

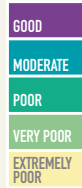


# Sustainable Rivers Audit

## Murray-Darling Basin Rivers: Ecosystem Health Check, 2004-2007

June 2008

## Key to Report Cards on SRA Valleys



### Ecosystem Health

The SRA assesses the health of the river ecosystem. Three key ecosystem components, *Fish*, *Macroinvertebrates* and *Hydrology*, represented as *Themes*, are used as 'windows' on the ecosystem. There are 23 river Valleys, each divided into *Zones*. Site information is combined to yield an *Index of Condition* for Themes at Zone and Valley level. These are combined to assess *Ecosystem Health*.

Health and Condition are rated as *Good*, *Moderate*, *Poor*, *Very Poor* or *Extremely Poor*. All indices are rated relative to *Reference Condition*, or 'the state of the ecosystem as it would be had there been no significant human intervention'.



### Fish Condition Index (FI)

Integrates two indicators: Expectedness and Nativeness. High scores indicate similarity to Reference Condition, when most or all expected native species are present and there are few or no alien fish. Low scores indicate absence of most expected native species and/or dominance by alien species.



#### Expectedness

Presence of native species relative to Reference Condition. High scores indicate presence of most expected native species. Low scores indicate loss of many expected native species.



#### Nativeness

Integrates the proportions of fish abundance, biomass and species richness that are native rather than alien. High scores indicate dominance by native species.



#### Number of species

Number of native and alien fish species found across all sites in the Valley or Zone.



#### Biomass

Average biomass per site of native and alien fish species found in the Valley and Zones.



### Macroinvertebrate Condition Index (MI)

Integrates two indicators: Expectedness and SIGNAL OE. A low score indicates that many expected and disturbance-sensitive invertebrate families are missing.



#### Expectedness

The proportion of expected families that was found. A high score indicates that many expected families were present, and a low score indicates the opposite.



#### SIGNAL OE Score

The SIGNAL (Stream Invertebrate Grade Number Average Level) score is based on the sensitivities of families to pollution or other disturbance. The SIGNAL OE Score compares the observed (O) SIGNAL score with that expected (E) under Reference Condition. A high SIGNAL OE score indicates low levels of pollution or other human disturbances, and a low score indicates the opposite.



#### Number of families

Number of macroinvertebrate families found in the Valley or Zone.



### Hydrology Condition Index (HI)

Integrates the five indicators below. Each of them assesses the difference between current and Reference Condition values of an ecologically significant aspect of the flow regime.

- HFE** High-flow events indicator
- LZFE** Low- and zero-flow events indicator
- V** Flow variability indicator
- S** Flow seasonality indicator
- GV** Gross annual flow volume indicator

High values of the HI index and the indicators signify little change relative to Reference Condition. Low values indicate large changes. Current and Reference Condition hydrology data include wet and dry periods. Results thus reflect long-term development impacts rather than the recent drought.



Mean monthly flows (GL) for current and Reference Condition flows for the modelled period of record.

## About this Report

The Sustainable Rivers Audit (SRA) is an initiative of the Murray–Darling Basin Commission, supported by the governments of the five Basin states and territory and the Australian Government. Overseen and reported by an independent group of river ecologists, the Independent Sustainable Rivers Audit Group (ISRAG), the SRA provides scientifically robust assessments of the ecological health of the Murray–Darling Basin rivers.

This summary report presents the main findings from ISRAG's *SRA Report 1: A Report on the Ecological Health of Rivers in the Murray–Darling Basin, 2004–2007*, submitted to the Murray–Darling Basin Ministerial Council in May 2008.

This report outlines the nature of the Audit and the ways that environmental data are used to assess ecosystem health. It presents Report Cards on river ecosystem health for each of the 23 valleys in the Basin, based on observations of fish, macroinvertebrates and hydrology. During the current reporting period (2004–2007), which included severe droughts, each of the valleys was sampled once for fish and macroinvertebrates. The report summarises results from this first sampling round, as well the first round of analysis of hydrology data.

The Report Cards include icons, indicators and indices for three Themes—Fish, Macroinvertebrates and Hydrology—representing 'windows' on the ecosystem. A key to this information is provided on the inside of this fold-out section, which can be accessed while viewing any of the Report Cards. A more detailed explanation of the various indicators and indices can be found on pages 8–13.

The results presented in this report should be interpreted in the context of the SRA sampling regime, the prevailing climate conditions and the current limited number of monitoring themes. Additional monitoring themes will be included for future assessment cycles to enable more comprehensive and robust conclusions to be drawn over time, including the identification of trends in river health.

The full *SRA Report 1* is available through the Murray–Darling Basin Commission website ([www.mdbc.gov.au](http://www.mdbc.gov.au)).

# Sustainable Rivers Audit



**Murray–Darling Basin Rivers:  
Ecosystem Health Check, 2004–2007**



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The contents of this publication do not purport to represent the position of the Murray–Darling Basin Commission. They are presented to inform discussion for improvement of the Basin's natural resources.



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## Foreword

The Murray–Darling Basin Rivers: Ecosystem Health Check 2004–2007 marks the first Basin-wide assessment of river health in the Murray–Darling Basin. It is the product of ground-breaking collaboration on river health monitoring by the governments of the six Basin jurisdictions—Queensland, NSW, Victoria, South Australia, ACT and the Australian Government—and an independent group of river ecologists as auditors (the Independent Sustainable Rivers Audit Group or ISRAG). They came together under the Sustainable Rivers Audit program to answer the question ‘What is the condition of our Basin’s rivers?’

The report summarises the findings of ISRAG’s report on the ecological health of the Basin’s rivers to the Murray–Darling Basin Ministerial Council. It is the first in a triennial series of reports planned for the long-term future, and the SRA program is well positioned to report on trends in river health over time.

The Murray–Darling Basin is of national significance economically, socially and environmentally. Thirteen of the Basin’s 23 valleys are in ‘very poor’ health and an additional seven are in ‘poor’ health the report concludes, reinforcing the challenge that has been identified nationally to improve the management of the Basin and its precious water resources. Striking the right balance between often competing priorities is fundamental if we are to significantly improve the health of the rivers and wetlands, ensuring that the Basin is managed on a sustainable footing for the long term.

Information provided by the SRA on the ecological health of the Basin’s rivers will be a key input to the development of the Basin Plan by the new Murray–Darling Basin Authority. The report provides critical information that, considered in conjunction with the CSIRO Sustainable Yields Project outputs, will assist in making informed decisions on sustainable diversion limits for Basin valleys.

The SRA program has already made important contributions to a number of other initiatives. The program is informing the development of indicators and protocols for river condition monitoring under the National Framework for Natural Resource Management as well the National Water Commission’s work on the development of a Framework for the Assessment of River and Wetland Health. The SRA results will be an important contribution to the next national State of the Environment report scheduled for 2011.

The report should help the general community, managers and policy-makers to be better informed about the ecological health of the rivers in the Murray–Darling Basin. I commend this report to all who have an interest in the sustainable management of the Murray–Darling Basin.



**Rt Hon Ian Sinclair, AC**

President, Murray–Darling Basin Commission

## 1. What is ‘river health’?

The idea of ‘river health’ requires us to think of a river as an ecological system, not merely a channel that conveys water from the uplands to the sea. The ‘ecosystem’ includes the flora and fauna and their habitats, linkages between the river and its catchment, the dynamics of water flow and the transport and transformation of nutrients. The health of a river ecosystem depends on its capacity to support key processes (eg carbon exchange, nutrient cycling, energy transfer, sediment transport) and to sustain its structural components (eg communities, populations).

A system is ‘healthy’ when its character, biodiversity and functions are sustained over time. It demonstrates good health by being resilient in the face of environmental changes, including changes in climate, resource exploitation or other impacts of human activity. It implies a long-term balance whereby the integrity of the natural system is preserved while meeting human needs.

An ‘unhealthy’ system is one where such a balance does not exist. It may be changed from its healthy state by losing species, or gaining new ones, it may be affected by salinisation or other environmental changes, or its resources may be intensively exploited. None of these factors is *inherently* unhealthy, but may become so if they exceed the ability of the system to recover (‘resilience’). The differences between ‘healthy’ and ‘unhealthy’ systems, then, are matters of degree.

Rivers transport, store, decompose and reconstitute the resources on which plant and animal communities depend. They are intimately linked to the surrounding landscape, and their ties with the floodplain are especially close. Just as wetlands and woodlands depend on the river for water, and as a corridor for dispersal of plants and animals, the channel depends on the floodplain as a refuge for biodiversity. Rivers and their floodplains are ecologically inseparable.

For human communities, rivers are a source of water for drinking and other household needs. They underwrite food production by the irrigation and pastoral industries, and they supply water for all forms of industry. They are used to transport waste, including domestic, agricultural and industrial effluents. They also provide for recreational activities, destinations for tourists and form a ‘common stream’ through the lives of families, towns and the histories of entire regions. An unhealthy river is one whose capacity to supply these resources and services is prejudiced.

## 2. The Murray–Darling Basin and its rivers

With a catchment of more than a million square kilometres, the Murray–Darling Basin is one of the world’s largest drainage systems. It extends over 13 degrees of latitude and 13 degrees of longitude, from Goolwa east to Warwick, and from the Warrego headwaters in the north to the Goulburn headwaters in the south.

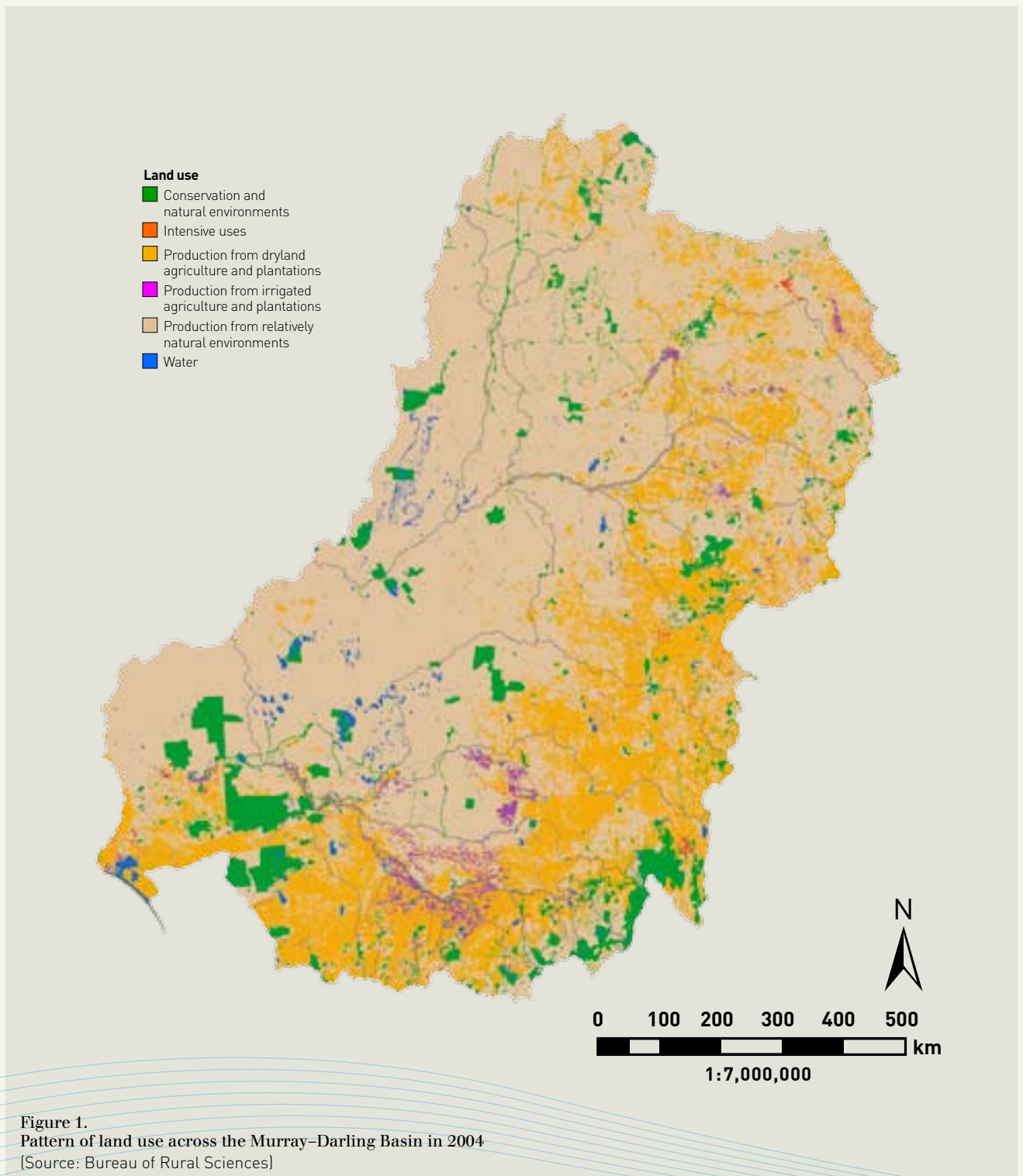
The Basin is Australia’s most significant agricultural region, accounting for 70% of irrigated agriculture and more than 40% of the gross value of agricultural production nationally. The Basin’s land use pattern for 2004 is shown in Figure 1.

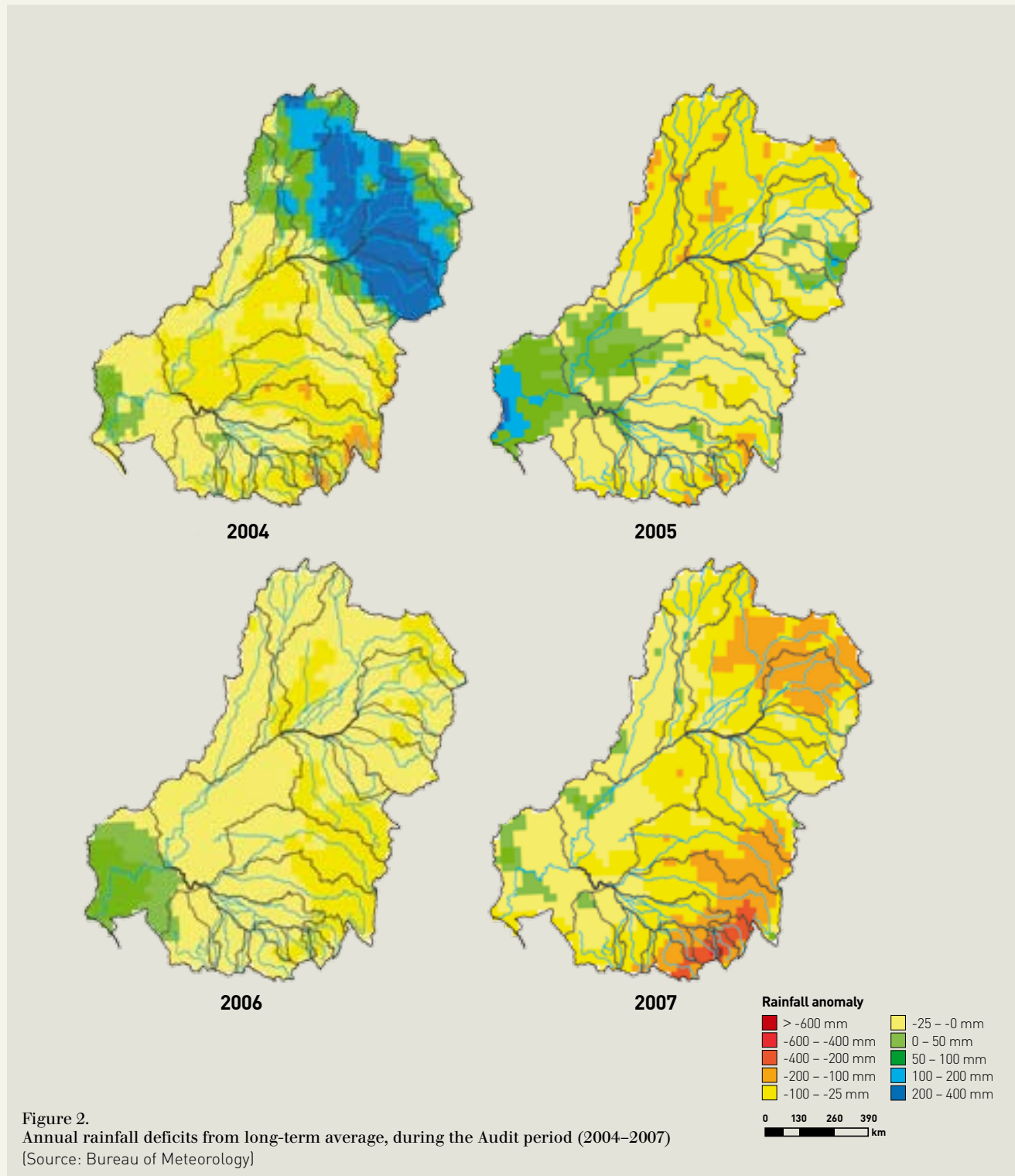
Most of the Basin is arid or semi-arid, and most of its flow comes from a small region near the headwaters of the Murray. Considerable volumes of water are lost as the rivers flow from their upper tributaries to the sea. Total run-off averages around 24,000 GL/year, but only about 5000 GL/year reaches the sea, a very low annual discharge by world standards.

In the last 5–10 years, the discharge has fallen even lower as a result of a sustained drought, and the Murray mouth now is kept open by constant dredging. Although erratic droughts and floods are part of the character of rivers in the Basin, the recent drought has placed agricultural systems, rural communities and the natural river environment under severe stress. Annual rainfall deficits for the Basin during the Audit period (2004–07) are shown in Figure 2.

The main rivers in the Basin are the Darling (2740 km) and the Murray (2530 km). The Darling and its tributaries contribute less than 10% of total flow, even though their catchments extend over about twice the area drained by the Murray and its tributaries. In the *Sustainable Rivers Audit*, 23 major valleys in the Basin, designated by the Australian Water Resources Council, are the basis for reporting. These are shown in Figure 3.







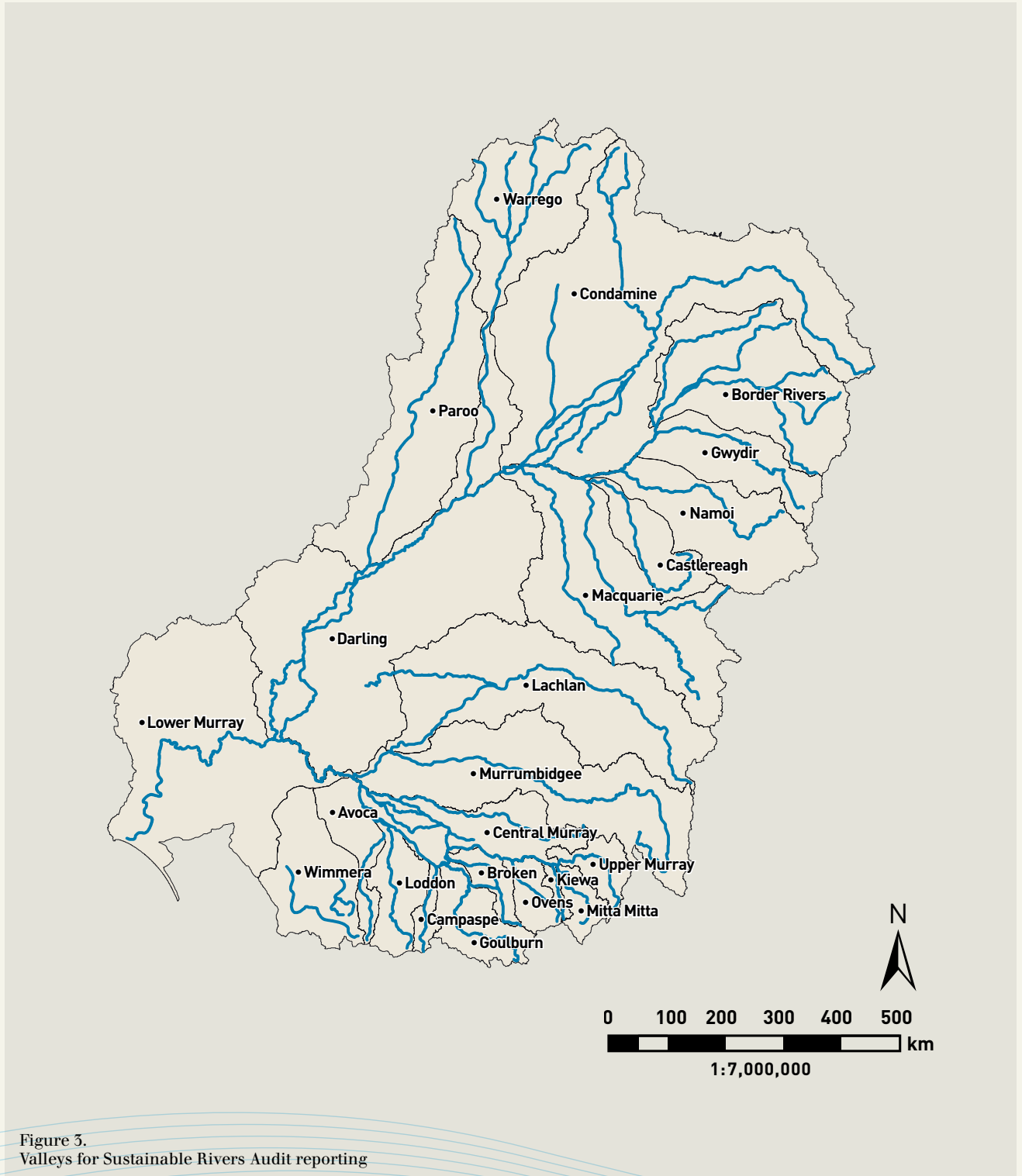


Figure 3.  
Valleys for Sustainable Rivers Audit reporting

### 3. What is the Sustainable Rivers Audit?

The Sustainable Rivers Audit (SRA) is a comprehensive assessment of the health of river ecosystems in the Murray–Darling Basin. It systematically collects and analyses biophysical data from locations in all 23 designated *Valleys*. Environmental indicators, grouped as *Themes*, are used to assess the *Condition* of key ecosystem components, and condition assessments are combined to indicate *Ecosystem Health*.

