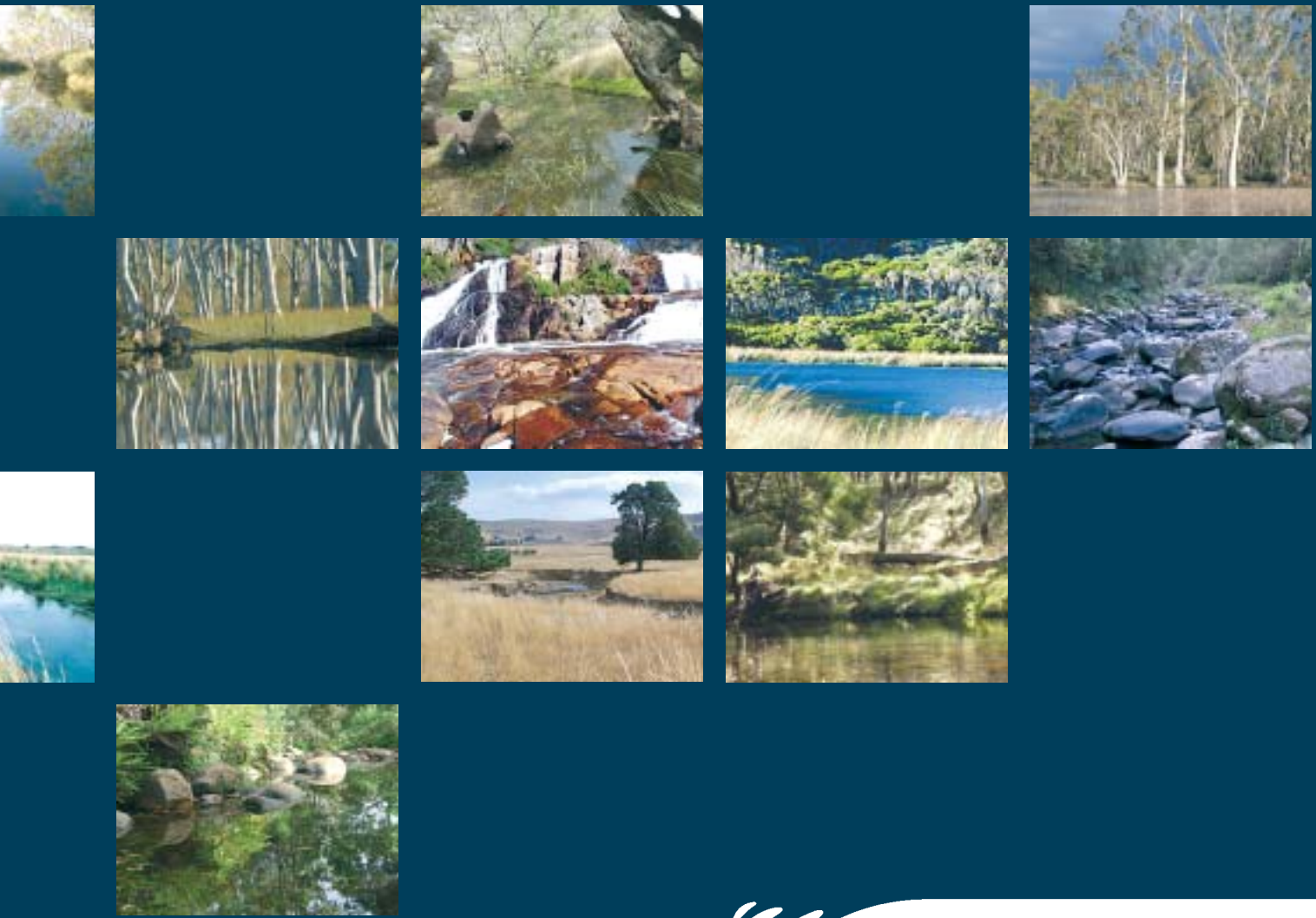


2 ISC



“The results of the 1999 and 2004 ISC benchmarking have provided an enormously valuable information resource, critical for setting long-term management objectives, developing priorities for action and evaluating the effectiveness of past efforts.”

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2 ISC

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Minister's Foreword



This second Index of Stream Condition (ISC) report shows that since the 1999 benchmark there has been no overall change in the condition of streams at the statewide scale and the deterioration in stream condition appears to have been controlled.

Now, the challenge is to consolidate and build on this result. We know that ongoing commitment and effort is necessary to keep our rivers healthy and functioning as the lifeblood of Victoria.

Just six years ago, the first Index of Stream Condition (ISC) showed how timely it was for the Government to undertake the first consistent and comprehensive study of environmental condition carried out anywhere in Australia. The results of this study indicated that after 200 years of neglect, while many streams still were in good or excellent condition, we faced a considerable task to ensure adequate environmental flow regimes, improve water quality and halt the degradation of riparian and floodplain areas.

With information gathered from this study, the Government developed the Victorian River Health Strategy and regionally, Catchment Management Authorities developed regional River Health Strategies. These strategies set priorities for directing government's annual investment in waterway management.

The second ISC benchmarking, undertaken during 2004, builds on the groundbreaking work begun in 1999 and documents the progress.

Recognising the role of rivers was a key part of the *Our Water Our Future* action plan launched last year. One of the fundamental principles of Victoria's new approach to water management is that a healthy economy and society depend on a healthy environment.

In the action plan, the Government committed to achieve significant improvements in the ecological condition of Victoria's rivers by 2010. We established the Environmental Water Reserve

to provide a share of water for environmental values, as well as establishing water recovery programs for priority stressed rivers, increased the level of investment in river and aquifer health, and sustainable water resource management by an additional \$100 million over four years, and continue to develop partnerships with CMAs and the community.

This second benchmarking of river condition will form the basis from which we can measure our progress towards the targets set in *Our Water Our Future*.

I congratulate everyone who has contributed to our achievements in improving the health of our waterways. Your support has provided the successful step forward for one of Victoria's most important environmental initiatives.



John Thwaites
Minister for Environment
Minister for Water

Foreword



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In 1999, the Victorian Government, in conjunction with its Catchment Management Authorities (CMAs) benchmarked the environmental condition of Victoria's major rivers and tributaries. This was an important milestone for two reasons. It was the first complete and comprehensive study of the environmental condition of rivers anywhere in Australia. Second, the benchmark was based on the first integrated measure of river condition – the Index of Stream Condition (ISC). Before the Victorian benchmarking exercise, river health was assessed by considering single features such as water quality or aquatic macroinvertebrates. These measures focused only on very narrow individual elements of a river and could not convey a total picture of the overall environmental condition.

Introduction



The development of the ISC allowed, for the first time:

- A consistent statewide picture of the environmental condition of rivers and streams
- A consistent approach to the identification of river values and threats
- A consistent approach to the setting of strategic objectives and targets for river health at the river or river reach scale
- A clear way to communicate all the aspects of rivers that contribute to river condition and that need to be managed together to maintain or improve river health
- A way to assess the long-term effectiveness of river rehabilitation programs.

The ISC combines information on five key aspects of river health. These components, or sub-indices, measure changes in hydrology, water quality, streamside zone (vegetation), physical form (bed and bank condition and instream habitat) and aquatic life.

The Index was developed using information that could be easily understood, collected at the regional scale and fed directly into regional planning exercises. In addition, the methodology had to be accurate, easy to use, cost effective, based on good science and able to be undertaken by CMA staff, Waterwatchers and others associated with natural resource management.

Since 1999, the science behind the ISC has evolved significantly, particularly in the areas of hydrology and environmental flows, vegetation assessment and water quality. Additional work has also been undertaken on river condition assessment as part of the National Land and Water Audit and the Sustainable Rivers Audit for the Murray Darling Basin.

As a result, the ISC has been reviewed and updated to provide the most accurate, up-to-date and appropriate data. The new methodologies used in the second ISC benchmarking exercise in 2004 and their linkage with the 1999 methodology are discussed in more detail in this report. The results of the 2004 ISC are summarised in this report and published on the internet, as part of the Victorian Water Resources Data Warehouse (www.vicwaterdata.net).



**The ISC
combines
information on
five key aspects
of river health:
hydrology
+ water quality
+ streamside zone
+ physical form
+ aquatic life**

The ISC – an integrated measurement tool

The concept

The ISC brings together data from a variety of sources to give a detailed overall picture of river condition. Five sub-indices make up the ISC score – hydrology, water quality, streamside zone, physical form, and aquatic life. Each sub-index comprises individually measured variables. The ISC is evaluated for individual river reaches, which are generally between 10 and 30 km long and with similar hydrological, vegetation and landscape characteristics.

Variables for streamside zone and physical form are measured in the field by Catchment Management Authority field staff. Within each reach, three sites for assessment are selected randomly to take account of the variability of condition found along the reach. The results from these sites are combined to then provide an assessment of the entire reach. In heavily forested reaches where there is less variability along the reach, only one site is assessed. All field work is done in autumn, when usually, streams are naturally at low flow.

The aquatic life sub-index is based on data that looks specifically at the presence of particular macroinvertebrate families. This work is undertaken by a Victorian Environment Protection Authority field program, covering, on average, 150 sites per year.

The hydrology sub-index is based on monthly flow data to determine changes to flow regimes.

The ISC uses monthly water quality data collected over 12 months, taken from a statewide network of 163 fixed water quality monitoring stations. These stations provide data to allow confident assessments of water quality to be made for 224 reaches.

Data for all five sub-indices is not available for all reaches. If at least 3 sub-index scores are available, then the missing sub-index scores are calculated on a pro rata basis. If only 1 or 2 sub-index scores are available, then an overall ISC score cannot be calculated.

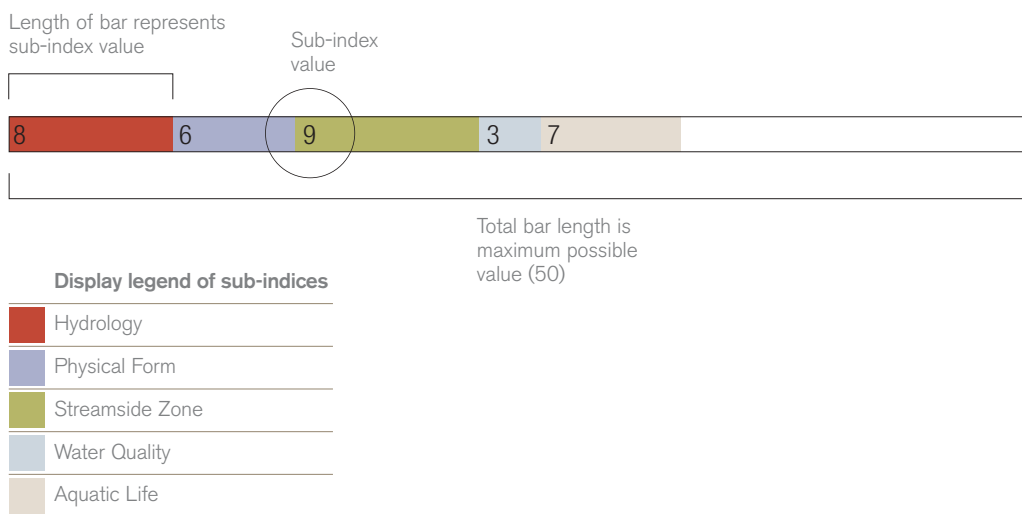
Each sub-index is scored out of 10 and the overall index out of 50. However, the overall score is not a simple aggregate of the five sub-indices; the ISC is weighted to recognise that a particularly low score in one sub-index may have a limiting effect on river health, even if the other sub-indices score highly.

Further information on the ISC, its sub-components, data collection and score calculations is at www.vicwaterdata.net.

The ISC result is presented as a bar graph of the five sub-indices, as shown in Figure 1.

The total ISC score is then categorised into one of five broad groups of condition – excellent, good, moderate, poor and very poor. It is important to emphasise that while this overall condition class is useful for providing a general picture of the condition of a reach, the detail of each sub-index and its sub-components (i.e. the individual variables) are required to better understand the issues affecting the environmental condition of streams on a reach basis.

Figure 1
The ISC bar showing the 5 sub-indices



The ISC in 1999

In 1999, 950 river reaches, representing 18,000 km of major rivers and tributaries, were assessed using the ISC. The actual variables measured in 1999, which made up the five sub-components, or sub-indices, are listed in Table 1 and defined in the glossary.

These variables represent the key factors that contribute to, or affect, river health. But while this set of variables represented the best available science at the time, in some cases, they are actually a coarse measure of the impact that the factor has on river health.

For example, the major hydrology variable only measured a very gross change in monthly flow volumes and seasonality. Very large changes in the flow regime due to water extraction (for example, the impact of large dams on a river) were able to be measured; but smaller changes, which can still cause significant river stress (for instance the impact of summer diversions on unregulated rivers or the supply of water to a small town), could not be measured.

Similarly, some of the variables assessed only the presence or absence of a particular feature rather than any measure of its quality. For example, the condition of streamside vegetation needs to reflect not only the amounts of vegetation present but also its health and how much of it is native.

Despite these limitations, the benefits of the 1999 benchmarking of river condition were immense. The ISC provided the first benchmark of stream condition in the State, giving a total picture of river health across Victoria to feed into statewide decision-making.

The ISC played an important educative role, drove the development of river assessment tools and improved evaluation of environmental condition.

The ISC also influenced the development of environmental assessment models by the National Land and Water Resources Audit (an Australia-wide assessment of stream health) and the Murray Darling Basin's Sustainable Rivers Audit.

At the regional level, CMAs used the ISC data gathered from the benchmark for developing regional river health strategies and identifying river values, assets and threats. The sub-indices used for the ISC provided a common language for setting management objectives and priorities and, significantly, resulted in a standardised understanding and interpretation of river health across the State.

The 1999 ISC benchmarking was instrumental in developing the *Victorian River Health Strategy* and the current set of regional river health strategies. The State strategy is the framework for the integrated management of Victoria's rivers and streams.

The regional strategies outline priorities, regional targets and integrated works programs needed to achieve these targets.

These State and regional strategies form the framework for tackling the causes of poor river health, including treating problems of low flows, declining water quality and degraded riverine habitats, as well as restoring stressed rivers and protecting healthy rivers. Activities undertaken under regional river health programs between 1999 and 2004 included:

- Installing fish ladders to open up large reaches of river for fish migration and breeding
- Riparian restoration with land holders including:
 - Fencing to limit stock access to riparian areas and improve the likelihood of regeneration and bank stabilisation
 - Planting native vegetation and weed control in riparian corridors
 - Removing willows and other exotics
- Reintroducing large wood into streams to improve instream habitat
- Stabilising bed and banks
- Increasing environmental flows and improving flow regimes
- Improved land management practices to minimise impact on water quality

Table 1

Sub-indices and variables used in the 1999 ISC

Hydrology	Physical form	Streamside zone	Water quality	Aquatic life
<ul style="list-style-type: none"> • Amended Annual Proportional Flow Deviation – a measure of the gross change between natural and existing monthly flows including any change in seasonality • Catchment permeability • Presence of hydroelectric power stations 	<ul style="list-style-type: none"> • Bank stability • Bed stability • Artificial barriers • Instream physical habitat 	<ul style="list-style-type: none"> • Width • Longitudinal Continuity • Structural intactness • Cover of exotic vegetation • Regeneration of native species • Billabong condition 	<ul style="list-style-type: none"> • Total Phosphorus • Turbidity • Electrical conductivity (salinity) • pH 	<ul style="list-style-type: none"> • Macroinvertebrates • AUSRIVAS (habitat) • SIGNAL (pollution)

Results of the 1999 Benchmarking of River Condition

The results of the 1999 benchmarking exercise allowed for the broad classification of the condition of Victorian rivers. In general, it showed that basins in the east of the State were in better condition than those in the west. This was largely attributed to the lack of development, both hydrological (dams, diversions and stream pumping) and land clearing, in the east. Results collated for each of the major river basins are shown in Figure 2 below. Results for each sub-index and variable at a reach level are available on the internet as part of the Victorian Water Resources Data Warehouse (www.vicwaterdata.net).

Improving the ISC

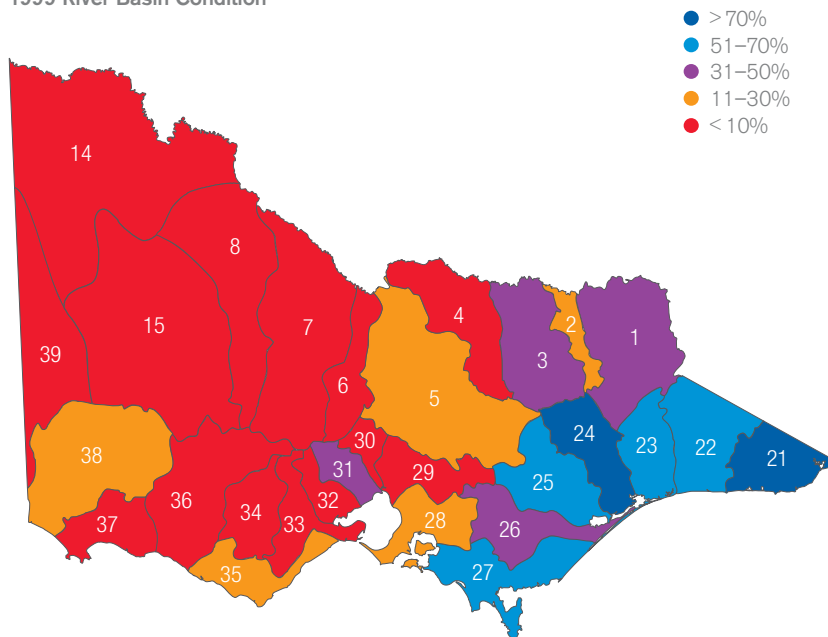
As with any scientifically based methodology, advancements in the measurement, collection and assessment of data can improve the methodology. In the case of the ISC, much of the methodology underpinning the 1999 benchmark was developed in the mid 1990s. Since then, scientific knowledge has advanced, particularly for environmental flows and the effects of changes to hydrology on river condition, assessing vegetation health and refining water quality models.

To take advantage of this and to ensure that the ISC was as up to date as possible for the second benchmark, the methodology was reviewed. A panel of independent scientific experts oversaw the review, which included all five sub-indices. The panel aimed to strike a balance between incorporating new scientific advances while maintaining comparability of results with the 1999 benchmark. A series of "rules" were developed to guide any changes made to the

“A panel of independent scientific experts oversaw the review, which included all five sub-indices. The panel aimed to strike a balance between incorporating new scientific advances while maintaining comparability of results with the 1999 benchmark.”

Figure 2
Percentage length of major rivers and tributaries in each river basin in good or excellent condition (a score above 37 out of 50 results in a condition rating of good or excellent)

1999 River Basin Condition



1 Upper Murray	21 East Gippsland	31 Werribee
2 Kiewa	22 Snowy	32 Moorabool
3 Ovens	23 Tambo	33 Barwon
4 Broken	24 Mitchell	34 Corangamite
5 Goulburn	25 Thomson	35 Otway
6 Campaspe	26 LaTrobe	36 Hopkins
7 Loddon	27 South Gippsland	37 Portland
8 Avoca	28 Bunyip	38 Glenelg
14 Mallee	29 Yarra	39 Millicent
15 Wimmera	30 Maribyrnong	

five sub-indices. It was agreed that a variable would only be changed or new variables added if:

- It was demonstrated that the new method was an improvement on the old method
- There was a strong reason to integrate with an existing method and improve it along the way
- The new method had been rigorously tested
- The new method conformed to the original ISC criteria (transparent, intuitive and an appropriate balance of cost, speed, accuracy and scientific rigour).

The improvements made to the method as a result of the review are shown in Table 2. The 23 variables measured in the 2004 ISC benchmarking exercise are listed in Table 3 and defined in the glossary.

As a result of the change to some variables, the method by which the total ISC data-set and scores were interpreted also required minor adjustments. In addition, improvements in technology meant that some factors, such as stream length could be measured digitally instead of manually.

In 1999, 950 reaches representing 18,000 km of major rivers and tributaries were assessed as part of the first benchmarking exercise. In 2004, the number of reaches assessed increased to 1,040, representing 26,000 km of major rivers and tributaries.

In keeping with standard assessment requirements, sample sites along each reach were re-randomised. The use of randomised sampling gives a better picture over the long-term of the condition of a reach, but can raise issues in comparing two different sets of reach samples (eg. when comparing data for streamside zone and physical form from 1999 and 2004 for an individual reach). This issue is discussed later. However, despite its limitations this field sampling remains the best alternative until technology has advanced enough to measure all the relevant variables for an entire reach using remote sensing.

Table 2
Comparison of 1999 and 2004 ISC sub-components

	1999	2004
Hydrology	Comparatively crude measure of change in monthly flow and change in seasonality	Measure of five ecologically sensitive flow attributes – low flow, high flow, zero flow, variability in monthly stream flows and the seasonal timing of when low and high flows occur.
	Use of 1 year's data	Use of 15 years' data
		Incorporation of impact of farm dams and sustainable diversion limits.
		Measure of summer and winter stress.
Water Quality	No allowance for the geographic regionalisation of stream types – only upland and lowland divisions	Delineation of several stream regions for each indicator taking better account of geographic variation.
Streamside Zone	ISC developed measures that concentrated on the function of the streamside zone. Included measures for width, longitudinal continuity, structural intactness, cover of exotic vegetation, regeneration and billabong condition.	Adoption of statewide standard method for assessing vegetation health, based on the method known as habitat hectares. The method combines a quality and quantity measure and takes into account narrow riparian corridors.
		Use of Ecological Vegetation Classes (EVCs), a standard method to assess and define natural, or undisturbed, condition of vegetation, regardless of where it occurs.
Physical Form	Bank stability, bed stability, artificial barriers and instream physical habitat (large woody debris) measured.	Measure of bed stability removed as it cannot be easily or accurately measured. It needs to occur over a longer period and placed in correct historical perspective.
Aquatic Life	No allowance for the geographic regionalisation of stream types – only upland and lowland divisions	A greater amount of biological data has enabled the delineation of 5 regions for aquatic macroinvertebrates, taking better account of geographic variation.

Table 3
Sub-indices and variables used in the 2004 ISC

- Hydrology**
 - Low flows
 - High flows
 - Zero flows
 - Seasonality
 - Variability
- Water quality**
 - Total Phosphorus
 - Turbidity
 - Salinity (EC)
 - pH
- Streamside zone**
 - Width
 - Longitudinal continuity
 - Understorey diversity
 - Recruitment
 - Large trees
 - Tree canopy
 - Litter
 - Logs
 - Weeds
- Physical form**
 - Bank stability
 - Large wood
 - Fish passage
- Aquatic life**
 - AUSRIVAS (habitat)
 - SIGNAL (pollution)

Comparing 1999 and 2004

In updating the methodologies for each sub-index, a trade-off had to be made between comparability of 1999 and 2004 results and an improved, more accurate and useful data set. The effects of the new methodologies were most pronounced for the hydrology and streamside zone sub-indices.

The new method for the hydrology sub-index was quite different to that used in 1999 so results could not be directly compared. Because of the greater degree of sensitivity and accuracy of the new methodology, many of the 2004 scores for hydrology were lower than those recorded in 1999. This does not mean that the actual river flows deteriorated since 1999; rather, the 2004 results provide a more accurate representation of the state of the flow regime in these river systems.

In fact since 1999, the Government has taken serious action to stop further deterioration in the flow regimes of rivers across the State. These actions include:

- Introducing and maintaining the Murray Darling Basin Cap in all the northern basins. This limits water extraction in these basins to 1993/94 levels of development
- Defining the balance of water for consumption and environment through Bulk Entitlement conversions
- Introducing legislation to include catchment dams in the water allocation framework
- Introducing sustainable diversion limits so any further water extraction is only allowed where this will not have a significant environmental effect
- Establishing Environmental Water Reserves for all rivers and groundwater aquifers.

The hydrology sub-index has been designed to allow a consistent statewide comparison of all major rivers and streams. However, it is not sufficient to use as a basis for determining environmental flows in water allocation decisions. These decisions require more detailed environment flow assessments, which will provide information on the flow regime required to maintain ecological values and the health of the river at a finer level of detail.

As with the hydrology sub-index, the new streamside zone methodology provided a more detailed, accurate result with a greater degree of differentiation between key site characteristics. For example, the use of the new methodology does not treat all vegetation “equally”. Sites with large numbers of exotic plant species, such as willows, would score lower in 2004 compared with sites with the equivalent amount of native vegetation in 1999.

The more detailed information available for the construction of the reference condition for both water quality and aquatic life sub-indices also has allowed for greater detail and accuracy.

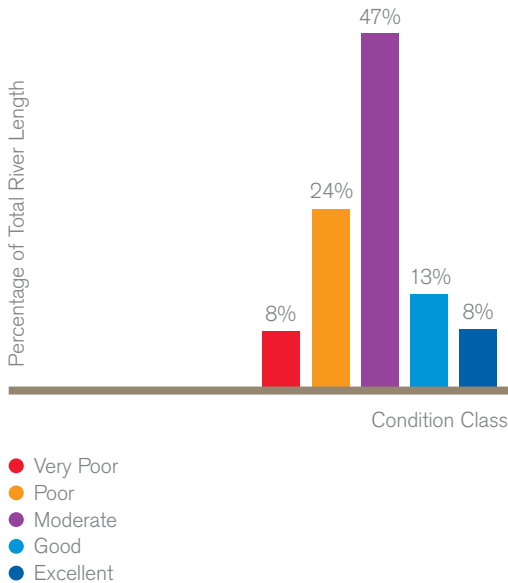
To determine comparability between the 1999 and 2004 results, the raw data for both 1999 and 2004 were run through the methodologies used for each benchmarking exercise, where possible. This allowed for the effects of the different methodologies to be corrected.

Using this analysis to compare the 1999 and 2004 results showed that overall at the statewide scale, no major changes had occurred to the condition of Victoria’s major rivers and tributaries in the intervening five years. No general improvement was detected, but importantly, overall deterioration in stream condition appears to have been controlled. In 2004, about 21% of major rivers and tributaries were in good or excellent condition, 47% were in moderate condition and 32% were in poor or very poor condition (Figure 3). At a statewide level, river health has remained basically the same, with basins in the east of the State generally in better condition than those in the mid and west regions (Figure 4).

Although the statewide distribution of river health has generally stayed the same, the condition of some individual reaches and streams may have changed. There have been improvements in river health and, in a few cases, deterioration. For this reason, it is useful to review the changes to overall river condition by basin and for each sub-index.

“At a statewide level, river health has remained basically the same, with basins in the east of the State generally in better condition than those in the mid and west regions.”

Figure 3
2004 statewide river condition



Comparing the proportion of streams in good or excellent condition in the major river basins between 1999 and 2004 shows some changes. However it should be noted that whilst it is possible to correct for the difference in methodologies when undertaking a statewide comparison, it is not appropriate at the basin or reach scale. Therefore a comparison at these scales will often show results that are purely due to the change in methodology or the fact that, in some basins, more streams were assessed in 2004 than in 1999. For example, in the Otway basin, the additional assessments revealed a higher proportion of streams in good or excellent condition.

Several basins, notably South Gippsland, Glenelg, Thomson, Ovens and Werribee, recorded a reduced proportion of stream length in good or excellent condition since 1999. These results are predominantly attributed to changes to the hydrology sub-index. In 1999, most reaches in those basins were assessed as having unmodified or natural hydrology, but impacted hydrology in 2004. For example, in the Thomson basin, almost 60% of reaches scored 10 (indicating no impact on natural flow regimes) for hydrology in 1999, while in 2004 only 6% of reaches scored 10. This does not mean that the hydrology is more impacted but rather, the new method more accurately describes the true hydrological condition.

In contrast, however, the new methodology for the hydrology sub-index also revealed less impacted natural flow regimes. For example in the Kiewa basin, many reaches in 2004 had higher hydrology sub-index scores, due to the 1999 method over-emphasising the impact of regulation caused by the hydro-electric power stations on the upper Kiewa River.

Changes to the methodology for streamside zone also affected some overall basin results. For example, in the South Gippsland basin, the more detailed approach taken in 2004 meant that many reaches scored lower than in 1999. This was due to the increased sensitivity of the new methodology to sites with large numbers of exotic plant species, such as willows.

The 2003 bushfires also had a measurable impact on vegetation, particularly in the north-east. This impact will be seen for many years to come. The longer term impact of the loss of riparian vegetation may not yet be fully revealed.

In relation to the aquatic life sub-index a comparison between the 1999 and 2004 results, taking into account the changed methodologies, revealed no consistent change in these scores. However, while the 1999 scores can be recalculated to reflect the 2004 method, the actual sites where the macroinvertebrates were collected were not the same for both years and therefore may not always be directly comparable at the reach scale.

In terms of water quality, there appears to have been some improvement since 1999 in total phosphorus and turbidity results, particularly in cleared agricultural areas. This is largely attributed to ongoing drought conditions – low runoff results in fewer nutrients and sediments entering waterways and consequently total phosphorus and turbidity levels have improved. Once the drought breaks, these levels could be expected to increase.

A more detailed analysis of statewide water quality trends will be available with the release later this year of DSE's next water quality analysis trend report.

2004 River Basin Condition

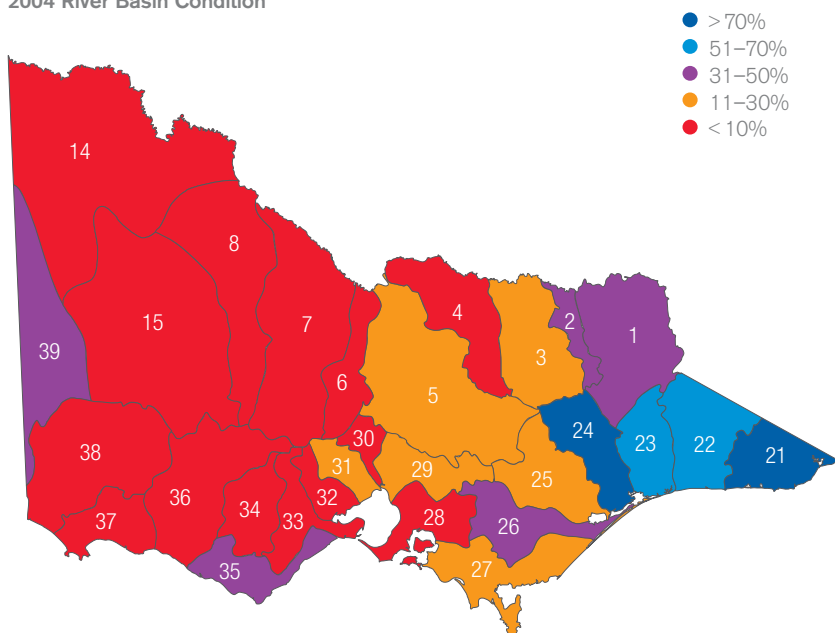


Figure 4

Percentage length of major rivers and tributaries in each river basin in good or excellent condition (a score above 37 out of 50 results in a condition rating of good or excellent)

1 Upper Murray	21 East Gippsland	31 Werribee
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6 Campaspe	26 LaTrobe	36 Hopkins
7 Loddon	27 South Gippsland	37 Portland
8 Avoca	28 Bunyip	38 Glenelg
14 Mallee	29 Yarra	39 Millicent
15 Wimmera	30 Maribyrnong	

Reference Condition

The term 'reference condition' is used throughout this report and in literature about the ISC. The term refers to the presumed natural, or pristine, condition of a site, in this case a stream.