In *SRA Report 1*, the first in a series of three-yearly reports, the SRA has utilised three Themes: Fish, Macroinvertebrates and Hydrology. Two more Themes, Vegetation and Physical Form, will be added to the next report, due in 2011. Future reports will also describe trends, showing how river ecosystem health changes from one Audit to the next, and over longer periods of time.

Assessments of condition are made relative to a benchmark called *Reference Condition*. This estimates measures of condition as they would be without significant human intervention. It represents the river ecosystem in good health, but it is not a target for management.

Depending on how much the condition of ecosystem components differs from Reference Condition, Ecosystem Health is rated on a five-point scale, from Good through Moderate, Poor and Very Poor to Extremely Poor.

The SRA reports primarily at the scale of *Valleys*, and secondarily at the scale of *Zones* within *Valleys*. There are 1–4 *Zones* in each *Valley*, defined in most cases by altitude. Sampling sites are required to be randomly distributed within *Zones*, to enable site-scale measurements to be aggregated to the *Valley* scale, and to enable statistical analyses and comparisons.

#### Who is responsible for the Sustainable Rivers Audit?

The SRA is an initiative of the Murray–Darling Basin Commission (MDBC), in partnership with state, territory and federal governments. The program is overseen by a panel of ecologists, the *Independent Sustainable Rivers Audit Group* (ISRAG), who report to the Murray–Darling Basin Ministerial Council and the wider community.

Each government partner contributes to the membership of an *SRA Implementation Working Group* (SRAIWG), and employs staff to conduct field sampling and data collection. The SRAIWG provides technical advice to program management and oversees field and laboratory work. There are also specialist *Taskforces*, responsible for refinement and implementation of the Themes. The MDBC maintains an *SRA Team* to manage the program, collate the data and conduct analyses, in line with ISRAG requirements. The SRA partners and interrelationships are shown in Figure 4.

The SRA is linked to a number of other regional, state and national river monitoring programs, through shared methods, data, reports and conceptual frameworks.

#### Box 1.

#### SRA Report 1

This report (titled *Murray–Darling Basin Rivers: Ecosystem Health Check, 2004–2007*) presents a summary of the results from the first three years of monitoring under the Sustainable Rivers Audit, which are contained in the full *SRA Report 1*. The full report can be accessed through the Murray–Darling Basin Commission website ([www.mdbc.gov.au](http://www.mdbc.gov.au)).

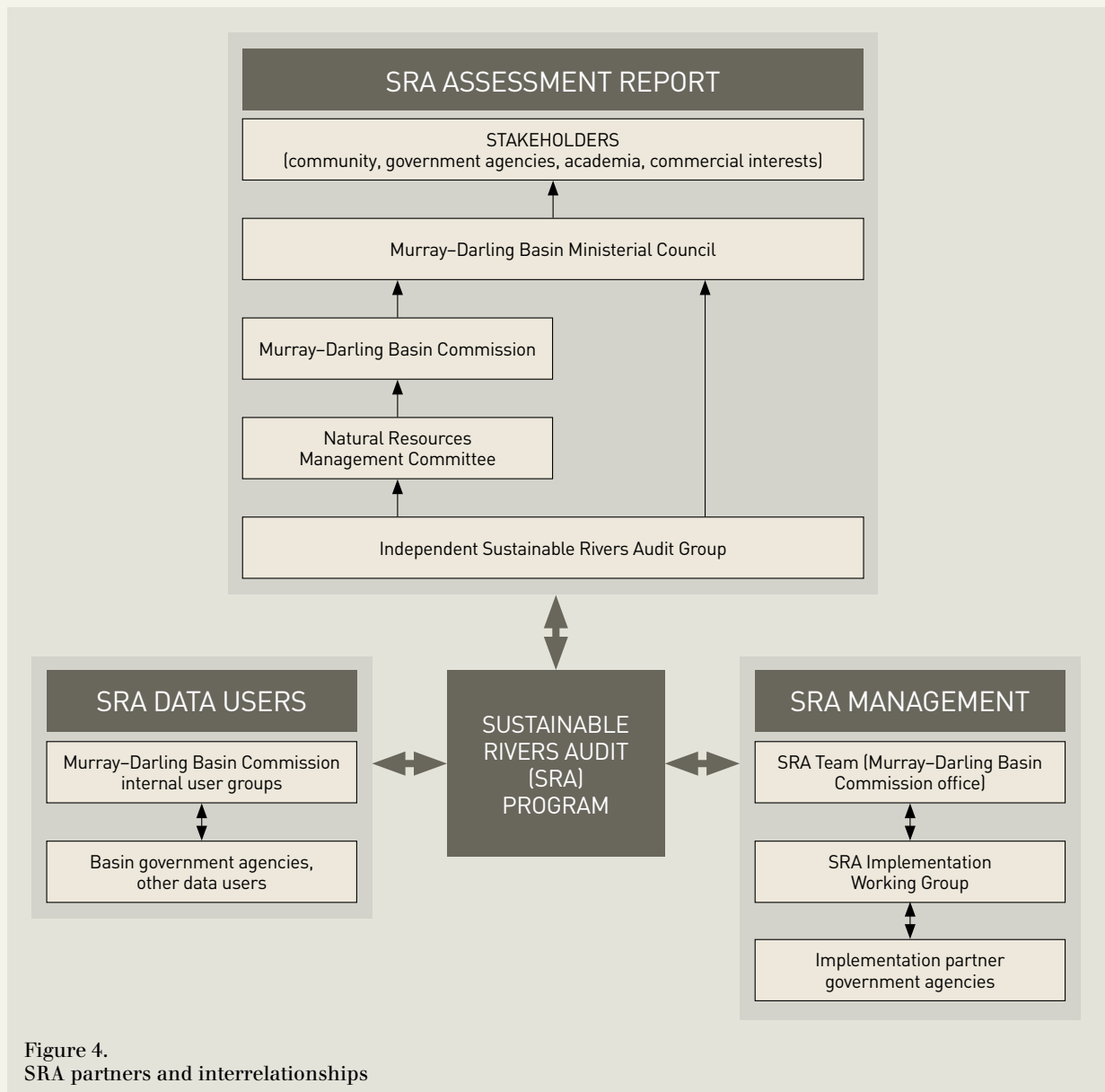


Figure 4. SRA partners and interrelationships

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## 4. Themes for monitoring river health

A wide variety of measurements and observations is needed to indicate ecosystem health. The possibilities are almost limitless, and strategic choices are needed.

Information might be gathered about algae, fish, invertebrates and water plants, about floodplain vegetation, amphibians, birds, mammals and reptiles, and microbial communities (see Figure 5). Ecological processes could be monitored, including carbon and nutrient cycling, primary production and recruitment. The physical landscape also could be monitored for signs of change.

All of these are 'windows' on ecosystem structure and function, and potentially could be Themes in the SRA. The best choices are components that are easily measured, that represent ecological roles, patterns and processes over a range of spatial and temporal scales and are responsive to river-ecosystem 'drivers' like the transport of water and sediment. Some Themes are easier and less costly to sample and analyse; some are more sensitive to environmental changes and some have more links to other components. The essential criterion is that a chosen Theme should inform assessments of Ecosystem Health.

### Active Themes

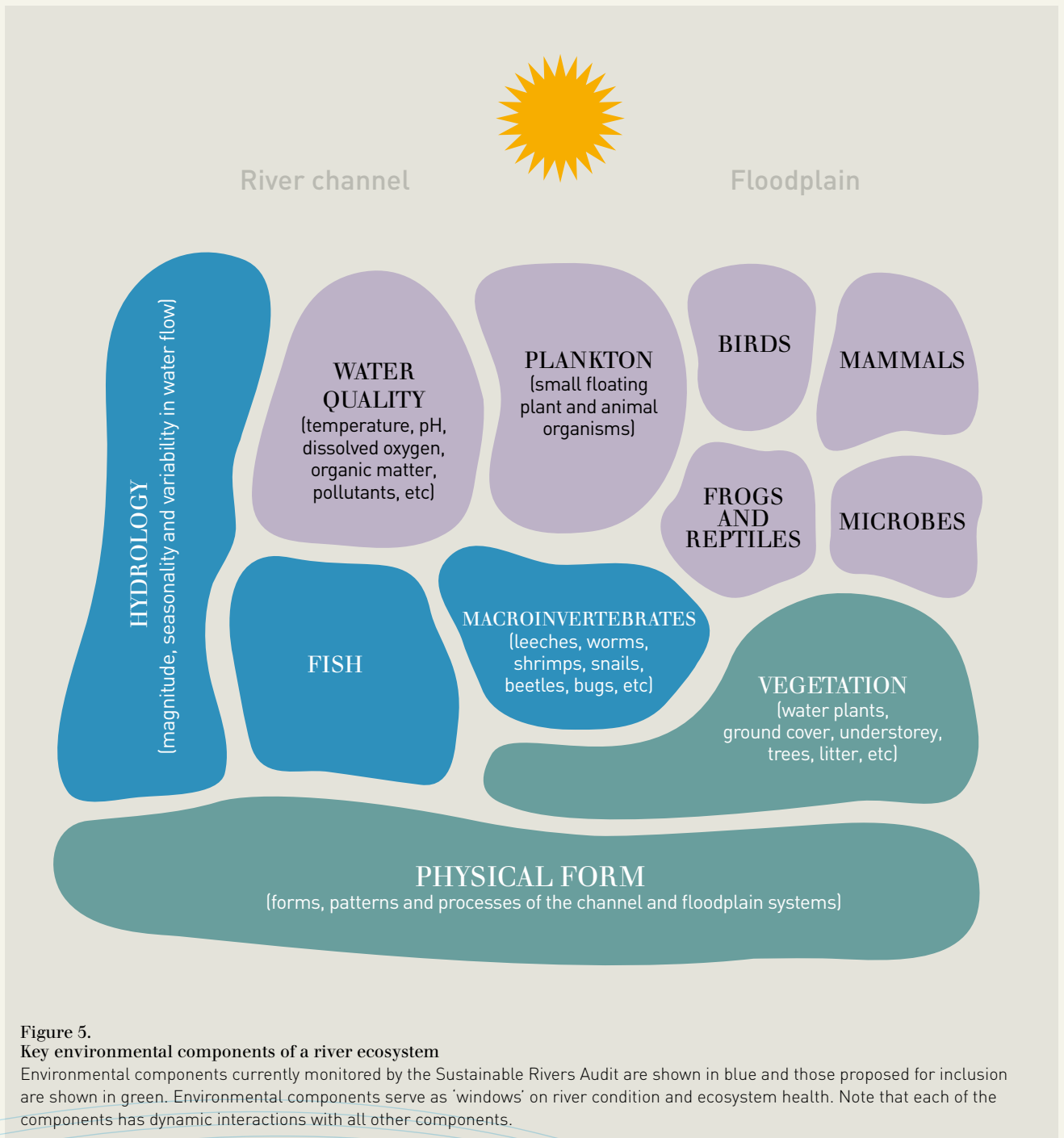
Three Themes—Fish, Macroinvertebrates and Hydrology—are active in this first stage of the SRA. They were chosen for their significance in river ecosystems, their sensitivities to interventions and their linkages to other features of river ecology. Each is amenable to sampling and measurement using proven methods. This first Audit is limited to river channels, however, and does not consider floodplains.

Two new Themes are under development and will expand the scope of future Audits to include assessments of the entire channel-floodplain system. The *Physical Form* Theme will assess geomorphic condition at the scale of the drainage network and of individual river reaches, and the *Vegetation* Theme will assess channel and floodplain vegetation at catchment- and reach-scales. By *SRA Report 2* (due in 2011), the Audit will present an integrated biophysical assessment of river health in channel-floodplain systems throughout the Basin.

**Box 2.**

### What is 'Reference Condition'?

Reference Condition is a reconstruction of the ecosystem's components as they would be had significant human intervention not occurred in the landscape. It is not a target for management, but is merely a benchmark representing the river ecosystem in a definitive state of good health. Estimates of Reference Condition are based on documented information that is open to revision and re-analysis in response to new knowledge.



**Figure 5.**  
**Key environmental components of a river ecosystem**

Environmental components currently monitored by the Sustainable Rivers Audit are shown in blue and those proposed for inclusion are shown in green. Environmental components serve as 'windows' on river condition and ecosystem health. Note that each of the components has dynamic interactions with all other components.

## Fish

The Fish Theme reports on the condition of fish communities, using fish numbers, biomass and community composition.

Fish are often near the top of the aquatic food chain, and are sensitive to short- and long-term environmental changes. They are food for some birds and, of course, a resource for humans.

Samples were taken at 487 sites, with at least 18 sites in each Valley. Sampling was in low-flow conditions in spring, summer or autumn, allowing for seasonal differences between northern and southern rivers. All main habitat types in channels were sampled in proportion to their extent. Wetlands and some ephemeral streams could not be sampled for logistical reasons, although these can be significant habitats for fish.

*Reference Condition for Fish* estimates community composition as it would be now, in a given Zone and Valley, in the absence of significant human intervention. It was determined through a combination of expert knowledge, previous research, museum records and historical data.

Thirteen *metrics* were derived from field data. Six of these were integrated as two *indicators* that measure community composition and the numbers and biomass of native and alien species, relative to Reference Condition. These were then merged to provide the *Fish Condition Index* (FI).



### FI—Fish Condition Index

Integrates the fish expectedness and nativeness indicators. High scores indicate many of the expected native species and less alien species; low scores indicate fewer of the expected native species and more alien species.



### Expectedness Indicator

A measure of the presence of native species, calculated from the numbers of observed and 'expected' native species (those expected under Reference Condition). High scores indicate that many of the expected native species are present; low scores indicate that many are missing.



### Nativeness Indicator

The proportions of abundance, biomass and species numbers that are native rather than alien species. High scores indicate dominance by native species; low scores indicate dominance by alien species.

## Additional information reported



### Number of species

The numbers of native and alien fish species found across all sites in the Valley or Zone.



### Biomass

The average biomass per site of native and alien fish species found in the Valley or Zone.

### Diagnostic Indicators

Additional 'diagnostic' indicators are discussed in the main *SRA Report 1*.

#### Box 3.

### What are Expert Rules ?

Expert rules are used to derive indicators and indices of Condition for each environmental Theme, as well as to integrate Condition indices to derive the index of Ecosystem Health.

Expert Rules are based on 'fuzzy logic', a branch of mathematics that deals with data that are approximate rather than precise.

This approach has several advantages: it avoids the need for arbitrary boundaries between categories of assessment; it is transparent and open to review if necessary; it integrates data in ways that cannot be achieved by simple arithmetic; and it is a useful way to include expert knowledge into data integration.

Rules were developed initially by ISRAG, then encoded using the computer program MatLab® (The Mathworks Inc., USA). They were used by ISRAG to calculate indicators and indices of Condition, and to make assessments of Ecosystem Health. The rules are shown in *SRA Report 1*.



## Macroinvertebrates

The Macroinvertebrate Theme describes the occurrence of macroinvertebrate families at each site, and includes measures of community composition and sensitivity to disturbance. Macroinvertebrates are bottom-dwelling invertebrates visible to the naked eye. Together, they account for a large part of aquatic biodiversity and are food for fish and other fauna. They contribute to carbon and nutrient processing, are sensitive to short- and medium-term disturbances, and are readily sampled.

Some large forms like crayfish, freshwater mussels and snails were not adequately sampled in this Audit but will be included in future sampling.

Samples were taken at 773 sites, including 35 sites per Valley and at least three sites per Zone. Sampling was in low-flow conditions in spring or autumn, and included both riffle- and edge-habitats where possible. Wetlands and some ephemeral pools and streams were not sampled, for logistical reasons, although these are significant habitats.

*The Reference Condition for Macroinvertebrates* is the estimated composition of macroinvertebrate communities that would occur now, at a given site, in the absence of significant human intervention. It is based on distributional limits of family tolerances for temperature, hydrology, geomorphology and biogeography.

Assessments were made using two indicators based on the presence of families and the composition of communities. These were combined as the *Macroinvertebrate Condition Index* (MI).



### MI—Macroinvertebrate Condition Index

Integrates the macroinvertebrate indicators for expectedness and sensitivity to disturbance. A low score indicates losses of many expected macro-invertebrate families, including disturbance-sensitive species.



### Expectedness Indicator

The proportion of families observed (O) relative to those expected (E) under Reference Condition. A high score means that many of the expected families are present; a low score indicates their absence.



### SIGNAL OE Indicator

The SIGNAL (Stream Invertebrate Grade Number Average Level) score is based on the sensitivities of families to pollution or other disturbances. In the SRA, the SIGNAL OE score is the ratio of the observed SIGNAL score to that expected under Reference Condition. A high score shows that the community is unaffected by disturbance; a low score indicates the opposite.

## Additional information reported



### Number of families

The numbers of macroinvertebrate families found across all sites in the Valley or Zone.

## Hydrology

The Hydrology Theme measures ecologically significant aspects of the flow regime including volume, variability, extreme flow events and seasonality.

Flow is a 'driver' that influences virtually every facet of a river ecosystem. The flow of water transports materials in suspension and solution and sustains aquatic and terrestrial organisms in both channel and floodplain environments. The pattern of flow is sensitive to short- and long-term human interventions.

For *SRA Report 1*, Hydrological Condition was assessed using data from 469 sites, with flow records over 15–117 years. *Reference Condition for Hydrology* was estimated using models that simulate conditions with no direct human influence within the Basin (storages, diversions and inter-valley transfers set to zero). The models were run for each site, covering the same period of record as for an observed 'current' scenario.

Five indicators, representing changes from Reference Condition in ecologically important features of the flow regime, were calculated from modelled monthly flows for each site. Although Condition ratings were made for all sites, fully quantitative Valley- and Zone-scale assessments were not possible in this first-stage Audit, as the sites were not randomly distributed. This will be rectified in future reports. For this report, assessments of the hydrological Condition of each Valley were made by semi-quantitative evaluation based on *Expert Rules* applied to site scores.

Current and Reference Condition data for Hydrology accounts for both wet and dry periods. Assessments therefore reflect the overall effects of water resource development on the historical flow regime rather than the recent prevailing drought.

Changes in vegetation cover and interception of runoff in farm dams are also important factors, but are not currently included in the hydrological models used in the SRA.



### HI—Hydrology Condition Index

Combines the five indicators below and reflects the relative ecological importance of high and low flow events, changes in flow variability and seasonality, and the annual flow volume.

### HFE—High-Flow Events Indicator

A measure of change in the size of high flow events relative to Reference Condition.

### LZFE—Low- and zero-flow events indicator

An integrated measure of change in the size of low flows and the duration of zero flow periods relative to Reference Condition.

### V—Flow variability indicator

A measure of change in the variability of flows relative to Reference Condition.

### S—Flow seasonality indicator

A measure of change in the seasonal pattern of flows relative to Reference Condition.

### GV—Gross annual flow volume indicator

An integrated measure of changes in mean and median annual flow volumes relative to Reference Condition.

For *SRA Report 1*, hydrological indices and indicators could only be calculated for individual sites, not for Zones or Valleys.

## Additional information reported



### Mean monthly flows

Current and Reference Condition mean monthly flows (GL) are presented for a sample of sites in each Valley.

## Condition and Ecosystem Health

<b>GOOD</b>	Ecosystem Health for each Valley is determined by integrating the Condition indices from all Themes using Expert Rules. It is reported using a five-point rating scale, from <i>Good</i> through <i>Moderate</i> , <i>Poor</i> , <i>Very Poor</i> to <i>Extremely Poor</i> .
<b>MODERATE</b>	
<b>POOR</b>	Condition of each ecosystem component is assessed by integrating the Theme's indicators to a Condition Index. In all Themes, the Condition Indices vary from 0–100, where 100 is Reference Condition.
<b>VERY POOR</b>	
<b>EXTREMELY POOR</b>	

For the Fish and Macroinvertebrate Themes, a Condition Index was calculated for each Valley and Zone, reported as both the index value (0–100) and a rating.

For the Hydrology Theme, the Condition Index could only be reported for individual sites. For Valleys and Zones, therefore, hydrological condition was evaluated semi-quantitatively and was reported only as a rating.

The Hydrology Theme is given less weight in determining Ecosystem Health than the other Themes. This was partly because it is a 'driver' as well as an outcome of environmental changes, and partly because there were difficulties in obtaining fully compatible data.

### Box 4.

#### Data, metrics, indicators, indices

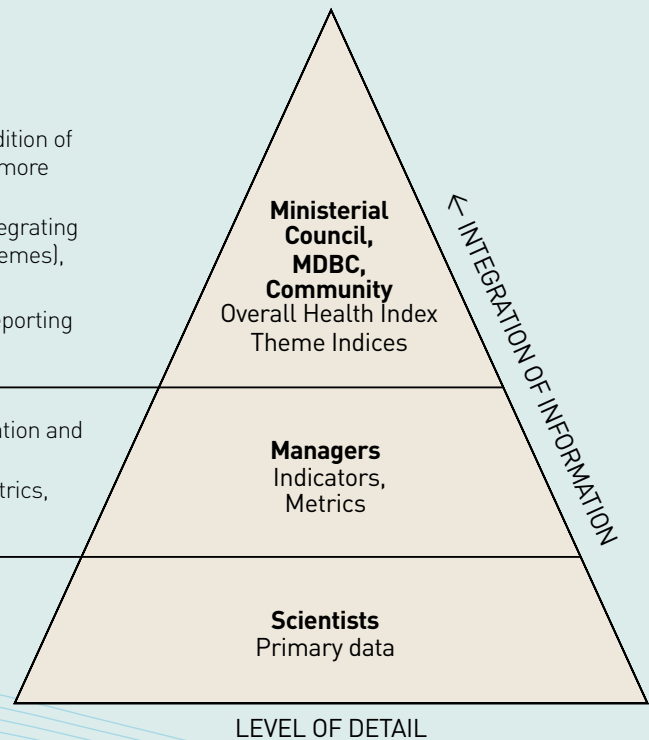
Because SRA data should be accessible to people wanting different levels of detail, they are preserved as a complete set of *primary data*, along with the *metrics*, *indicators* and *indices* derived from them.

- An *Index of Condition* is the integrated value for Condition of a component (Theme), derived by integrating two or more Indicators using Expert Rules.
- The *Ecosystem Health Index* is a value derived by integrating Condition indices from a number of components (Themes), also using Expert Rules.

Index values are also aggregated from site values for reporting at Valley- and Zone-scales.

- *Metrics* represent the difference between an observation and its estimated value under Reference Condition.
- *Indicators* are derived by integrating two or more Metrics, using *Expert Rules*.

- *Primary data* are field observations of variables (eg counts, measurements, modelled flow data).



Stages in integrating information in the SRA—from primary data to health assessments—and the main audiences

## 5. Report Cards for Valleys

### Overview

Using the Valley- and Zone-level Condition assessments for fish, macroinvertebrates and hydrology, each Valley and its constituent Zones was assigned an Ecosystem Health rating.

The Paroo Valley was rated in Good Health, and the Border Rivers and Condamine were rated in Moderate Health. Most Valleys were rated Poor (7 Valleys) or Very Poor (13 Valleys). The lowest ranking valleys, the Murrumbidgee and Goulburn, were in Very Poor Health. No Valley was rated in Extremely Poor Health.

Northern 'summer rainfall' Valleys were generally in better health than southern 'winter-spring rainfall' Valleys. Only two of the nine northern Valleys were rated in Very Poor Health, compared to nine of the 14 southern Valleys. All three Valleys rated in Moderate to Good Health were in the northern Basin.

Ecosystem Health assessments by Valley are shown in Figure 6.

Assessments of Condition and Ecosystem Health partly reflect the very dry conditions that have prevailed in the Basin before and during the Audit period. In some cases, the ecological effects of drought will have compounded human-induced effects within the Basin. The magnitude of these effects should be apparent in later Audit reports, once trend analyses become possible. With due allowance for the drought, ISRAG considers that the assessments reported here are a realistic indication of underlying conditions. Based on their Health Ratings, the 23 Valleys are grouped into Good, Moderate, Poor, and Very Poor in Table 1. The Ecosystem Health and Condition assessments for each Valley in the Basin are summarised in Table 3 (page 73).

### Report cards

Individual Report Cards for the 23 SRA Valleys, covering Ecosystem Health and Condition of three environmental components—fish, macroinvertebrates and hydrology—are provided in the following section of this report.

**Table 1.**  
Ecosystem Health assessments by Valley, 2004–2007  
Valleys are arranged in rank order of Health Ratings.

HEALTH RATING	VALLEY	RANK
Good	Paroo	1
Moderate	Border Rivers, Condamine	2
Poor	Namoi, Ovens, Warrego	3
	Gwydir	4
	Darling, Murray Lower, Murray Central	5
Very Poor	Murray Upper, Wimmera	6
	Avoca, Broken, Macquarie	7
	Campaspe, Castlereagh, Kiewa, Lachlan, Loddon, Mitta Mitta	8
	Murrumbidgee, Goulburn	9

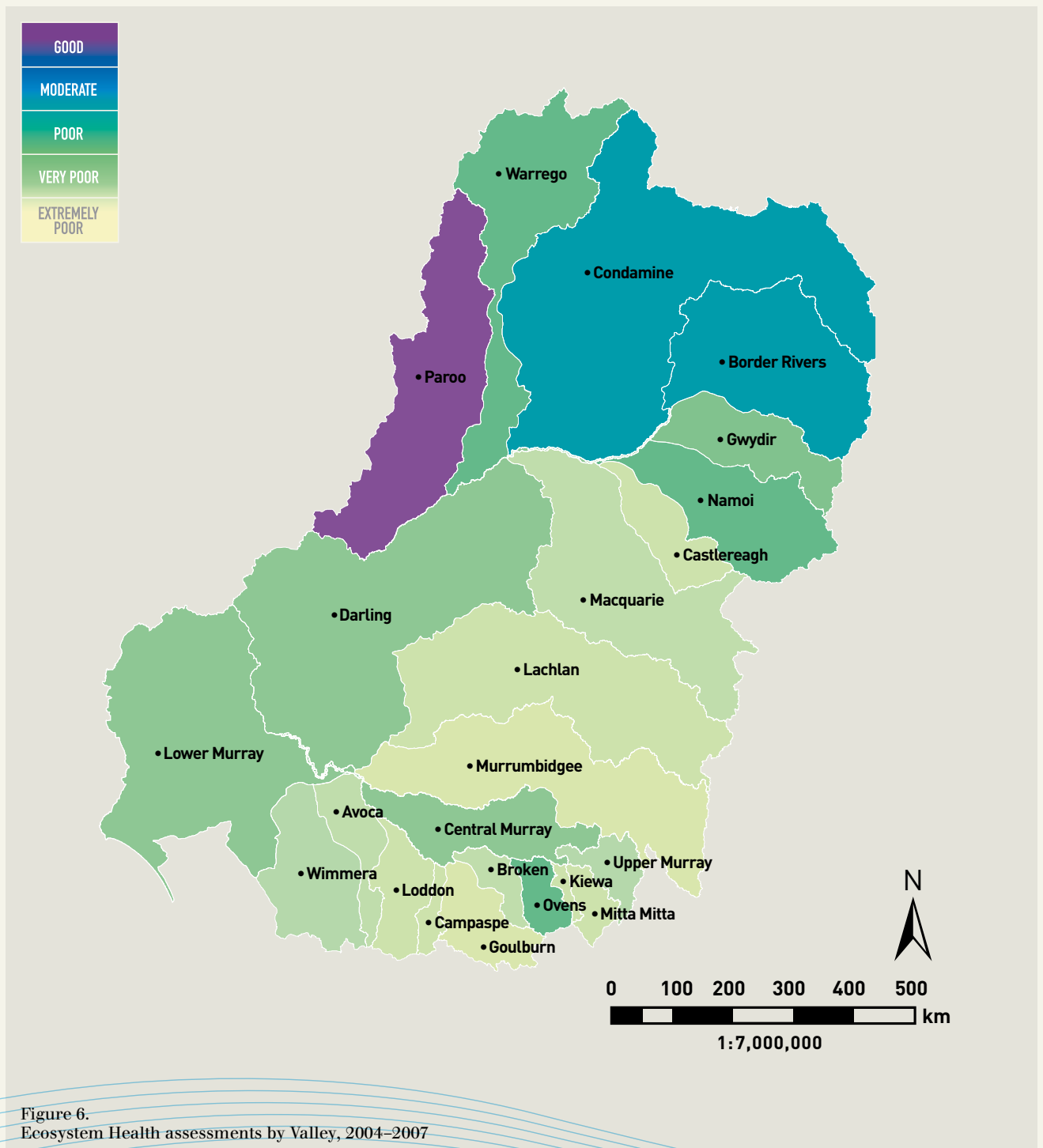
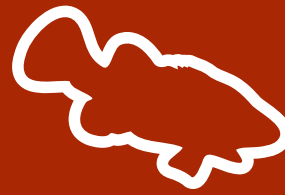
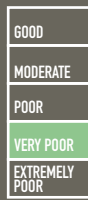


Figure 6. Ecosystem Health assessments by Valley, 2004–2007

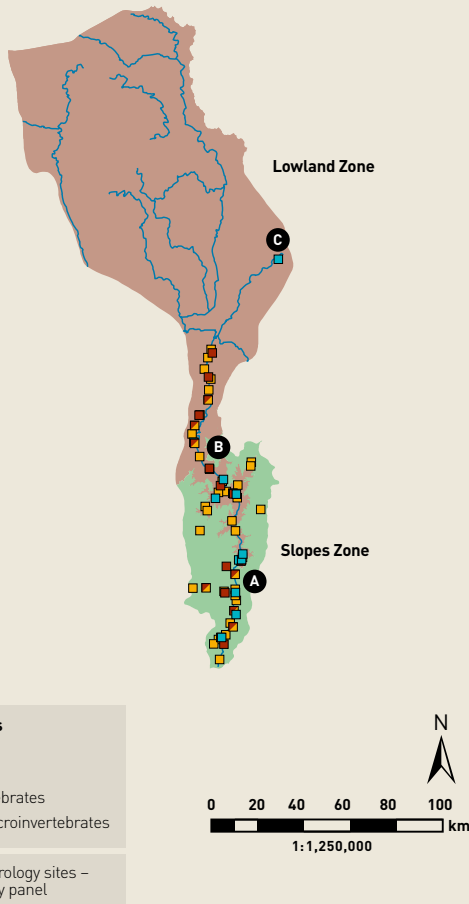


# Avoca Valley

## Ecosystem Health



## Fish



## The Avoca Valley

The Avoca River rises near Amphitheatre, Victoria, and flows north for 270 km toward the Murray, terminating at the Kerang Wetlands. The river flows within a confined valley to Charlton before entering a broad alluvial plain. Floodwaters are dissipated across a wide area, the Avoca Floodway.

The Avoca Valley covers 14,000 km<sup>2</sup>, about 1.5% of the Basin area.

## River Ecosystem Health

The Avoca Valley river ecosystem was in Very Poor Health (Lowland Zone: Very Poor; Slopes Zone: Poor).

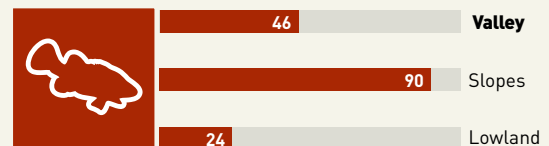
The Avoca Valley fish community was in Poor Condition (FI = 46) (Lowland Zone: Very Poor; Slopes Zone: Good).

Eighteen sample sites yielded 905 fish. Alien species were over 90% of the fish biomass, and large alien species – especially Common carp and Redfin perch – dominated the biomass in both Zones. The native fish were mainly small species, although a few larger Golden perch were recorded at three sites. Alien fish were, on average, 50 times heavier than native fish. These factors contributed to an extremely low percentage of native biomass (8%), even though native species dominated numerically (68%).

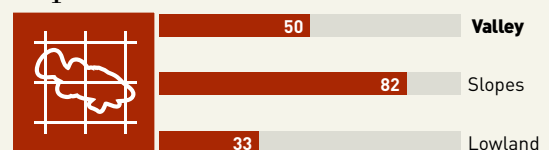
In the Lowland Zone, only five of 16 predicted native fish and four alien species were recorded. In the Slopes Zone, all six predicted native species were recorded, with three alien species.

Southern pygmy perch were predicted to be common in the Lowland Zone, but were not caught at any sites. Species such as Silver perch and Freshwater catfish were not detected either although they were predicted, under Reference Condition, to be rare or moderately rare in one or more Zones. Golden perch and Murray cod were rare or absent from catches.

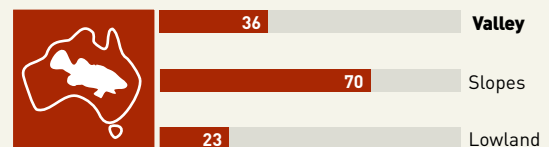
## Fish Condition Index



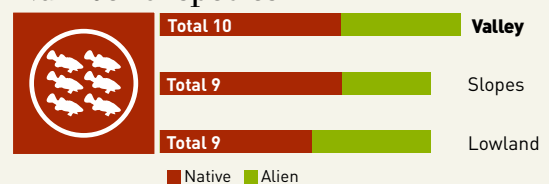
## Expectedness



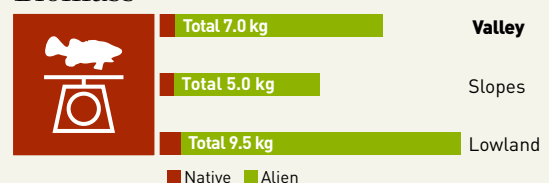
## Nativeness



## Number of species

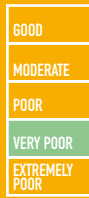


## Biomass





## Macroinvertebrates



## Hydrology



The Avoca Valley macroinvertebrate community had a condition index (MI) of 34, the lowest score for any Valley, and was in Very Poor Condition throughout (Lowland and Slopes Zones: Very Poor).

Thirty-five sites were surveyed across the Avoca Valley in April 2005, yielding 6,707 macroinvertebrates in 54 families (39% of all Basin families).

Most sites had a lower than expected diversity of macroinvertebrates, and low representation of disturbance-sensitive families, particularly in the Slopes Zone. A little over half (57%) of the Valley's expected families were found. Family richness generally was low compared to Reference Condition. Diversity was low (average 17 families per site), with the Slopes Zone being most diverse (21 families per site). Each Zone contained a high proportion of the range of Valley fauna (75–84%).

The three common families in the Valley were marsh beetles, whirligig beetles and water scorpions. There were 17 rare families (found at few sites across the Basin), including particular families of crustaceans, snails and insects.

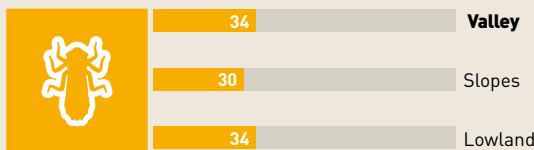
The Avoca Valley was in Moderate to Good hydrological condition (Lowland and Slopes Zones: Good Condition), with Hydrology Index scores (HI) at 11 sites from 75–100.

Sites on the Avoca mainstem (Lowland Zone) were Near Reference Condition or showed a Moderate Difference from Reference Condition. Tributary sites in the Slopes Zone were Near Reference Condition.

At mainstem sites, the Low- and Zero-Flow Events indicator (LZFE) was the most reduced, reflecting diversions during summer. At tributary sites, values were Near Reference Condition. High flows were slightly reduced at all sites and annual flow volumes in the mainstem were reduced (15–30% as means; 30–50% as medians). Flow Variability and Seasonality were near Reference Condition at most sites, with a slight shift in Seasonality at the most downstream Lowland Zone sites.

Overall, the Valley flow regime had reduced magnitudes of annual flow volumes and high flows and reduced low flows in the mainstem, with little change in variability and seasonality.

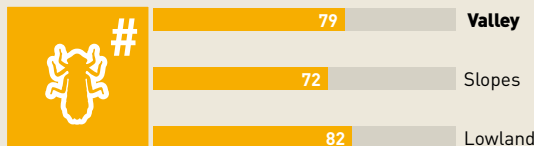
### Macroinvertebrate Condition Index



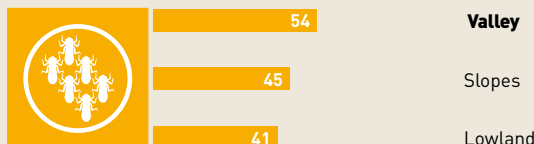
### Expectedness



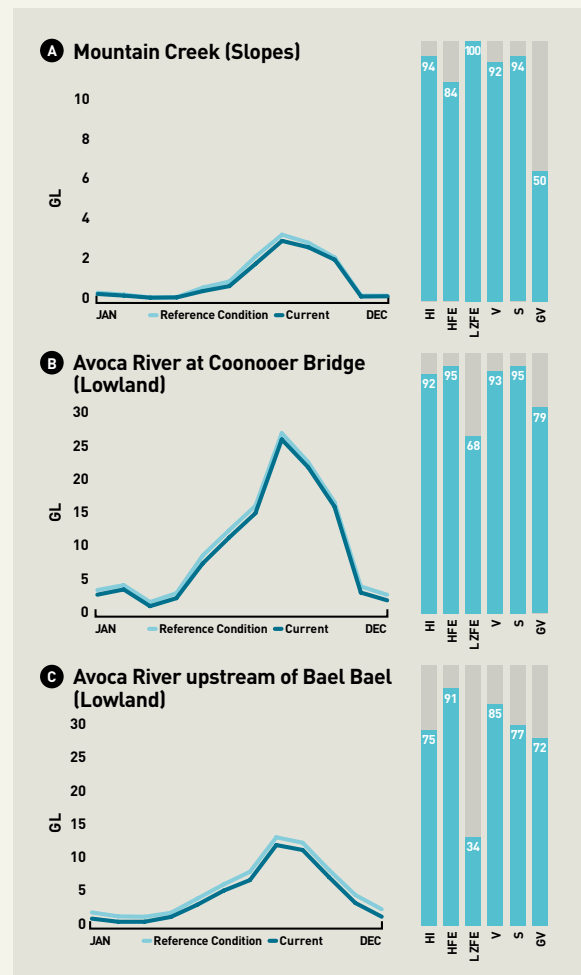
### SIGNAL OE Score



### Number of families

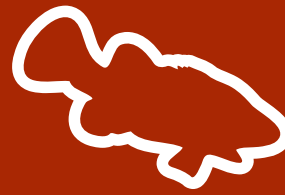
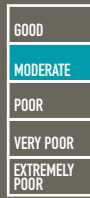


### Selected Hydrology sites

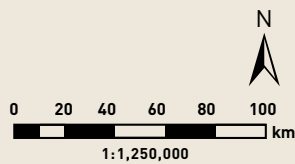
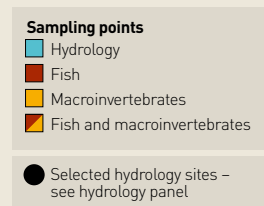
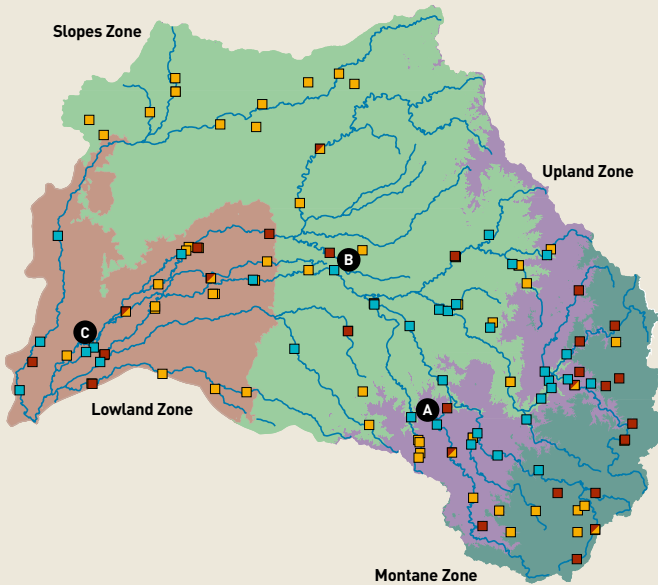




# Border Rivers Valley Ecosystem Health



## Fish



## The Border Rivers Valley

The Border Rivers rise on the western slopes of the Great Dividing Range in the area straddling the NSW–Queensland border, and flow to the Barwon River at the head of the Darling Valley. The Macintyre Brook and the Dumaresq River enter the Macintyre River, which flows through a broad floodplain before entering the upper reaches of the Barwon. The Moonie River joins the Barwon separately, draining the north-west, and the Severn River drains the south, from NSW. Instream storages include the Coolmunda, Glenlyon, Pindara and Rangers Valley Dams (total 641 GL).