The ISC essentially compares two measurements – the field or current condition measurement and the reference condition measurement. The field measurement is compared with reference condition to measure the departure from reference or natural condition. For example, if there is very little difference or change between current condition and natural condition, then a reach is deemed to be in good condition. Where there is a large difference between current and natural condition, then the reach is deemed to be in poor condition.

Viewing or measuring natural condition is not always possible because of extensive development or alterations to the land. Where this has occurred, a combination of approaches are taken to establish the best possible representation of reference condition. These approaches include the use of expert opinion, historical records and computer modelling.

In lowland river reaches where there was little or no unmodified habitat, reference sites were selected to represent the "best available" habitat in the region. This was particularly the case for the aquatic life and water quality components.

The use of reference condition as a point of measurement – or, in other words, focusing on the degree of change from natural to current condition – allows comparison of different sites or reaches from anywhere in Victoria. Therefore, comparisons are not restricted to streams in the same geographical zones; more general comparisons about overall improvement or deterioration of riverine health can be made between catchments. This ease of comparison is an important feature of the ISC.

Reach data and interpretation

The basin results for condition class provide a useful snapshot of river health, but it is the results of the sub-indices for each reach that reveal the actual changes in stream condition. As described in the introductory section, the ISC is a composite of five sub-indices, weighted to reflect the individual components of river health (see Figure 1).

Caution is required when comparing the 1999 and 2004 results at the reach level. This is due to the combination of changes made to the methodology, the re-randomisation of field sites, and the addition of newly assessed streams. Any proper

comparison of individual reaches requires the effect of each of these changes to be understood, so that any real change in condition can be identified.

The individual ISC results for all reaches, for both 1999 and 2004, are available on the Internet, as part of the Victorian Water Resources Data Warehouse (www.vicwaterdata.net). Information for each reach includes the scores for each sub-index, photographs of the sample sites and all the raw data. An example follows that demonstrates what information is available from the web site for an individual reach:



Basin 35 reach 16 Gellibrand River
– Good condition



Hydrology is modified with increased periods of low flow

Physical form generally good but score lowered by downstream barrier to fish migration

Streamside Zone in near reference condition

Water Quality is good but with elevated total phosphorus

Aquatic life at reference condition



Basin 23 reach 9 Tambo River
– Poor condition



Hydrology is slightly modified with increased periods of summer low flow

Physical form is moderate with low levels of instream wood and some bank instability

Streamside Zone is highly modified with many willows lining the banks

Water Quality is very poor with elevated levels of total phosphorus, turbidity and salinity

Aquatic life is showing a modified environment

Conclusion and the way forward

The results of the 1999 and 2004 ISC benchmarking have provided an enormously valuable information resource, critical for setting long-term management objectives, developing priorities for action and evaluating the effectiveness of past efforts.

The 2004 ISC results provide an opportunity to review the impact of both human and natural intervention in river health. Comparing the 1999 and 2004 results shows that the condition of waterways appears to have stabilised, at least at the statewide scale. Streams in good or excellent condition have been identified and protected and those in poor or very poor condition – with only a few exceptions – do not appear to have deteriorated further.

As the ISC results suggest, there are no quick or easy solutions to solving river health problems. Instead, long-term management objectives, clear priorities for on-ground works and continued investment and commitment by government and natural resource management agencies are required for long-term improvements in river health.

This has been recognised by the Victorian Government in its long-term action plan for sustainable water management – the White Paper *Our Water Our Future* released in June 2004. The Government recognises the importance of healthy rivers and groundwater aquifers as the major underpinning to achieve sustainable water management. The

Government has set a target to significantly improve the condition of Victoria's rivers and streams by 2010 and has provided the tools to achieve it. These include:

- Establishing an Environmental Water Reserve (a share of water to maintain environmental values) for all rivers and groundwater aquifers.
- Establishing significant water recovery programs to increase flows in priority regulated rivers – the Thomson, Macalister, Wimmera, Glenelg, Broken, Goulburn, Loddon, Campaspe, Snowy and Murray Rivers.
- Achieving agreed improvements in Environmental Water Reserves in 21 priority unregulated rivers in five years.
- Providing an additional \$100 million over four years to improve water management and restore and protect rivers and aquifers through an environmental contribution from water authorities. This will provide funds for activities including:
 - metering of water extractions
 - improved monitoring of water resources including a statewide survey of fish communities
 - improved management of groundwater and unregulated rivers
 - large scale river restoration works
 - managing Environmental Water Reserves.

Many of these activities are aimed at protecting rivers in good condition and restoring those where there is a significant environmental benefit. As these activities are implemented, Victoria will continue to monitor river health and assess the impact of these major river restoration programs using the ISC and other assessment programs. The ISC will continue to evolve as the science behind it evolves. Further changes will need to be tempered to allow for the detection of trends in condition.

The ISC and other assessment tools provide Victoria with a unique capability – to implement a truly adaptive approach to river management. Victoria can measure changes to our rivers and streams, improve our understanding of these complex natural systems and refine our management programs over the long-term, providing Victorians with the best investment programs to restore rivers and secure our water resources for the future.

Conclusion

Generic Terms

Basin

The catchment of a large river or group of rivers. There are 29 basins within Victoria.

Catchment Management Authority (CMA)

Every region in Victoria has a Catchment Management Authority. These authorities are the community caretakers of river health, responsible for regional and catchment planning and coordination, and waterway, floodplain, salinity and water quality management.

Estuary

A semi-enclosed coastal water body where salt from the open sea mixes with freshwater in a river.

Hydrology

Amended Annual Proportional Flow Deviation (AAPFD)

An estimate of the change in monthly flows between natural and existing conditions.

Catchment permeability

The level of artificial impervious surfaces in a catchment.

Environmental flow

The flow regime required to maintain rivers in a healthy condition. Includes components of the flow regime such as minimum flows, floods and flushes.

Environmental Water Reserve

The share of water resources set aside to maintain the environmental values of a water system and other water services which are dependent on the environmental condition of the system.

Ephemeral stream

A stream with temporary surface flow that varies between seasons and years. Will usually be dry for part of the year.

Flood plain

A flat area adjacent to a stream that is covered by floods every year or two.

Flow regime

The pattern of the flow of water in a river over time. All elements of a river's pattern of flow are important – timing (when), duration (how long) and flow frequency (how often).

High flow

The two highest monthly flows in a year.

Hydrology

The occurrence, distribution, and movement of water in rivers.

Low flow

The two lowest monthly flows in a year.

Presence of hydro-electric power stations

Hydro-electric stations operate to supply electricity peak demand can create water surges on a daily basis. These surges can have a significant influence on stream ecology.

Regulated stream

A stream where flows are controlled by releases from a dam.

Seasonality index

The month of the lowest flow and highest flow.

Sustainable diversion limit

The maximum volume of water that can be diverted from a catchment during winter while still protecting the environment.

Variability index

The difference between the flow in the month with the lowest and highest flows.

Zero flows index

The period of time when the stream is dry (or nearly so).

Water Quality

Electrical conductivity (EC)

A measure of salinity. The higher the electrical conductivity of a stream the greater the salinity.

pH

A measure of acidity or alkalinity of water (based on the concentration of hydrogen ions).

Sedimentation

The deposition or settling of soil particles suspended in water.

Total phosphorus

The sum of the concentrations of soluble and in-soluble phosphorus.

Turbidity

Cloudiness or haziness of the water caused by individual particles that are too small to be seen without magnification.

Streamside Zone

Large trees

The number of large trees (dead or alive) that are larger than a prescribed diameter (usually greater than 80 cm).

Logs

Timber that has fallen on the ground which has a diameter greater than 10 cm.

Longitudinal continuity

A measure of how much of the stream bank is covered in vegetation.

Organic Litter

Organic material such as fallen leaves, twigs and small branches less than 10 cm diameter present at ground level.

Recruitment

A measure of the number of immature plants that show no evidence of flowering or fruiting.

Regeneration

The amount of native woody vegetation less than 1m high.

Riparian

The vegetation along the stream bank.

Structural intactness

A measure of the percentage cover of 3 strata of vegetation – trees, shrubs and ground cover.

Tree Canopy

Upper-most stratum of woody vegetation usually consisting of trees greater than 5 m tall that contributes to or forms the vegetation 'canopy'.

Understorey life forms

Native plants that are not part of the tree canopy. A Life form is a grouping of plants that share a similar three-dimensional structure (height, shape and cover).

Weeds/Cover of exotic vegetation

The percentage cover of exotic (ie. non-native) plants in three strata – trees, shrubs and ground cover.

Physical Form

Bank

The generally steep part of a stream channel cross-section, generally considered as being above the usual water level.

Bank Stability

A measure of how stable a stream bank is. Considers factors such as amount of vegetative cover, bare banks, exposed roots and undercut banks.

Billabong

A section of cutoff stream channel (e.g. an oxbow lake) usually on a floodplain.

Desnagging

Removing large trees (usually willows and river red gum) from the bed and banks of streams.

Fish barrier

An artificial obstacle in a stream (e.g. a dam wall, weir, culvert or causeway) that affects (halts or delays) fish migration.

Large wood

A tree, branch or root system that has fallen into or is immersed (totally or partially) in a stream. Often referred to as 'snags'.

Aquatic Life

AUSRIVAS

Australian River Assessment System – an indicator of the quality of instream habitat based on the presence of particular macroinvertebrate species.

Macroinvertebrate

An invertebrate (animal without a backbone) that is visible to the naked eye.

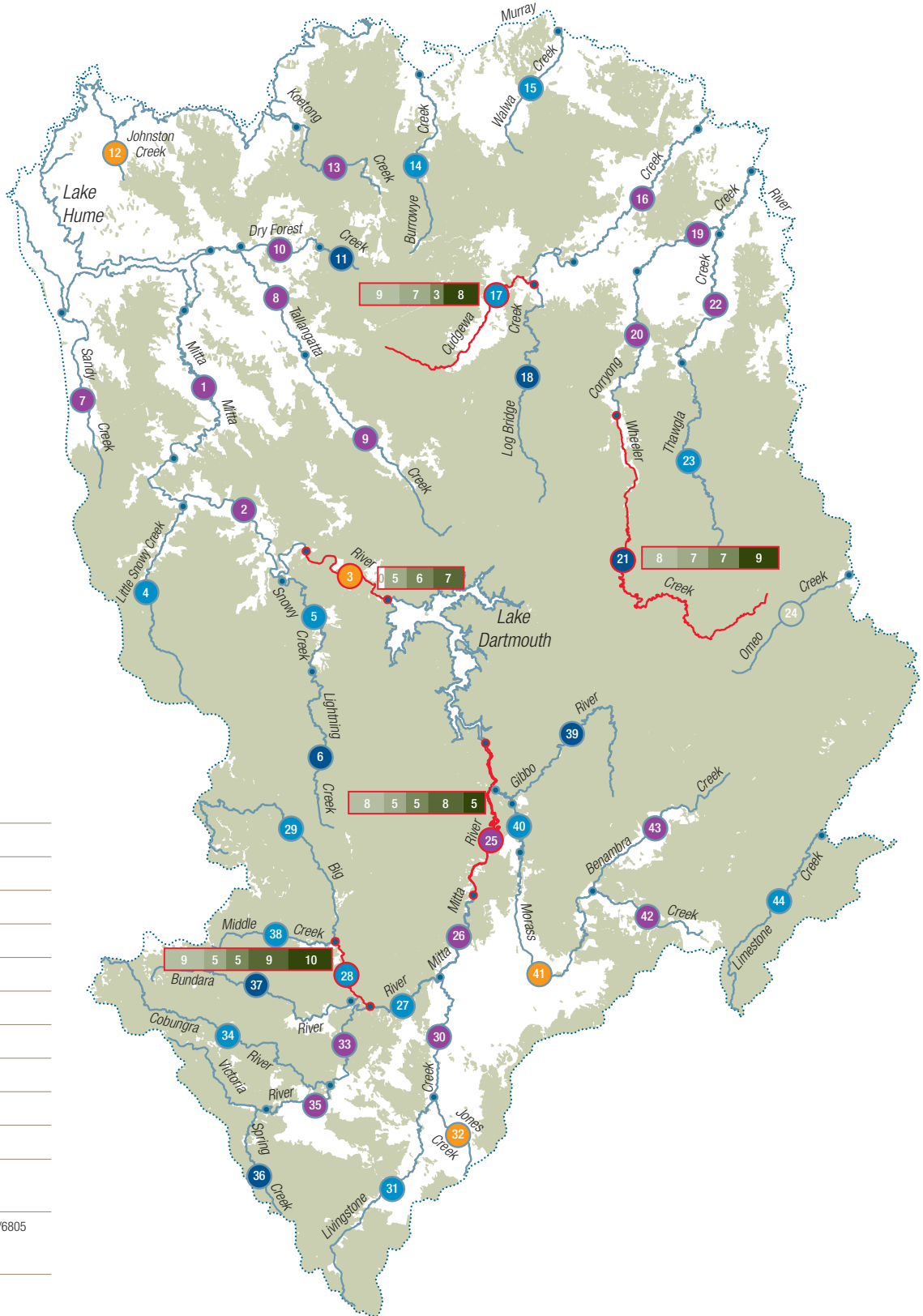
SIGNAL

A measure of the effect of pollution on macroinvertebrates. SIGNAL is an acronym for Stream Invertebrate Grade Number-Average Level.



Basins

Basin 1 Upper Murray



Environmental Condition

- Excellent
- Good
- Moderate
- Poor
- Very Poor
- Insufficient Data
- Reach Division
- Highlighted Reach
- Forest (uncleared)
- 10 Reach number

Cartography by Spatial Vision, 2000 M/6805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

Most of the basin remains forested (about 80%) although all major valleys in the north have been cleared for agriculture, mainly grazing and dairying. The principal land uses are water conservation (Lakes Hume and Dartmouth) and forestry.

Because most of the basin is forested and largely undeveloped, most stream length was in good or excellent condition (53%). The remaining stream length is in mainly moderate condition. Only 6% of stream length is classified as poor (reaches 3, 12, 32 and 41), which can be attributed to poor physical form and poor vegetation coverage. The 2003 bushfires affected water quality and streamside zone scores. Overall condition scores for many reaches, particularly those rivers above Lake Dartmouth (reaches 25-44), were slightly lowered.

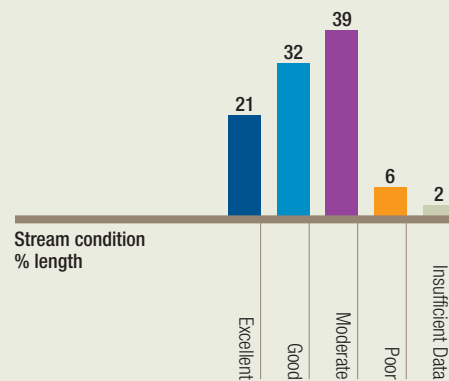
Most reaches show only minor change to natural hydrological patterns. The exception is the lower Mitta Mitta River (reaches 1-3). This is a highly regulated stream, which transfers water between Lake Dartmouth and Lake Hume and consequently had increased periods of low flow and stressed flows in both summer and winter.

Eight of the basin's 44 reaches were assessed for water quality and results varied considerably across the catchment. The 2003 bushfires affected water quality at reaches 26, 35 and 41, which all showed elevated levels of phosphorus. Reach 41 also had elevated levels of salinity and turbidity.

The 2003 fires also affected the condition of the streamside zone. One-half of the reaches notably lacked large trees and tree canopy because of vegetation lost or damaged in the bushfires. The highest quality streamside zone was found at reaches 11, 18, 24 and 39, in the north-east. The one random site selected on Koetong Creek (reach 13) showed vegetation in poor condition. But this site was not typical of most of Koetong Creek, which has been named as a representative river by the North East CMA.

The physical form of half the reaches in the Upper Murray River basin was assessed as in physically moderate or good condition. Many streams have been desnagged in the past, resulting in moderate to poor levels of large wood. Fish migration on reaches 25-44 is severely restricted by Lake Dartmouth, which acts as a barrier to fish migration to the basin's upper reaches.

Half of the basin's reaches were assessed for aquatic life. Just over 50% of the streams measured scored very highly for all parameters. The relatively pristine environment of headwater streams is associated with a healthy macroinvertebrate population. As a result, a number of reaches were at reference condition (reaches 6, 29 and 36). The lowest scores for aquatic life were found in reaches 19, 42 and 43, which had been affected by bushfires.



Upper Murray

“One-half of the reaches had a notable lack of large trees and tree canopy because of vegetation lost or damaged in the bushfires.”



Big River



Koetong Creek

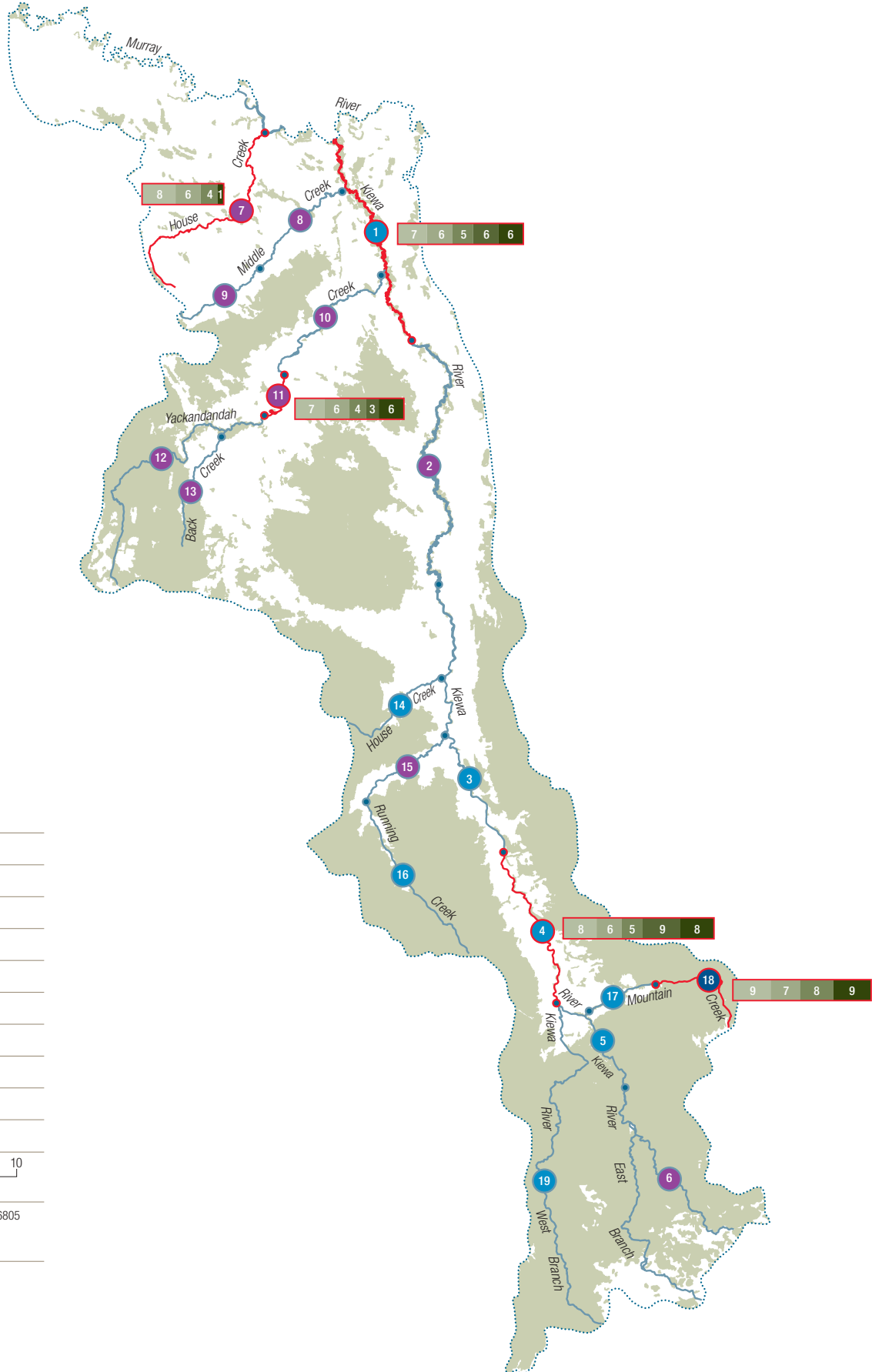


Wheeler Creek

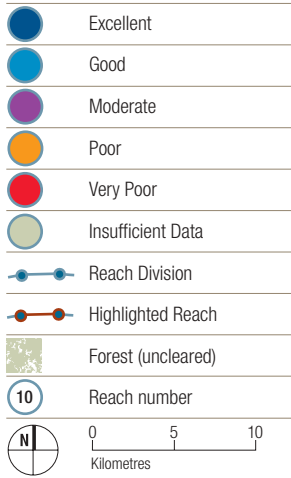


Bundara River

Basin 2 Kiewa



Environmental Condition



Cartography by Spatial Vision, 2000 M/6805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

Some of Victoria's most productive land lies on the cleared river flats and terraces of the Kiewa basin. Intensive dairying near Dederang and tobacco crops on the lower slopes of Mt Beauty dominate agricultural land use. About one-third of the basin remains forested, mainly the steeper hill slopes in the south.

The good condition of streams reflects the relative high forest coverage and low level of hydrological development compared with other Victorian basins. Nearly half of stream length was rated in good or excellent condition. All of the remainder was in moderate condition.

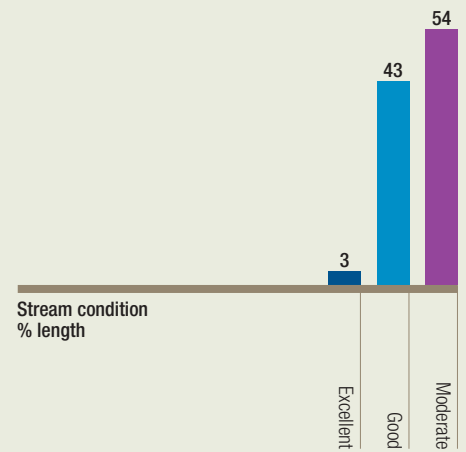
Hydro-electric stations on the east and west branches of the Kiewa River, have not had a significant impact on the natural hydrological patterns. All reaches above Mt Beauty (reaches 5, 6, 17-19) have largely unmodified hydrology. The remainder of reaches showed a small level of change to natural flow regimes. The exception was the upper Yackandandah Creek (reach 12) which had significant long periods of low flow and had the most stressed summer flows in the basin.

Six of the 19 reaches were tested for water quality (reaches 1, 3, 4, 11, 18 and 19). Reaches 3, 4 and 19 had very good water quality results but reaches 1 and 11 were of lower quality. The poor result for Yackandandah Creek (reach 11), and to a lesser extent, the lower Kiewa River (reach 1), could be attributed to on-going sediment problems associated with gold mining in the region.

Results for the streamside zone varied considerably. In correlation to the forested higher elevation areas, the best vegetation condition was found at reaches 16, 18 and 19. The poorest vegetation condition was recorded for reaches on the lower floodplains where land has been cleared or heavily grazed. These heavily modified reaches also showed poor results for longitudinal continuity and understorey diversity.

Except for the upper Mountain Creek (reach 18), all reaches contained low levels of large wood, indicating either extensive clearing or desnagging in the past. Nearly all reaches showed moderate levels of bank stability. Only one major fish barrier (reach 6) was stopping access to the upper sections of the Kiewa River.

Data on aquatic life in the Kiewa basin was collected for 80% of reaches. Results varied, from high scores in the essentially unmodified reaches upstream of Mt Beauty to low, in heavily modified reaches in the lowland regions of the basin. Most were in the moderate to good range.



Kiewa

“Nearly half of stream length was rated in good or excellent condition.”



Kiewa River West Branch

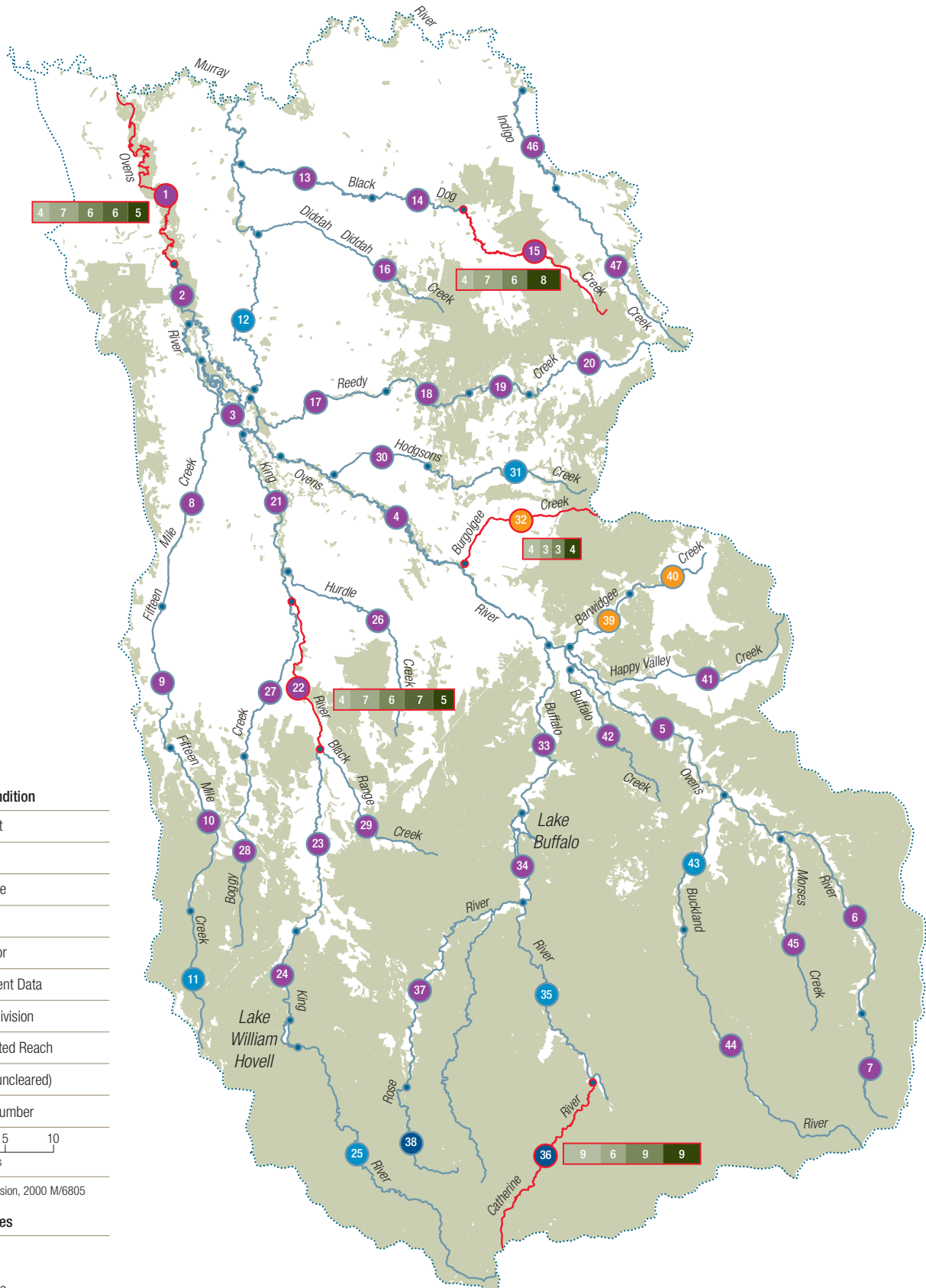


House Creek



Yackandandah Creek

Basin 3 Ovens



Environmental Condition

- Excellent
- Good
- Moderate
- Poor
- Very Poor
- Insufficient Data
- Reach Division
- Highlighted Reach
- Forest (uncleared)
- 10 Reach number
- 0 5 10
Kilometres

Cartography by Spatial Vision, 2000 M/6805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

In the south, the mountainous land is characterised by extensive forest cover. This gives way to gentle slopes and alluvial river flats in the middle reaches of the Ovens River. Tobacco, the most economically significant crop in the basin, is grown here. Other agricultural industry is confined to the central and north-east regions of the basin, between the townships of Beechworth and Chiltern. The Ovens River from Killawarra to Lake Mulwala is a Heritage River and has special nature conservation, recreation, scenic and cultural heritage attributes.

Almost one-fifth of the basin's stream length was rated in good or excellent condition (19%) with most of the remaining stream length in moderate condition (78%). Two reaches were in excellent, or reference, condition – Catherine River (reach 36), and Rose River (reach 38) – in the heavily forested region in the south. The generally good results reflect the low level of hydrological development and extensive areas of dense forest cover. Three reaches (32, 39 and 40), representing 3% of total stream length in the basin, were classed in poor condition.

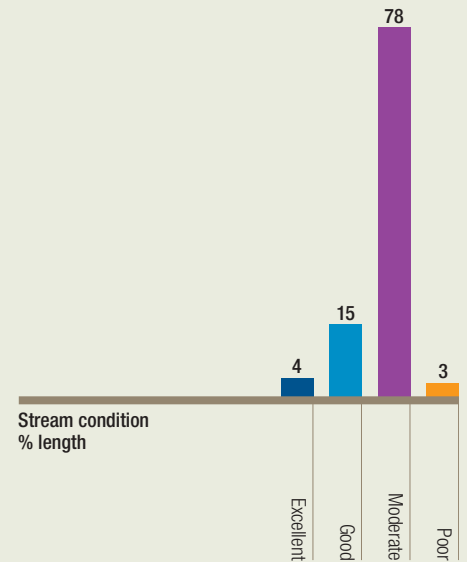
Many of the reaches had only slightly modified hydrology – for example, the upper Ovens River (reaches 5-7), Fifteen Mile Creek (reaches 8-11), Buffalo, Rose and Catherine Rivers (reaches 34-38) and the Buckland River (reaches 43 and 44). However, results for the hydrology sub-index ranged greatly. Lower scores were attributed to extended periods of low flow, consistent with summer extractions for agricultural and urban use. Reaches with the most modified flows were on the Ovens River below Wangaratta, where demand for urban water supply is highest, as well as on the King River (reaches 22-24) and tributaries, Black Dog, Reedy and Hodgsons Creeks. In contrast, the King River (reach 25), above Lake William Howell, had a natural flow regime, consistent with the pristine environment of heavily vegetated headwater streams.

Six reaches (1, 5, 6, 9, 22 and 37) of the basin's 47 reaches, had water quality data available and results varied from moderate to good. While the 2003 bushfires impacted generally on water quality in the basin, reaches 1, 5, 9 and 37 in particular had elevated phosphorus levels. This could be attributed to the longer term impact of surrounding agricultural industry. Reaches 5 and 9 – in cleared, sloping river valleys where run-off may be high – had high levels of turbidity. Reach 6, near the headwaters of the Ovens River, had the best water quality for the basin.

The quality of vegetation varied across the basin. Many reaches had poor understory vegetation and regeneration, and most reaches had moderate to high levels of weeds. Buffalo River (reach 34) was the most modified reach with an extremely poor streamside zone. Reaches 24, 26, 32, 39 and 40, in land cleared of forest, were also heavily modified.

Despite the heavily vegetated area in the south, no reach had stable banks. Most reaches had a small to moderate level of erosion. Most reaches had limited amounts of large wood, except reaches 1-3, 11 and 36. Very few reaches had unrestricted fish access because of barriers, such as Wangaratta weir.