The Border Rivers catchment is 62,500 km<sup>2</sup>, or about 6% of the Basin area.

## River Ecosystem Health

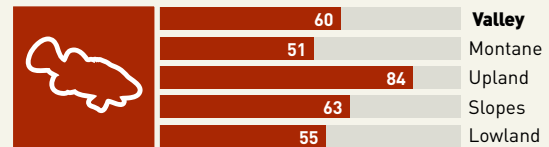
The Border Rivers Valley river ecosystem was in Moderate Health (Lowland Zone: Moderate; Slopes Zone: Good; Upland Zone: Moderate; Montane Zone: Poor).

The Border Rivers fish community was in Moderate Condition (FI = 60) (Lowland and Montane Zones: Poor Condition; Slopes Zone: Moderate; Upland Zone: Good), and had the third highest score among all Valleys.

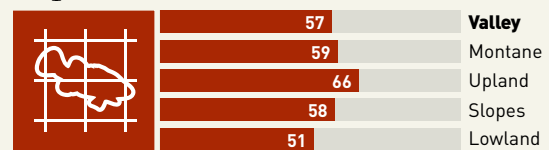
Twenty-eight sites were sampled yielding 4,345 fish. Across the Valley, 63% of individuals and 60% of fish biomass were native, and 13 of the 16 native species expected under Reference Condition were caught. Lowland Zone sites had few native species and were dominated by the alien Common carp and Goldfish, with some Gambusia. Montane Zone sites had variable numbers of native species and the alien species, redfin perch was common.

Silver perch were absent from catches in Zones where they were expected to be common. Other species missing in catches from one or more Zones where they were expected under Reference Condition included Darling River hardyhead, Flathead gudgeon, Olive perchlet, River blackfish, Mountain galaxias, Southern purple-spotted gudgeon and Un-specked hardyhead.

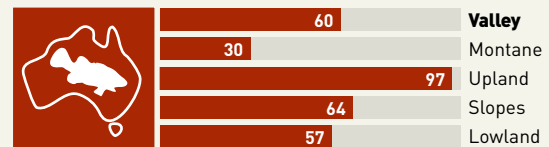
## Fish Condition Index



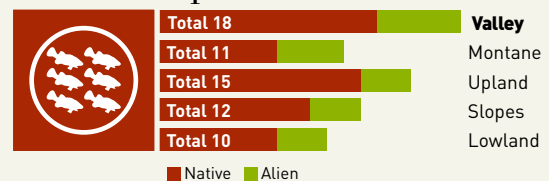
## Expectedness



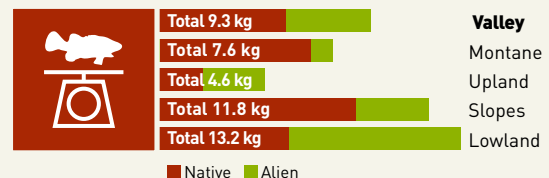
## Nativeness



## Number of species



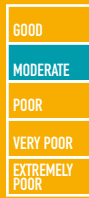
## Biomass







# Macroinvertebrates



# Hydrology



The Border Rivers Valley macroinvertebrate community had an index (MI) of 66, the highest score of all Valleys, and was in Moderate Condition (Lowland and Slopes Zones: Moderate Condition; Upland and Montane Zones: Poor).

Thirty-four sites were surveyed, yielding 63 families of macroinvertebrates (44% of all Basin families).

The Lowland and Slopes Zones had more expected families than the Upland and Montane Zones. The Upland and Montane Zones had depleted communities, especially of disturbance-sensitive families. There was also significant variation among sites in the Upland and Montane Zones.

Sixty-six percent of expected families were found, and family richness was less than Reference Condition at more than 40% of sites. Diversity was high (average 26 families per site), and least in Lowland Zone sites (22 families per site). Most (90%) of the range of the Valley fauna was in the Slopes Zone (compared to 68–75% for the Lowland, Upland and Montane Zones).

There were 19 common families recorded in the Valley, including snails, prawns and 16 aquatic insect families. Eight rare families were recorded, including isopod crustaceans and a variety of insects.

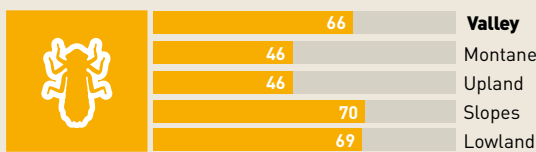
The Border Rivers Valley was in Moderate to Good hydrological condition (Lowland Zone: Moderate to Good; Slopes, Upland and Montane Zones: Good), with Hydrological Index scores from 34 sites of 70–100.

The eight sites in the Lowland Zone varied from a Moderate Difference from Reference to Near Reference Condition. The 19 Slopes sites, five Upland sites, and the single Montane site were all in Near Reference Condition.

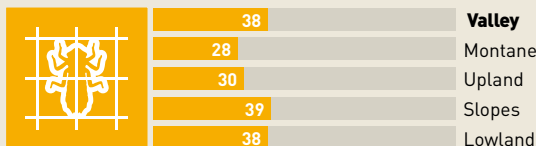
Upstream, High-Flow Events (HFE) were in Near Reference Condition, but in the Lowland Zone, HFE ranged from a Very Large Difference from Reference (2 of 8 sites) to Near Reference Condition (2 of 8 sites). Similarly, Gross Annual Volumes Indicator were substantially different from Reference Condition (30–75% less) in the Barwon Lowland Zone and in the Boomi and Little Weir Rivers.

Overall, the flow regime of the Border Rivers Valley was characterised by reductions in the magnitude of high-flow events and annual volumes, as well as small shifts in seasonality. There was little change, however, in low- and zero-flow events and variability. This reflects the diversion of significant volumes of water from the system and the effect of differentially harvesting high flows.

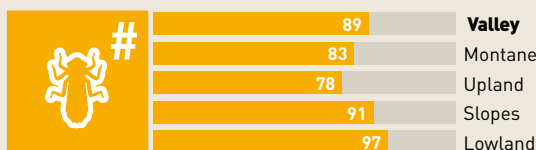
## Macroinvertebrate Condition Index



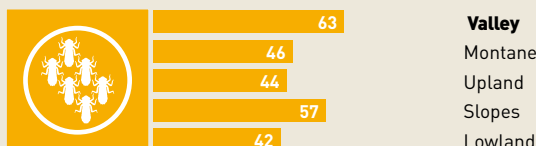
## Expectedness



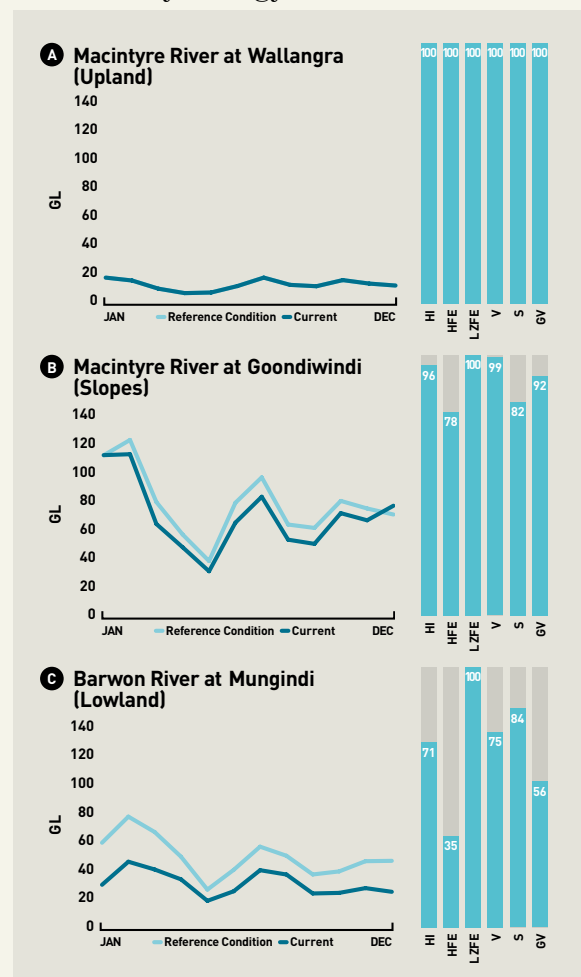
## SIGNAL OE Score



## Number of families

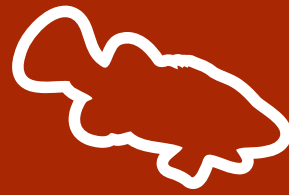


## Selected Hydrology sites

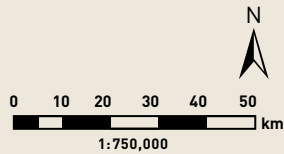
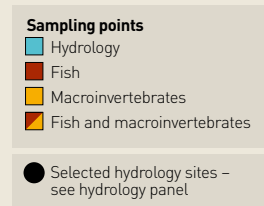




# Broken Valley Ecosystem Health



# Fish



## The Broken Valley

The Broken River rises east of Mansfield, Victoria, flows west to Lake Nillahcootie then north to Benalla, then west again to join the Goulburn River above Shepparton. Tributaries include Hollands Creek, Ryans Creek and Lima East Creek. A distributary, Broken Creek, leaves the river downstream of Benalla and joins the Murray downstream of Barmah Forest. The one instream storage is Lake Nillahcootie (40 GL). Lake Mokoan (26 GL) near Benalla has been used as an offstream storage in the past.

The Broken Valley catchment covers 6800 km<sup>2</sup>, less than 1% of the Murray–Darling Basin.

## River Ecosystem Health

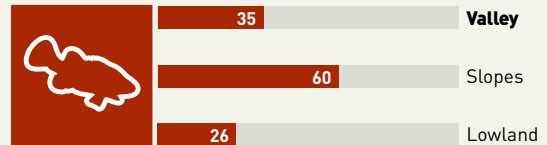
The Broken Valley river ecosystem was in Very Poor Health (Lowland Zone: Very Poor; Slopes Zone: Moderate).

The Broken Valley fish community was in Very Poor Condition, with a score (FI = 38) near the average for all Valleys (Lowland Zone: Very Poor Condition; Slopes Zone: Moderate).

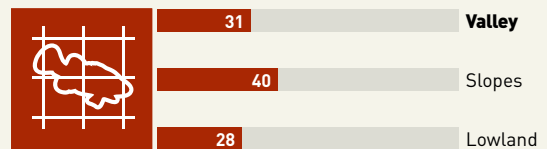
Nineteen sites were sampled, yielding 1,816 fish. Native fish were numerically dominant, but fewer than half of the predicted native species were found, and these were only one-third of the total biomass. Eleven (mostly small) native species and six alien species were recorded. Common carp and Goldfish were common in the Lowland Zone, and Redfin perch and Brown trout were common in the Slopes Zone.

Trout cod and Silver perch were not caught, but were expected to be common under Reference Condition. Other species not caught but expected to be rare or moderately rare in one or more Zones under Reference Condition, included Trout cod, Murray cod, Golden perch, Macquarie perch, Southern purple-spotted gudgeon and Silver perch.

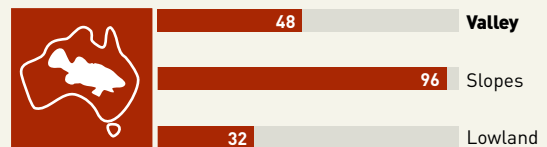
## Fish Condition Index



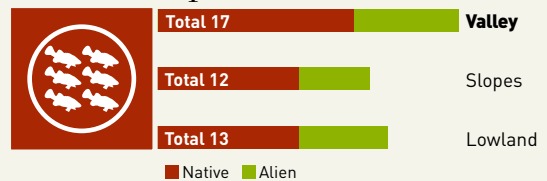
## Expectedness



## Nativeness



## Number of species

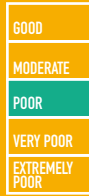


## Biomass





# Macroinvertebrates



The Broken Valley macroinvertebrate community had a condition index (MI) of 51, and was in Poor Condition (Lowland and Slopes Zones: Poor Condition).

Thirty-five sites were sampled yielding 78 families (57% of all Basin families).

Family richness at all sites was less than Reference Condition. Diversity was moderate (average 24 families per site), and highest at some Slopes Zone sites (31 families per site).

The fauna at all sites had reduced Expectedness scores indicating absence of several to many expected families. Most sites had SIGNAL OE scores indicating some loss of disturbance-sensitive families.

Seven common families included longhorn caddis, mayflies, snails, whirligig beetles and water measurers. The 22 rare families recorded included 17 families of aquatic insects.



# Hydrology

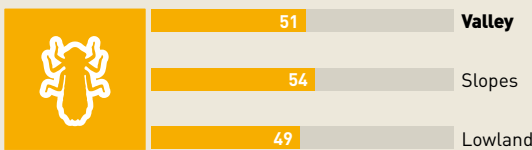


The Broken Valley was in Moderate to Good hydrological Condition (Lowland Zone: Moderate to Good Condition; Slopes Zone: Good), Hydrology Index scores (HI) for the 18 sites ranged between 41–100, indicating Near Reference Condition upstream of storages and Moderate to Large Differences from Reference Condition at downstream sites.

Above the diversion to Lake Mokoan, two sites were Near Reference Condition (HI = 95–100) and two showed a Moderate Difference from Reference Condition. Downstream, all indicators showed substantial reductions. High flows were reduced by 50% downstream of Broken Weir, where water is diverted to Lake Mokoan. Lake Nillahcootie appeared to have little downstream effect.

The Valley flow regime was characterised by reduced magnitudes of annual and high flows and changes to low flows and seasonality in the mainstem and two tributaries in the Lowland Zone, but minimal changes elsewhere.

## Macroinvertebrate Condition Index



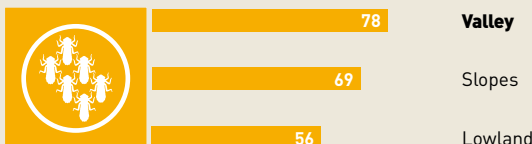
## Expectedness



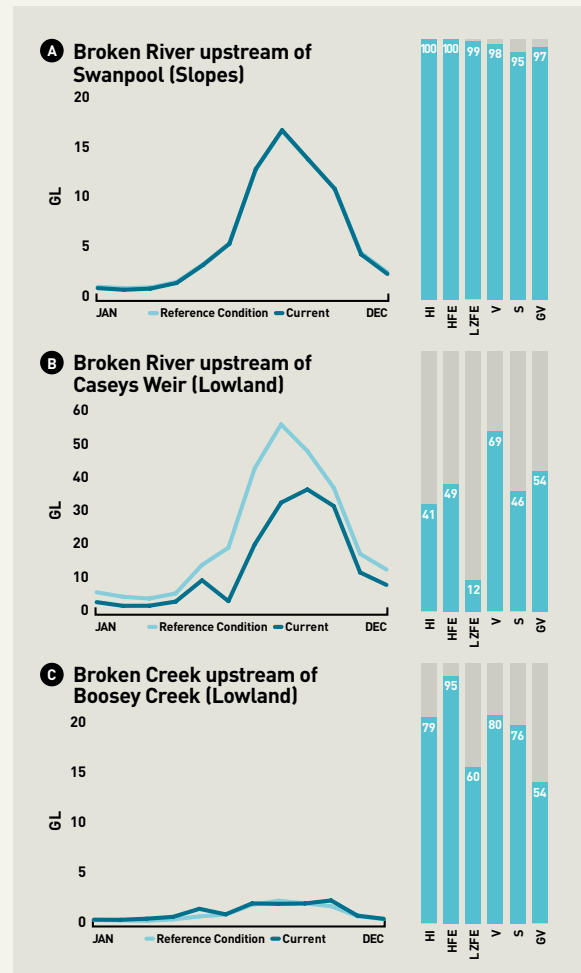
## SIGNAL OE Score



## Number of families



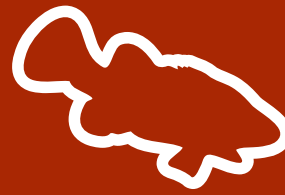
## Selected Hydrology sites



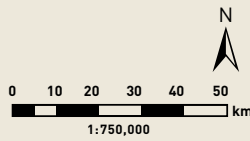
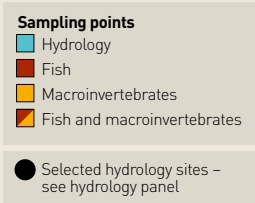
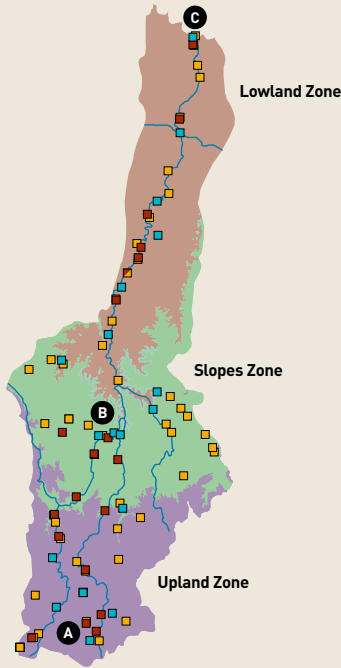


# Campaspe Valley

## Ecosystem Health



# Fish



## The Campaspe Valley

The Campaspe River rises near Woodend, Victoria, and flows north for 50 km to the main instream storage, Lake Eppalock (304 GL), near Bendigo. The tributary Coliban River meets the Campaspe just above Lake Eppalock. The Coliban includes the Malmsbury (18 GL), Lauriston (20 GL) and Upper Coliban (38 GL) reservoirs. From Lake Eppalock, the Campaspe flows to Elmore and Rochester Weir, and joins the Murray near Echuca.

The Campaspe Valley covers about 4,000 km<sup>2</sup>, or 0.4% of the Basin area.

## River Ecosystem Health

The Campaspe Valley river ecosystem was in Very Poor Health (Lowland Zone: Very Poor; Slopes Zone: Extremely Poor; Upland Zone: Extremely Poor).

The Campaspe Valley fish community was in Extremely Poor Condition (FI = 5) (Lowland and Slopes Zones: Extremely Poor Condition; Upland Zone: Very Poor) and was equal lowest, with the Goulburn, among all Valleys.

Twenty one sites were surveyed yielding 1,362 fish. Average numbers of fish per site were very low in Lowland and Upland Zone sites, but higher in the Slopes Zone. Larger body sizes of alien fish, and low proportions of native fish in Slopes and Upland catches, resulted in a native proportion of total biomass of only 7% for the Valley.

Native fish were only 21% of the total fish caught, and almost all were small. Sixty-four percent of 22 predicted native species were missing. Only one site, in the Lowland Zone, had more than three native species, and 14 sites had only one or none. River blackfish, Macquarie perch, the Obscure galaxias species complex and Trout cod were not caught in Zones where they were predicted to be common. Other species such as Murray cod and Bony herring – predicted to occur rarely or occasionally – were also not caught.

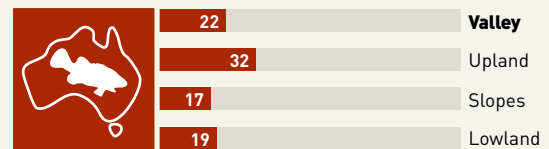
## Fish Condition Index



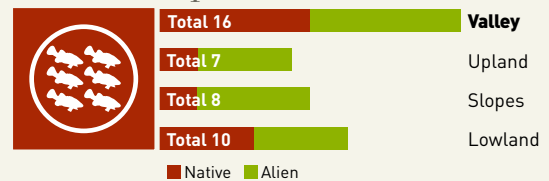
## Expectedness



## Nativeness



## Number of species

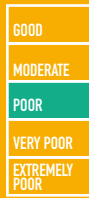


## Biomass





## Macroinvertebrates



The Campaspe Valley macroinvertebrate community had a condition index (MI) of 41, the equal third lowest score of all Valleys, and was in Poor Condition (Lowland Zone: Poor; Slopes and Upland Zones: Very Poor).

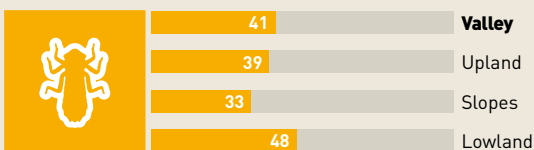
Thirty-five sites were surveyed across the Campaspe yielding 78 families, 55% of the families found in the Basin.

Most Slopes and Upland Zone sites had impoverished faunas, lacking some disturbance-sensitive families. Only a moderate to low proportion of expected families expected were actually observed. There was substantial variation in condition evident among sites in the Upland Zone.

Family richness was less than Reference Condition at all sites, although diversity was moderate to high in all Zones (average 25 families per site). SIGNAL OE scores were consistently low for all Zones.

Fourteen common families were recorded, including limpets and snails amphipods, mites, damselflies and several aquatic insects. The 27 rare families included caddisflies and other aquatic insects.

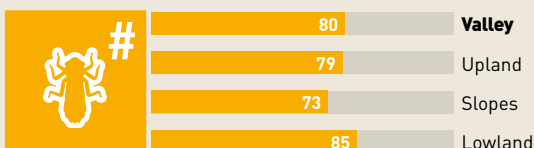
### Macroinvertebrate Condition Index



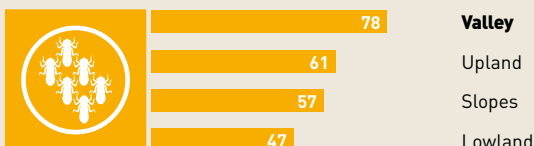
### Expectedness



### SIGNAL OE Score



### Number of families



## Hydrology

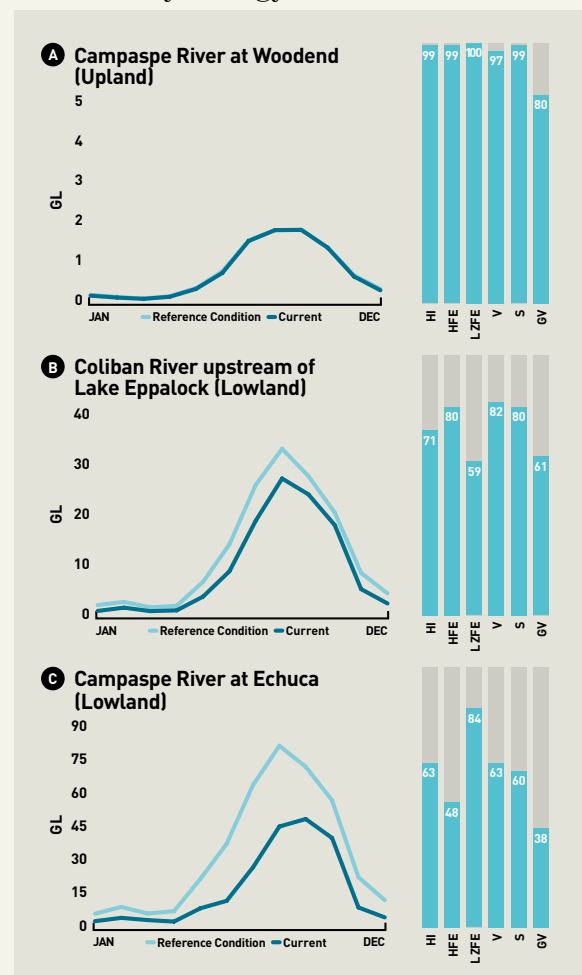


The Campaspe Valley was in Moderate hydrological Condition (Lowland Zone: Poor to Moderate Condition; Slopes Zone: Moderate; Upland Zone: Good), Hydrology Index scores (HI) for 18 sites were 58–100.

High-Flow Events were reduced on the Coliban, and on the Campaspe downstream of Lake Eppalock, showing a Large Difference from Reference Condition. Low- and Zero-Flow Events in the main channel showed Very Large Differences from Reference Condition in the Lowland Zone, but Near Reference Condition in the Upland Zone. Three tributaries showed an Extreme Difference from Reference, reflecting low-flow (summer) diversions and/or interception of runoff in farm dams. Upstream of Eppalock, measures of Seasonality were Near Reference Condition, but there were Very Large to Moderate Differences downstream.

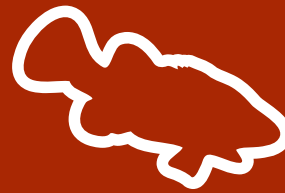
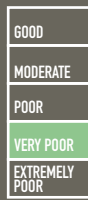
In general, the flow regime of the Campaspe River system was in Moderate Condition, except on the Coliban and lower Campaspe where volumes of annual flows and high flow events were reduced and variability and seasonality also were affected.

### Selected Hydrology sites

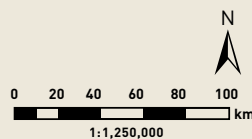
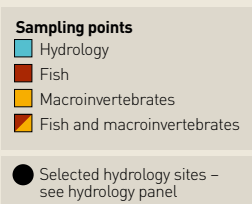
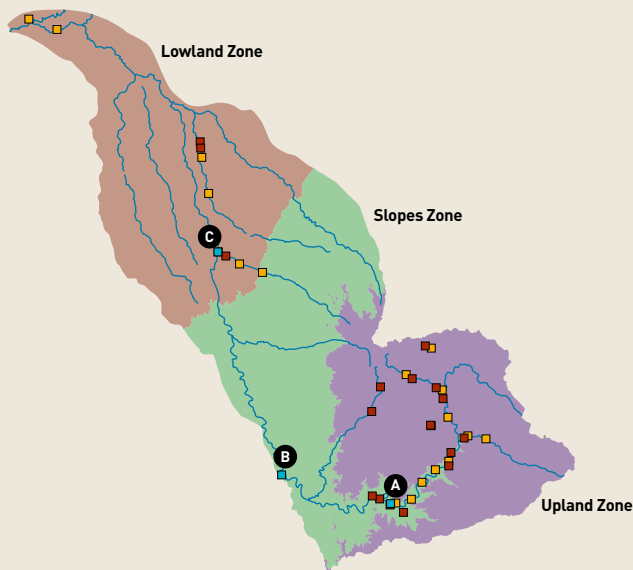




# Castlereagh Valley Ecosystem Health



## Fish



## The Castlereagh Valley

The Castlereagh River rises south-west of Coonabarabran, NSW, and flows north-west to the Barwon and lower Macquarie rivers via a network of channels. It has several foothill tributaries and others running parallel to the channel in the Lowland Zone, some joining the river within 50 km of the Valley terminus. There are no major instream storages or irrigation developments.

The Castlereagh catchment covers 17,500 km<sup>2</sup> (1.7% of the Basin area).

## River Ecosystem Health

The Castlereagh Valley river ecosystem was in Very Poor Health (Lowland Zone: Very Poor; Slopes Zone: Extremely Poor; Upland Zone: Very Poor).

The Castlereagh Valley fish community was in Extremely Poor Condition (FI = 14) (Lowland and Slopes Zones: Extremely Poor Condition; Upland Zone: Very Poor).

Twenty-one sites were sampled yielding 5,112 fish. Some Upland sites had abundant native fish and few alien species; others had the opposite. Only 33%, 23% and 25% of predicted species were recorded from the Lowland, Slopes, and Upland Zones, respectively. These Zones had two, three and three alien species, respectively. Only 37% of fish abundance and 19% of biomass were contributed by native species.

No fish were caught at four sites, and no native fish were caught at six sites. Only a single Spangled perch and two Golden perch were caught in the Lowland Zone, where they were expected to be common. Other species not caught but predicted to occur rarely or occasionally under Reference Condition, included Freshwater catfish, Golden perch, Murray cod, River blackfish and Silver perch.

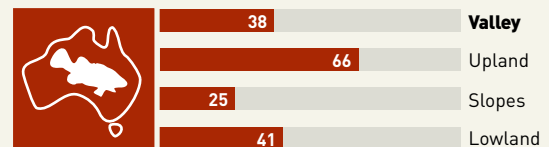
## Fish Condition Index



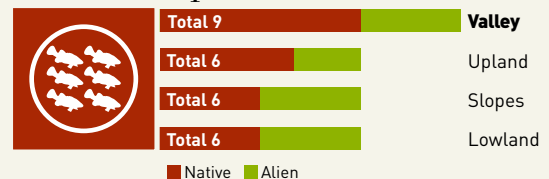
## Expectedness



## Nativeness



## Number of species

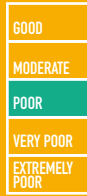


## Biomass





## Macroinvertebrates



The Castlereagh Valley macroinvertebrate community had a condition index (MI) of 41, the equal third lowest score of all Valleys, and was in Poor Condition (Lowland Zone: Poor Condition; Slopes and Upland Zones: Very Poor).

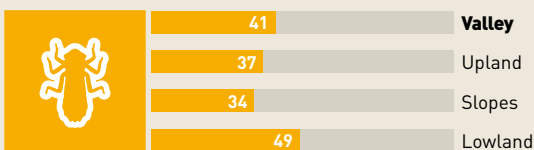
Dry conditions meant that only 18 sites were surveyed, yielding 53 families (39% of all Basin families).

Only 57% of expected Valley families were recorded, and family richness was less than Reference Condition at all but one site. Diversity overall was moderate to high (average 21 families per site, ranging from 23 families per Upland site to 17 families per Lowland site).

The Expectedness scores indicated substantial loss of expected families. SIGNAL OE scores were consistently low for the Slopes and Upland Zones, and a high proportion (7 of 10) of sites in these Zones had low SIGNAL OE scores. The faunas at most Slopes and Upland Zones were impoverished and missing most disturbance-sensitive families.

The 14 common families observed included midge larvae, diving beetles, crustaceans, backswimmers and other aquatic insects. The four rare families included caddisflies, water striders and blackfly larvae.

### Macroinvertebrate Condition Index



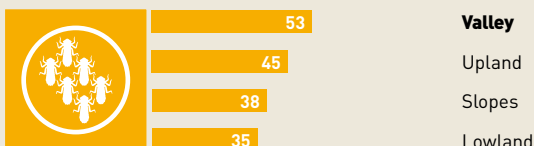
### Expectedness



### SIGNAL OE Score



### Number of families



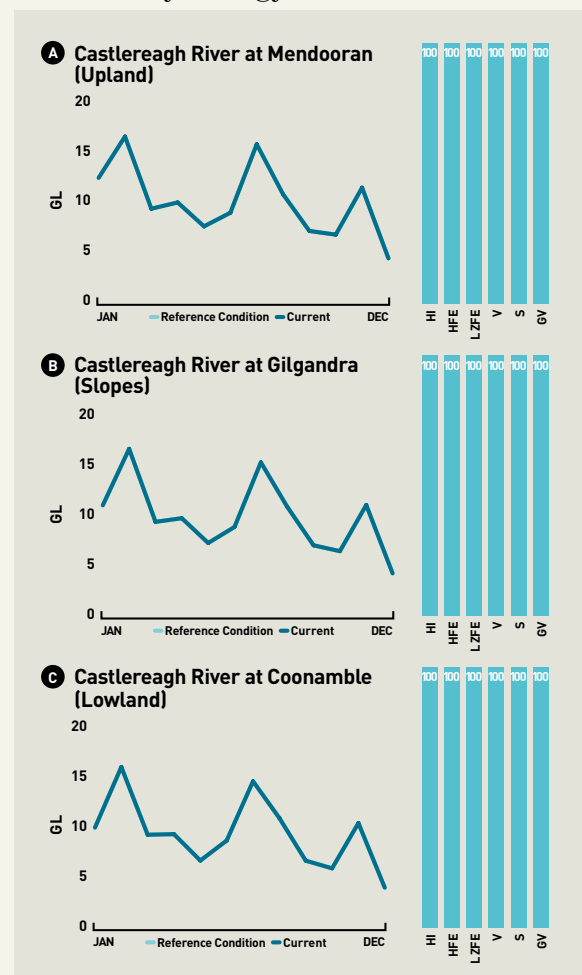
## Hydrology



The Castlereagh Valley was in Good hydrological condition, with Hydrology Index scores (HI) for the three sites all equal to 100.

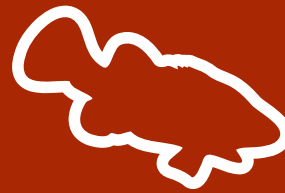
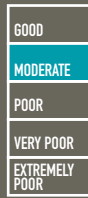
All sites were in Near Reference Condition, across all indicators. Data were available for only three sites, and the furthest downstream, at Coonamble, is over 100 km from the end of the valley and upstream of several tributary inflows. Assuming little or no modification to flow downstream of Coonamble, or in tributaries below that point, the flow regime appears little modified from natural conditions.

### Selected Hydrology sites

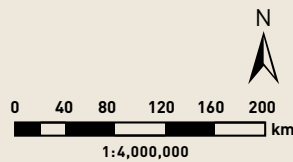
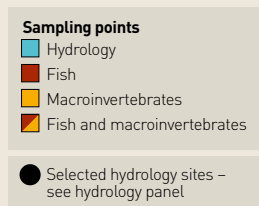
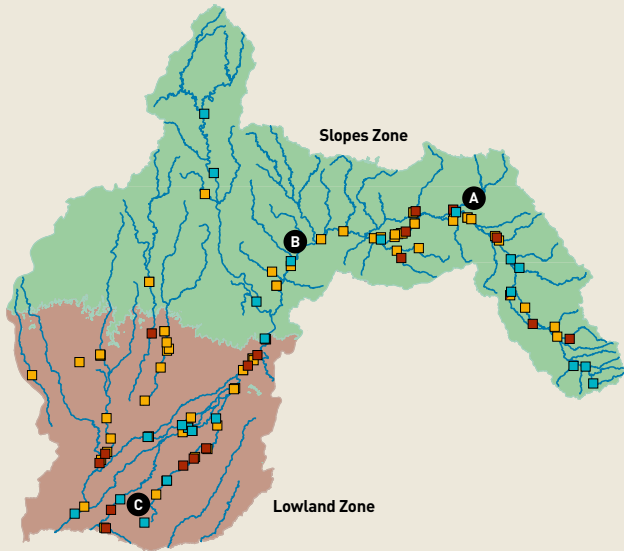




# Condamine Valley Ecosystem Health



## Fish



## The Condamine Valley

The Condamine River flows through southern Queensland, and discharges either to the Barwon (via the Culgoa and Bokhara rivers), or to terminal lakes at Narran (via the Lower Balonne Floodplain). The river changes name along its course. The Condamine rises in the north-eastern Basin, flows north-west then west to Surat, where it becomes the Balonne River and flows south-westerly, breaking into distributary channels, the largest becoming the Culgoa River. More than 20 unregulated tributaries feed the system upstream of St George. Flows are regulated by instream storages on the Condamine (Leslie Dam: 106 GL; Chinchilla Weir: 10 GL) and Beardmore Dam on the Balonne (including Buckinbah, Moolabah and Jack Taylor Weirs, total 93.5 GL). The capacities of private offstream storages, however, greatly exceed those of the instream storages.

The Condamine Valley covers 162,000 km<sup>2</sup>, or about 15% of the Basin area.

## River Ecosystem Health

The Condamine Valley river ecosystem was in Moderate Health (Lowland Zone: Moderate; Slopes Zone: Moderate).

The Condamine Valley fish community was in Moderate Condition (FI = 63) (Lowland and Slopes Zones: Moderate Condition) and had the second highest Condition score for all Valleys.

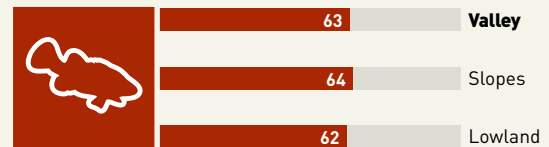
Nineteen sites were sampled yielding 3482 fish. Most fish caught (86%) were native species, but native fish were only half the total biomass, and alien fish were widespread. Ten of 18 expected native species were recorded.

Catches averaged a high 184 fish per site. Bony herring were numerous. Carp gudgeons, Australian smelt, Golden perch, Murray-Darling rainbowfish and Spangled perch were common.

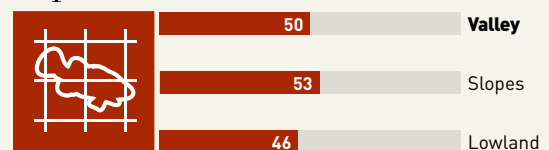
Only a single Murray cod was found in the Slopes Zone, where they were predicted to be common. Species not caught, but predicted to occur rarely or occasionally under Reference Condition included Freshwater catfish, River blackfish, Rendahl's tandan and Silver perch.

Three alien species, Gambusia, Goldfish and Common carp, were frequent: there were between one and three alien species at all but four of the 19 sites.

## Fish Condition Index



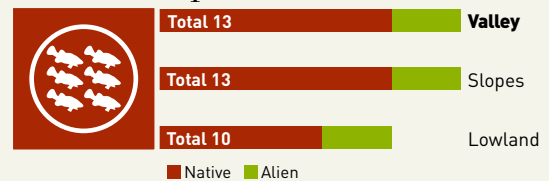
## Expectedness



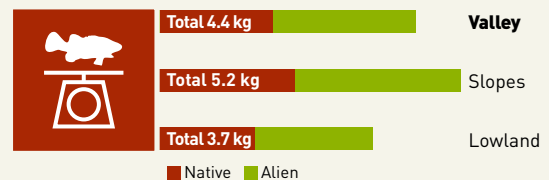
## Nativeness



## Number of species



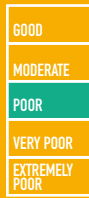
## Biomass







## Macroinvertebrates



The Condamine Valley macroinvertebrate community had a condition index (MI) of 55, the equal third lowest score of all Valleys, and was in Poor Condition (Lowland Zone: Moderate Condition; Slopes Zone: Poor).

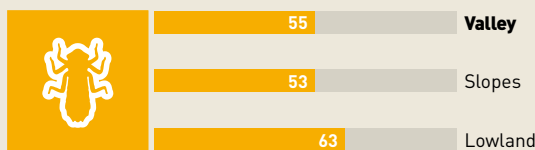
Thirty-five sites were surveyed across two Zones yielding 55 families (representative of 39% of Basin families).

The Expectedness scores indicated a moderate to substantial loss of expected families. Only four sites had a high Expectedness score, and three sites had a low score. 70% of macroinvertebrate families expected in the Valley were recorded, and family richness was below Reference Condition at 31 of 35 sites.

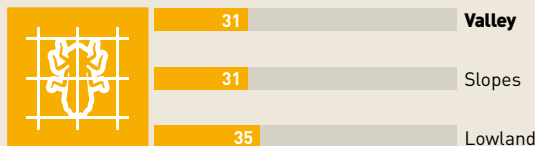
Diversity was moderate to low (average 18 families per site). Most (86–91%) of the range of the Valley macroinvertebrate fauna was found in both Zones. SIGNAL OE scores were below Reference values across both Zones. Most sites across both Zones had impoverished communities, without many disturbance-sensitive families.

The 10 common families recorded included midges, damselflies, crustaceans and aquatic beetles. The 16 rare families included a variety of crustaceans, molluscs and aquatic insects.

### Macroinvertebrate Condition Index



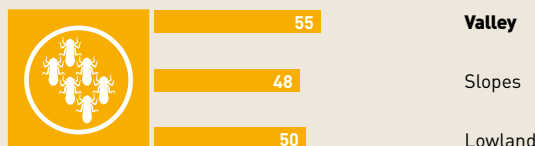
### Expectedness



### SIGNAL OE Score



### Number of families



## Hydrology



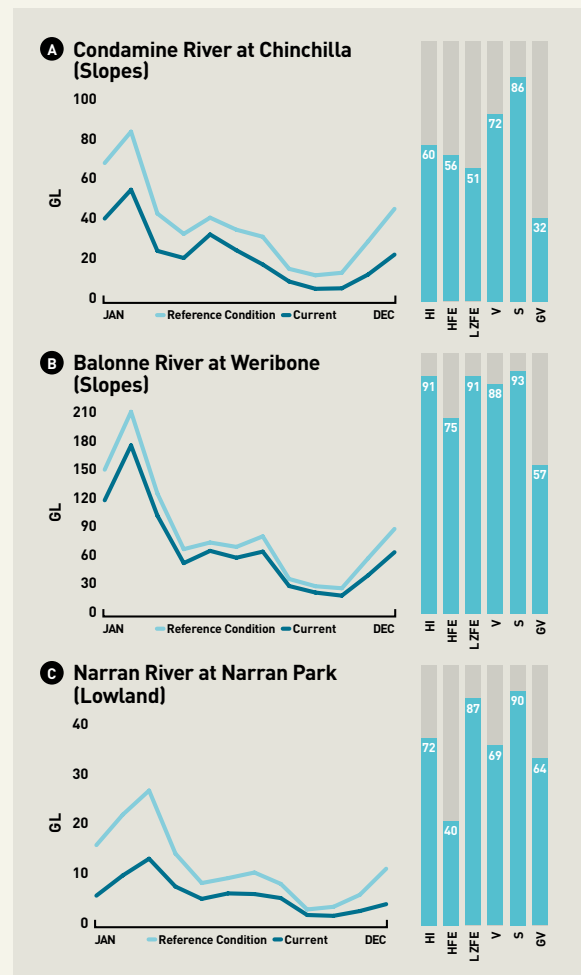
Hydrology Index scores (HI) at 22 sites in the Condamine, Valley were 44–100, indicating Moderate to Good Condition overall.