Aquatic life was assessed in 36 reaches. Results varied, with reaches in the vegetated region of the upper catchment (such as reaches 14, 25, 35, 36 and 38) in reference condition. Those with the lowest scores (such as reaches 3, 17, 32 and 39) were all along cleared land or around townships.



Ovens

“The generally good results reflect the low level of flow stress in the catchment and extensive areas of dense forest cover.”



Buffalo Creek

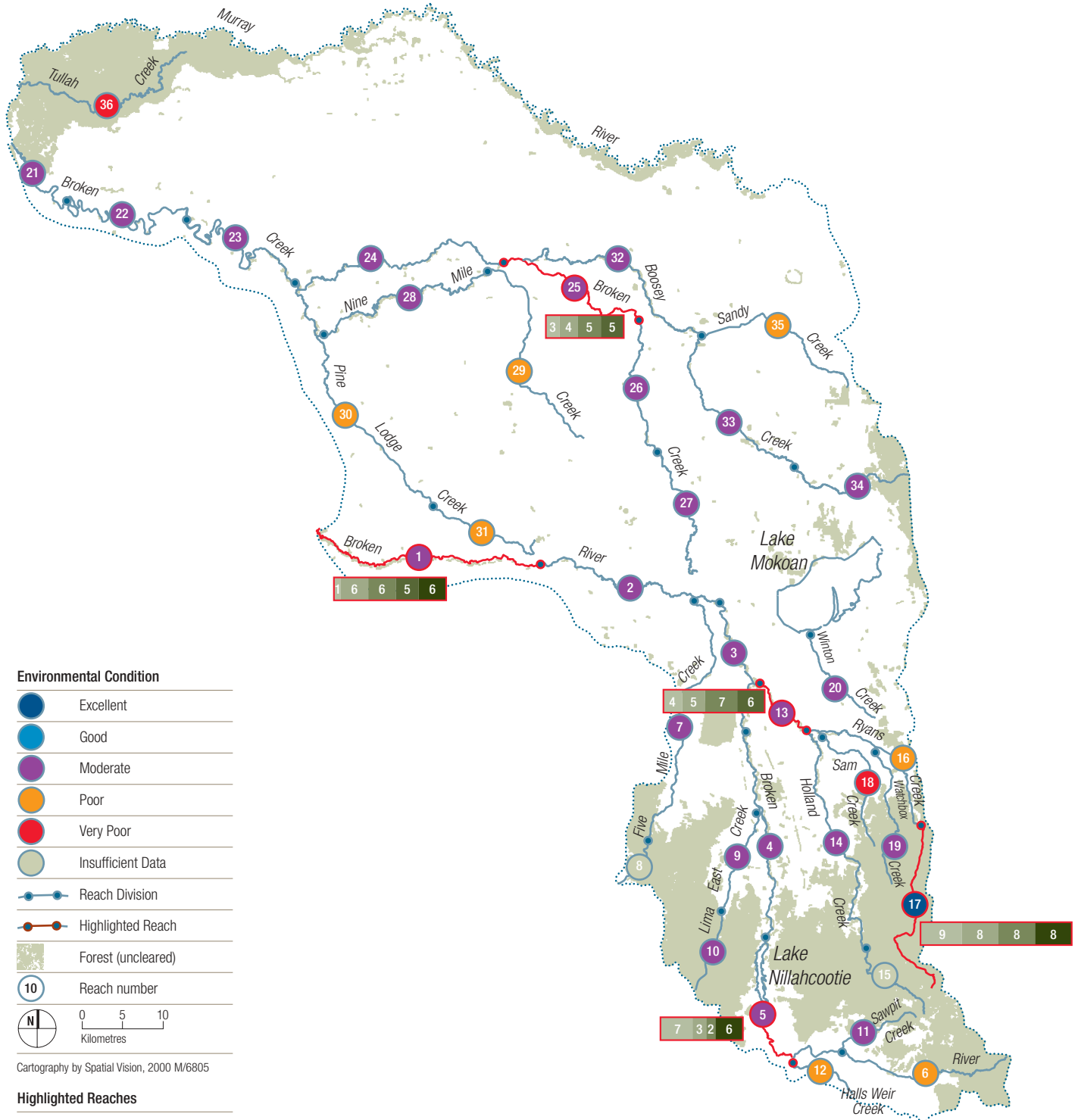


Hodgsons Creek



Catherine River

Basin 4 Broken



Environmental Condition

- Excellent
- Good
- Moderate
- Poor
- Very Poor
- Insufficient Data
- Reach Division
- Highlighted Reach
- 10 Reach number



Cartography by Spatial Vision, 2000 M/6805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

Most of the catchment has been cleared of its native vegetation for agriculture (mainly grazing in the south, mixed cereal and dryland grazing in the central region and intensive horticultural, dairy and livestock production in the north).

Seventy percent of stream length was in moderate condition and one-quarter in poor or very poor condition. Only 3% of stream length was classed in good or excellent condition. This comprised only the upper reach of Ryans Creek (reach 17). Data was insufficient to establish the condition of 2% of stream length.

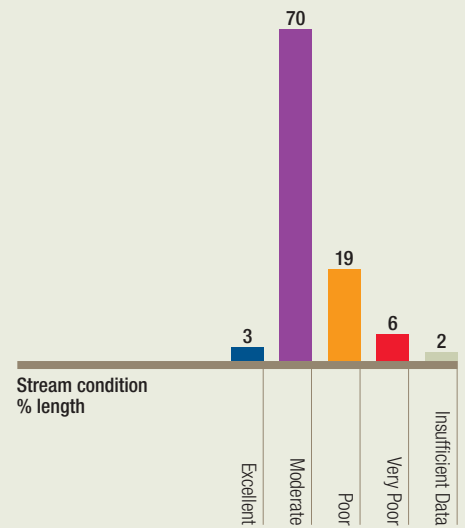
While 50% of reaches show only minor change to natural hydrological patterns, some stress may still be evident. The flow regime of upper Ryans Creek (reach 17) was close to natural. Reaches on the lower Broken River (reaches 1-3) had the most altered hydrology of any waterway due to diversions to the Mokoan and Broken Creek systems for domestic and stock purposes. The Upper Broken Creek and Boosey Creek also had highly altered hydrology due to the operation of Casey's Weir to deliver irrigation, domestic and stock flows. One-half of all reaches within the basin were stressed in summer, due to extraction for agriculture over the drier summer months.

Six of the basin's 36 reaches had water quality data available. All reaches scored well for salinity (with the exception of reach 4) and pH. However all reaches had elevated levels of total phosphorus. The generally poor water quality of the basin reflects the highly modified natural environment.

Results for the condition of vegetation and understorey diversity in the streamside zone were moderate to low and nearly all reaches scored very poorly for regeneration. The poorest reaches were located in clusters in the south (reaches 5, 11 and 12) and in the west central region (reaches 29-31). A number of reaches (reaches 5, 6, 12, 16, 18 and 29-31) scored zero for longitudinal continuity equating to essentially no vegetation. Ryans Creek (reach 17) had the best vegetation condition. The poor vegetation and physical form results are due to extensive clearing and grazing.

Very few reaches were in physically good, or stable, condition. Most reaches had poor amounts of large wood (except reaches 2, 13 and 17), indicating considerable large wood had been removed from these streams, significantly decreasing instream habitat. All reaches were affected by barriers to fish migration.

Data on the aquatic life was collected for 12 reaches (30% of overall stream length). Many of the streams sampled were in good biological condition, despite the generally modified environment. The upper reach of Five Mile Creek (reach 8) was assessed as in pristine condition. At the other end of the spectrum, Sandy Creek (reach 35) and Sams Creek (reach 18) scored very poorly, indicating an extremely modified aquatic environment. Both these reaches also had an overall ISC condition of very poor.



Broken

“Nearly all reaches within the basin were stressed in summer, due to the concentrated water use for agriculture over the drier summer months.”



Broken Creek



Boosey Creek

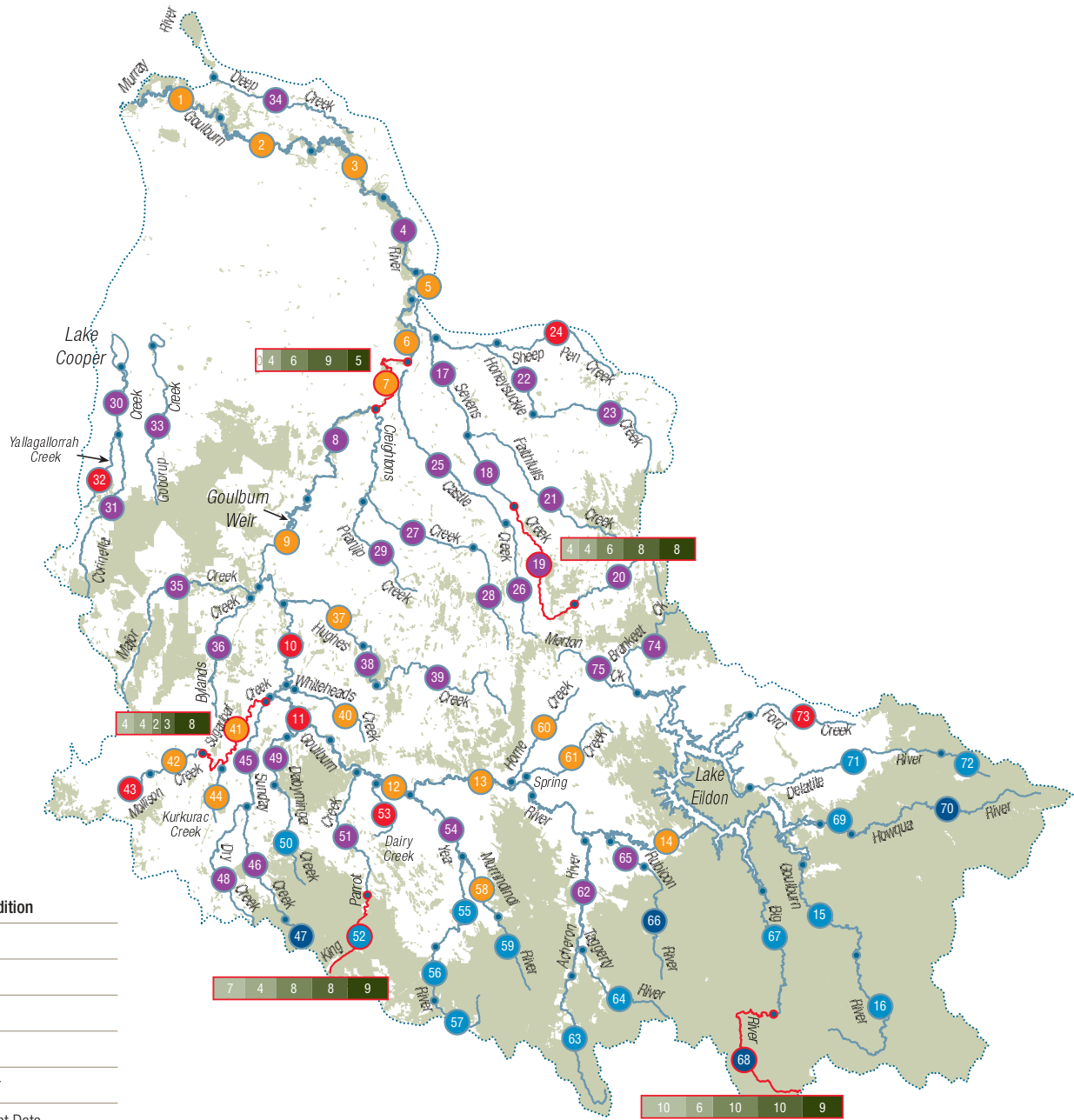


Broken River



Sam Creek

Basin 5 Goulburn



Environmental Condition

- Excellent
- Good
- Moderate
- Poor
- Very Poor
- Insufficient Data
- Reach Division
- Highlighted Reach
- Forest (uncleared)
- Reach number



Cartography by Spatial Vision, 2000 M/6805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

In the south, the forested mountains of the Great Dividing Range dominate the landscape. These give way to the flat country of the Murray Plain in the north. Valleys and plains have been mostly cleared for agriculture. There are two major water storages, Goulburn Weir and Lake Eildon.

Just under half the stream length was rated in moderate condition. Of the remainder, 22% of reaches – all located in the southern mountainous region – were in good or excellent condition. Reaches classified as poor or very poor (32%) were in heavily cleared areas of the basin.

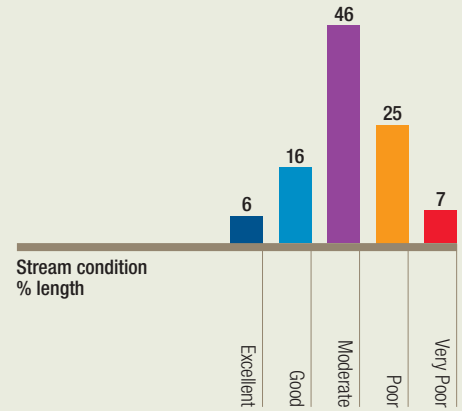
Results for the hydrology sub-index were extremely variable, ranging from reaches with highly modified flows to those with a natural flow regime. The impact of Lake Eildon is considerable, with most Goulburn River reaches (reaches 1-14) showing highly altered flow regimes. These reaches demonstrated extended periods of low, zero flow, altered periods of high flow, reversed seasonality as well as summer and winter stress. In contrast, reaches upstream of Lake Eildon, notably the Big, Howqua, Delatite, Rubicon and Goulburn Rivers, had largely unmodified flow regimes.

Water quality data was collected for 19 of the 75 reaches in the basin. Overall condition was assessed as moderate to good. A number of reaches had water quality in excellent condition (such as reaches 8, 14, 15, 59, 68 and 71). The poorest results were at reaches 41 and 45, which both had elevated turbidity, salinity and total phosphorus levels. Most reaches had pH and salinity levels at or close to reference condition. Turbidity was generally good with the exception of a few reaches. Total phosphorus results were more variable and a number of reaches had elevated phosphorus levels (such as reaches 2, 5, 19, 20, 25, 41, 45 and 74). These reaches are located in cleared areas of the basin.

Results for streamside zone varied considerably, ranging from reaches in very poor condition, such as Mollison Creek (reach 43) to those at reference condition, such as Big River (reach 68). The range in scores reflects the contrast in land use, from the relatively untouched mountainous area in the south to the cleared agricultural region in the lower section. Only two reaches had no weeds (reaches 47 and 59).

Similar to results for streamside zone, those for physical form ranged from good for headwater streams in the south, to poor for streams in the lower parts. Banks were generally moderately unstable and, one-quarter of reaches had significant quantities of large wood. Creightons Creek (reach 27), Sunday Creek (reach 47) and Rubicon River (reach 66) had good results for physical form.

Half the reaches were assessed for aquatic life and, like results for streamside zone and physical form, scores ranged from very poor to reaches in reference condition. More than half the reaches assessed were close to or at reference condition and were confined to the southern highlands.



Goulburn

“The range in scores reflects the contrast in land use, from the relatively untouched mountainous area in the south to the cleared agricultural region in the north.”



Goulburn River

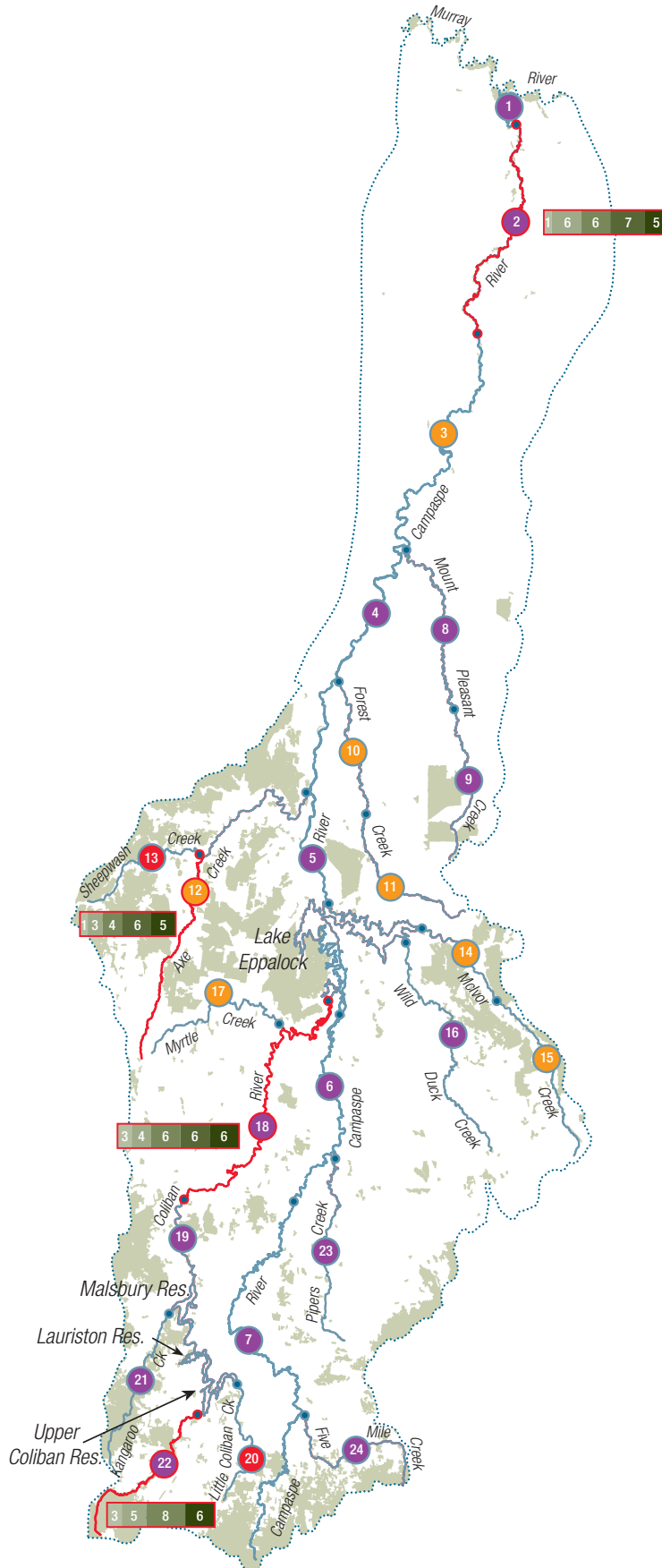


Dabyminga Creek

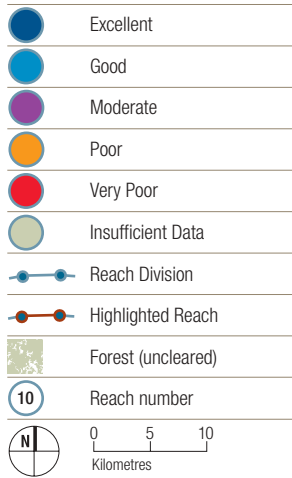


Sevens Creek

Basin 6 Campaspe



Environmental Condition



Cartography by Spatial Vision, 2000 M/6805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

The Great Dividing Range dominates the southern part of the landscape. Although considerable natural forest has been cleared for agriculture, significant pockets of vegetation remain on the southern hills and around Lake Eppalock and Axe Creek in the central region. In the north, flat alluvial plains follow the Campaspe River's journey to its end point at the River Murray. There are four major water storages – the Malmsbury, Lauriston and Upper Coliban Reservoirs, on the Upper Coliban River, and Lake Eppalock, on the junction of the Campaspe and Coliban Rivers.

The majority of stream length was rated in moderate condition (65%). The remainder was in poor or very poor condition (29% and 6% respectively). There were no reaches in good or excellent condition, largely due to the extensively cleared land and the modified hydrology associated with water storages.

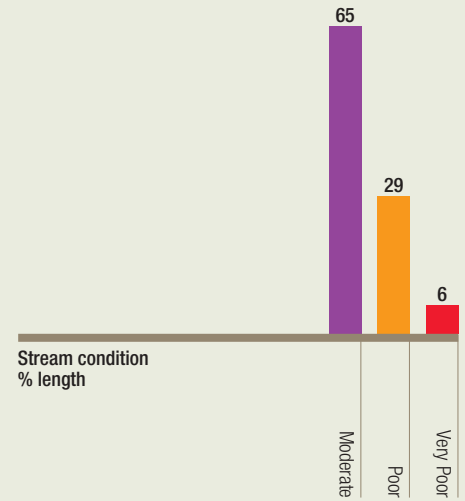
Storages on the upper Coliban River and Lake Eppalock on the Campaspe River have had a significant impact on downstream flow regimes. The most affected sites are downstream of Lake Eppalock where reaches had extended periods of low flows and summer and winter stress. Reaches 12 and 13 are also heavily impacted and suffer from summer stress, possibly due to the large number of farm dams. In contrast, reaches 7, 8 and 9 had flow regimes in near natural state.

Water quality data was available for ten out of 24 reaches. With the exception of reach 8, turbidity levels were low for all sites. However all sites had elevated levels of total phosphorus. The basin has salinity problems associated with dryland and irrigation farming practices, as well as soil acidification; this may explain the generally poor results for salinity. Reach 7, on the upper Campaspe River, was the only reach with close to unmodified water quality.

Much of the native riparian vegetation has been cleared or degraded due to stock access. This is highlighted in the moderate to low scores for all vegetation parameters. In particular, scores for longitudinal continuity and diversity were poor for most reaches. A number of headwater streams located upstream of water storages on the Coliban River, particularly reaches 21 and 22, were in the best condition.

The significantly altered hydrology and extensive clearing have had major impacts on the physical condition of the streams. All reaches (except reaches 6 and 22) had moderate amounts of bank erosion. Most reaches had low quantities of instream wood, consistent with the effects of cleared land adjacent to waterways. The storages, as well as Campaspe Weir and the Waranga Channel Siphon, are major barriers to fish migration. Overall, scores for physical form were poor to moderate.

Thirteen reaches were assessed for aquatic life and scores varied from very poor (reach 13) to a reach in near reference condition (reach 5). The low score for reach 13 could be attributed to its highly modified hydrology (it is an ephemeral waterway and disconnected pools would have to be sampled). The expansion of rural living also would affect water quality. All other sampled reaches scored moderately, consistent with the modified surrounding environment.



Campaspe

“The significantly altered flow patterns and extensive vegetation clearing have had major impacts on the physical condition of the streams.”



Campaspe River

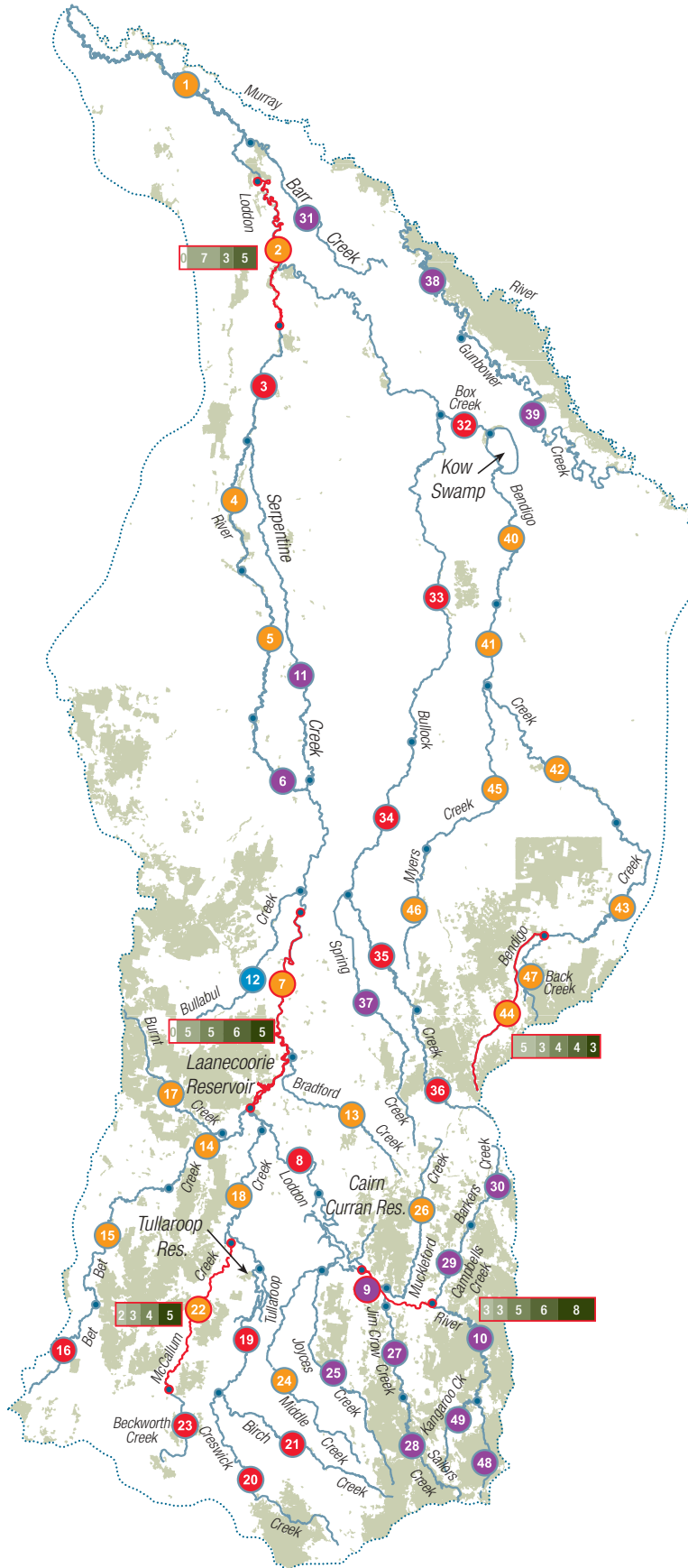


Campaspe River

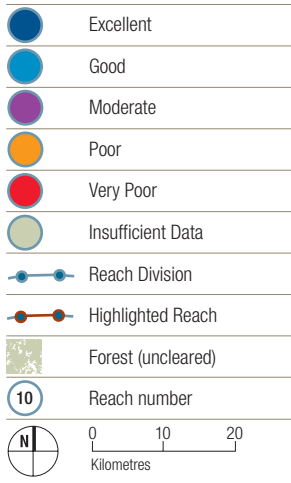


Coliban River

Basin 7 Loddon



Environmental Condition



Cartography by Spatial Vision, 2004 M/6805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

The forested slopes of the Great Dividing Range form the basin's southern boundary. Towards the north, the landscape is dominated by flat alluvial plains, mainly cleared for agriculture. Salinisation – attributed to the shallow groundwater table – is a significant issue in the north. There are 60 artificial water storages in the basin, including three major reservoirs (Tullaroop, Cairn Curran and Laanecoorie), which are used for irrigation, stock and domestic water supply.

Extensive clearing of the Loddon basin has contributed to 65% of stream length being classified as in poor or very poor condition (42% and 23% respectively). One reach on Bullabul Creek (reach 12) was rated in good condition and the remaining 32% of stream length was classified in moderate condition. Bullabul Creek was rated as good based on only three sub-index values as no data was available for water quality and aquatic life. Reaches in moderate condition were largely confined to the forested south, around the Wombat State Forest, and on Gunbower Creek in the north.

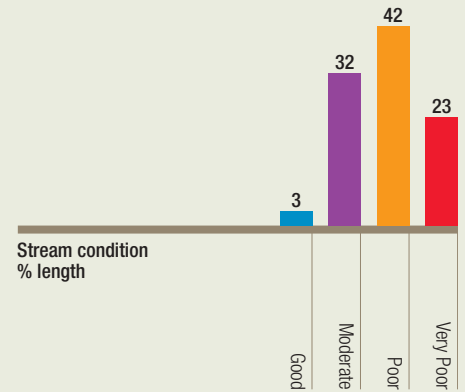
All reaches had modified hydrology. All reaches demonstrated increased periods of low flow and summer stress. The most altered flow regimes were in the Loddon River downstream of Cairn Curran Reservoir. The reservoir has highly controlled flows to meet irrigation demands. The downstream reaches have increased periods of low flow, zero flows, decreased periods of high flow and also demonstrate considerable summer and winter stress.

Ten of the basin's 47 reaches were assessed for water quality. Results varied for each parameter. All reaches had good condition for pH. All reaches, except reaches 5 and 6, had elevated total phosphorus. Salinity levels were high, except for reaches 2, 38 and 41. Elevated salinity levels were attributed to the shallow groundwater table and the problem of dryland salinity in the region. Turbidity was variable, but notably poor for reaches 2 and 41.

Results for streamside zone were generally poor, consistent with the largely cleared environment. Longitudinal continuity and understorey vegetation were highly modified for most reaches. Reaches with the poorest streamside zones were on Bullock, Barr and Box Creeks (reaches 31-34) in the north and reaches 16, 19, 21 and 23-24 in the south. The best reaches were on Sailors Creek and the upper Loddon River (reaches 28 and 48) in the forested southern highlands.

Extensive water supply infrastructure presents significant barriers to fish migration on nearly all reaches in the catchment. Most reaches had moderate levels of bank erosion and limited quantities of large wood, except reaches 3-7 on the Loddon River, which had good quantities of instream wood.

Most of the 15 reaches assessed for aquatic life were below reference condition. Notably, the best sites (reach 18 at reference condition and reaches 9, 10 and 25 near reference condition) are in the south in the forested highlands. The lowest scoring reach, on the upper Bendigo Creek (reach 44), runs through urban land.



Loddon

“Results for streamside zone were generally poor, consistent with the largely cleared environment.”