High-Flow Events were Near Reference Condition upstream of Warwick, but reduced downstream by 40–55% in Lowland Zone sites. Low- and Zero-Flow Events, Variability and Seasonality were Near Reference Condition at most sites, with some moderate shifts. Annual flow volumes were reduced by 20–60% compared to Reference Condition. Median annual volumes in the Condamine–Balonne channel were reduced by 40–95%.

The Condamine headwaters were unmodified and the Maranoa River was in Good Condition throughout. The remaining sites were affected by flow regulation and high-flow harvesting, partly offset by unregulated tributary flows.

Lowland Zone sites on the Narran, Bokhara and Culgoa rivers have their high-flow magnitudes halved, with reduced annual flow volumes and flow variability. This indicates substantial changes to the hydrology of the Narran Lakes terminal wetland complex. The Valley flow regime was characterised by reduced high flows and annual volumes, and minor changes in variability and seasonality.

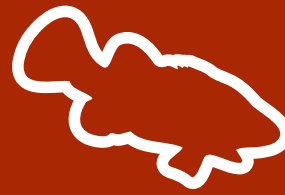
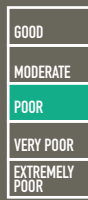
### Selected Hydrology sites



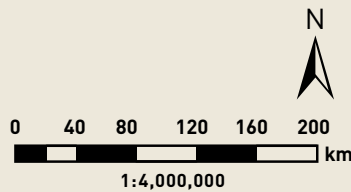
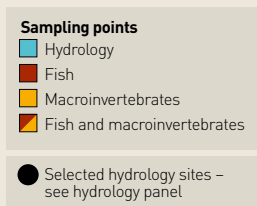


# Darling Valley

## Ecosystem Health



# Fish



## The Darling Valley

The Darling River and its tributaries rise on the flanks of the Great Dividing Range in south-eastern Queensland and north-eastern NSW. The main inflows are the Border Rivers (35% of long-term annual discharge), Namoi (25%), Condamine (20%), Gwydir (10%), Castlereagh and Macquarie (5%) and Paroo and Warrego Valleys (5%). All but the Macquarie are 'summer flow' rivers, with flows derived mainly from rainfall in summer. The Paroo and Warrego are highly episodic, and usually do not reach the Darling. There are irrigation storages on the Condamine, Border Rivers, Gwydir, Namoi, and Macquarie rivers, but no regulators, other than low-level weirs, on the Darling itself.

The Darling Valley covers an area of 136,000 km<sup>2</sup> (about 13% of the Basin).

## River Ecosystem Health

The Darling Valley river ecosystem was in Poor Health (Lower Zone: Poor; Middle Zone: Poor; Upper Zone: Moderate).

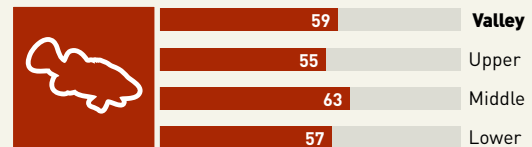
The Darling Valley fish community was in Poor Condition (FI = 59) (Lower and Upper Zones: Poor Condition; Middle Zone: Moderate Condition), but had the equal fourth-highest score among Valleys.

Twenty-one sites were sampled, yielding 3,156 fish. Seven native species and three alien species (Common carp, Gambusia and Goldfish) occurred in each Zone. Bony herring, Carp gudgeons and Golden perch were conspicuous among the native species.

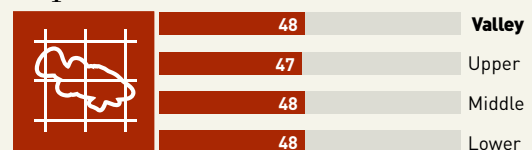
Over half the predicted species were not found, including Un-specked hardyhead, Murray-Darling rainbowfish and Freshwater catfish, which were expected to be common. Other species not caught but expected to be rare or moderately rare, included Silver perch, Southern purple-spotted gudgeon and Freshwater catfish.

Fish numbers in the Upper Zone were about half those in the Lower Zone and one-third those in the Middle Zone, but the Upper Zone individuals were larger. The Middle Zone yielded most fish per site and the highest proportion of total fish biomass, as well as the highest percentage of individual native fish (95%).

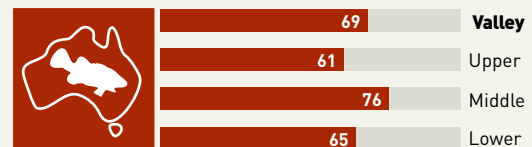
## Fish Condition Index



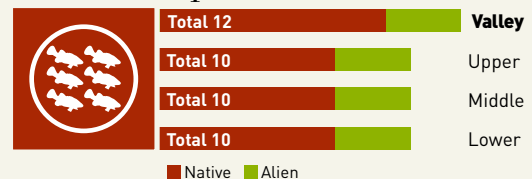
## Expectedness



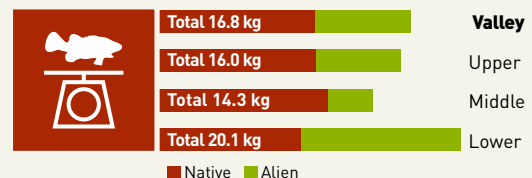
## Nativeness



## Number of species

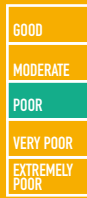


## Biomass





## Macroinvertebrates



The Darling Valley macroinvertebrate community had a condition index (MI) of 52 and was in Poor Condition (Lower and Middle Zones: Poor Condition; Upper Zone: Good). The Upper Zone, although in Near Reference Condition (MI = 83) showed considerable variation among sites.

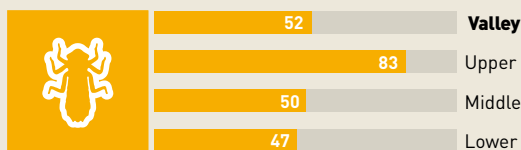
Thirty-eight sites were surveyed across the Darling Valley yielding 49 families (36% of all Basin families).

Eighty-six percent of expected families were recorded, although richness was less than Reference Condition at most sites. Diversity was low to moderate (average 16 families per site), and highest in the Upper Zone (average 21 families per site). Most (88%) of the range of Valley fauna was found in the Middle Zone (compared to 71–73% for Lower and Upper Zones).

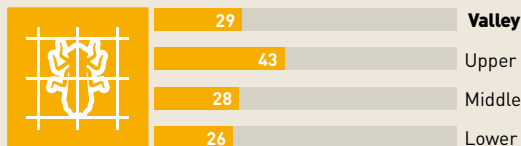
Expectedness scores indicated substantial loss of expected families. Most sites in all three Zones had impoverished communities, lacking most disturbance-sensitive families.

Nine common families included crayfish, mayflies, midges and water boatmen, and the common prawn, part of the diet of many fish and often used by fishermen as bait. The 18 rare families found in the Valley included some families of crustaceans, beetles, little basket shells, dragonflies and damselflies.

### Macroinvertebrate Condition Index



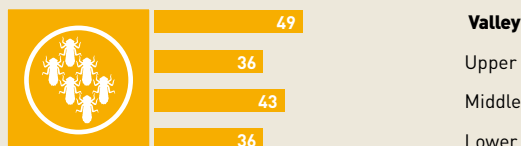
### Expectedness



### SIGNAL OE Score



### Number of families



## Hydrology



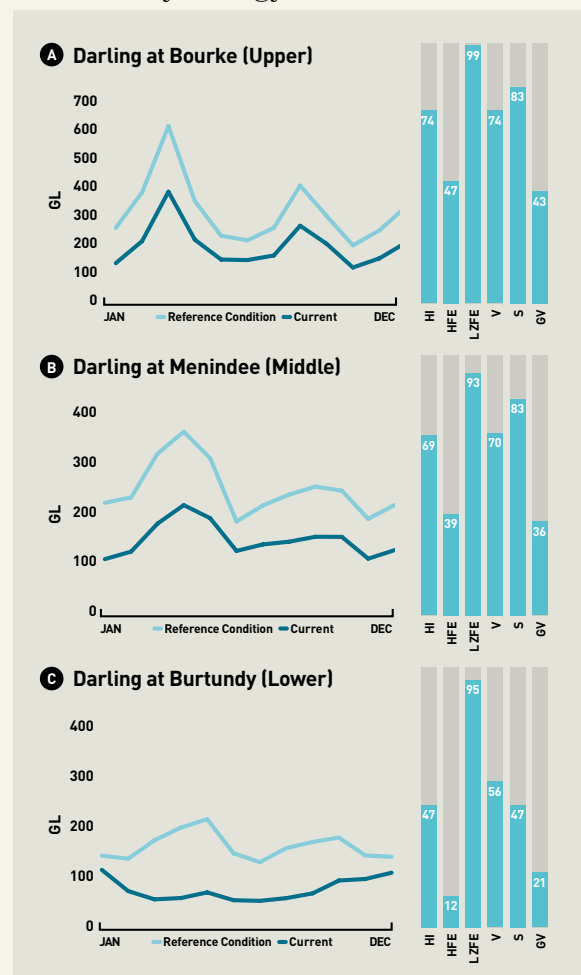
Hydrology Index scores (HI) at eight sites were 47–74, indicating Poor Condition overall of river system hydrology (Upper and Middle Zones: Moderate Condition; Lower Zone: Poor).

In general, there is a gradual downstream decline from a Moderate Difference from Reference Condition near Walgett to a Large Difference from Reference near Burtundy.

At all but one site the High-flow Event indicator showed an Extreme to Large Difference from Reference. High-flow magnitudes were reduced, particularly in the Lower Zone, by 30–88%. Mean and median annual flow volumes were reduced by 33–55% and 60–90%, respectively, particularly in the Lower Zone. Low- and Zero-Flow Events, however, were Near Reference Condition. Variability of monthly flows was reduced, by 20–50%, particularly in the Lower Zone, reflecting suppression of high flows.

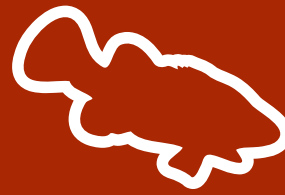
Overall, the flow regime had fewer high flows, and reduced annual volumes and variability, with little change to low and zero flows and flow seasonality. This pattern reflects the diversion of a significant volume of water from the system and the effect of differentially harvesting high flows.

### Selected Hydrology sites

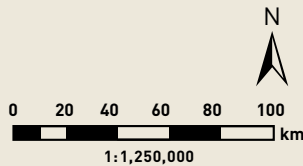
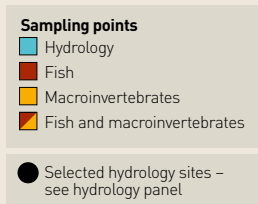
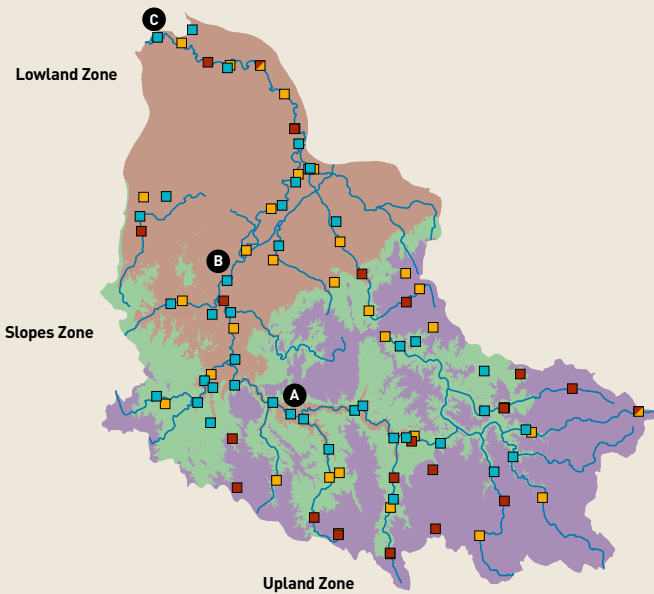




# Goulburn Valley Ecosystem Health



## Fish



## The Goulburn Valley

The Goulburn River rises in the Great Dividing Range and joins the Murray upstream of Echuca. Headwater streams join the Goulburn at Lake Eildon (3,334 GL), upstream of Shepparton. A second instream storage, Goulburn Reservoir (25.5 GL), impounded by Goulburn Weir, is used to transfer water to the Loddon or Campaspe valleys via the Waranga Basin (432 GL). Another off-stream storage is Greens Lake (28 GL).

The Goulburn Valley covers 16,800 km<sup>2</sup>, less than 2% of the Basin area.

## River Ecosystem Health

The Goulburn Valley river ecosystem was in Very Poor Health (Lowland Zone: Very Poor; Slopes Zone: Very Poor; Upland Zone: Very Poor).

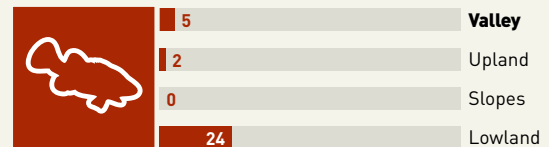
The Goulburn Valley fish community was in Extremely Poor Condition (FI = 5) (Lowland Zone: Very Poor Condition; Slopes and Upland Zones: Extremely Poor). It had the equal-lowest score of all Valleys, with the Campaspe.

Twenty-one sites were sampled, yielding 726 fish. Fish abundance was low and only 42% of individual fish were native. Only 56% of predicted native species were recorded. Fourteen native species and nine alien species were recorded. Alien species were 63% of total biomass.

In the Upland Zone, native species were only 10% of biomass and 29% of abundance. The Slopes Zone had an FI Fish Index = 0. The average biomass of Lowland Zone native species was substantially higher due to catches of 20 Murray cod and five Golden perch.

A population of the 'threatened' species, Barred galaxias, was found. Freshwater catfish, River blackfish, Macquarie perch and Mountain galaxias were not caught in Zones where they were expected to be common. Other species expected to occur rarely or occasionally—Silver perch, Golden perch and Macquarie perch, River blackfish and Trout cod—were also not caught.

## Fish Condition Index



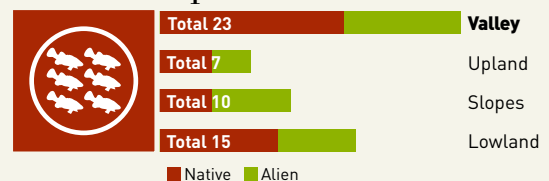
## Expectedness



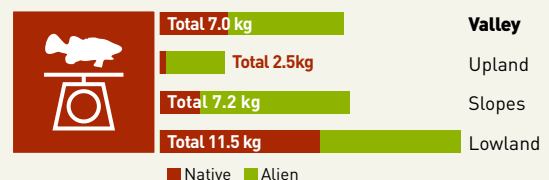
## Nativeness



## Number of species

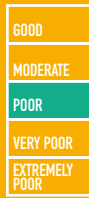


## Biomass





## Macroinvertebrates



The Goulburn Valley macroinvertebrate community had a condition index (MI) of 50 and was in Poor Condition (Lowland Zone: Poor Condition; Slopes and Upland Zones: Moderate).

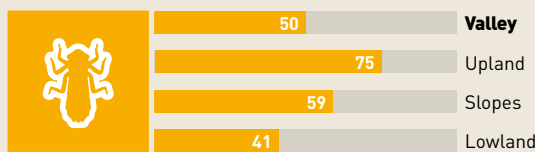
Thirty-four sites were surveyed, yielding 88 families (62% of Basin families).

Eighty-five percent of families expected in the Valley were recorded. Family richness was less than Reference Condition at all sites bar one. The communities at most Slopes and Upland Zones sites were depleted, lacking most disturbance-sensitive families.

Diversity was moderate to high (average 26 families per site), with some Slopes and Upland Zone sites being particularly diverse (approximately 40 families per site), and Lowland Zone sites being less diverse (average 21 families per site).

There were six common families, including midges, broad-shouldered water striders and damselflies. The 21 rare families included many aquatic insect families.

### Macroinvertebrate Condition Index



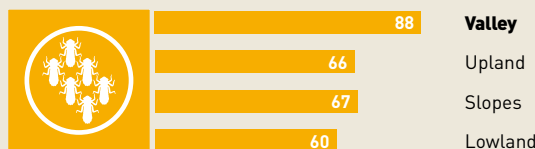
### Expectedness



### SIGNAL OE Score



### Number of families



## Hydrology



The Goulburn Valley was in Poor hydrological condition. Hydrology Index scores (HI) for the 41 sites were 34–100 (Slopes, Lowland Zones: Very Poor to Poor Condition; Upland Zone: Good).

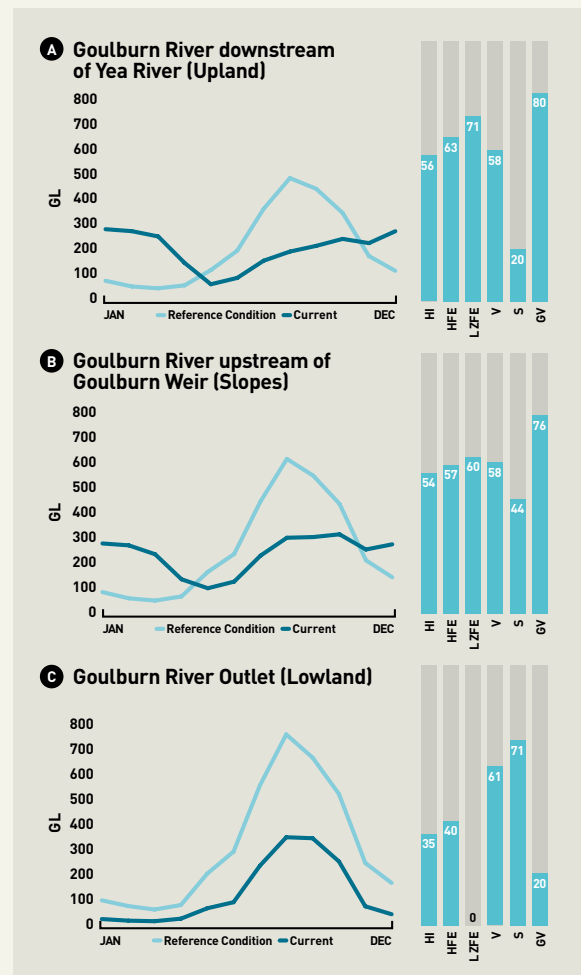
The 29 Lowland Zone sites ranged from a Very Large Difference from Reference Condition to Near Reference. The 11 Slopes Zone sites were all Near Reference Condition.

High-Flow Events were 40% lower downstream of Lake Eildon and 60% lower downstream of Goulburn Weir, but were Near Reference Condition in tributaries and the Goulburn upstream of Lake Eildon. Low- and Zero-flow Events were Extremely Different from Reference in the lower reaches of the Goulburn. Annual flow volumes were Near Reference Condition upstream of the main diversions but declined downstream. Mean and median volumes in the Goulburn below Goulburn Weir were reduced by 60 and 90%, respectively.

The indicators reflected regulation through the operation of storages at Lake Eildon and Goulburn Weir, and the removal of water for irrigation and inter-valley transfers

The Valley flow regime had substantial changes in mean and median annual volumes and magnitudes and incidence of low- and high-flow events, with changes increasing downstream.

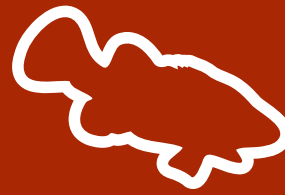
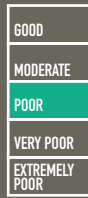
### Selected Hydrology sites



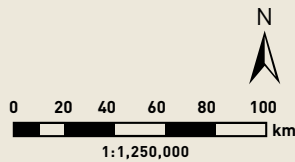
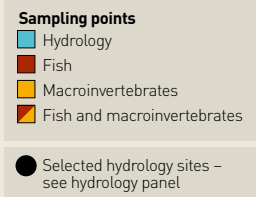
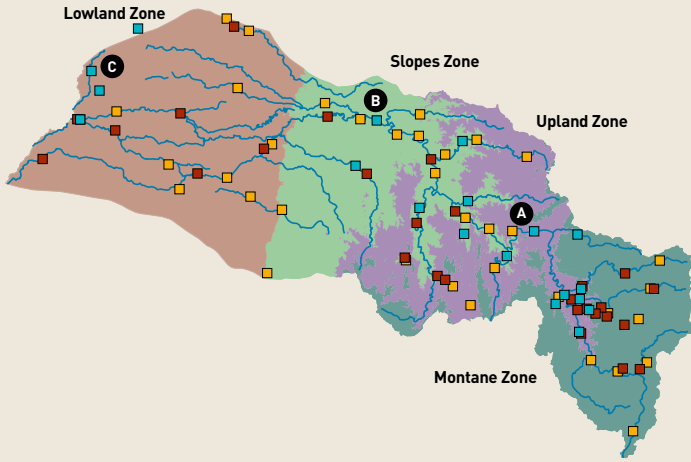


# Gwydir Valley

## Ecosystem Health



# Fish



## The Gwydir Valley

The Gwydir River rises near Armidale, NSW, and flows westward. It divides as the Gwydir and Lower Gwydir rivers near Moree, and the latter divides again as distributaries, some feeding wetland complexes. Copeton Dam (1,345 GL) provides instream storage on the upper Gwydir.

The Gwydir Valley covers 26,500 km<sup>2</sup> (about 2.5% of the Basin).

## River Ecosystem Health

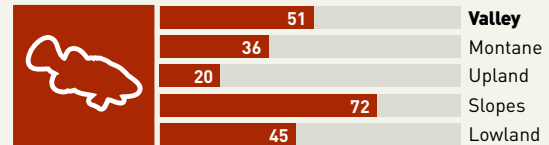
The Gwydir Valley river ecosystem was in Poor Health (Lowland Zone: Poor; Slopes Zone: Poor; Upland Zone: Very Poor; Montane Zone: Very Poor).

The Gwydir Valley fish community was in Poor Condition (FI = 51) (Slopes Zone: Moderate Condition; Lowland Zone: Poor; Montane and Upland Zones: Very Poor).

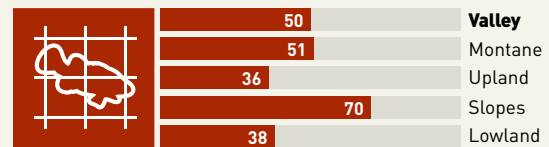
Twenty-eight sites were surveyed, yielding 5,905 fish. Eleven of the 15 expected native species were recorded, but were only a quarter of the total catch and a third of the biomass. Six alien species were caught. Montane Zone sites had only one to two native species, which represented only 3% of abundance, but were much larger than aliens, so their proportion of biomass was moderate.

Freshwater catfish, Golden perch and Murray cod were recorded but Murray–Darling rainbowfish and Freshwater catfish were not found in Zones where they were expected to be common. Among the alien species, Gambusia and Redfin perch were extremely abundant, with moderate numbers of Common carp and Goldfish.

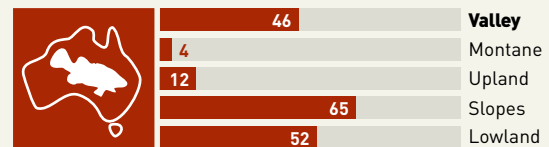
## Fish Condition Index



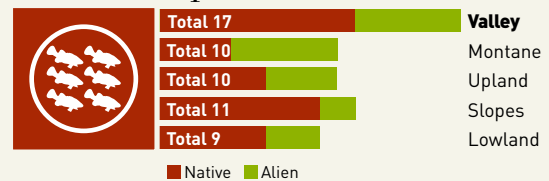
## Expectedness



## Nativeness



## Number of species

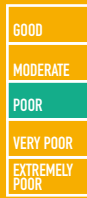


## Biomass





## Macroinvertebrates



## Hydrology



The Gwydir Valley macroinvertebrate community had a condition index (MI) of 56 and was in Poor Condition (all Zones: Poor).

The Lowland, Slopes and Upland Zones showed a Large Difference from Reference Condition (MI = 58–59). The Montane Zone sites were in worse Condition, with MI = 43. Communities at most sites were impoverished and had lost disturbance-sensitive families.

Sixty-nine percent of families expected in the Valley were recorded. Expectedness scores indicated moderate to substantial loss of expected families. Family richness was less than Reference Condition at most sites. Diversity was moderate to high (average 24 families per site), and was least at Lowland Zone sites (19 families per site). Most (67–80%) of the range of Valley fauna was found in each of the Zones.

There were eight common families included crayfish, little basket shells and snails, mayflies and water scorpions. Notable among these are the Thiaridae, a group of high-spined snails that are now rare in many areas, but formerly were common throughout the Basin. The 11 rare families included particular dragonflies and damselflies, viviparid river snails and a variety of aquatic beetles and flies. The viviparid snails, like the thiarids, were once common.

The Gwydir Valley was in Moderate to Good hydrological Condition (Lowland Zone: Moderate Condition; Slopes Zone: Poor; Upland: Moderate to Poor). The single Montane Zone site was in Very Poor Condition. Hydrology Index scores (HI) for the 19 sites were 37–99.

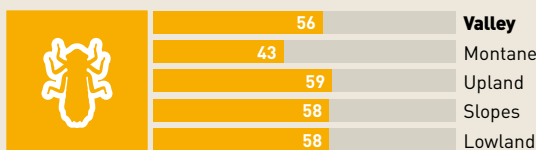
The four Lowland Zone sites showed a Moderate Difference from Reference Condition. The seven Slopes Zone sites ranged from a Very Large Difference from Reference to Near Reference Condition. Most Upland sites showed a Moderate Difference from Reference or were Near Reference Condition. The five Gwydir mainstream sites were in Moderate to Good Condition.

High-flows have dropped by up to 67% in the lower Gwydir and 90–98% in many tributaries. Flow volumes are reduced by 80–95% on many tributaries and by 80% in the lower Gwydir. This reflects the widespread opportunistic diversions of high flows.

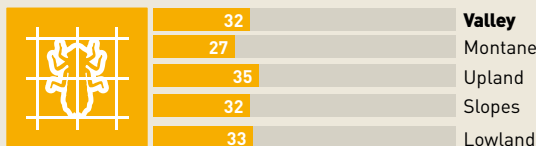
Low- or Zero Flow Events showed Large to Moderate Differences from Reference in several tributaries and the Gwydir below Copeton Dam. Flow Variability was Near Reference Condition for most sites.

In general, the flow regime is characterised by substantial reductions in annual volumes and high flow magnitudes with changes in seasonality in most tributaries and the Gwydir below Copeton Dam.

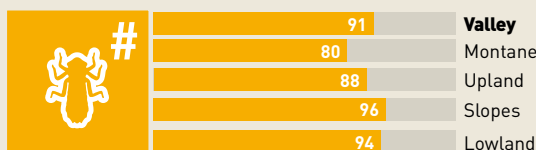
### Macroinvertebrate Condition Index



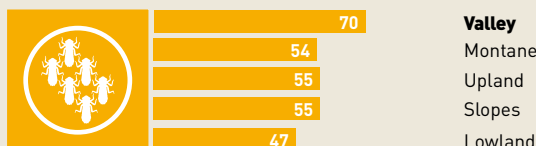
### Expectedness



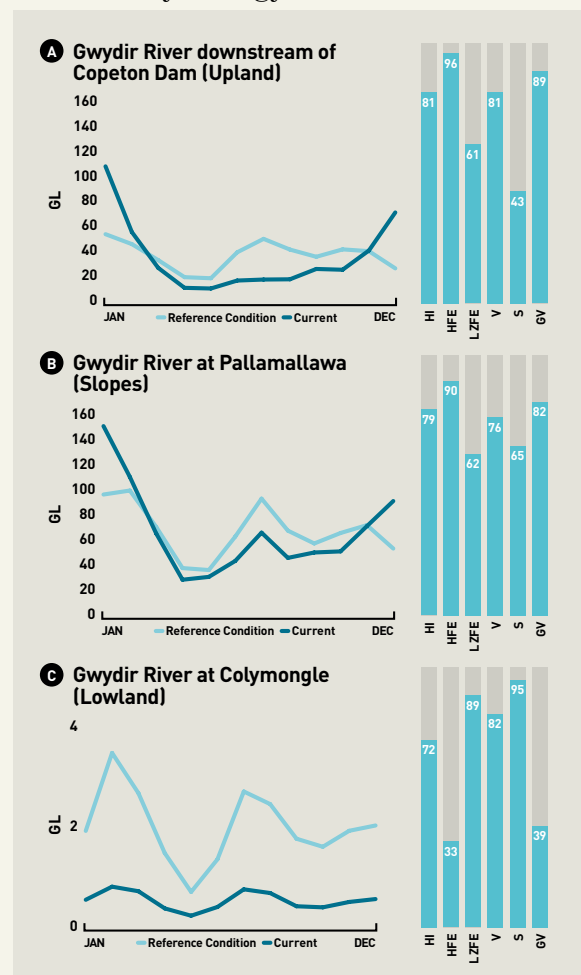
### SIGNAL OE Score



### Number of families



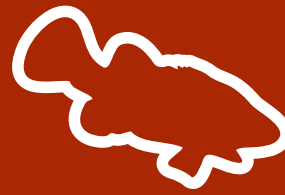
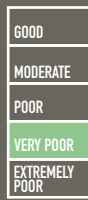
### Selected Hydrology sites



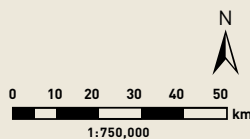
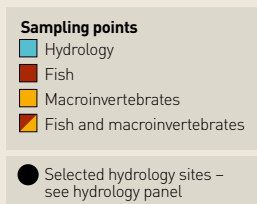
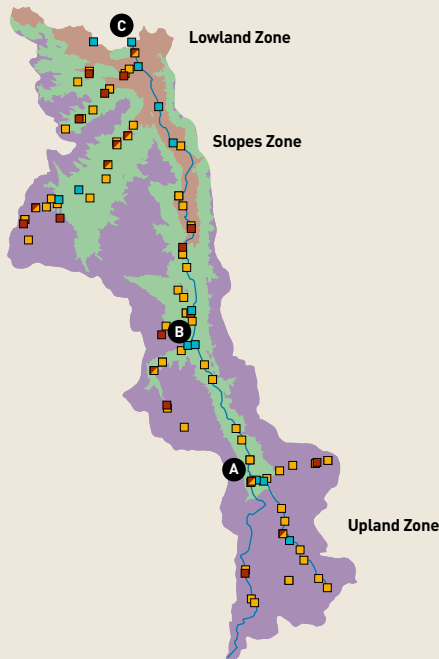


# Kiewa Valley

## Ecosystem Health



# Fish



## The Kiewa Valley

The West Kiewa River rises near Mt Hotham, Victoria, and the East Kiewa River rises above Falls Creek township. They join near Mount Beauty and flow northward to meet the Murray below Lake Hume. Tributaries include Yackandandah, Middle, House and Huon Creeks. The Valley is narrow and steep for much of its length, but the river develops a broad floodplain in its lower reaches. Rocky Valley Dam (28.4 GL), on the East Kiewa River, is the main storage.

The Kiewa Valley covers 1,800 km<sup>2</sup>, the smallest of the valleys in the Basin.

## River Ecosystem Health

The Kiewa Valley river ecosystem was in Very Poor Health (Lowland Zone: Very Poor; Slopes Zone: Poor; Upland Zone: Very Poor).

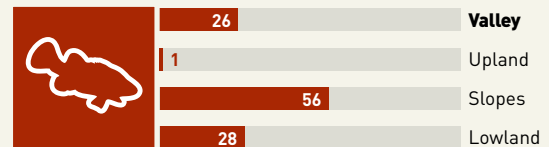
The Kiewa Valley fish community was in Very Poor Condition (FI = 26) (Lowland Zone: Very Poor Condition; Slopes Zone: Poor; Upland Zone: Extremely Poor).

Twenty-one sites were sampled, yielding 2,174 fish. Sixty-five percent of the predicted native species were caught, but alien species were 90% of total biomass and 57% of total abundance. Mountain galaxias were not caught at any Upland sites, although they were predicted to be common. Also not caught, but predicted to occur rarely or occasionally under Reference Condition, were Macquarie perch, Silver perch and Trout cod.

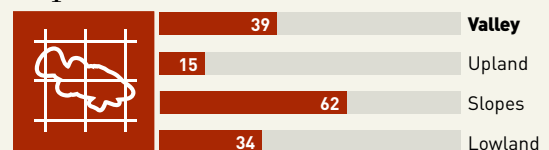
Only two Lowland Zone sites recorded more than two species, as did the Slopes Zone. Two Upland sites each yielded only one native species.

Brown trout and rainbow trout dominated the Valley community, being present at all Upland Zone sites. Other alien species, especially Gambusia, Goldfish and Common carp, were widespread and abundant. The recently invading alien, Oriental weatherloach, was found at two Lowland Zone sites.

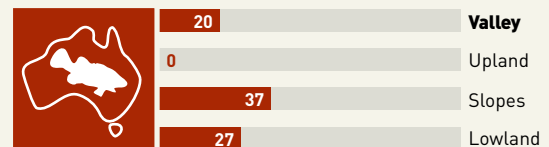
## Fish Condition Index



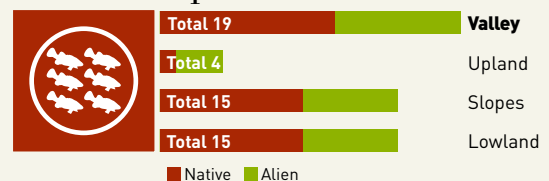
## Expectedness



## Nativeness



## Number of species



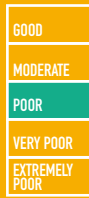
## Biomass







## Macroinvertebrates



The Kiewa Valley macroinvertebrate community had a condition index (MI) of 59 and was in Poor Condition (Lowland, Slopes Zones: Poor Condition; Upland Zone: Moderate).

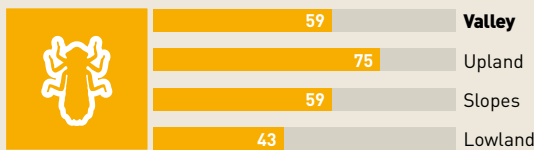
Thirty-five sites were surveyed across the Kiewa yielding 84 families (representative of 57% of Basin families).

Analyses showed a Large Difference from Reference Condition overall, although there was substantial variation in condition between sites in the Upland Zone. Most sites had depleted diversity, but retained many of their disturbance-sensitive families.

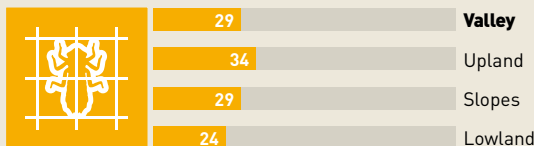
Eighty-one percent of families expected in the Valley were recorded, and family richness was less than Reference Condition at all sites except one. Diversity was moderate to high (average 30 families per site), being highest at some Upland Zone sites and least at Lowland Zone sites (24 families per site). Most (79 and 82%) of the range of Valley fauna was found in the Slopes and Upland Zones (compared to 59% for the Lowland Zone).

Twenty-five common families were recorded, including 19 families of aquatic insects that indicate good water and habitat quality (eg mayflies, caddisflies, stoneflies). The 19 rare families included many lowland and slow-flowing water groups such as shrimps and other crustaceans, diving beetles, bugs and snails.

### Macroinvertebrate Condition Index



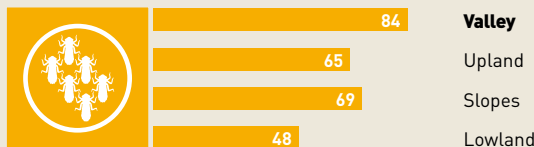
### Expectedness



### SIGNAL OE Score



### Number of families



## Hydrology



Hydrology Index scores (HI) for the 14 sites were 90–100, indicating Good Condition throughout (all Zones: Good Condition).

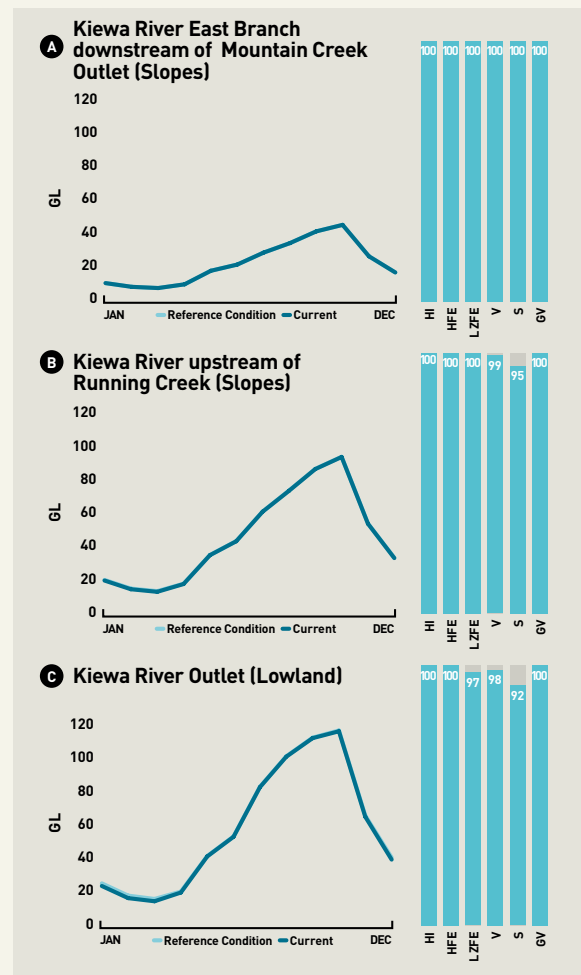
High flow magnitudes, monthly flow variation, flow seasonality and annual flow volumes were all Near Reference Condition.

Low- and Zero-flows at Yackandandah Creek (downstream of the offtake) was the only instance of an indicator falling below Near Reference Condition, reflecting the effects of diversion from naturally low summer flows.

Storages on the Kiewa are primarily for power generation, creating possible short-term water-level fluctuations. The monthly flow variability data assessed for the SRA may not reflect such short-term changes.

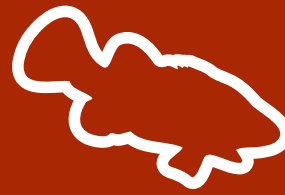
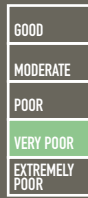
The indicators showed that flows in the Kiewa were substantially unaffected by current management, being Near Reference Condition at nearly all sites.

### Selected Hydrology sites

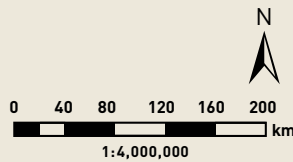
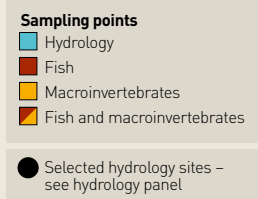
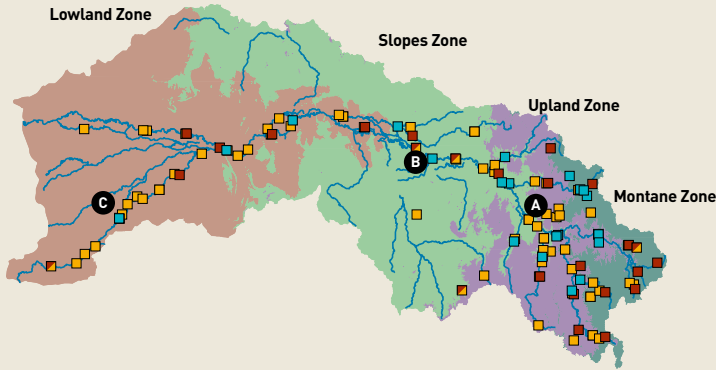




# Lachlan Valley Ecosystem Health



## Fish



## The Lachlan Valley

The Lachlan River rises near Gunning, NSW, and arcs westward, fed by foothill tributaries, to discharge into the Great Cumbung Swamp near Oxley. Tributaries include the Abercrombie, Boorowa, Belubula and Crookwell rivers and Mandagery Creek. The main instream storage is Wyangala Dam (1,218 GL), at the junction of the Lachlan and Abercrombie rivers. In addition, there is Carcoar Dam (36 GL) on the Belubula, two offstream storages (Lake Brewster: 153 GL; Lake Cargelligo: 36 GL) and numerous on-farm storages.

The Lachlan Valley covers 86,000 km<sup>2</sup>, or about 8% of the Basin area.

## River Ecosystem Health

The Lachlan Valley river ecosystem was in Very Poor Health (Lowland Zone: Poor; Slopes Zone: Very Poor; Upland Zone: Very Poor; Montane Zone: Poor).