Loddon River



Loddon River

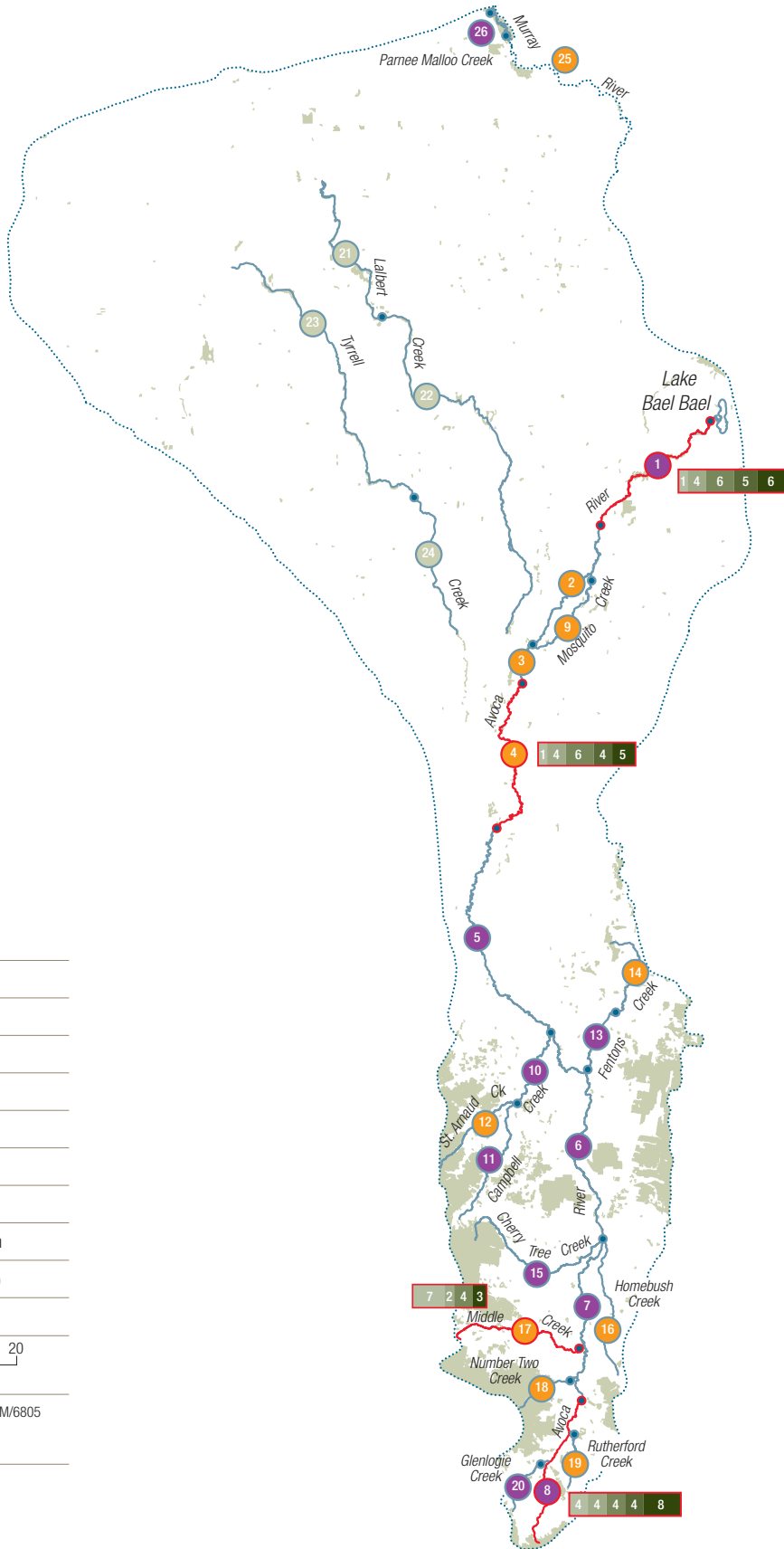


Gunbower Creek

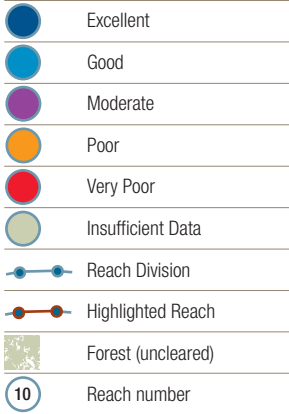


Bet Bet Creek

Basin 8 Avoca



Environmental Condition



Cartography by Spatial Vision, 2003 M/6805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

The basin is characterised by a mountainous region in the south, which gradually gives way to undulating alluvial plains in the north. Agricultural industry is dominated by broad acre cropping in the north and grazing in the south. Land in the south was widely cleared at the turn of the last century to make way for agricultural development and gold mining. The Avoca River regularly ceases to flow for many months of the year. There are 12 weirs along its length but no major water storages.

Clearing for agriculture and the modified hydrological patterns result in most of the stream length being classified as in moderate (40%) or poor condition (35%). Condition scores could not be calculated for Tyrell and Lalbert Creeks (reaches 21-24) which make up 25% of total reach length, because of insufficient data. Both these creeks are ephemeral and flow only when the Avoca River floods.

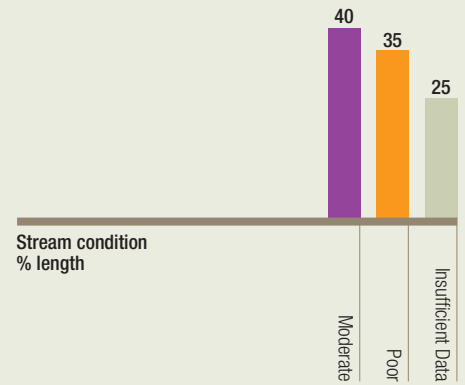
The 12 weirs along the Avoca River and the associated extractions for irrigation have significantly altered the natural flow regimes. Results ranged from reaches with extremely modified flow regimes to those with only minor modifications to natural hydrological patterns. Reaches 1-4 in the north were flow stressed during summer with extended periods of low flow. The smaller creeks off the Avoca River have less impacted hydrology and scored higher than reaches impacted by weirs and the associated extractions. No information was available for Tyrell and Lalbert Creeks.

Water quality data was available for seven of the basin's 26 reaches. All showed generally poor results. All assessed reaches had elevated salinity levels, symptomatic of ongoing salinity problems or the acid sulphate soils typical to the region.

Most reaches had highly disturbed streamside zones and scored poorly for vegetation width, regeneration, diversity and longitudinal continuity. In particular, a number of reaches (7, 11, 12, 16-20, and 24) had extremely poor results for longitudinal continuity. Reach 5 on the Avoca River and reach 26 on Parnee Malloo Creek, had the highest quality (but still degraded) streamside zones. Reach 16 on Homebush Creek had the most degraded streamside zone.

In terms of physical form, the heavily cleared land and low scores for longitudinal continuity are associated with equally low scores for large wood, bank stability and bank erosion. In particular, reaches 10, 11, 13, 16 and 17 had very high levels of bank instability. The weirs along the Avoca River are a significant barrier to fish movement.

Aquatic life was assessed for 8 reaches. Reach 8, at the headwaters of the Avoca River, scored marginally below reference condition. In contrast, reaches 16 and 17 were heavily impacted and scored well below reference condition.



Avoca

“The smaller creeks off the Avoca River have less flow stress and scored higher than reaches impacted by weirs and the associated water use.”



Avoca River

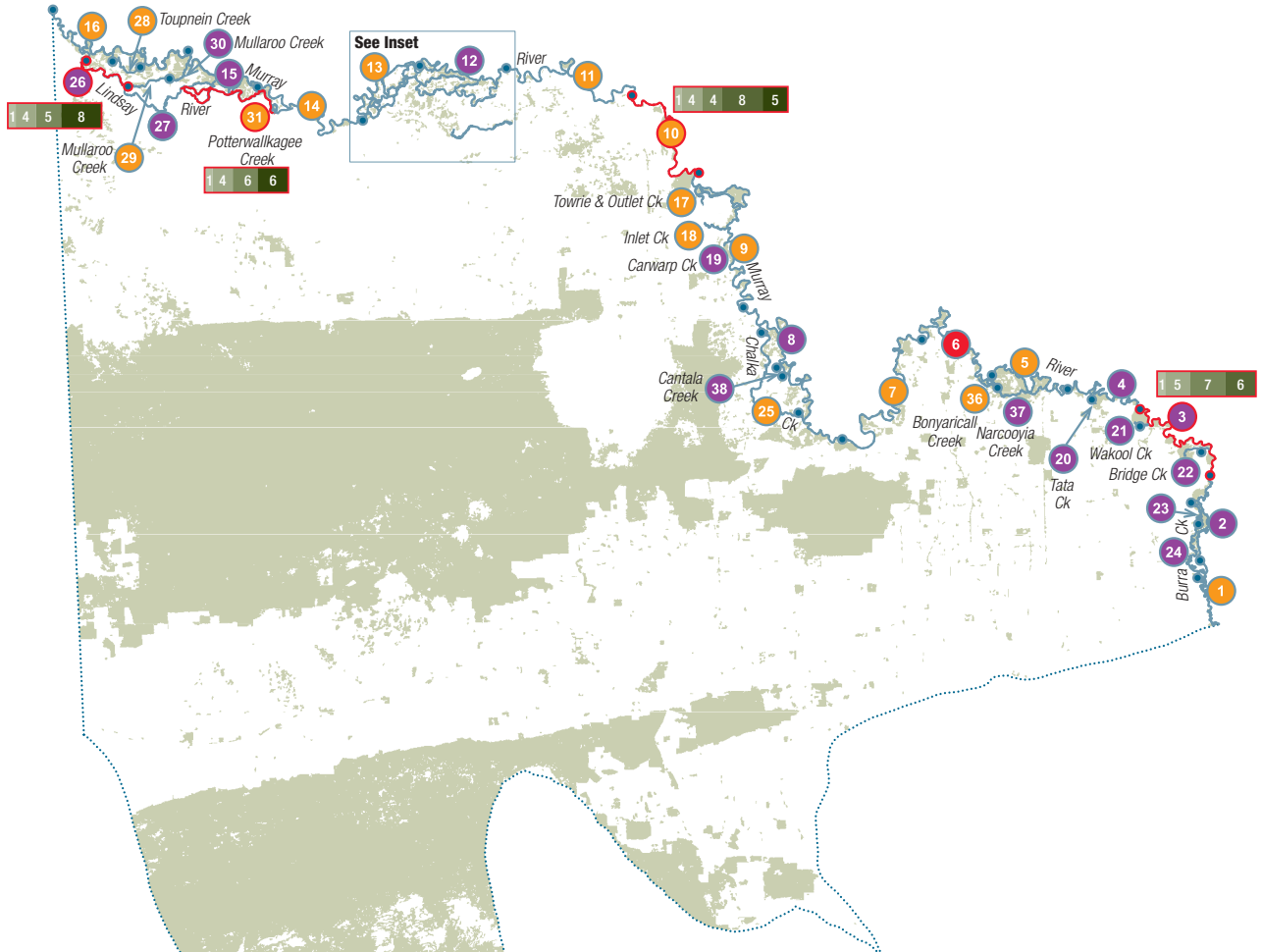


Number Two Creek

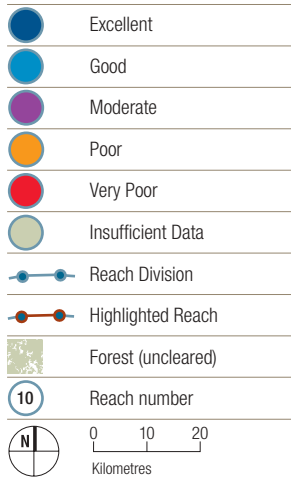


Lalbert Creek

Basin 14 Mallee



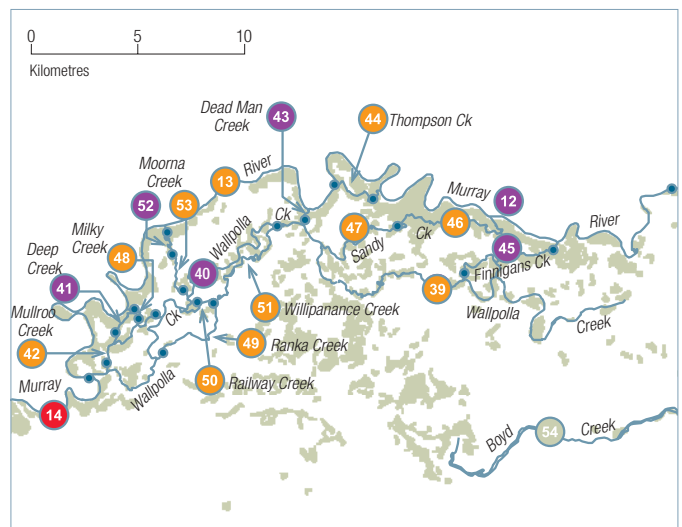
Environmental Condition



Cartography by Spatial Vision, 2000 M/6805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life



The vast majority of land in the Mallee basin is semi-arid. Although the basin is the largest river basin in Victoria, it contributes least to total annual average streamflow across the State, with a median annual runoff of 10 mm or less. Reserves and Parks occupy substantial areas of the basin and include the Murray-Sunset National Park and the northern section of Wyperfield National Park. The basin is also an important area for agricultural production, both from dryland production of sheep and cereal crops and from irrigated horticulture along the River Murray.

The River Murray, its floodplain, anabranches and associated wetland systems dominate the northern part of the basin between the Tyntynder Flats and the South Australian border, which is characterised by three distinct riverine bioregions, the Murray Scroll Belt, Robinvale Plains and Murray Fans. The basin is bordered by the River Murray in the north and its waterways are comprised of distributaries and anabranches, clustered along the floodplain of the Murray Trench. The confluences of the River Murray with the Darling, Wakool and Murrumbidgee Rivers occur in this region. The seven weirs across the River Murray in this region also have a major influence on its flow. In addition to the weirs, flow regimes for the basin's waterways are heavily influenced by flows along the River Murray.

Fifty river reaches were assessed and include 16 reaches along the River Murray. Overall stream condition results were heavily influenced by the flow regimes of the River Murray and the altered hydrology associated with irrigation. In total, 95% of reach length was in poor (57%) or moderate (38%) condition. The remainder (5%) was in either in very poor condition or there was insufficient data to classify the reach.

Flow regimes are largely dependent on the flows of the River Murray, which in turn are influenced by flows upstream of the Mallee basin. All reaches had major modifications to natural flow regimes. The least impacted reaches are located in the east, where the Wakool River enters the River Murray. Between the townships of Echuca and Mildura, winter flows were more stressed than summer flows. This is most likely caused by the irrigation supply systems operating in the large

tributaries entering the Murray, including the Loddon, Campaspe, Goulburn and Broken Rivers. In these systems, flows are harvested in winter and released in summer. However, downstream of Mildura, the degree of flow stress is similar during winter and summer, possibly due to additional inflows from the Darling River system.

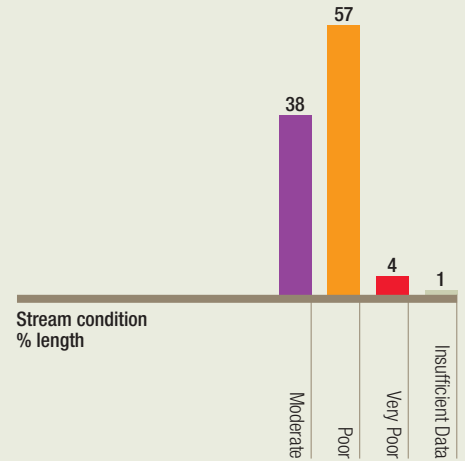
Streams in the basin also had reduced periods of high flow and increased periods of low summer flows. This is attributed to the fact that large storages upstream of the Mallee basin release water mainly for irrigation during summer, with a large proportion of these releases diverted to channels and irrigation districts before the flows reach the Mallee.

Only two of the basin's 55 reaches were assessed for water quality, both on the River Murray (reaches 3 and 10). Both reaches were in good condition in terms of salinity and pH, however turbidity levels were extremely high. No data was available for total phosphorus.

Results for streamside zone varied, however, most were in moderate to good condition. All sites had very few weeds and generally good numbers of large trees indicating very little clearing has been undertaken. Scores for longitudinal continuity, regeneration and diversity parameters were mixed with reaches 2, 5, 19 and 37 in the best condition.

Consistent with the good numbers of large trees, many reaches had very good quantities of instream large wood. In the majority of reaches, banks were stable and there were few major barriers to fish migration. This excludes the existing weirs along the River Murray, which are progressively being upgraded with major fishways.

Twelve reaches were assessed for aquatic life and of these, four were in near pristine ecological condition (reaches 2, 8, 26 and 40). The two poorest scoring reaches, 15 and 30, are in close proximity to each other in the far west of the basin.



Mallee

“Consistent with the good numbers of large trees, many reaches had very good quantities of instream large wood.”



Wallpolla Creek

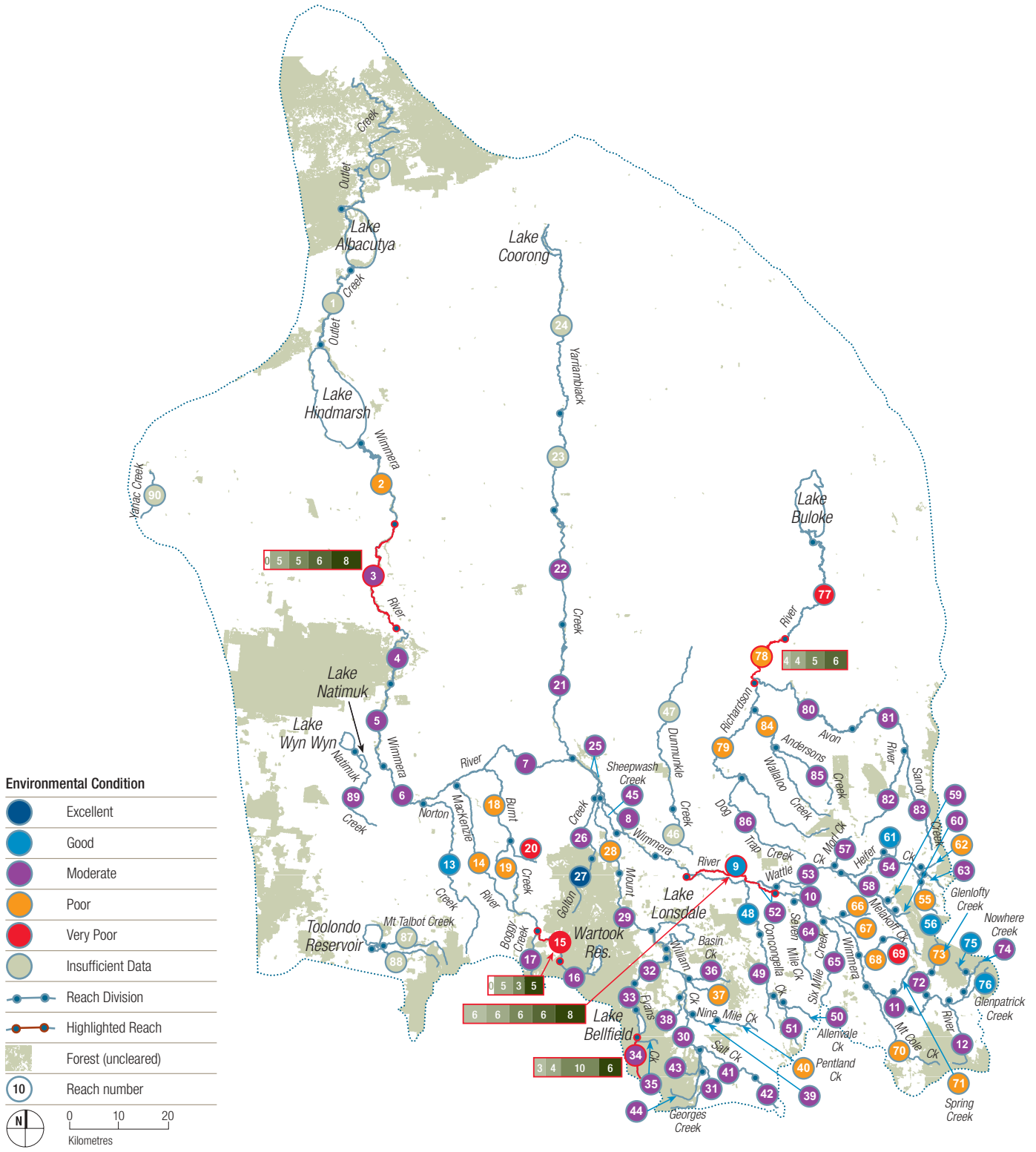


Milky Creek



Murray River

Basin 15 Wimmera



Environmental Condition

- Excellent
 - Good
 - Moderate
 - Poor
 - Very Poor
 - Insufficient Data
 - Reach Division
 - Highlighted Reach
 - Forest (uncleared)
 - Reach number
- 0 10 20
 Kilometres

Cartography by Spatial Vision, 2000 M/6805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

The basin is characterised by the mountainous landscape of the Pyrenees and Grampians in the south and, in contrast, the extensive plains of the Little Desert and part of the Big Desert in the north. The basin is unusual in Victoria – it is internally draining (no outlet to the sea or the River Murray). Streams flow to a series of terminal lakes, some only filling in exceptionally wet years, such as Lake Hindmarsh and Lake Albacutya (which has not filled since 1974).

Most streams were classified in moderate (53%) or poor (21%) condition. Of the remainder, 8% of total stream length was rated in good or excellent condition, and 3% in very poor condition. Data was insufficient for 15% of stream length. The moderate to poor condition of most streams was attributed to modified hydrology and cleared land.

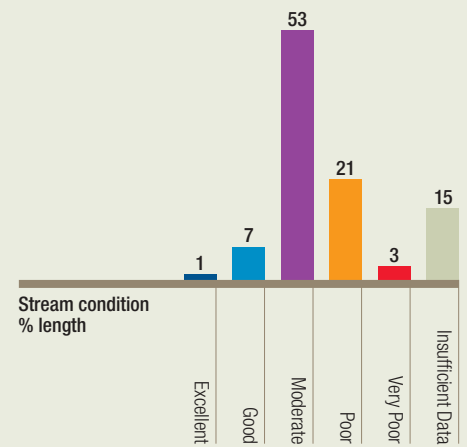
Hydrology sub-index scores varied, from highly modified systems to those in near natural condition. Most of the reaches in good condition are in the mountainous south and east. Notably, Golton Creek (reaches 26 and 27), had a near natural flow regime. Richardson River tributaries and the whole of Concongella Creek (reaches 48-51) also had only minor alterations to natural flow regimes. In contrast, a number of reaches that had significantly altered low flows and showed summer stress due to diversions for irrigation and domestic use, scored very poorly. In particular, the Wimmera River below Yarriambiack Creek (reaches 1-7) had the most altered hydrology. MacKenzie River (reaches 14-16) and Mt William Creek (reaches 28 and 29) also scored poorly for all hydrology parameters. This was attributed to the effects of modified flow regimes of upstream water storages.

Only eight of the basin's 91 reaches were assessed for water quality. Most sites, except reaches 78 and 80, had high salinity levels. Total phosphorus levels were high in reaches 9, 11, 77, 78 and 80. Turbidity levels were high in reaches 77, 78 and 80.

Scores for streamside zone ranged from sites which had been heavily modified to those in reference condition. About 20% of reaches were assessed as heavily modified and did not score higher than a poor rating for all streamside zone parameters. Most Wimmera River tributaries in the south-east fell into this category. The worst reaches all had heavily disturbed riparian zones and low scores for longitudinal continuity, understorey vegetation and regeneration parameters. In contrast, 30% of reaches scored well, notably reaches 29 and 71, which were at reference condition.

Overall results for physical form were poor, with 90% of reaches given a moderate or lower rating, indicating the highly modified environment. Except for Mt Talbot Creek, all reaches were affected by barriers to fish migration. Most reaches had minor levels of bank instability. Few streams had good quantities of large wood (except reaches 16, 33, and 75). The reaches in best condition were on Burnt Creek (reach 16), directly below Wartook Reservoir and Outlet Creek upstream of Lake Albacutya (reach 91).

Aquatic life was assessed for 15 of the basin's 91 reaches. Reaches 3, 7, 8, 11, 16 and 29 were at or near reference condition. The most impacted reaches were on Mt Cole Creek (reach 70) and the Wimmera River downstream of Dimboola weir (reach 3). Some streams showed variation between reaches – for example reach 16 on the MacKenzie River was near reference condition but further downstream, reach 15 was in moderate condition.



Wimmerera

“Hydrology scores varied, from highly modified systems to those in near natural condition.”



Richardson River



Wimmera River

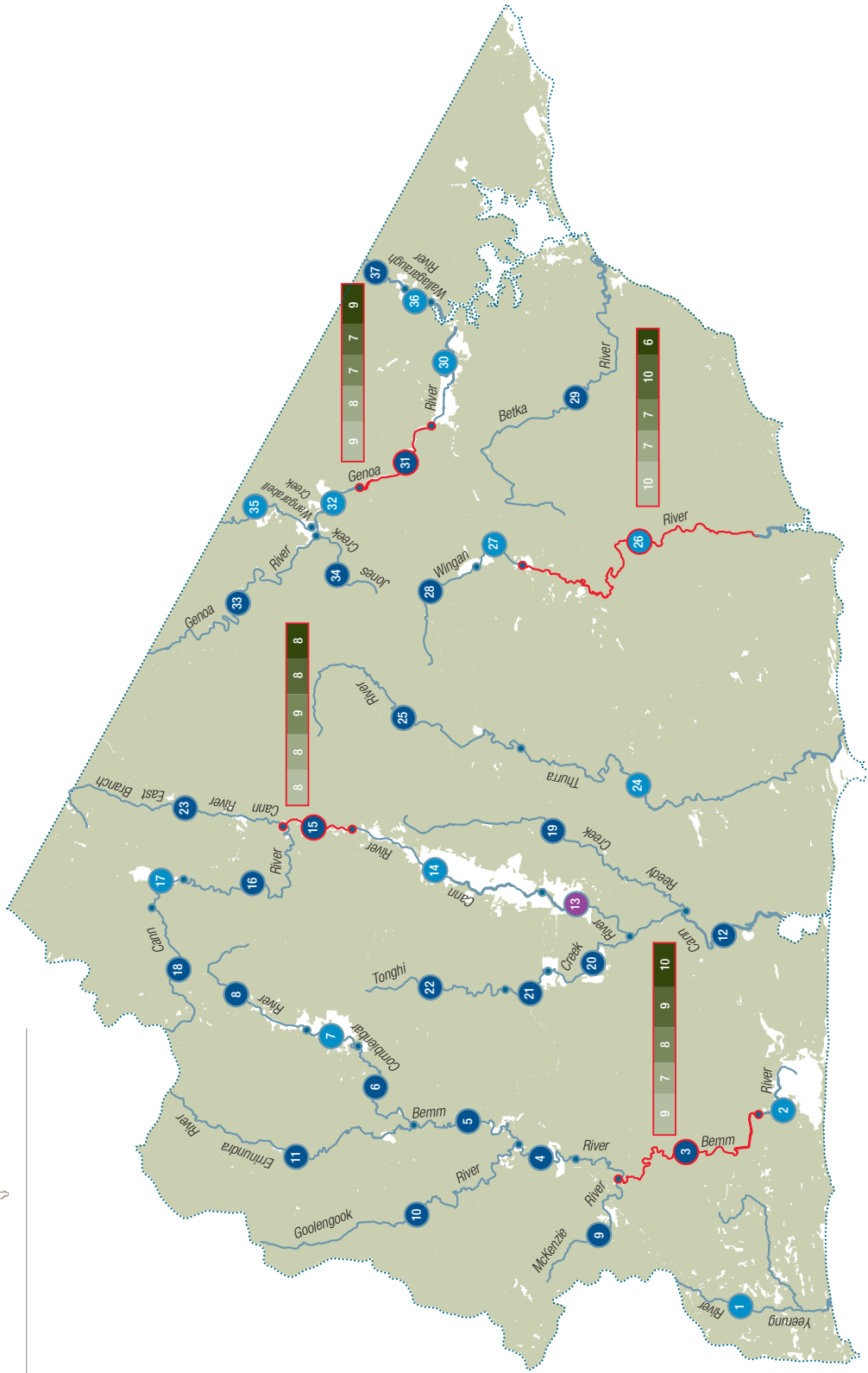


Wimmera River



Wimmera River

Basin 21 East Gippsland



Environmental Condition

- Excellent
- Good
- Moderate
- Poor
- Very Poor
- Insufficient Data

Reach Division

- Reach Division
- Highlighted Reach
- Forest (uncleared)

Reach number

10

Scale

0 5 10
kilometres

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

Cartography by Spatial Vision, 2000 M/6805

The basin is characterised by extensive forest cover. More than 90% of the total area is covered by natural forest, most is either State Forest or National Park. Production of hardwood timber is a significant industry. Some river valleys, particularly of the Cann and Genoa Rivers, have been cleared for agriculture. In the south, the steep forested terrain flattens out to sloping foothills, then to broad coastal plains and extensive dune systems. There are no major water storages.

The high proportion of natural forest and the absence of hydrological development have resulted in the basin having Victoria's highest percentage of reaches in good to excellent condition. Nearly 100% of stream length was classified in excellent (69%) or good condition (30%). The remainder, which was in moderate condition, comprises only one reach (reach 13) on the lower Cann River. The land surrounding this reach has been extensively cleared.

Consistent with the absence of hydrological development, scores for the hydrology sub-index were very high for all reaches. The lowest score was on the Betka River (reach 29) which provides domestic water supply for the Maccacoota township.

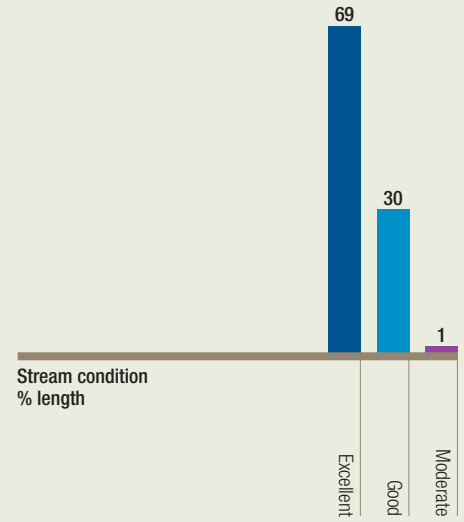
Nine of the basin's 37 reaches were assessed for water quality. Consistent with the heavily forested land in the basin, water quality scores were high. Phosphorus levels for all assessed reaches were low, which is consistent with the low levels of agricultural industry. There was elevated salinity levels in reach 31 (Genoa River). Turbidity levels were elevated in reaches 6 and 11. This could be

attributed to various causes, such as forestry operations, plantation establishment or erosion due to stock access to waterways.

Results for streamside zone were generally good – 80% of reaches had minor or no modifications to riparian vegetation. Again, consistent with land that is heavily forested with little development, vegetation parameters for all reaches were at or close to reference condition. This included weeds, which were generally at very low levels. The most modified reaches were all in cleared valleys. The poorest quality vegetation was on reach 17 on the upper Cann River.

Over half the reaches had only minor modifications to physical form, with two reaches rated in pristine, or reference condition. These reaches are a highland stream in the basin's north-west (Errinundra River, reach 11) and a section of heavily-vegetated lowland in the basin's south (Cann River, reach 12). Large wood levels were variable, with 11 reaches at reference condition. There was limited bank erosion on all reaches, with the exception of Wangarabell Creek (reach 35). Fish have unrestricted access throughout the basin, because there are no major artificial fish barriers.

Healthy macroinvertebrate populations for most of the 27 reaches assessed for aquatic life was attributed to the relatively untouched environment. Only six reaches (reaches 1, 13, 14, 26, 27 and 28) fell short of being in reference condition. Reach 1 scored very poorly possibly due to estuarine influences.



East Gippsland

“The high proportion of natural forest and the absence of major water development have resulted in the basin having Victoria's highest percentage of reaches in good to excellent condition.”



Genoa River



Bemm River

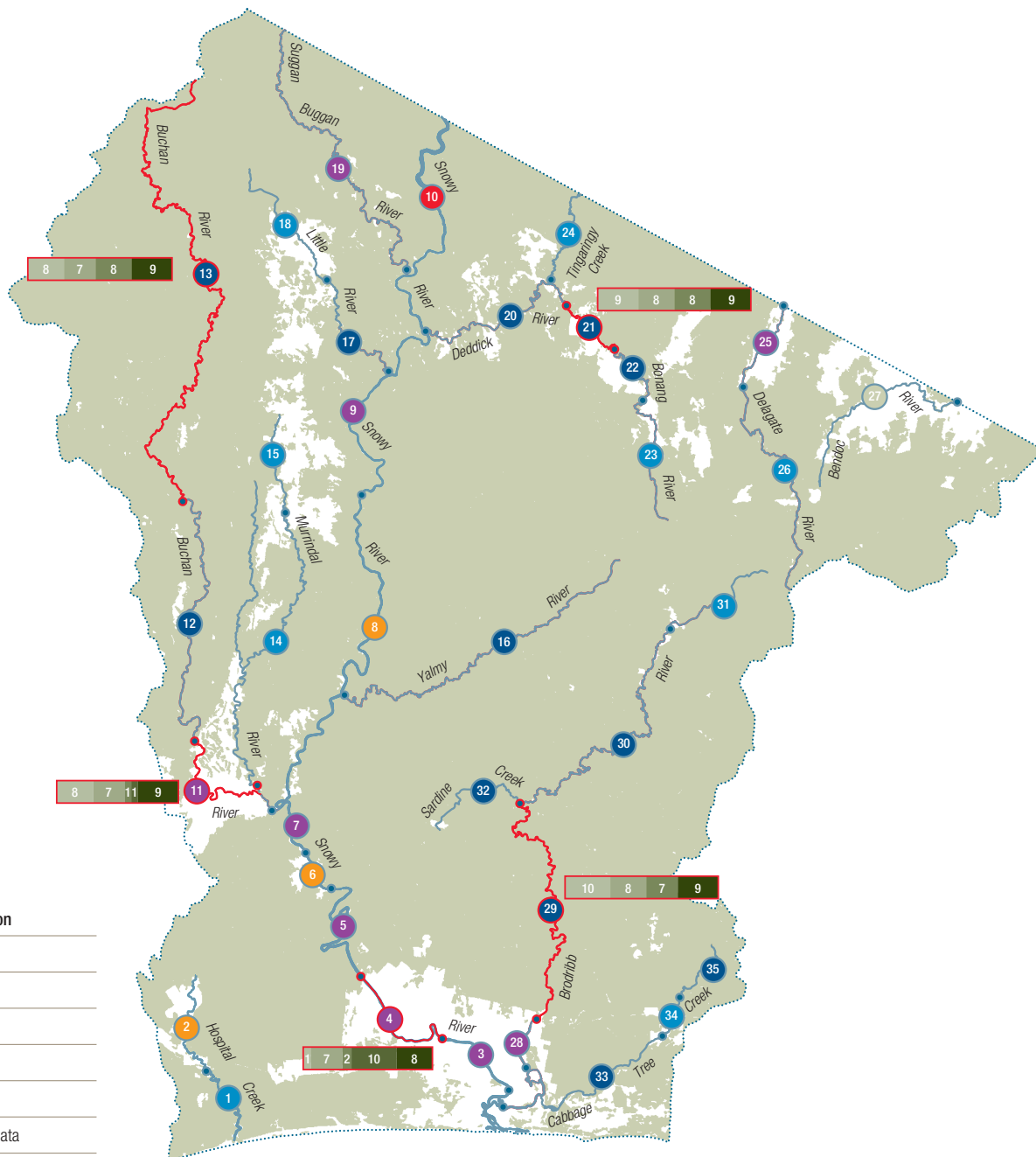


Wingar River



Genoa River

Basin 22 Snowy



Environmental Condition

- Excellent
 - Good
 - Moderate
 - Poor
 - Very Poor
 - Insufficient Data
 - Reach Division
 - Highlighted Reach
 - Forest (uncleared)
 - 10 Reach number
-

Cartography by Spatial Vision, 2000 M/6805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

The basin is characterised by spectacular mountain ranges and elevated plateaux in the north. The central section is dissected by deep, sinuous river valleys. Further south, undulating foothills line the valleys before flattening out to coastal plains and dune systems. Most of the catchment is heavily vegetated, although cleared areas exist near the township of Orbost on the Snowy River floodplain and other cleared valleys and floodplains along the Buchan, Brodribb and Murrindal Rivers. These cleared areas support agriculture, such as, dairying, sheep, cattle and horticulture. Industry is dominated by hardwood timber production, although extensive areas of forested land have been gazetted as conservation reserves, forming parts of the Snowy River National Park and the Cobberas-Tingaringy Unit of the Alpine National Park. Although there are no major dams, the flow regime of the Snowy River is impacted by dams in New South Wales.

Sixty-six percent of stream length in the basin was in good or excellent condition. The remainder, which ranges from moderate to very poor condition, is mainly in reaches along the Snowy River where heavily modified hydrology and extensive willow populations lower condition scores.

The entire length of the Snowy River has extremely modified flow regimes as a result of upstream extraction of water for the Snowy Mountains Hydro-electric Scheme. The impact of these extractions is essentially high stress in summer and winter as well as extended periods of low flow and fewer periods of high flow. In contrast, the remainder of reaches in the basin have largely unmodified hydrology. Reaches 29-31 on the Brodribb River, Sardine Creek (reach 32) and the Yalmy River (reach 16) all had natural flow regimes.

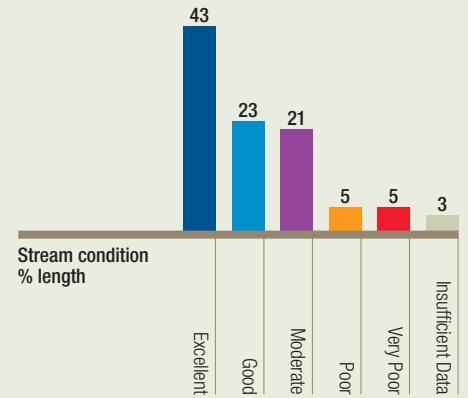
Of the basin's 35 reaches, five reaches on the Snowy River (reaches 3-5, 8 and 10) and one reach on the lower Buchan River (reach 11)

were assessed for water quality. The results show a reversal of expected trends along the Snowy River. For the uplands reach (reach 10), water quality is significantly poorer than the mid and lowland reaches (reaches 8 and 4). Reach 4 was at reference condition for all four parameters, but reach 10 had very poor results for all parameters. This was attributed to the testing station site being in an area severely affected by the 2003 bushfires. Reach 11 on the Buchan River also recorded extremely low scores for all parameters, attributed to the effect of cattle grazing and cleared land around this reach.

Results for streamside zone were highly varied, reflecting extremes in land use. Fourteen reaches, representing 43% of total stream length, were at or near reference condition. All are in heavily vegetated areas. In contrast, the reaches that scored very poorly (reaches 2, 8, 10, 11 and 25) are all in cleared areas that have stock access or extensive stands of willows. The effect of the bushfires was apparent at reaches 9 and 10 along the Snowy River.

The limited access to many of the reaches, the typically rocky nature of bed and banks, and the high levels of natural forest cover ensure that the physical form of the majority of reaches are in good condition. Banks are stable for most of the basin and there are no artificial barriers to restrict fish migration. Despite the extensive forest cover, large wood levels are low for most of the basin. In floodplain areas this could be attributed to desnagging in the past. The reach in the poorest condition was Hospital Creek (reach 2). The reach in best condition was on the Bonang River (reach 22).

Most reaches were assessed for aquatic life and results were consistently high. Over 70% of the reaches were near or at reference condition. The high scores are consistent with a relatively undisturbed basin.



Snowy

“Reach 10 had very poor results for all parameters which was attributed to the testing station site being in an area severely affected by the 2003 bushfires.”



Little River



Deddick River

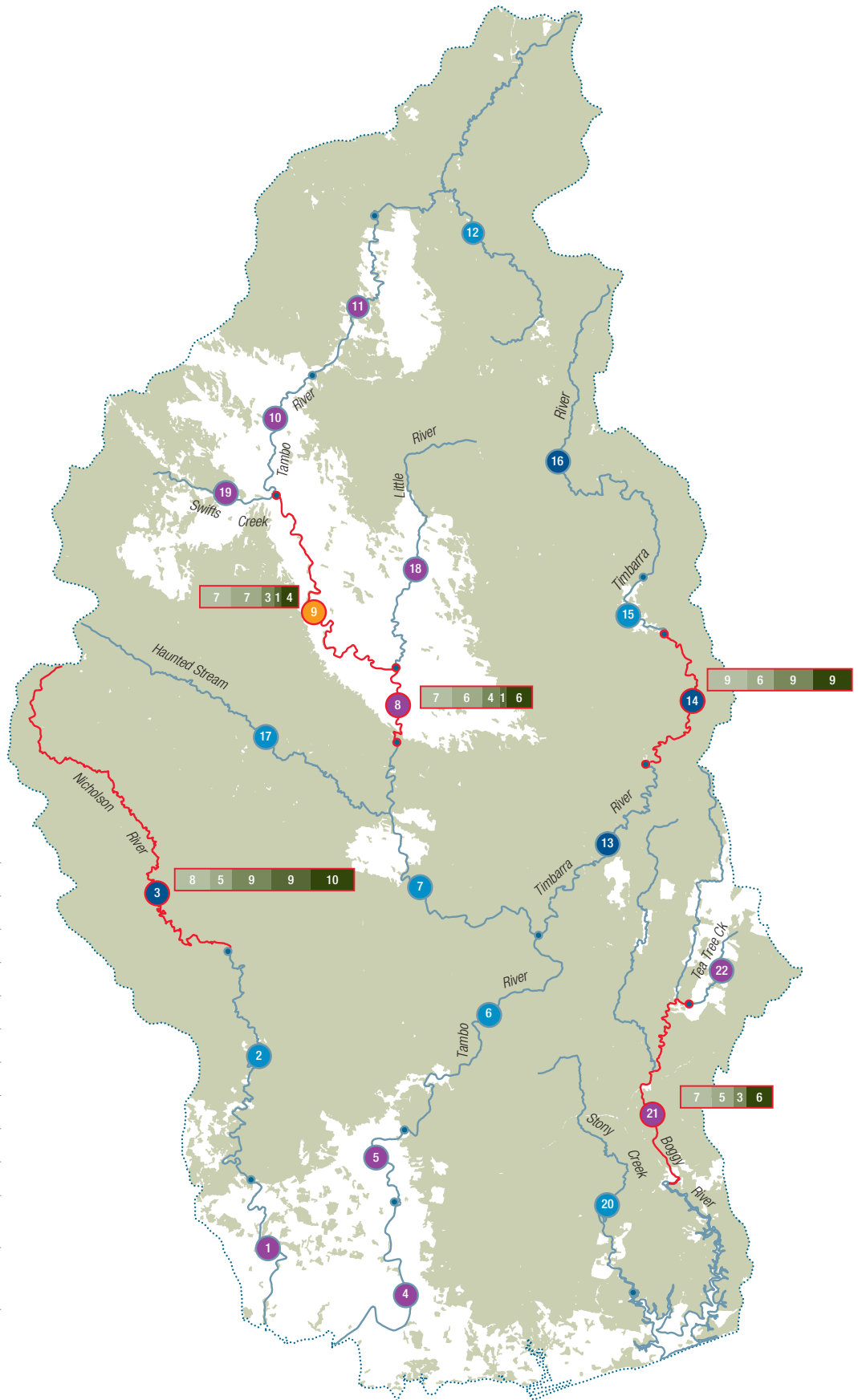


Sardine Creek

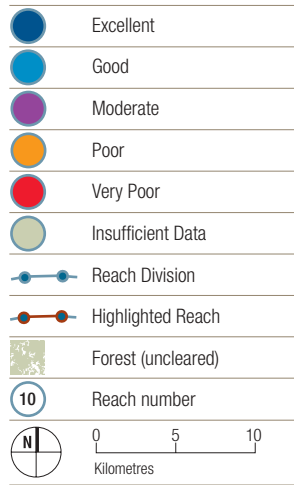


Deddick River

Basin 23 Tambo



Environmental Condition



Cartography by Spatial Vision, 2000 M/6805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

Although much of the basin is forested, large pockets of land in the upper catchment and on the floodplains have been extensively cleared for agriculture. In addition to agriculture, a major industry of early European settlement was alluvial gold mining in the upper tributaries of the basin. Since settlement, there has been a history of erosion and sediment transport associated with land clearing, grazing and mining activities. The Tambo and Nicholson Rivers feed into the Gippsland Lakes in the south. The only significant water storage is the Nicholson River Dam.

Consistent with the largely undisturbed nature of the basin, well over half of the stream length was classified in good or excellent condition (58%). Of the remainder, 36% was in moderate condition and only 6% in poor condition. The only reach in poor condition (reach 9) is in an area cleared for agriculture.

With only one major water storage, natural hydrological patterns have been largely maintained. This is reflected in the basin wide high scores for the hydrology sub-index. All reaches had minor, if any notable changes from natural flow regimes. Haunted Stream (reach 17) was unmodified. The Tambo and Nicholson Rivers show slight summer stress and minor increases in periods of low flows in their lower sections. This is due to offtakes for domestic and stock water supplies.

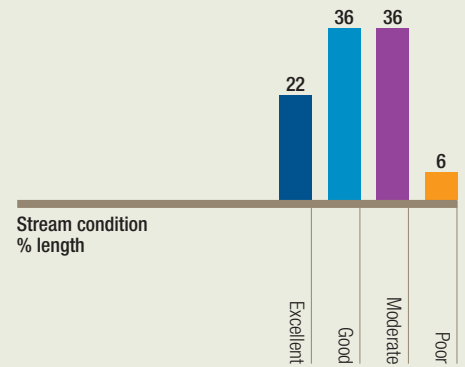
Water quality was assessed at three of the basin's 22 reaches, with vastly different results. At reach 3, in the heavily-forested west of the basin, the Upper Nicholson River was in near pristine condition. All parameters measured indicated very good water quality. The exception was salinity levels, which were

slightly elevated. In contrast, the mid-section of the Tambo River (reaches 8 and 9), had poor results for all parameters, except pH. This could be due to the surrounding land having been heavily cleared for agriculture, the impact of stock access to the riverbanks or the impact of the 2003 bushfires.

Results for streamside zone also varied markedly, reflecting the contrast between reaches in forested and cleared areas. Reaches in forested areas (such as reaches 3, 13, 14, 16 and 17) had the best riparian vegetation while the lowest scores were recorded for reaches in cleared areas of the basin, mainly on the Tambo River (such as reaches 5 and 8-11).

About three-quarters of the reaches had moderate modifications to physical form. Again, the range of scores correlated to reaches in cleared or forested areas. For a largely forested basin, scores for large wood were low. The exception was the Nicholson River (reaches 1-3), which had plentiful supplies of instream wood. Most reaches had moderately stable banks. Nearly all reaches were available for fish migration except the upper Nicholson River where fish migration is restricted by the Nicholson River Dam.

Most reaches were assessed for macroinvertebrates and scores varied, again in part reflecting the impact of contrasting land uses. Reaches with the poorest ecological condition (reaches 9, 10 and 22), were all in cleared areas. Those reaches at reference condition (reaches 3 and 12-14) were in forested upper catchment areas.



Tambo

“Consistent with the largely undisturbed nature of the basin, well over half of the stream length was classified in good or excellent condition.”



Nicholson River

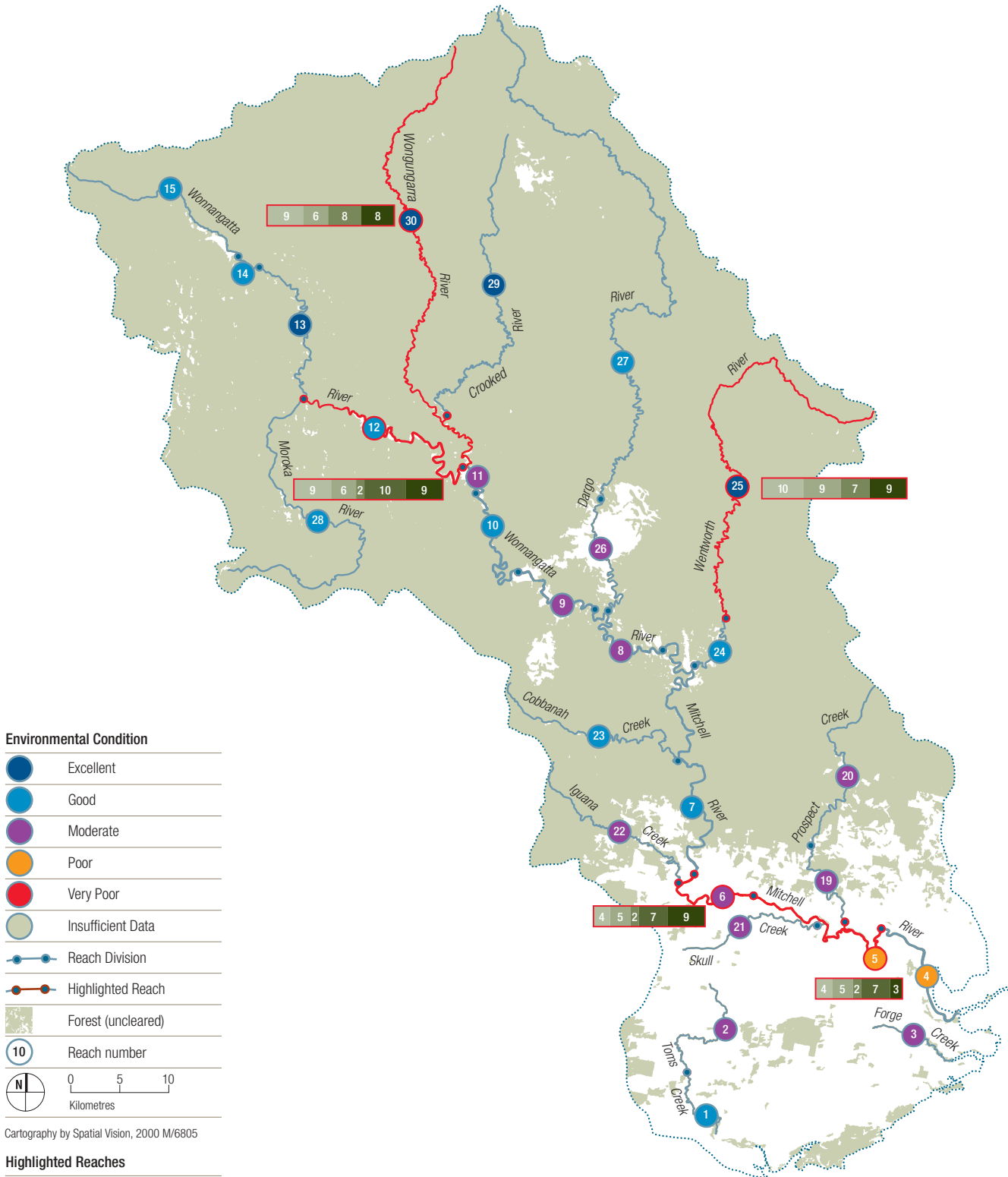


Tambo River



Timbarra River

Basin 24 Mitchell



The heavily-forested Eastern Highlands form the northern boundary of the basin. Apart from small clearings for grazing along the Dargo and Wonnangatta Rivers, the northern and central sections are naturally forested and sparsely populated. The Alpine and Mitchell River National Parks are in these sections. The Gippsland Red Gum Plains in the south have been extensively cleared and used intensively for agriculture, such as grazing and grain production. In addition to agriculture, a major industry of early European settlement was alluvial mining in the upper tributaries of the Mitchell River. There are no major in-stream water storages in the basin.

The high level of forest cover and low level of hydrological development is reflected in the good condition of the basin's streams, with 70% of stream length in good or excellent condition. Of the remainder, 25% was classed in moderate condition and 5% in poor condition. The reaches assessed as poor (reaches 4 and 5) were in areas of cleared floodplain.

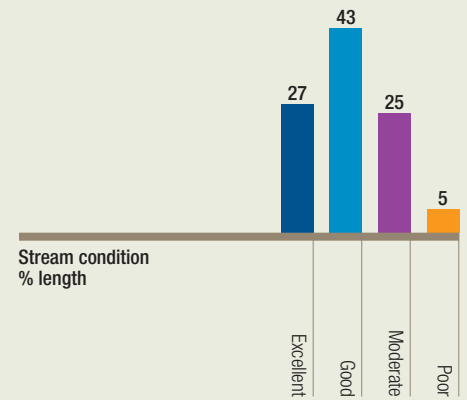
The lack of any major hydrological development means that the hydrology is mostly in near natural condition. Scores varied from streams with moderate modifications to those that were unmodified. The poorest scoring reaches (reaches 4-6) were on the Mitchell River floodplain where water supply to the major population centres of East Gippsland and irrigated horticulture on the Lindenow flats has altered the natural flow regimes. These reaches have increased periods of low flow and show slight summer stress. The highest scoring reaches (reaches 7-15 and 23-30) are in forested upper catchment areas.

Five of the basin's 27 reaches were assessed for water quality (reaches 3, 5, 8, 12 and 26) and the results reflect their locations. Reach 12, on the densely forested Wonnangatta River, had good water quality. In contrast, reaches 5, 6 and 26, all in cleared parts of the basin had elevated total phosphorus and salinity levels.

Results for the streamside zone varied widely, with higher scoring reaches in forested areas and the lower scoring reaches in cleared areas. As expected, floodplain reaches that had been heavily modified, scored poorly on all aspects of vegetation. The exception was longitudinal continuity, indicating that a narrow band of vegetation remains along most streams. Surprisingly, in the forested reaches, where consistently high scores would be expected, some reaches scored only moderately for understorey diversity, regeneration and number of larger trees. The effect of the bushfires was apparent at reaches 29 and 30.

In terms of physical form, reaches ranged from those with major modification to those in near reference condition. All reaches had minor to moderate levels of bank instability. Large wood was abundant on all the upland tributaries of the Mitchell River, with very little on the floodplain sections.

Aquatic life was assessed for nearly half the reaches. Like results for water quality and streamside zone, scores were generally high, at or near reference condition for all upland reaches and lower for cleared floodplain reaches.



Mitchell

“Scores were generally high for all upland reaches and lower for reaches in cleared floodplains.”



Cobbanah Creek

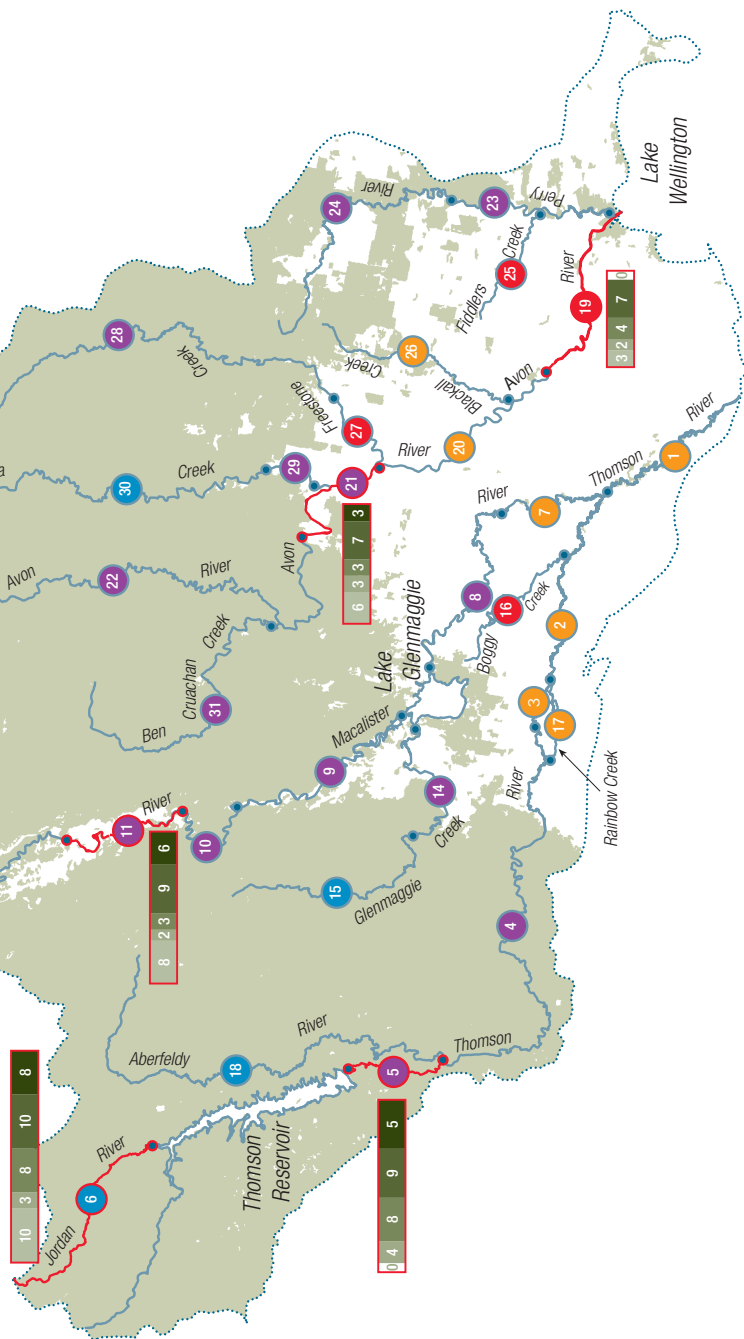


Wonnangatta River



Dargo River

Basin 25 Thomson



Environmental Condition

- Excellent
- Good
- Moderate
- Poor
- Very Poor
- Insufficient Data

Reach Division

Highlighted Reach

Forest (uncleared)

Reach number

0 5 10
Kilometres

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

Cartography by Spatial Vision, 2000 M/6805

The northern two-thirds of the Thomson catchment are dominated by the mountain forests of the Eastern Highlands. At the foot of the highlands are two major dams, Lake Glenmaggie and the Thomson Reservoir. In the south, the low relief, rich soils and availability of water for irrigation has meant that the land has been favoured for agriculture, particularly around Lake Glenmaggie, the township of Heyfield and on the Macalister, Avon and Thomson River flats.

The condition of streams reflects the impact of surrounding land use. In the forested highland reaches, stream health was mainly good to moderate. Twenty-two percent of stream length was in good condition. Most streams in the mid-catchment were in moderate condition (55% of total stream length) and towards the south, stream health deteriorated to poor (16%) or very poor (7%). This was attributed to a concentration of farming activities on the cleared lowlands of the south.

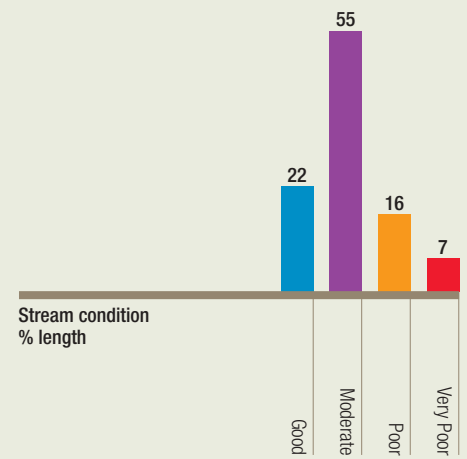
Lake Glenmaggie and the Thomson Reservoir have had significant impact on the basin's hydrology. The hydrological condition of streams ranged from those with extreme modifications to flow regimes to those in natural condition. Generally, reaches below Lake Glenmaggie and Thomson Reservoir had highly modified flow regimes. These reaches had increased periods of low flow, decreased periods of high flow and both winter and summer stress. Reach 5, immediately downstream of the Thomson Reservoir, had the most impacted flow regime in the basin. This reach had reversed seasonality due to the Reservoir, meaning high flows occur during January and February and low flows during the winter months. In contrast, reaches above the water storages had only slight or no modifications to natural flow regimes. Two reaches were assessed as in natural condition (reaches 6 and 13), both headwater streams in the north.

Seven of the basin's 31 reaches were assessed for water quality. Of these, four reaches had good water quality (reaches 5, 6, 8 and 11). Reach 20 on the lower Avon River, had high salinity levels and acidic pH. This could be attributed to inflows from Boisdale No. 1 and 2 irrigation drains.

The wide range of results for streamside zone parameters directly reflected surrounding land use. More than 30% of reaches were assessed as being close to reference condition. These reaches were in the vegetated north and west of the catchment. In comparison, the reaches that scored very poorly for streamside zone parameters were in the lowland regions of the basin where surrounding land has been heavily modified for agriculture or urban development.

Overall, results for physical form were poor. All reaches were affected by major barriers to fish migration and, with the exception of two reaches (reaches 13 and 30), all had low levels of large wood. This is surprising because much of the basin is heavily forested, however, all lowland reaches have been desnagged in the past. Banks were generally stable for most reaches in the forested north and less stable in the cleared lowlands in the south.

Half the basin's reaches were assessed for aquatic life and, like the results for streamside zone, results reflected surrounding land use. Most of the headwater streams were at or near reference condition but reaches in the agricultural lowlands (such as reaches 1, 14, 16, 19 and 27) scored poorly, indicating highly impacted biological populations.



Thomson

“Lake Glenmaggie and the Thomson Reservoir have had significant impact on the hydrology of the basin.”



Macalister River

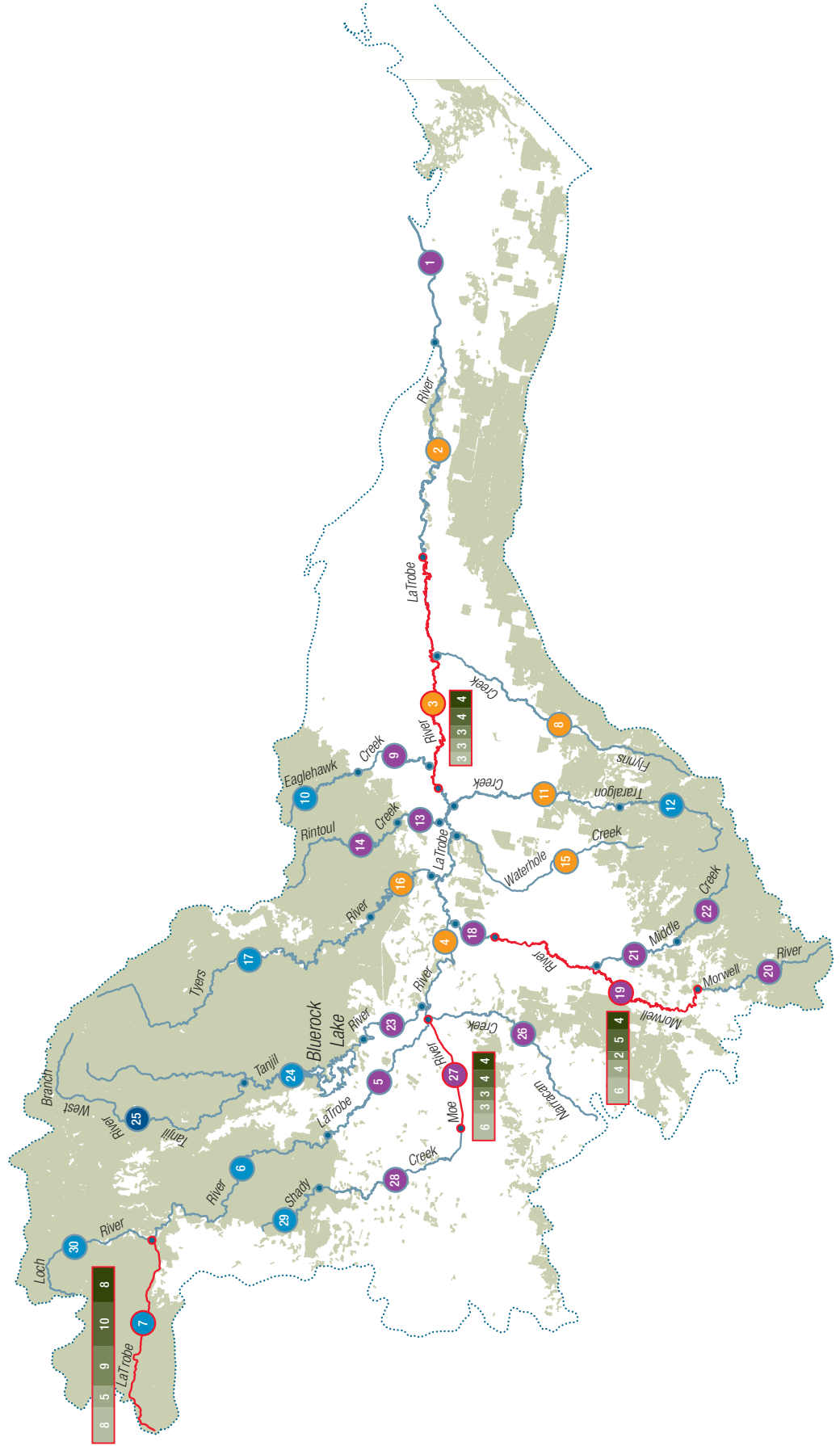


Valencia Creek

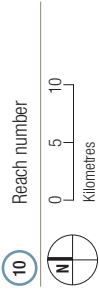
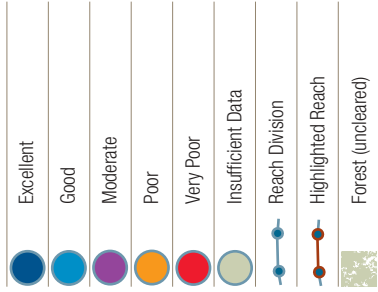


Avon River

Basin 26 LaTrobe



Environmental Condition



Cartography by Spatial Vision, 2000 M66805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

The basin is characterised by extensive forested areas of the Strezlecki Ranges on the southern boundary and of the Great Dividing Range on the northern boundary. The basin's streams rise in these mountainous areas and drain to Lake Wellington, outside the catchment to the east. Although agriculture (mainly dairying and potato farming) and timber production are important industries in the basin, the dominant feature of land use is the mining of brown coal for the major thermal power stations at Loy Yang, Hazelwood and Yallourn. There are four major water storages: Bluerock Dam, Moondarra Reservoir, Yallourn storage (Lake Narracan) and the Hazelwood Pondage.

Reaches rated in good to excellent condition dominated the northern forested region, making up 35% of total stream length. The remainder of reaches were in moderate to poor condition (65%) and are distributed in a band running east to west across the centre of the catchment. Notably, the health of both the LaTrobe and Tanjil Rivers deteriorates markedly as they wind downstream. This was attributed largely to modified hydrology and a lack of native vegetation.

Reflecting the extremes in land use, results for the hydrology sub-index ranged from streams with extreme modifications to natural flow regimes to those in near natural condition. The poorest scoring reaches, 16 and 26, both supply water to the township of Moe and therefore have highly modified flows. All hydrological parameters for Narracan Creek (reach 26) were modified. A number of reaches had long periods of low flow and summer stress (reaches 1-4, 8, 15, 16, 18, 23 and 26). This was attributed to the operation

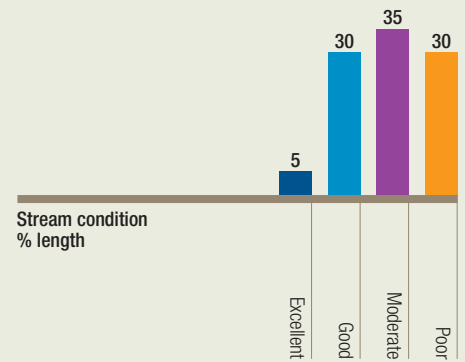
of upstream reservoirs and offtakes for irrigation, stock and domestic water supply and the presence of significant farm dams in the drainage gullies of the potato farming district.

Eight of the basin's 30 reaches were assessed for water quality, with scores ranging from poor to good water quality. Forested headwater reaches, (reaches 7 and 24), had good water quality. Reaches 2, 3, 6, 19 and 27 all had elevated total phosphorus, turbidity and salinity levels. This was attributed to a range of factors including dairying in high rainfall zones, effects of drainage scheme discharge and run-off from unsealed roads.

Results for the streamside zone strongly reflected surrounding land use. Seven reaches, all in the forested region in the north, showed only slight or no modification from reference state. The remainder, in cleared agricultural and mining regions, scored poorly for all parameters, due to narrow and disjointed sections of streamside vegetation.

Similarly, results for physical form were also poor. Even reaches in the forested sections of the catchment scored only moderate results for all physical form parameters. The remainder had minor to moderate levels of bank instability, low levels of large wood and significant barriers inhibiting fish migration.

More than half of the basin's reaches were assessed for aquatic life. Of these, six were at reference condition (reaches 5, 6, 7, and 23-25) and six showed little diversity for macroinvertebrate populations (reaches 3, 4, 8, 19, 21 and 27).



LaTrobe

“The health of both the LaTrobe and Tanjil Rivers deteriorates markedly as they wind downstream, attributed largely to modifications to flow patterns and a lack of native vegetation.”



LaTrobe River



LaTrobe River

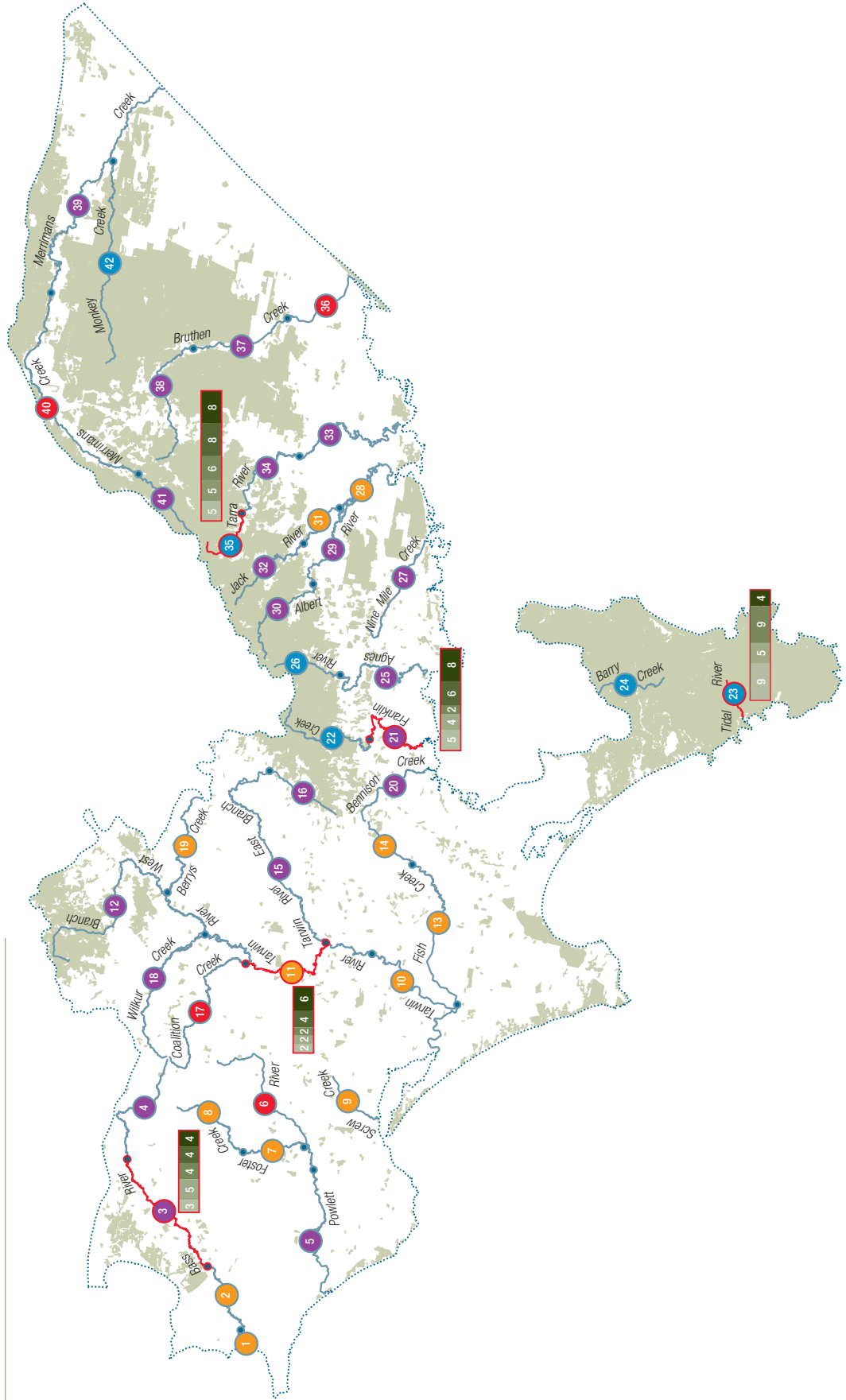


Traralgon Creek



Morwell River

Basin 27 South Gippsland



Environmental Condition

- Excellent
- Good
- Moderate
- Poor
- Very Poor
- Insufficient Data

Reach Division

- Highlighted Reach

Forest (uncleared)

- Reach number

Scale: 0 5 10 Kilometres

Cartography by Spatial Vision, 2000 M16605

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

The basin contains some of Victoria's most productive agricultural land as well as significant areas of high conservation value, such as Wilsons Promontory, which is bordered by the Corner Inlet and Nooramunga Marine and Coastal Park. Mountain ranges form the northern boundary, giving way to gentle hills in the central region and undulating coastal plains in the south. There are two major water storages, Candowie and Lance Creek Reservoirs.

Over half the stream length (54%) in the basin was in moderate condition and one-third in poor to very poor condition (25% and 11% respectively). Most reaches classed as poor or very poor are in the west of the basin, where altered hydrology and sparse vegetation coverage has had a marked impact. Five reaches, representing 10% of total stream length, were in good condition. All are in the forested east area of the catchment and Wilsons Promontory.

Reflecting the extremes in land use, scores for the hydrology sub-index varied dramatically. Reaches in Wilsons Promontory had natural flow regimes. The large number of water diversions for irrigation, stock and domestic supply has caused considerable changes to the flow regimes of most streams. In particular, increased periods of low flow and summer stress were noted, especially on reaches in the west (reaches 1-14) and Merrimans Creek (reaches 39-41) in the east.

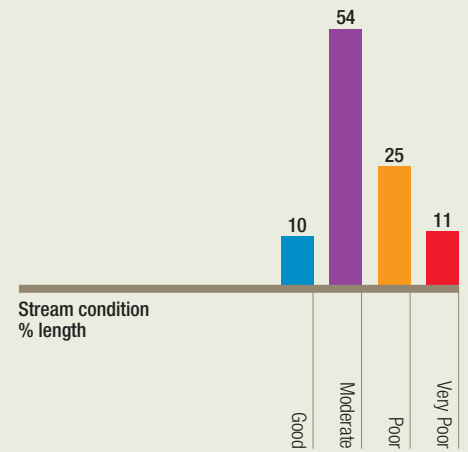
Eight of the basin's 42 reaches were assessed for water quality. Generally, reaches in the forested east (reaches 33, 35 and 39) had better water quality compared to reaches 2 and 11, in heavily cleared parts of the basin.

Water quality in these reaches was poor and was probably affected by inflow from Coalition, Ruby and Little Ruby Creeks and stormwater runoff from the township of Leongatha. In particular, phosphorus levels for sites assessed in the west were very high, as was turbidity in reaches 11 and 21.

Most reaches scored poorly for streamside zone parameters, indicating highly modified streamside environments. Almost half the reaches had a significant amount of weeds, mainly willow and hawthorn trees. Four reaches were in reference condition (reaches 22-24 and 41), all in heavily forested areas.

Similar to results for streamside zone, most reaches scored poorly for physical form. Most banks showed minor to moderate levels of instability and all reaches, except reaches 24, 26 and 42, had low levels of instream wood. The highest scoring reach was on Monkey River (reach 42) in the heavily forested north-east corner of the basin. Monkey River was the only stream in the basin with unrestricted fish access.

Nearly half the basin's reaches were assessed for aquatic life. The four poorest quality reaches were on the Bass River (reaches 2 and 4), Screw Creek (reach 9) and on Tidal River (reach 23). The poor result for reach 23 was largely attributed to the macroinvertebrate assessments being developed for freshwater and not estuarine systems. Three reaches were at or near reference condition (reaches 10, 15 and 19). Surprisingly, all are in the central region of the basin where results for streamside zone and physical form were only poor to moderate.



South Gippsland

“The basin contains some of Victoria's most productive agricultural land as well as significant areas of high conservation value, such as Wilsons Promontory, which is bordered by the Corner Inlet and Nooramunga Marine and Coastal Park.”



Albert River

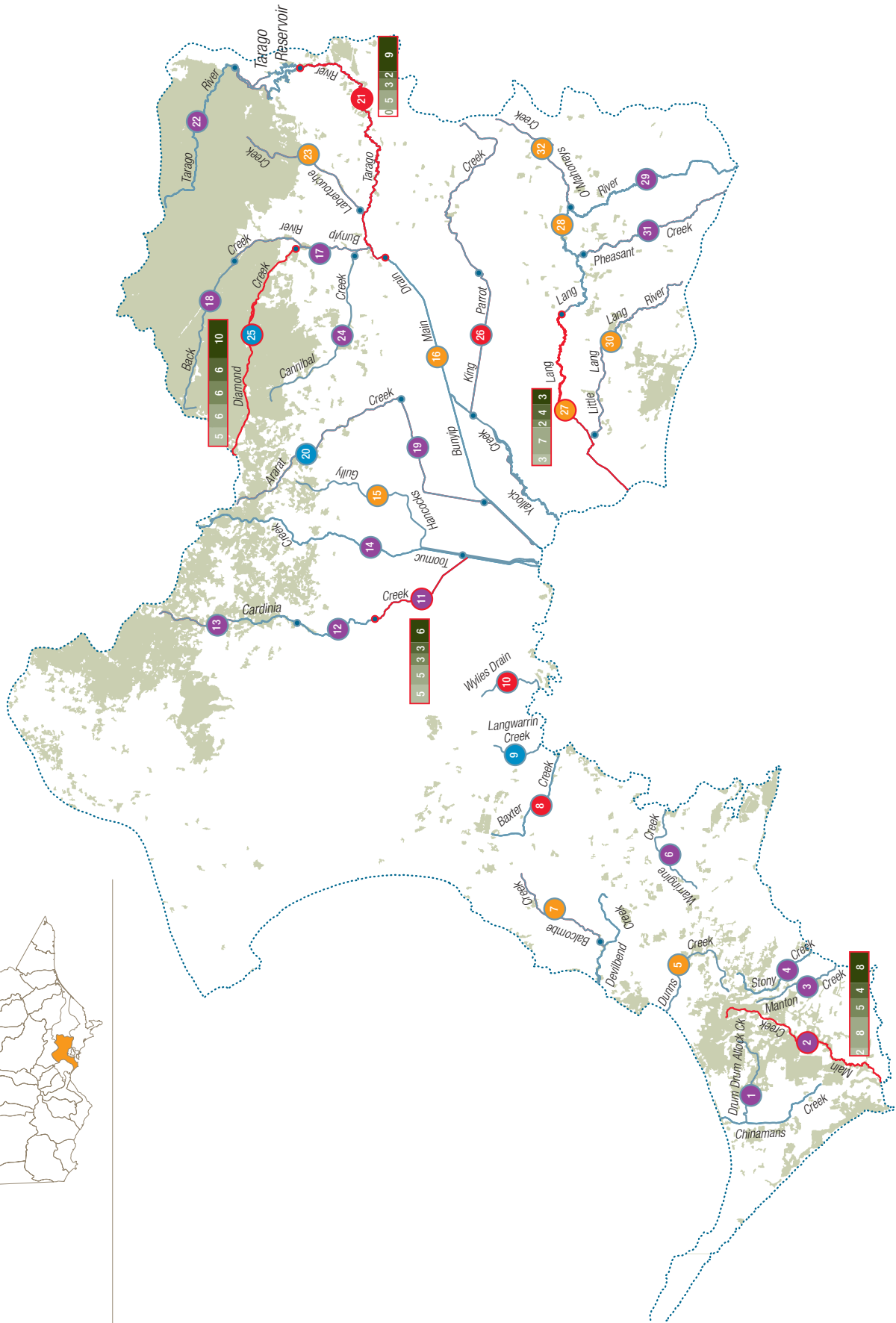


Monkey Creek



Jack River

Basin 28 Bunyyip



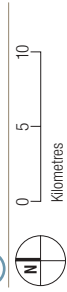
Environmental Condition

- Excellent
- Good
- Moderate
- Poor
- Very Poor
- Insufficient Data

Reach Division

- Highlighted Reach
- Forest (uncleared)

Reach number



Cartography by Spatial Vision, 2005 M6805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

Land use is split between the sprawling south-eastern suburbs of metropolitan Melbourne and the Mornington Peninsula and the agricultural areas to the north and east of Western Port Bay and French Island. The northern highlands, including the Bunyip State Park, and the southern uplands, including parts of the Strezlecki Ranges, peter out to the flat, undulating terrain of the former Koo Wee Rup Swamp region. Since European settlement, the Swamp has been drained for agriculture and today supports extensive market gardens. There are two major water storages within the basin, the Tarago and Cardinia Reservoirs.

Only three reaches (reaches 9, 20 and 25), were in good health. Most reaches were in moderate to poor condition (47% and 27% respectively). The remainder were in very poor condition. The poor results reflect the heavily modified vegetation and modified hydrological patterns.

Natural flow regimes have been highly modified due to the operation of the reservoirs, private diversions and farm dams. Nearly all reaches experienced increased periods of low flow and summer stress. Reaches 21-23 on the Tarago River and Labertouche Creek also experienced winter stress. Reaches 8, 21 and 23 had extended periods of zero flow. Back Creek (reach 18) had no diversions and therefore a natural flow regime.

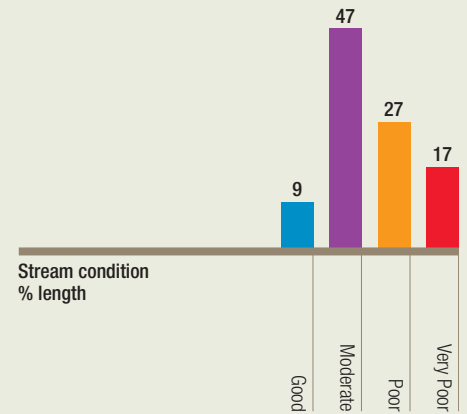
Two-thirds of the basin's 32 reaches were assessed for water quality. Only two reaches – 22 and 25, both in the basin's vegetated north-

east – scored above a moderate condition rating. Reach 22 on the Upper Tarago River, however, showed a high pH. Nearly all reaches surveyed had elevated levels for total phosphorus, salinity and turbidity. These poor results can be attributed to the effects of the highly modified environment and intensive agriculture.

Although scores for the streamside zone ranged from very poor to moderate, only six of the basin's 33 reaches scored above a poor rating, indicating that very little native vegetation remains. One-third of reaches were extensively cleared and had very little vegetation remaining.

Results for physical condition varied from poor to good. Except for some upper reaches of streams in the north, all reaches had little instream large wood. All reaches had minor to moderate levels of bank instability. Nearly all reaches were affected by barriers impeding fish migration.

Eighteen of the basin's 33 reaches were assessed for aquatic life. All reaches in the upper, more forested part of the basin scored highly, indicating that they are at or near reference condition. However, due to the clustered location of the sampling points, the results are not representative of the more developed parts of the basin.



Bunyip

“Nearly all reaches surveyed had elevated levels for total phosphorus, salinity and turbidity, due to the effects of the highly modified environment and intensive agriculture.”

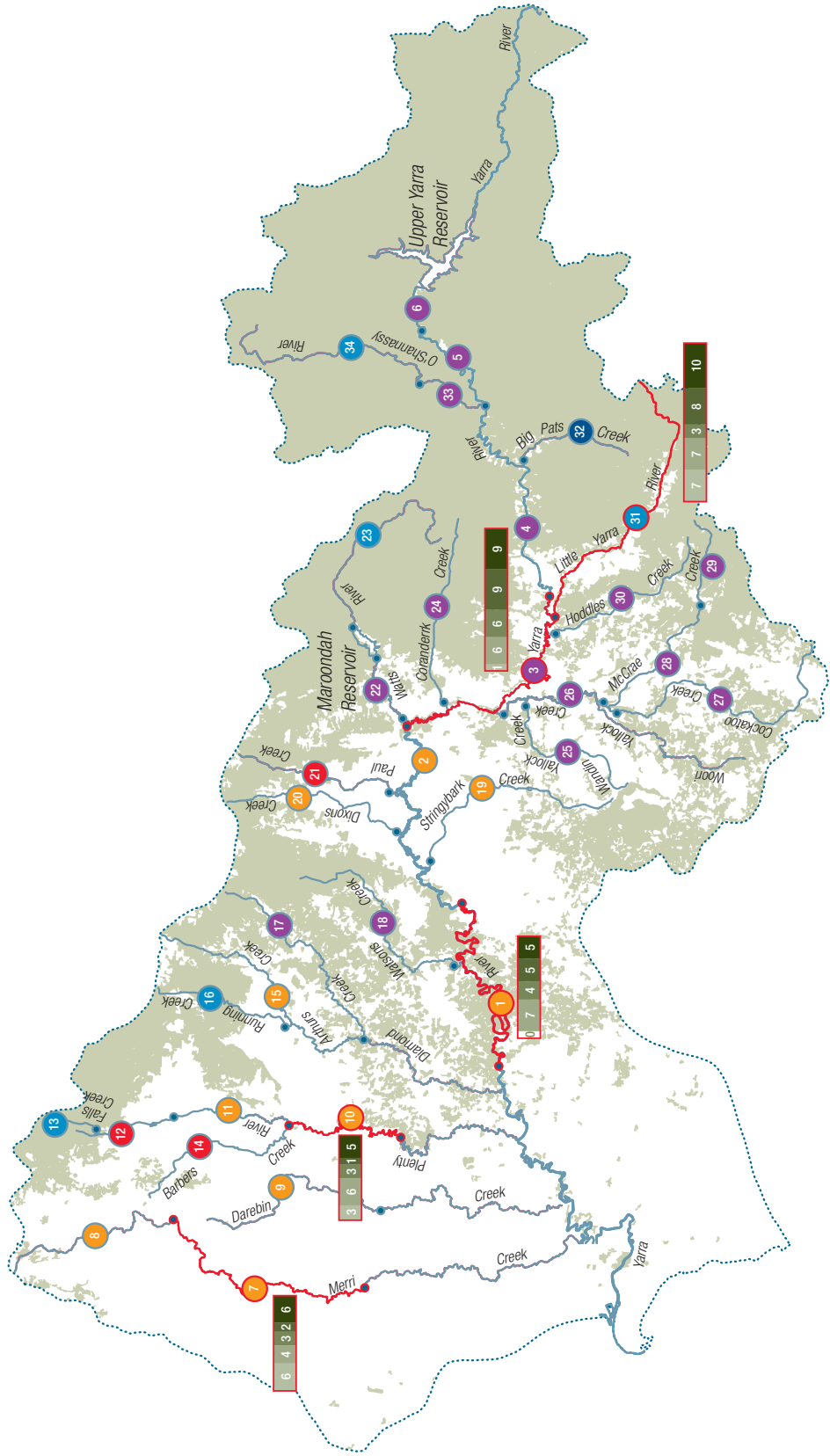


Tarago River



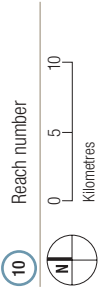
Balcombe Creek

Basin 29 Yarra



Environmental Condition

- Excellent
- Good
- Moderate
- Poor
- Very Poor
- Insufficient Data
- Reach Division
- Highlighted Reach
- Forest (uncleared)



Cartography by Spatial Vision, 2005 M66805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

The basin is bounded in the north by the Great Dividing Range and in the east and south-west by extensive urban development, making up a large portion of the northern and eastern suburbs of metropolitan Melbourne. Beyond the urban area, to the north, east and south-east, diverse agricultural production includes market gardens, orchards, berry farms and beef cattle. Some areas are among Victoria's highest levels of farm density. The flows of the Yarra River are highly regulated by storages, including the Upper Yarra and Maroondah Reservoirs, and are reduced by major diversions for the Melbourne water supply system.

Only stream reaches outside the Melbourne metropolitan area were assessed in this benchmarking exercise. An urban ISC is currently under development by Melbourne Water, but in the meantime, their Index of River Condition (IRC) is available at the rivers and creeks link on the Melbourne Water website (www.melbournewater.com.au).

Most of the non-metropolitan reaches were rated in moderate condition (40% of total stream length). Of the others: 14% – in the northern and eastern forested all areas – were in good to excellent condition; and 46% – mostly located along the rural sections of the three lowest tributaries (Merri Creek, Darebin Creek and Plenty River) – were in poor to very poor condition.

The operation of major reservoirs has had significant impact on basin hydrology. With the exception of reaches 23, 32 and 34, which were not impacted by regulated water storages, most reaches had extensively altered flow regimes. Nearly all reaches had extended periods of low flow and showed summer stress. In addition, reaches 1-4 on the middle section of the Yarra River, had reduced periods of high flow, and extreme summer and winter stress.

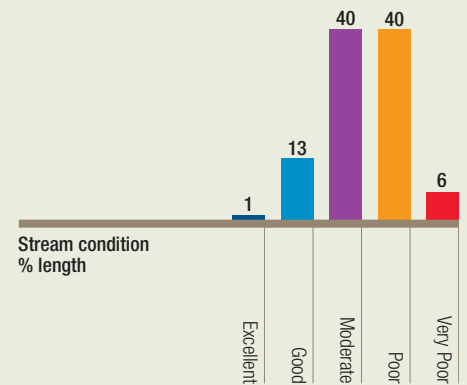
Water quality data was available for 23 of the 34 non-metropolitan reaches. Scores

varied markedly across the basin. The poorest scoring reach was reach 10 on the lower Plenty River. This is attributed to pollution from surrounding urban and industrial development. Reaches 3 and 4 along the Yarra River had water quality at near reference condition. Scores for pH were near or at reference for all assessed reaches, except reaches 7 and 8 on the Merri Creek. Scores for both salinity and total phosphorus tended to be very good in the east of the basin, but poor toward the west. This is attributed to the impact of cleared land.

Half the reaches scored poorly for streamside zone, indicating extreme modification from reference condition. Reaches on the Merri, Darebin and Stringybark Creeks (reaches 8, 9 and 19 respectively) had the poorest streamside zones. The highest scoring reaches, (reaches 5, 6, 24, 29 and 33) were predominantly recorded on headwater streams in the forested areas of the basin. Overall, reaches in the forested upper catchment scored well for longitudinal continuity, vegetation width and diversity.

Results ranged dramatically for physical form and, like those for streamside zone, reaches in forested sections of the upper catchment tended to be in the best condition. The highest scoring reaches were all in the east (reaches 5, 6, 22, 30, 32 and 33). The poorest scoring reaches (reaches 8, 9, 14 and 21) were in the west. Poor scores may be due to cleared forest cover or that grasslands are typical to the area and instream wood is therefore naturally less likely. All other reaches had moderate to high amounts of large wood and relatively stable banks.

Seven reaches were assessed for aquatic life. Scores were high, indicating healthy macroinvertebrate populations. Reaches 5 and 20 were near reference condition while reaches 2, 22 and 24 were also of high quality. The lowest score was at reach 4 on the Yarra River.



Yarra

“The ISC has only been applied to stream reaches outside the Melbourne metropolitan area.”



Plenty River

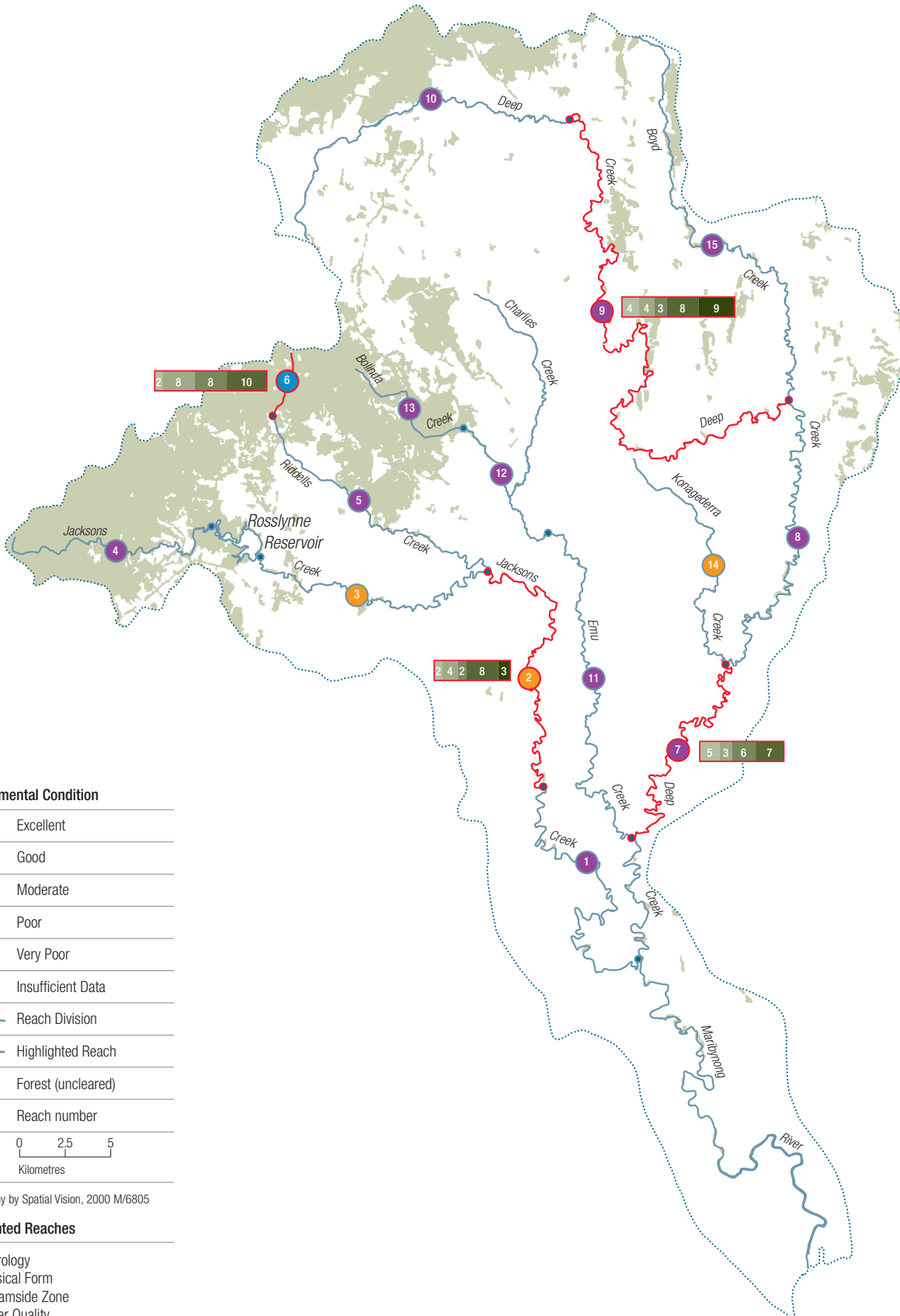


Big Pats Creek

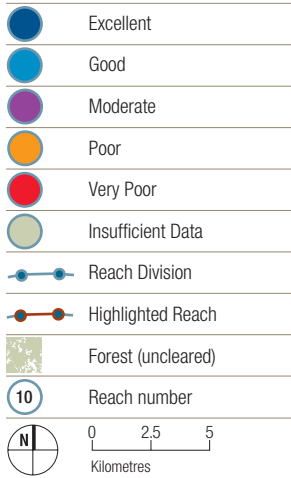


Yarra River

Basin 30 Maribyrnong



Environmental Condition



Cartography by Spatial Vision, 2000 M/6805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

Nearly 80% of the basin is rural land, supporting dairy and beef cattle, sheep and cereal crops. In the south, small pockets of intensive market gardening remain on the low-lying river flats around the suburb of Keilor. The lower 15 km is heavily developed, comprising the north-western suburbs of Melbourne. Rosslynne Reservoir on Jacksons Creek is the only major water storage.

Only stream reaches outside the Melbourne metropolitan area were assessed in this benchmarking exercise. An urban ISC is currently under development by Melbourne Water, but in the meantime, their Index of River Condition (IRC) is available at the rivers and creeks link on the Melbourne Water website (www.melbournewater.com.au).

Over 80% of stream length was in moderate condition and 15% in poor condition, consistent with the heavily developed land and extremely modified hydrology. Only one reach was in good condition – reach 6 (upper Riddells Creek).

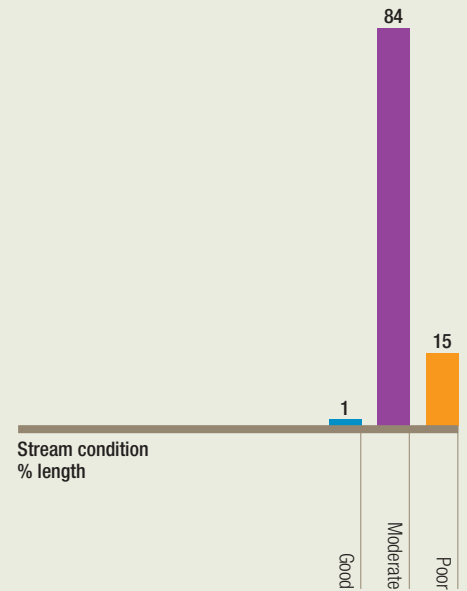
The natural hydrological patterns have been heavily affected by altered flows for both private diversions and demand for urban water supply for large towns including Sunbury, Gisborne and Macedon. All reaches have increased levels of low flow and experience summer stress. Reaches on Riddells and Jacksons Creeks had the most altered flow regimes.

Seven of the basin's 41 reaches were assessed for water quality. Despite the highly developed environment, all reaches had generally good water quality. The only exception was the elevated salinity levels for reaches 2, 3, 7 and 8.

Reaches 6 and 13 – all in the vegetated highlands in the western corner of the basin – had streamside zones assessed as close to reference condition. Most reaches had poor vegetation condition. The poor scores for longitudinal continuity, large trees and tree cover parameters indicate that considerable vegetation has been removed from the streamside zone.

Consistent with the intensively developed land, most reaches were assessed as having major modifications to physical form. Riddells Creek (reach 6), located in the vegetated western corner of the basin, was assessed as being in the best condition. Fish migration was severely restricted on all reaches, with numerous barriers throughout the basin preventing fish movement. Generally, banks were stable for all reaches. There were low levels of large wood for all reaches, with the exception of reaches 6 and 13. Both of these reaches are located in the vegetated western corner of the basin.

One-third of the basin's reaches were assessed for aquatic life. Results ranged from very modified to reference. The lowest score was at reach 2 on Jacksons Creek, where land has been totally cleared for urban development. Reaches 9, 10 and 12 were at or near reference condition.



Maribyrnong

“Fish migration was severely restricted on all reaches, with numerous barriers throughout the basin preventing fish movement.”



Deep Creek



Jacksons Creek



Jacksons Creek



Deep Creek

Basin 31 Werribee



Cartography by Spatial Vision, 2000 M/6805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

Most of the land has been cleared for agriculture and urban development. Reclaimed swamp lands around Bacchus Marsh support orchards and market gardens. Towards the south, expanding metropolitan populations have changed the region from rural land to an urbanised commuter suburb. There are many major dams, notably Pykes Creek, Merrimu and Melton Reservoirs. Flow regimes are highly regulated and water is extracted for irrigation and domestic use.

Only stream reaches outside the Melbourne metropolitan area were assessed in this benchmarking exercise. An urban ISC is currently under development by Melbourne Water, but in the meantime, their Index of River Condition (IRC) is available at the rivers and creeks link on the Melbourne Water website (www.melbournwater.com.au).

Most of the basin was in moderate to poor condition (36% and 39% respectively), reflecting the impact of highly regulated flow regimes and highly developed land. The 19% of stream length in good or excellent condition was confined to headwater streams, mainly in the vegetated northern corner of the basin.

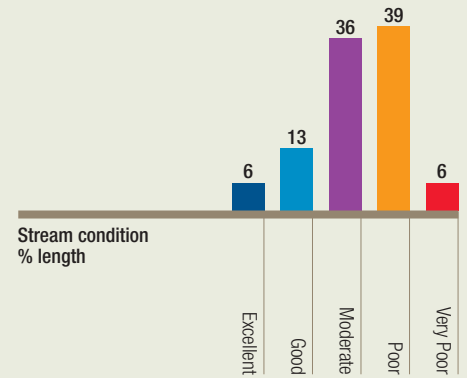
Results for the hydrology sub-index varied considerably from flow regimes that have been heavily modified to those in near natural state. A number of reaches, all upstream of major reservoirs, were in near natural state (reaches 6, 10, 12, 19, and 20). Reaches downstream had poorer results. Toolern Creek (reaches 7 and 8) and the lower Werribee River (reaches 1-3) had increased levels of low flow due to private diversions. The lower Werribee River also showed summer and winter stress. Reaches 18 and 24 experienced summer stress and reaches 7-9, experienced winter stress.

Four of the basin's 26 reaches were assessed for water quality. Conditions ranged from poor to very good. Reach 15 on the upper Lerderberg River had the best water quality. Reaches in cleared agricultural areas had poorer results – for example, elevated total phosphorus levels at reaches 2 and 7 and elevated salinity levels at reaches 7 and 18.

The condition of the streamside zone varied widely from heavily modified to near reference condition. Like results for hydrology and water quality, reaches in the forested northern part of the basin were in good to excellent condition. In contrast, reaches in the south and east of the basin scored poorly, consistent with the highly developed surrounding land. In particular, a number of creeks (including Parwin, Kororoit and Skeleton) had little or no quality native vegetation remaining.

Results for physical form were generally poor – no reach was assessed above moderate condition. Stream banks showed moderate levels of instability. A number of barriers restricted fish migration. Quantities of large wood in all reaches were poor except for three forested reaches (reaches 6, 12, and 21).

Almost half of the basin's reaches were assessed for aquatic life. The Werribee River below Bostock Reservoir (reaches 2, 3 and 5) was in the poorest condition. Generally, poorer scores were recorded in cleared reaches. The highest scores were recorded at the headwaters of the Lerderberg River (reach 15) and at reach 4, a section of the Werribee River, in an isolated pocket of forest. Both these reaches were near reference condition.



Werribee

“The highest aquatic life scores were recorded at the headwaters of the Lerderberg River and in a section of the Werribee River situated in an isolated pocket of forest.”



Goodmans Creek



Spring Creek

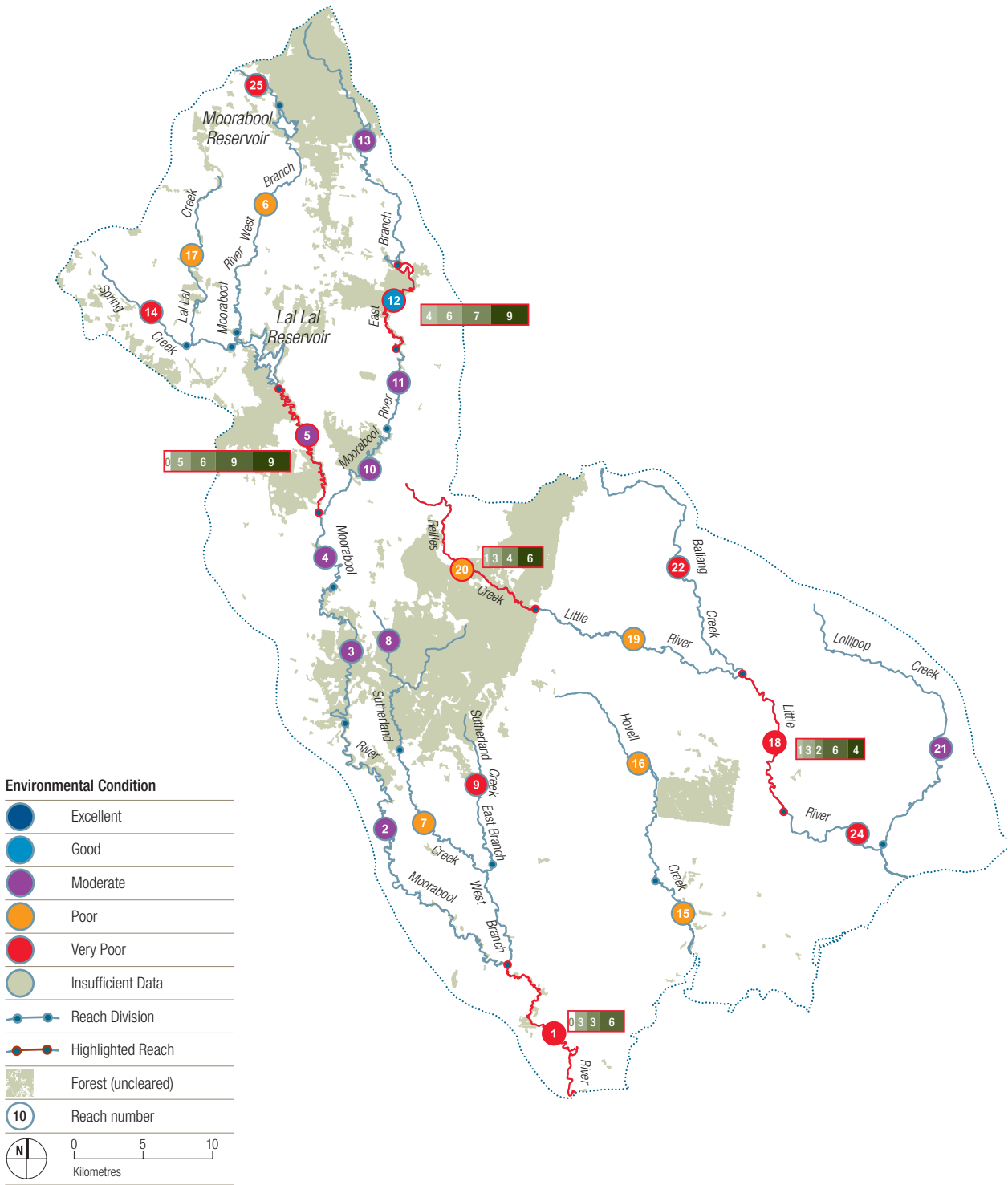


Kororoit Creek East Branch



Lerderberg River

Basin 32 Moorabool



Environmental Condition

- Excellent
- Good
- Moderate
- Poor
- Very Poor
- Insufficient Data
- Reach Division
- Highlighted Reach
- Forest (uncleared)
- 10 Reach number



Cartography by Spatial Vision, 2004 M/6805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

Although large pockets of natural forest remain in the basin's central and north-east regions, most of the catchment has been developed for cereal production and sheep and cattle grazing. There are three significant water storages – Lal Lal, Moorabool and Bostock Reservoirs. Water is exported to the Barwon and Lake Corangamite basins for urban and industrial use.

The condition of stream length is evenly divided between moderate, poor and very poor. Only reach 12, representing 3% of total stream length, was classified in good condition. Reaches in moderate condition were generally in forested areas of the basin. Those with poorer ratings were on streams with significantly impacted hydrology or in areas of heavily cleared land.

Except for reach 13, all reaches had extremely modified flow regimes. Possible causes include the effects of artificial water storages, urban demand, intensive farm dam development, summer irrigation and winter storage and pumping. These reaches had increased periods of low and zero flow, decreased periods of high flow and summer and winter stress.

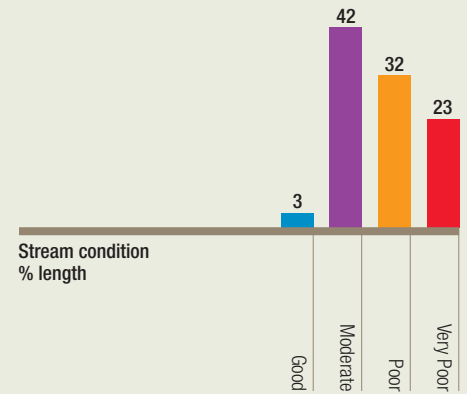
Despite the heavily modified environment, water quality was generally good to excellent. Five reaches (1, 4, 5, 6 and 18) of the basin's 24 reaches had water quality data available. Reaches 4 and 5 on the Moorabool River and reach 6 on the Moorabool River west branch

had good water quality. Reaches 1 and 18 had elevated salinity due to saline groundwater intrusions. Reach 1 had slightly elevated phosphorus levels due to un-sewered towns.

Most reaches had poor streamside zone vegetation. Because of extensive clearing, streamside vegetation has been severely affected by grazing and urban development. This resulted, in low scores for all streamside zone parameters, particularly longitudinal continuity. Reach 8, on the west branch of the Sutherland River, in the forested Brisbane Ranges, was the only reach with good vegetation.

Like the streamside zone results, most reaches scored poorly for physical form. Low levels of instream large wood and restricted fish access were common for all reaches. There was only minor amounts of bank instability.

Seven reaches (reaches 2, 3, 5, 12, 18, 20 and 24) were assessed for aquatic life. Reaches 3, 5 and 12 were close to or at reference condition. All are in the forested areas of the Moorabool River and the Moorabool River east branch.



Moorabool

“Streamside vegetation has been severely affected by grazing and urban development.”



Moorabool River

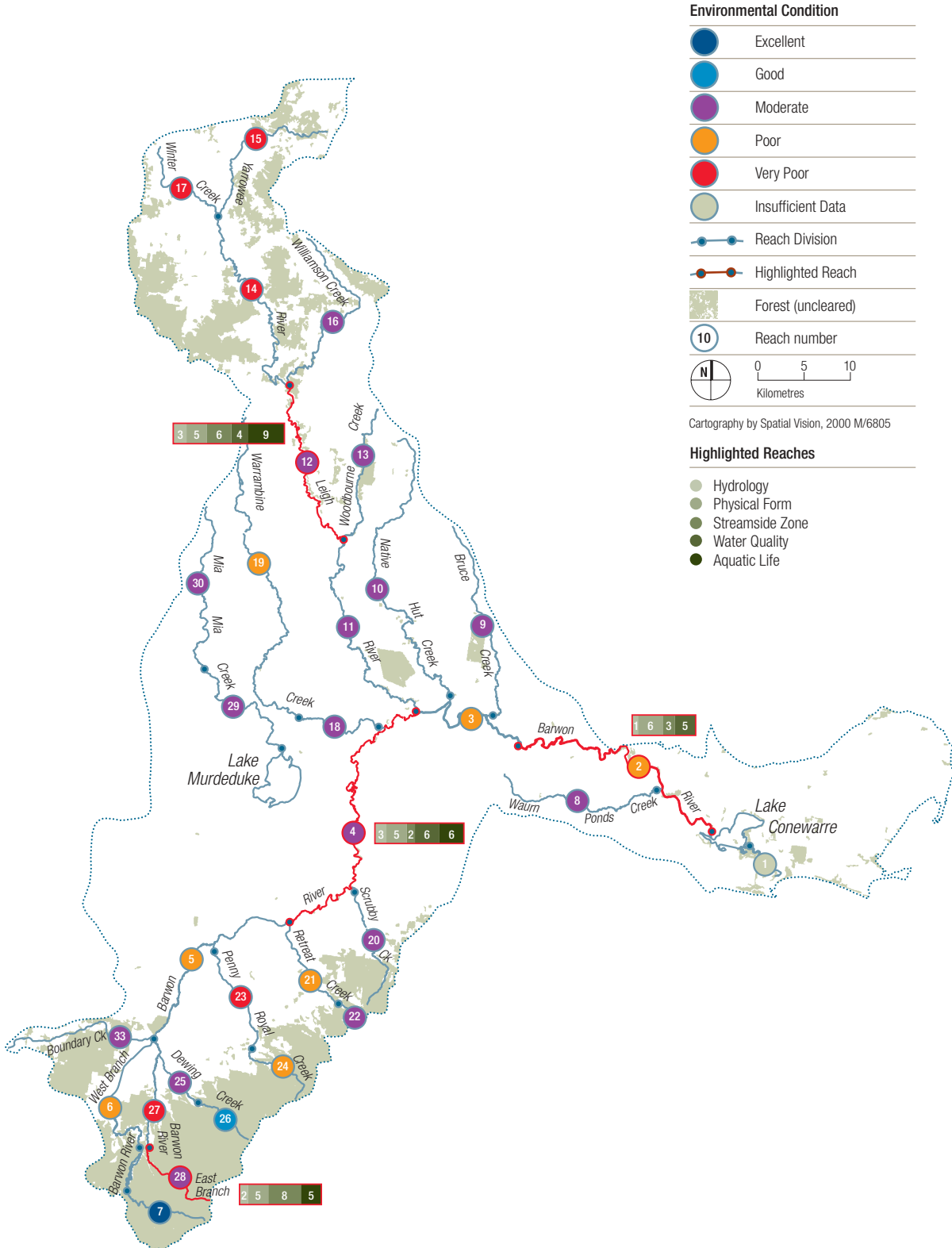


Moorabool River East Branch



Moorabool River East Branch

Basin 33 Barwon



This basin contains the major urban area of Geelong, Victoria's largest provincial town. Small forested pockets remain in the far north and south-west, and are important water supply catchments. Water supplies are supplemented by imports from the surface water resources of the Otway Coast and Moorabool River basins. More than 60% of the water used in the region is imported and contributes mainly to urban and industrial supplies.

Over one-half of the stream length in the basin was in moderate condition; most of the remaining stream length was either in poor or very poor condition. Only reaches 7 and 26, were in good or excellent condition. These results reflect the high level of modification to the vegetation cover and hydrology.

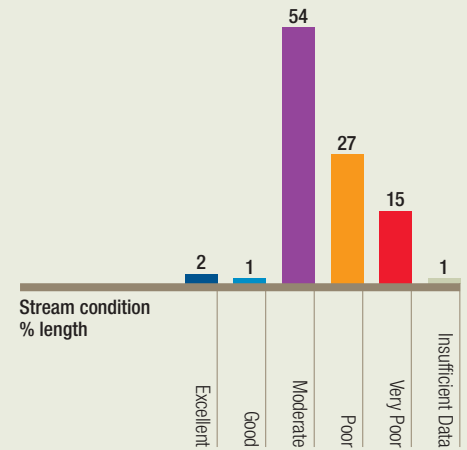
Results for the hydrology sub-index varied considerably. The only reach with a natural flow regime was reach 7, in the headwaters of the Barwon River above the West Barwon Reservoir. Three reaches (reaches 2, 15 and 17) had extreme modifications to natural flows. The low scores for reaches 15 and 17 were attributed to the operation of a series of reservoirs in the upper catchment of the Leigh River that supply water to Ballarat and transfer water to neighbouring basins. The low score for reach 2 is due to high urban demand. Nearly all reaches showed longer periods of low flow, summer stress as well as slight winter stress. This was particularly apparent on the Leigh River and Yarrowee Creek. Diversions into the Wurdee Boluc Reservoir caused reduced periods of high flow on reaches 5, 6, 27 and 28.

Water quality was assessed at five of the basin's 31 reaches. Moderate water quality was recorded at all five reaches. All reaches had elevated levels for total phosphorus and salinity (with the exception of reach 6). Elevated salinity levels are attributed to saline water from groundwater discharge. Reaches 2, 4 and 5 had slightly elevated levels of turbidity; pH was a notable issue at reach 12.

Results for the streamside zone varied from reaches in reference condition to those that have been highly modified. Half the reaches were largely cleared of native vegetation and scored poorly. Only three reaches (7, 26 and 28) were classified as having good vegetation. All were headwater streams in the southern forested portion of the basin.

The large areas of developed land and the altered hydrology resulted in poor to moderate physical form. Bank instability and low levels of instream large wood were common to all reaches, except reaches 22 and 26, which had good amounts of large wood. Fish movement was restricted by the many weirs and reservoirs.

Eight reaches were assessed for aquatic life. Macroinvertebrate populations recorded at reach 11 on the Leigh River indicated that the reach was in near natural ecological condition. In contrast, reach 8 on Waum Ponds Creek and reach 27 on the eastern branch of the Barwon River scored lowest for aquatic life parameters.



Barwon

“The large areas of developed land and the altered hydrology resulted in poor to moderate physical form. Bank instability and low levels of instream large wood were common to all reaches.”



Leigh River



Yarrowee River

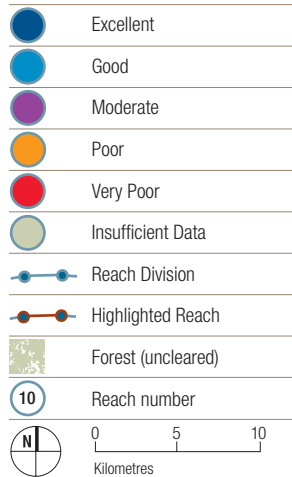


Barwon River

Basin 34 Corangamite



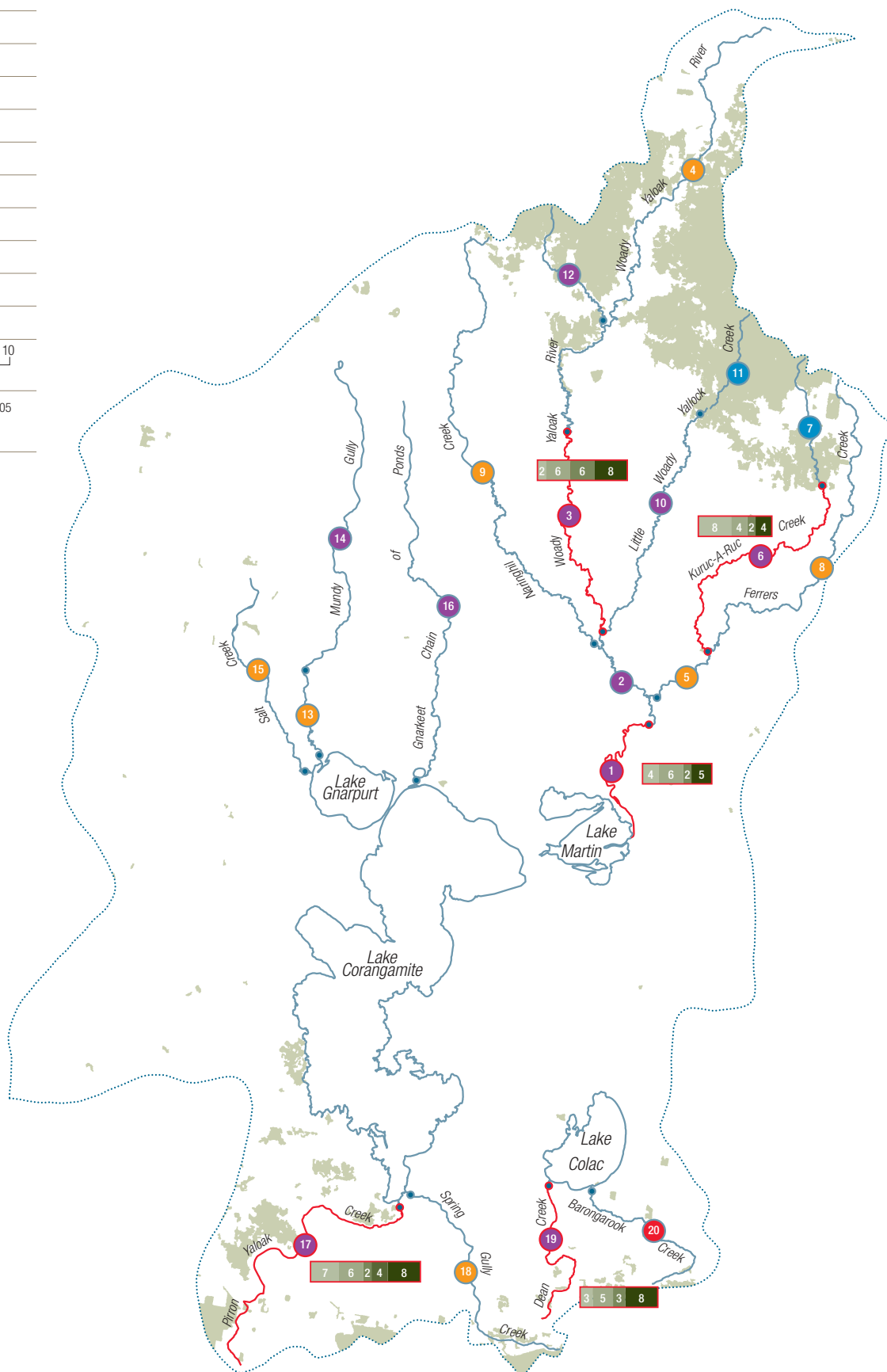
Environmental Condition



Cartography by Spatial Vision, 2000 M/6805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life



The basin is unusual – it has no natural outlet to the sea; drainage works have established an inter-connection to the Barwon basin; there are no artificial freshwater storages; and it is dominated by a series of terminal saline lakes. Except for a small area of natural forest in the north, the basin has been cleared for pasture and agriculture. Sheep and beef cattle grazing dominate on the basalt plains; dairying and prime lamb grazing are important in the south; and crops, such as oats, barley and wheat, are common in the north.

Apart from two reaches (reaches 7 and 11) in good condition in the forested north, most of the remaining streams were rated in moderate or poor condition (48% and 43% of total stream length respectively). The poor overall condition is consistent with the highly modified land and hydrological patterns.

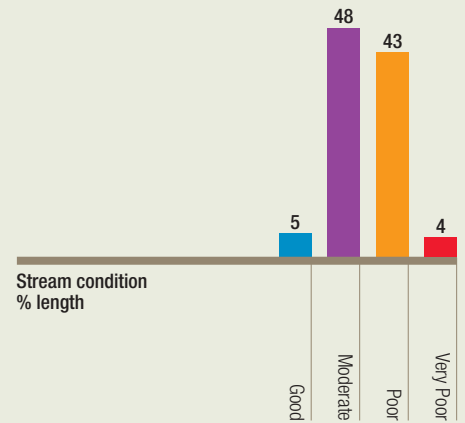
Most streams showed some modification to the natural flow regimes. All streams also exhibited some degree of summer stress. The streams flowing into Lake Colac, and Salt, Ferrers, Naringhil, and the lower sections of Woody Yaloak Creeks had increased periods of low flow. Pirron Yaloak, Little Woody Yaloak and Kuruc-A-Ruc Creeks had hydrology close to reference condition.

Two of the basin's 20 reaches were assessed for water quality (reaches 2 and 17). Both reaches had high total phosphorus levels and elevated salinity levels. These results are consistent with the change in land use and drainage operations.

Most reaches had a highly modified streamside zone. This reflects the heavily cleared land. More than half the reaches were assessed as largely cleared of native vegetation and scored poorly. Reach 11 on the upper Little Woody Yaloak Creek was the only reach to achieve a good score for longitudinal continuity and width. This is one of the few forested reaches in the basin.

Similar to streamside zone results, most reaches scored poorly for most parameters for physical form. Apart from reach 11 on Woody Yaloak Creek, all reaches had very little instream large wood. Land clearing and desnagging, coupled with poor streamside zone, means that there is little capacity to replace instream large wood supplies naturally. Bank instability – attributed to vegetation clearing, and in some cases cattle access – was an issue for most reaches.

A quarter of the basin's reaches were assessed for aquatic life (reaches 1, 3, 6, 17 and 19). Of these, reaches 3, 17 and 19 were close to reference condition. All three reaches were in cleared areas of the basin and poor results have been expected. However in this instance, the favourable results could be attributed to the lack of good reference sites for comparison.



Corangamite

“The basin is unusual – it has no natural outlet to the sea; drainage works have established an inter-connection to the Barwon basin; there are no artificial freshwater storages; and it is dominated by a series of terminal saline lakes.”



Woody Yaloak River

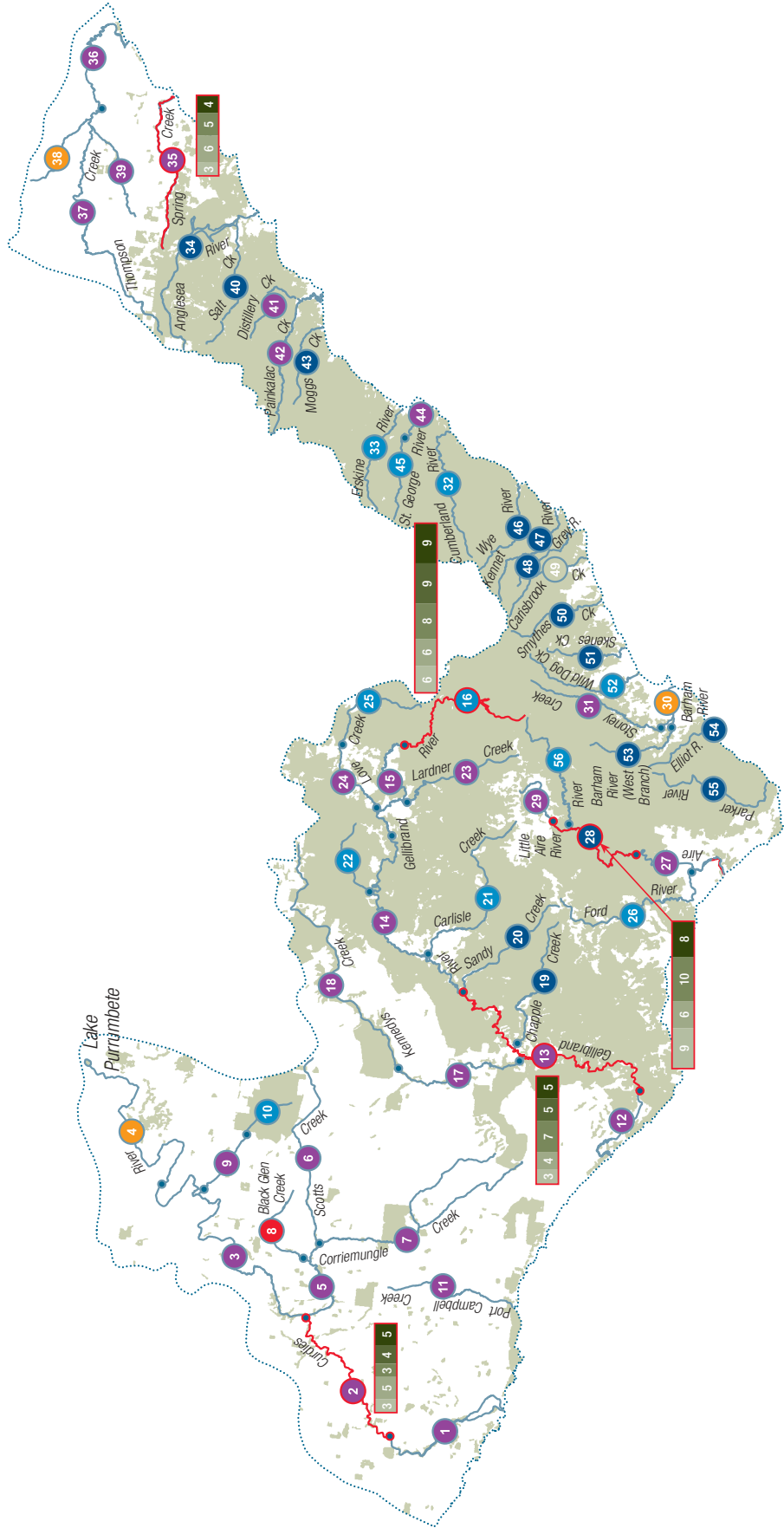


Pirron Yaloak Creek



Kuruc-A-Ruc Creek

Basin 35 Otway



Environmental Condition

- Excellent
- Good
- Moderate
- Poor
- Very Poor
- Insufficient Data
- Reach Division
- Highlighted Reach
- Forest (uncleared)



Cartography by Spatial Vision, 2000 M/6605

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

Extensive native hardwood forests cover more than 60% of the catchment. Towards the west, forests have been logged to make way for agriculture, mainly dairying and cattle grazing. There are no major water storages.

Almost half of the stream length was in good or excellent condition (16% and 24% respectively). This was attributed to the largely undisturbed environment. Just over half the stream length was in moderate condition (53%), mainly in the cleared western section of the basin. Four reaches, representing 6% of total stream length, were in poor or very poor condition.

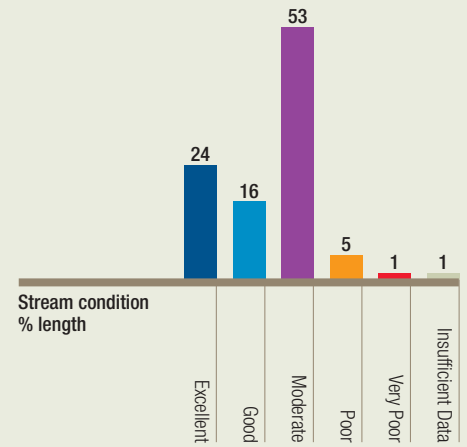
Of the 56 reaches, 17 had flow regimes at or near natural conditions. These reaches included many tributaries of the Gellibrand and Aire Rivers and small mountain streams, including Wye, Kennet and Parker Rivers and Carisbrook and Smythes Creeks. The Curdies River, the lower Gellibrand River, Kennedys Creek and Barham River, demonstrated periods of low flow and summer stress. Lower scores were attributed to water diversions for small coastal towns.

Water quality data was collected for nine reaches. Water quality at reaches 16 and 21 was near reference condition. The two poorest quality sites were on reaches 17 and 24. Both recorded elevated levels for total phosphorus, salinity and turbidity. High levels of total phosphorus were recorded in nearly all tested reaches. This was attributed to stock access, dairy effluent and agricultural run-off.

The heavily vegetated catchment meant that nearly 60% of reaches scored well for streamside zone parameters. Reaches 25, 28, 32, 40, 51 and 55 – all in the forested mountains – were in reference condition. Reaches with highly modified streamside zones, are on the Upper Curdies River and Black Glen Creek (reaches 4 and 8). Both have been degraded by grazing.

Like streamside zone results, scores for physical form were generally moderate to good. Reaches 34, 51 and 55 were in near pristine condition. In contrast, reach 15 (upper Gellibrand River) scored poorly for all physical form parameters, indicating a highly modified environment. For most reaches banks were generally stable. Typically, forested reaches had higher levels of instream wood.

Seventeen reaches were assessed for aquatic life and of these, two-thirds had above average macroinvertebrate populations. Reach 15, on the upper Gellibrand River, was in reference condition. Other high quality reaches included reaches 14, 16, 28 and 29, all located in forested sections. The two lowest scoring reaches, 27 and 35, were in cleared areas.



Otway

“Just under one-half of the basin’s stream length is in good or excellent condition attributed to the largely undisturbed environment.”



Gellibrand River



Kennet River

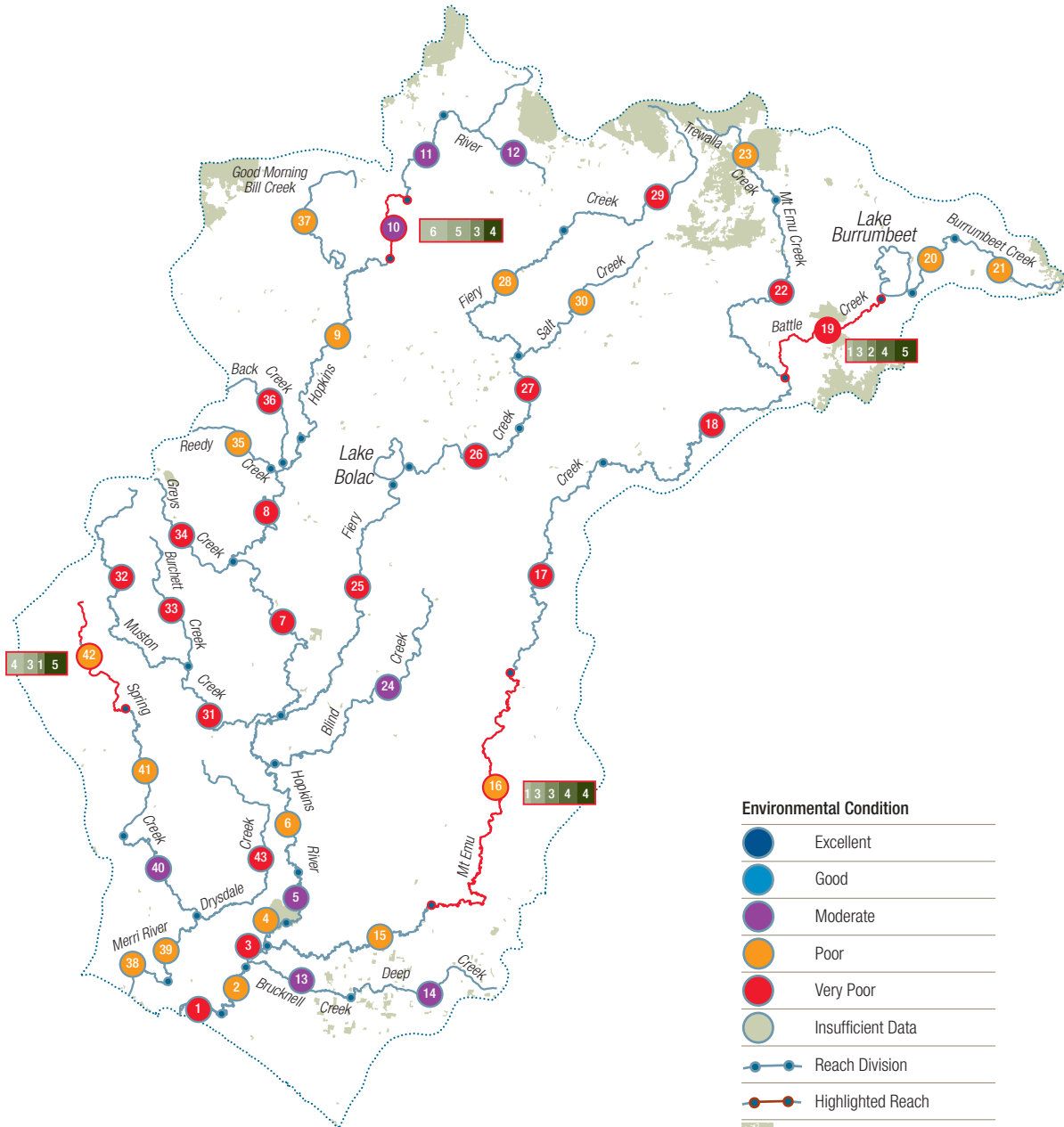


Gellibrand River

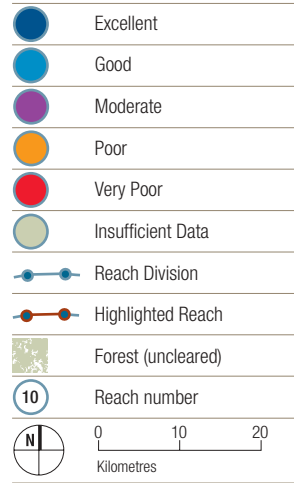


Cumberland River

Basin 36 Hopkins



Environmental Condition



Cartography by Spatial Vision, 2000 M/6805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

The basin is bounded in the north by the Great Dividing Range and in the west by the Grampians National Park. Except for a small pocket of forest in the north, the basin has been extensively cleared for agriculture (mainly wool, prime lamb and beef) and urban development. Dryland grazing, with limited cropping, is practised in the north and dairying the south.

Consistent with the heavily modified environment, 85% of stream length was in poor or very poor condition. These results were attributed to modified hydrology, a result of water extractions for irrigation, stock and domestic use, and poor riparian habitat. The remaining 15% of stream length was in moderate condition.

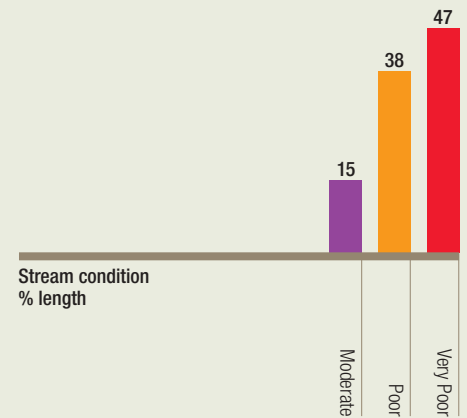
Most reaches had heavily-modified natural flow patterns associated with diversions. Most reaches experienced extended periods of low flow and reaches 7 and 8 on the Hopkins River and reaches 22 and 23 on Mt Emu Creek also had extended periods of zero flow. Reaches 9-12 on the upper Hopkins River had moderate modifications to natural flow regimes, but were the best in the basin.

Water quality data was collected for five of the basin's 43 reaches (1, 15, 16, 19 and 20). All five had elevated salinity and total phosphorus levels but turbidity levels were at, or just below, reference condition. The elevated salinity results were attributed to both saline groundwater and land use change over the past century. Salinity levels have increased due to drainage of wetland areas. This has allowed saline groundwater to flow into surface drainage all year round.

Typically for a heavily cleared catchment, the streamside zone was heavily modified. Results indicated that vegetation along stream banks was patchy or non-existent. Reach 5 on the lower Hopkins River, in a small isolated area of forest, had the best vegetation condition (although still heavily modified). The lowest scoring reaches (reaches 31, 33, 36 and 41-43) are all in the west of the basin.

Most reaches had a lack of instream large wood and generally unstable banks. Hopkins Falls, which forms the boundary between reaches 3 and 4, acts as a major barrier to fish migration for the whole of the basin. Eels are the exception, as they can navigate the falls to migrate.

Aquatic life was assessed for sixteen reaches in the catchment. Scores ranged from moderate to minor variance from reference condition. Reach 23, at the headwaters of Trewalla Creek, was in the best condition. The overall low scores were consistent with the generally low scores for the other sub-indices.



Hopkins

“Typically for a heavily cleared catchment, the streamside zone was heavily modified.”



Hopkins River

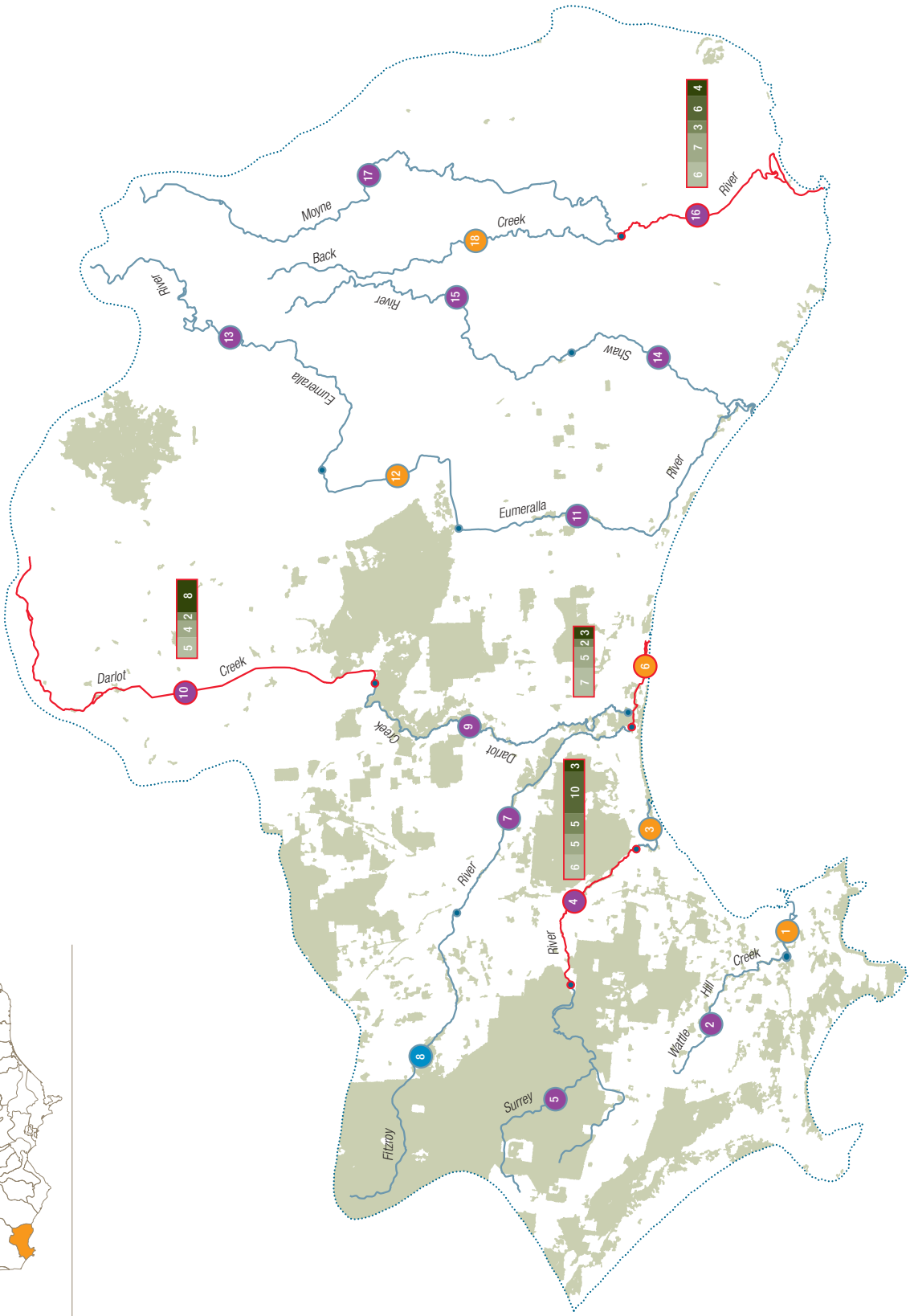


Hopkins River



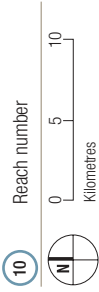
Battle Creek

Basin 37 Portland



Environmental Condition

- Excellent
- Good
- Moderate
- Poor
- Very Poor
- Insufficient Data
- Reach Division
- Highlighted Reach
- Forest (uncleared)



Cartography by Spatial Vision, 2000 M16605

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

The basin is characterised by gently undulating to flat land, which has been mostly cleared to support the pastoral industry – sheep and cattle grazing for wool, meat and dairying. The western corner is densely vegetated and much of this area forms part of the Lower Glenelg National Park and the Cobobbonee State Forest.

Most streams were in moderate condition (78% of stream length). Four reaches, representing 16% of total stream length, were in poor condition; reach 8, in the headwaters of the Fitzroy River, was in good condition.

The hydrology sub-index results indicated moderate to minor modifications to natural flow regimes. All reaches showed increased periods of low flow and summer stress. The lowest scores were on the lower Eumeralla River (reaches 11 and 12) and Wattle Hill Creek (reaches 1 and 2).

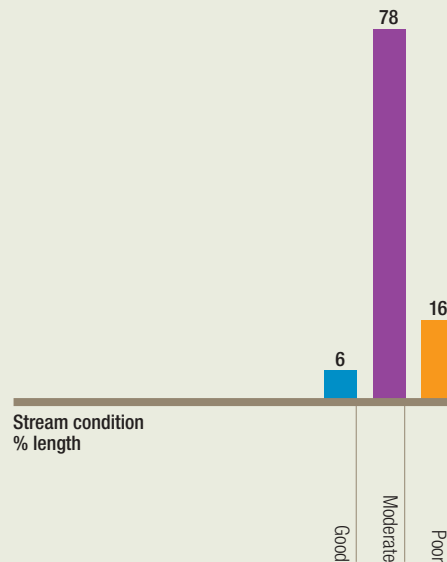
Two of the basin's 18 reaches were assessed for water quality (reaches 4 and 16). Reach 4, on the Surrey River, in the west of the basin was at reference condition for all parameters. Reach 16, on the Moyne River, in the east, had poor results for total phosphorus and salinity. These poor results may be attributed to the historic significantly modified drainage regimes in the area.

Most reaches had poor to moderate results for streamside zone. All reaches scored poorly on all parameters for streamside zone

including longitudinal continuity and vegetation width. This indicated considerable riparian vegetation has been cleared. Reach 4 on the Surrey River and reach 7 on the Fitzroy River, in the well vegetated west, were exceptions.

Consistent with the poor to moderate results for streamside zone, all reaches – except those on the upper Surrey River – had little or no instream large wood. Many streams have had wood removed in the past and the lack of high quality streamside vegetation means there is little scope for instream wood values to increase. Stream banks were considered fairly stable in all reaches, except reaches 11 and 14. There were no major fish barriers to restrict fish migration.

Seven reaches were assessed for aquatic life; scores varied from extremely poor to near reference condition. Reach 10 on Darlot Creek was at reference condition. The lowest score was recorded at reach 3 on the lower Surrey River. This poor result is largely attributed to the macroinvertebrate assessments being developed for freshwater and not estuarine systems. The generally poor scores for macroinvertebrates are consistent with a heavily modified catchment.



Portland

“Overall, the generally poor scores for aquatic life are consistent with a heavily modified catchment.”



Surrey River

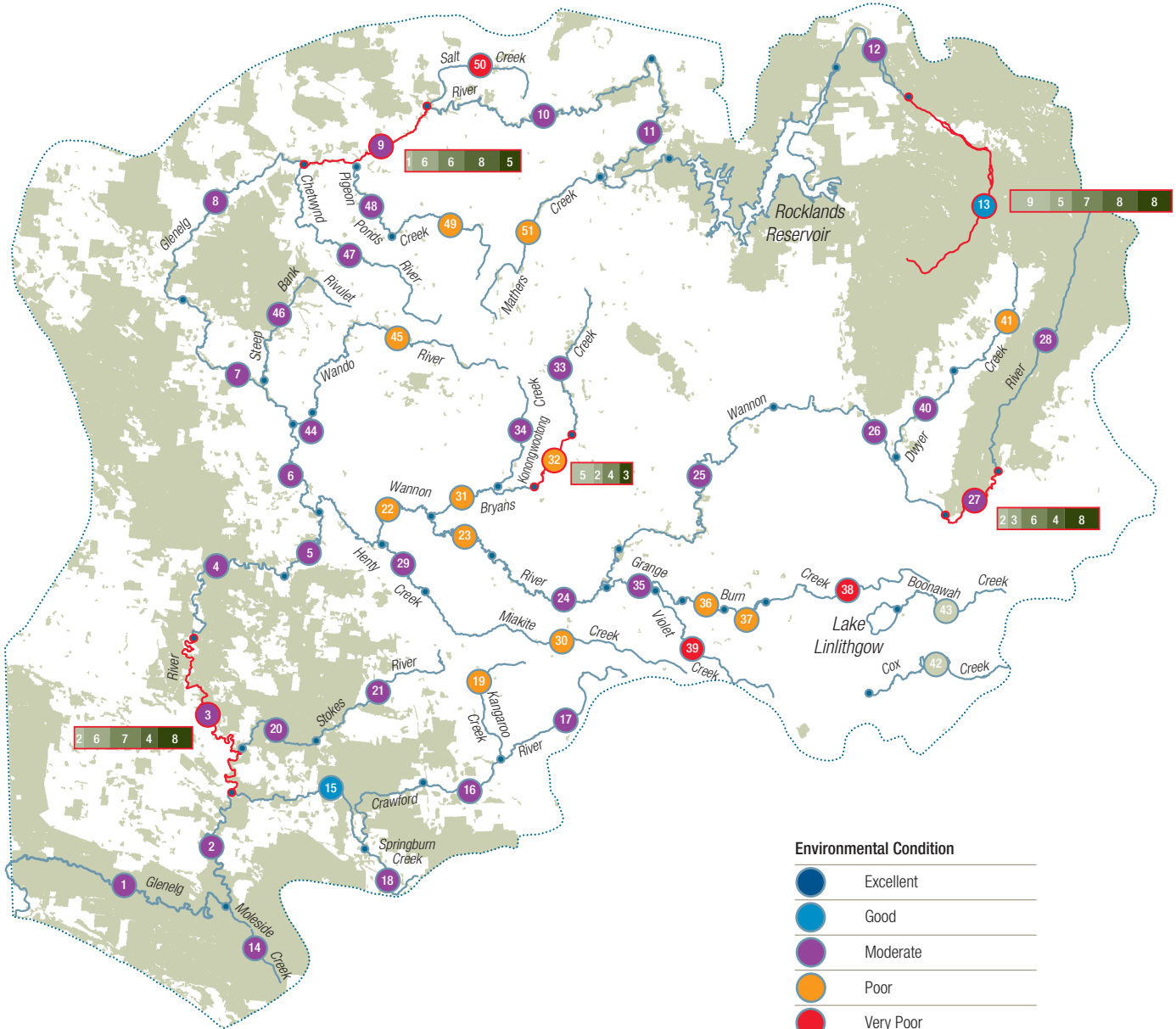


Fitzroy River

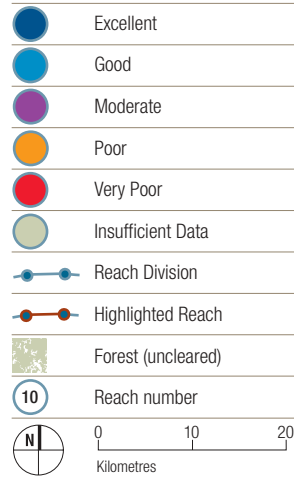


Darlot Creek

Basin 38 Glenelg



Environmental Condition



Cartography by Spatial Vision, 2000 M/6805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

One-third of the basin is remnant native forest – the Grampians National Park in the north-east corner, the Lower Glenelg National Park in the south and pockets of State forest throughout the basin. The remainder of the land has been largely cleared for sheep and cattle grazing. The two major water storages, Rocklands and Moora Moora Reservoirs are on the headwaters of the Glenelg River. These, with diversions from the headwaters of the Wannon River provide substantial volumes of water to the Mallee and Wimmera districts through the Wimmera-Mallee Stock and Domestic Supply System.

Most stream length was in moderate condition (63%) and one-quarter of stream length was in poor or very poor condition. Only reaches 13 and 15 were in good condition.

Impoundments, diversions and farm dams have significantly affected natural flow regimes. All reaches downstream of the Rocklands Reservoir had highly modified hydrology; similarly, all reaches on the Wannon River were greatly affected by diversions. All streams and particularly the Wannon and Glenelg Rivers had greatly increased periods of low flow and showed summer stress. Reaches 12 and 13, on the headwaters of the Glenelg River, had near natural flow regimes.

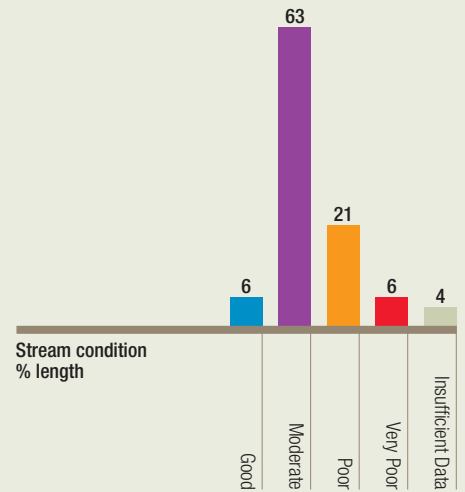
Fourteen of the basin's 51 reaches were assessed for water quality – results ranged from poor to good quality. The lowest scoring reach, reach 23 on the Wannon River, had extremely elevated levels of salinity, total phosphorus and turbidity. The highest scoring reaches, (reaches 10 and 13), were in the north, on the upper Glenelg River. These reaches scored well for all parameters, except pH for reach 13, indicating problems associated with

the sulphate soils typical to the swampy land around this reach. Most reaches scored very poorly for total phosphorus and turbidity. This was attributed to nutrient leaching and turbidity caused by erosion and stock access. Salinity also was an issue for many reaches, due primarily to the highly saline tributaries (Salt Creek and Grange Burn Creek), saline groundwater and altered drainage patterns.

Due to the amount of cleared land, most reaches scored poorly for streamside zone parameters. Reaches 17, 38, 39 and 42 were extremely modified, with practically no vegetation cover. The highest scoring reaches, reaches 1 and 28, were close to reference condition and were in National Parks.

Similar to results for the streamside zone, the vast majority of reaches scored poorly for physical form. The lowest scoring reach was on Boonawah Creek (reach 43). The highest scoring reach (reach 14) was in the Lower Glenelg National Park. Reaches in the forested parts of the basin tended to have stable banks and good levels of instream large wood. Many streams were affected by barriers to fish migration. Notable exceptions were the Crawford River and the lower Wannon River and its tributaries.

More than half the reaches were assessed for aquatic life. Scores ranged from poor to reference condition. The reaches in reference condition were largely restricted to the forested areas (reaches 11, 15 and 17). Salt Creek (reach 50) in the north, scored very poorly and was the worst in the catchment. This was attributed to its saline waters, as the name suggests.



Glenelg

“One-third of the basin is remnant native forest – the Grampians National Park in the north-east corner, the Lower Glenelg National Park in the south and pockets of State forest throughout the basin.”



Dwyer Creek



Wannon River

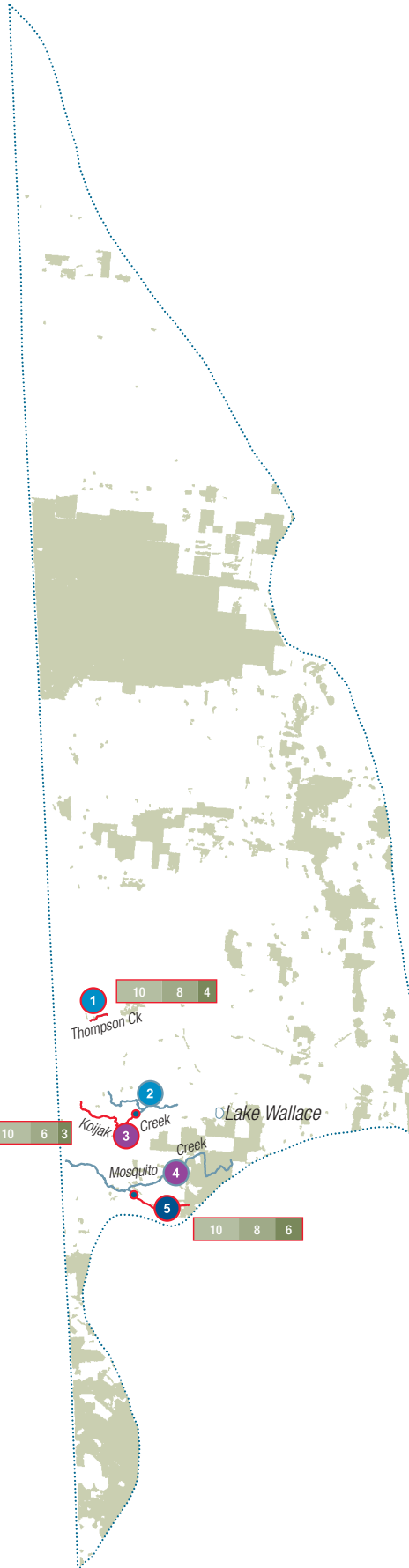


Glenelg River

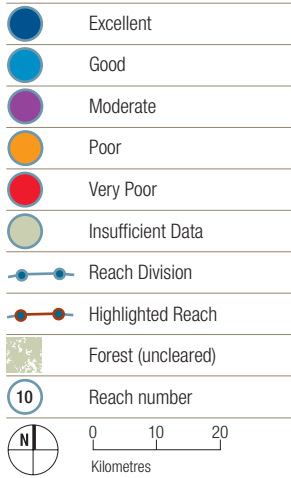


Glenelg River

Basin 39 Millicent



Environmental Condition



Cartography by Spatial Vision, 2004 M/6805

Highlighted Reaches

- Hydrology
- Physical Form
- Streamside Zone
- Water Quality
- Aquatic Life

The basin is characterised by its semi-arid environment. Low ridges, dunes and hummocks rise from typically flat terrain. Much of the dry land is generally used for growing cereal crops, mainly wheat. The basin contains no perennial streams and the sandy nature of the soils result in very little, if any, run-off. Natural swamps and lakes of varying salinity are common.

Of the five river reaches, reach 5 (Mosquito Creek) is in excellent condition. Reaches 1 and 2 (Thompson Creek and Kojak Creek) were in good condition; reaches 3 and 4 were in moderate condition. Overall scores were boosted by high scores for the hydrology sub-index. This was balanced by moderate scores for physical form and poor scores for streamside zone.

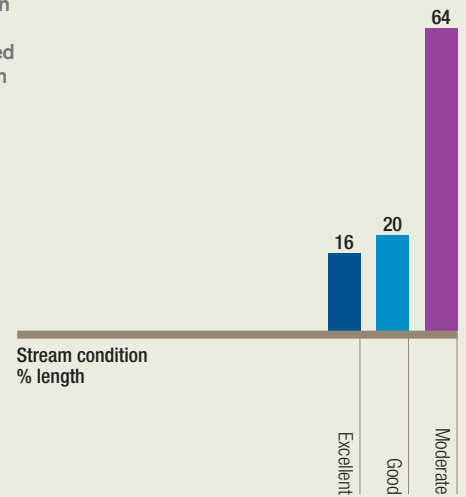
Hydrologically, the basin's streams have been relatively untouched. This is due to the high intermediacy and unpredictability of flows and the difficulty of storing surface water. As a result, all reaches were in natural condition for the hydrology sub-index.

No data was available for water quality.

All reaches had a highly modified streamside zone. All reaches scored poorly for longitudinal continuity, understory diversity and regeneration, indicating there is very little native vegetation remaining in the streamside zone.

All reaches were in moderate to good condition for physical form. Bank stability was generally good for all reaches and no fish barriers restricted fish migration. However, there was little instream large wood, consistent with heavily modified tree cover.

No data was available for aquatic life.



Millicent

“Bank stability was generally good for all reaches and no fish barriers are present to restrict fish migration.”



Mosquito Creek



Kojak Creek



Mosquito Creek