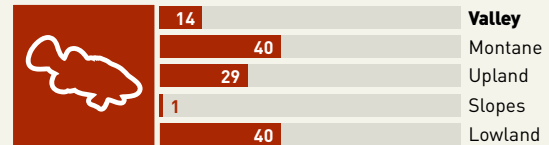
The Lachlan Valley fish community was in Extremely Poor Condition (FI = 14) (Lowland and Montane Zones: Poor Condition; Slopes Zone: Extremely Poor; Upland Zone: Very Poor).

Twenty-eight sites yielded 3,433 fish. Native fish, mainly Carp gudgeons and Bony herring, were 68% of the catch, but only 30% of biomass. Six alien species and ten native species (only half the expected number) were caught. Only three Upland sites had more than two native species. The Montane Zone had only one—Mountain galaxias. The Slopes Zone had none of the predicted 19 native species except Carp gudgeons and a single Australian smelt.

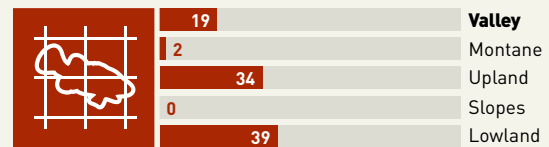
Species not caught in Zones where they were predicted to be common included Carp gudgeons, Macquarie perch, Silver perch, Golden perch, Macquarie perch, Southern pygmy perch, River blackfish, Trout cod, Murray cod, Southern purple-spotted gudgeon and Freshwater catfish.

Common carp and Gambusia dominated the alien species, occurring abundantly in Lowland and Slopes Zones. In the Upland Zone, Goldfish and Redfin perch were present. In the Montane Zone, Gambusia was abundant and Common carp, Rainbow trout and Brown trout were found occasionally.

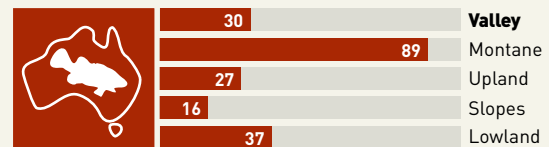
## Fish Condition Index



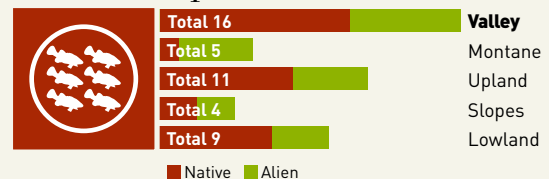
## Expectedness



## Nativeness



## Number of species

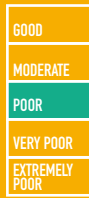


## Biomass





## Macroinvertebrates



## Hydrology



The Lachlan Valley macroinvertebrate community had a condition index (MI) of 53 and was in Poor Condition (all Zones: Poor Condition).

Thirty-five sites were sampled yielding 69 families (49% of all Basin families).

Most sites had substantial loss of expected families and of disturbance-sensitive families. Most site communities showed a Large Difference from Reference Condition, the largest in the Slopes Zone (MI = 42).

Two-thirds (67%) of families expected in the Valley were recorded. Family richness was less than Reference Condition at 91% of sites. Diversity was moderate (average 24 families per site), increasing with altitude, with Lowland Zone sites being least diverse (20 families per site). Higher proportions (79%) of the range of Valley fauna were found in the Slopes and Upland Zones, compared with 67 and 71% for the Lowland and Montane Zones.

Expectedness scores indicated substantial loss of expected families, with significant variation among sites in the Slopes and Montane Zones.

Seven common families included dragonflies and damselflies, mayflies, and water beetles. The 12 rare families included several caddisfly, stonefly and mayfly families known from cool flowing waters. Thiarid snails, a group which has declined throughout the Basin, were particularly rare in the Lachlan Valley.

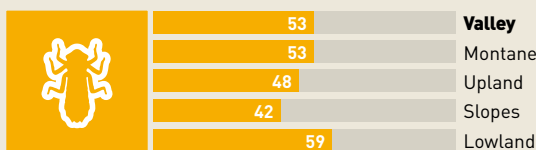
The Lachlan Valley was in Moderate to Good hydrological Condition (Lowland Zone: Moderate Condition; Upland, Montane Zones: Good; Slopes Zone: Moderate to Good). Hydrology Index scores (HI) for the 21 sites were 66–100.

Four sites in the Lowland Zone showed a Moderate Difference from Reference. Ten Slopes sites ranged from a Moderate Difference to Near Reference Condition, as did the four Montane sites. All four Upland Zone sites were Near Reference Condition.

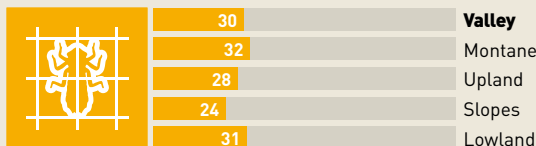
Mean and median annual flow volumes were reduced by 20–40 and 30–50%, respectively. No substantial changes were apparent in the Upland and Montane Zones, or in tributaries. Flows in the lower Lachlan at Booligal, reflected changes due to regulation and diversions.

Overall, the flow regime was similar to Reference Condition except for the Lachlan and Belubula Rivers downstream of Wyangala and Carcoar storages, respectively, where there were changed magnitudes of high-, low- and annual-flows and changes in flow variability and seasonality.

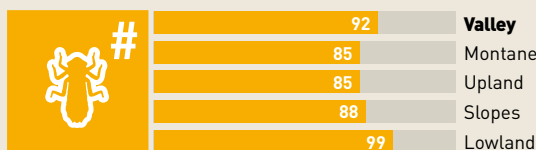
### Macroinvertebrate Condition Index



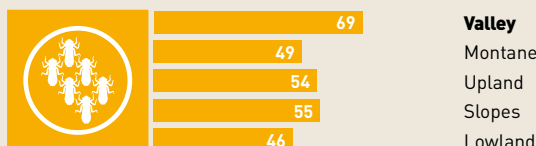
### Expectedness



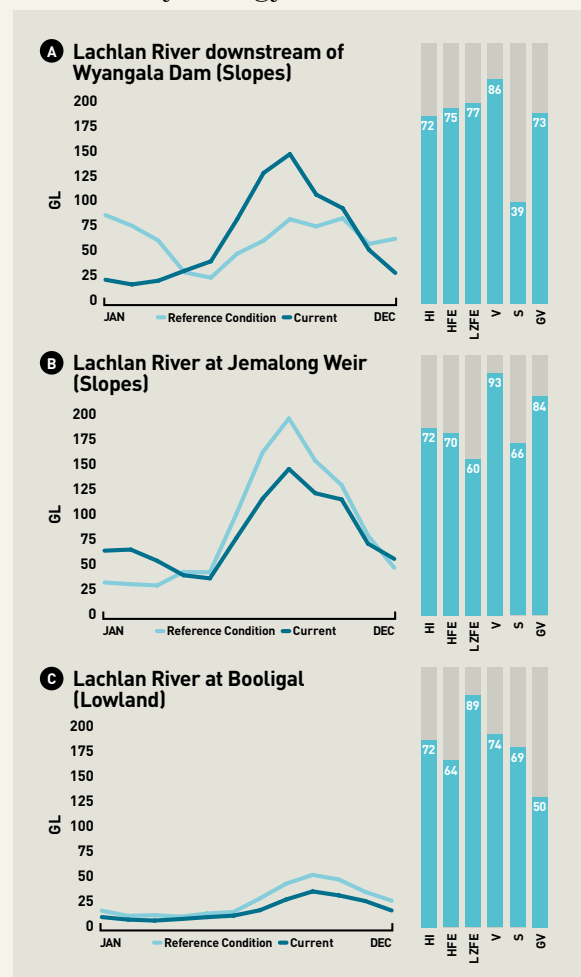
### SIGNAL OE Score



### Number of families

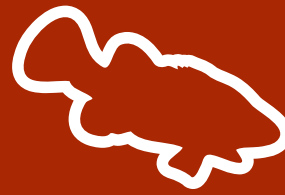
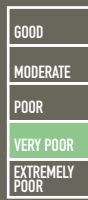


### Selected Hydrology sites

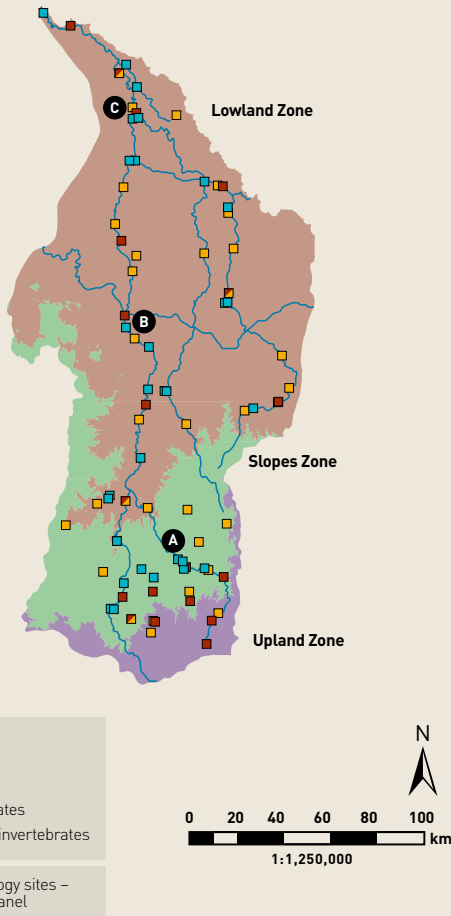




# Loddon Valley Ecosystem Health



# Fish



The Loddon Valley fish community was in Extremely Poor Condition (FI = 12) (Lowland Zone Very Poor Condition; Slopes Zone: Extremely Poor); only three Valleys had lower scores.

Twenty sites were sampled, yielding 659 fish. Ten native species—only half those expected—were caught. Native fish were 60% of the total numbers but only 21% of the total biomass.

Freshwater catfish were not caught, although expected to be common under Reference Condition. Southern purple-spotted gudgeon were not caught although they were expected to be rare or moderately rare under Reference Condition.

Six alien species were recorded—four in each Zone—and individuals were considerably larger overall. Common carp, Brown trout and Redfin perch were the most abundant. Goldfish, Gambusia and Tench also were present.

(Note: The data from fish sampling sites in the Slopes and Upland zones were combined for assessment purposes. The results are shown against Slopes Zone in the following bar charts.)

## The Loddon Valley

The Loddon River flows northward through Central Victoria to join the Murray near Kerang, downstream of Torrumbarry Weir. Instream storages include Cairn Curran and Tullaroop Dams and Laanecoorie Reservoir (total 228 GL). Inter-valley transfers from the Murray and Goulburn (via the Waranga Basin) enter the Loddon at Kerang Weir and Loddon Weir, respectively. Instream weirs (Serpentine, Loddon, Boags, Kerang) provide for diversions.

The Loddon Valley covers 15,000 km<sup>2</sup>, or about 1.5% of the Basin area.

## River Ecosystem Health

The Loddon Valley river ecosystem was in Very Poor Health (Lowland Zone: Very Poor; Slopes Zone: Very Poor).

## Fish Condition Index



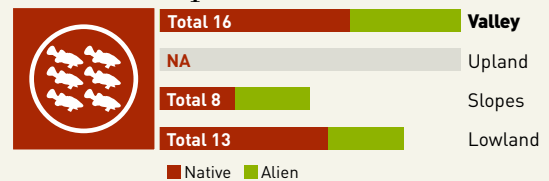
## Expectedness



## Nativeness



## Number of species

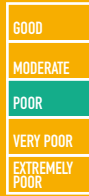


## Biomass





## Macroinvertebrates



The Loddon Valley macroinvertebrate community had a condition index (MI) of 51 and was in Poor Condition (all Zones: Poor).

Thirty-four sites were sampled yielding 76 families (54% of all Basin families).

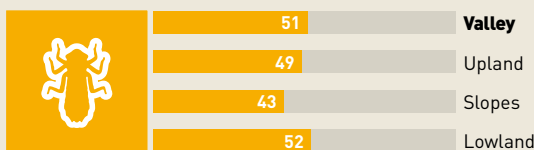
The fauna at most sites was impoverished. All Zone communities showed a Large Difference from Reference Condition (MI = 43–52), with the Slopes Zone having the lowest rating (MI = 43) and exhibiting substantial variation among sites.

Three quarters (75%) of families expected in the Valley were recorded. Family richness was less than Reference Condition at all but three sites. Diversity was moderate (average 25 families per site), with Lowland Zone sites being least diverse (22 families per site). Most (82 and 78%) of the range of the Valley fauna was found in both the Lowland and Slopes Zones (compared to 65% in the Upland Zone).

Expectedness scores showed substantial loss of expected families. The communities in most Slopes and Upland Zone sites were impoverished and lacking most disturbance-sensitive families.

The 11 common families included midges, snails and beetles. The 16 rare families included several aquatic insect families normally associated with cool, flowing waters.

### Macroinvertebrate Condition Index



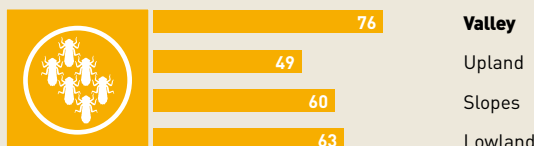
### Expectedness



### SIGNAL OE Score



### Number of families



## Hydrology



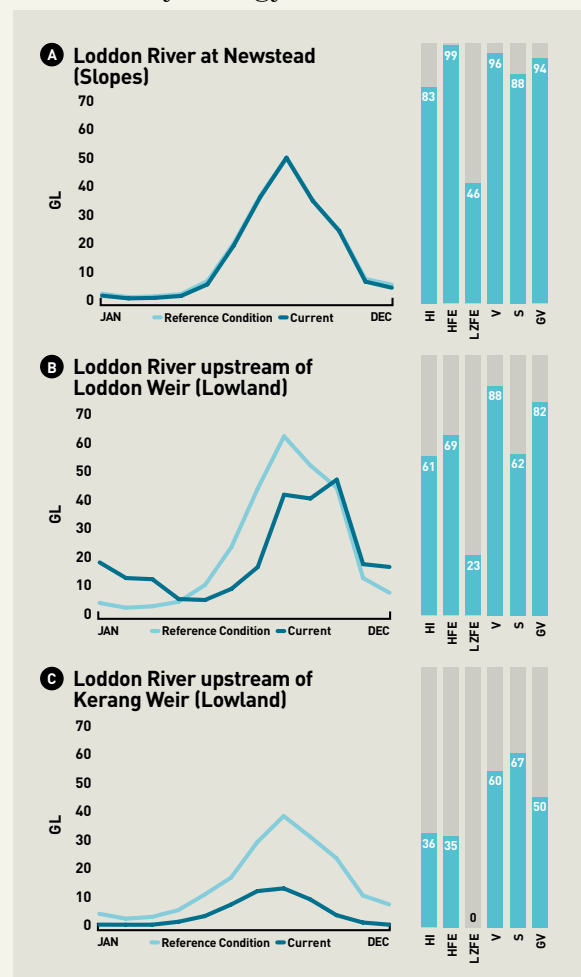
The Loddon Valley was in Moderate hydrological condition (Lowland Zone: Very Poor to Moderate Condition; Slopes Zone: Moderate to Good). Hydrology Index scores (HI) for the 30 sites were 34–100.

Twenty-one sites in the Lowland Zone ranged from Very Large Difference from Reference to Near Reference Condition. Nine sites in the Slopes Zone ranged from a Moderate Difference from Reference to Near Reference Condition.

Low and zero flows exhibited Very Large to Extreme Differences from Reference Condition at most Lowland Zone sites, and Very Large to Large Differences in the Slopes Zone. Flow variability was slightly modified at most sites, more so upstream of Kerang Weir. Seasonality was modified at sites between the major storages and diversions, but was Near Reference Condition in the Slopes Zone. Mean and median annual flow volumes respectively were reduced by 20% and 10–75% in Slopes Zone sites, and by 10% and 45–90% in the Lowland sites.

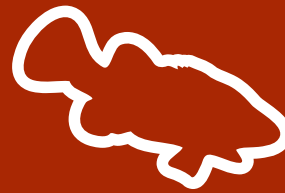
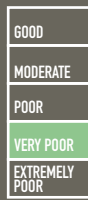
Overall, the flow regime had a markedly increased incidence and duration of low-flow events in summer, particularly in the lower reaches, reflecting the pattern and extent of diversions. In the Lowland Zone there were also major reductions in annual volumes and high flows.

### Selected Hydrology sites

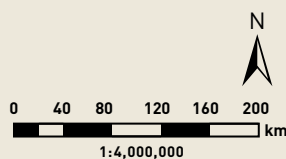
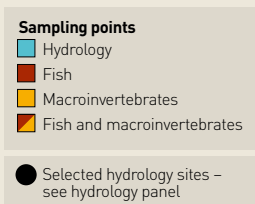




# Macquarie Valley Ecosystem Health



## Fish



## The Macquarie Valley

The Macquarie River rises near Oberon, NSW, and flows north-west through the Macquarie Marshes to join the Barwon River between Walgett and Brewarrina. The system is a complex network of tributaries, anabranches and distributary streams. The Bogan River also flows through the Valley, joining the Darling near Bourke. Instream storages include Burrendong Dam (1,189 GL), at the junction of the Macquarie and Cudgegong rivers, Windamere Dam (361 GL) on the Cudgegong and the Ben Chifley Dam (16 GL) on the upper Macquarie.

The Macquarie Valley covers 75,000 km<sup>2</sup>, 7% of the Basin area.

## River Ecosystem Health

The Macquarie Valley river ecosystem was in Very Poor Health (Lowland Zone: Poor; Slopes Zone: Very Poor; Upland Zone: Very Poor).

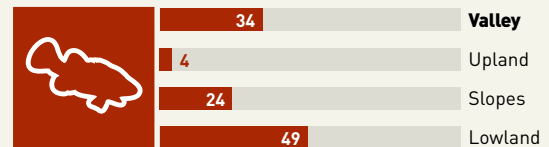
The Macquarie Valley fish community was in Very Poor Condition (FI = 34) (Lowland Zone: Poor Condition; Slopes Zone: Very Poor; Upland Zone: Extremely Poor).

Twenty-one sites were surveyed, yielding 7,521 fish. Native species made up only 21% numerically and 38% of biomass. Of 19 expected native species, only 10 were found. Murray cod were caught occasionally. Freshwater catfish and Golden perch were rare, but small native species often were abundant.

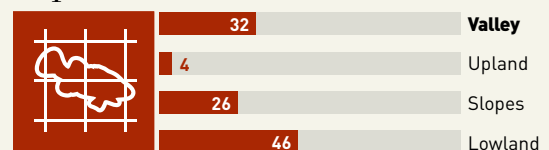
Three Slopes sites yielded only one native species. Two Upland sites had no native fish and four had only one species. Only one Golden perch and one Murray–Darling rainbowfish were caught in the Lowland Zone, where both were expected to occur commonly. Freshwater catfish, Macquarie perch and River blackfish were not caught in Zones where they were expected to be common. Other species not caught but expected to occur rarely or occasionally included Silver perch and Trout cod.

Six alien species were recorded. Common carp were abundant and Goldfish, Redfin perch and the two trout species were common or occasional.

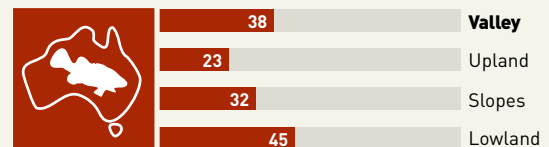
## Fish Condition Index



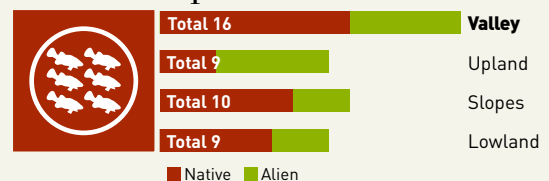
## Expectedness



## Nativeness



## Number of species

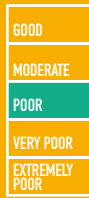


## Biomass





## Macroinvertebrates



The Macquarie Valley macroinvertebrate community had a condition index (MI) of 50 and was in Poor Condition (all Zones: Poor Condition).

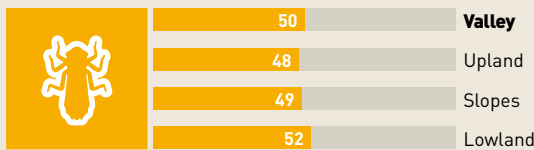
Thirty-five sites were sampled yielding 72 families (51% of all Basin families).

Seventy percent of families expected in the Valley were recorded. Family richness was less than Reference Condition at 94% of sites. Diversity was moderate (average 22 families per site), with Lowland Zone sites being least diverse (17 families per site). Most (87%) of the range of Valley fauna was found in the Upland Zone (compared to 60–66% for Lowland and Slopes Zones).

Expectedness scores indicated substantial loss of expected families in all Zones. Most sites in all Zones had sparse communities lacking most disturbance-sensitive families.

Eight common families included midges and mosquitoes, damselflies and aquatic leeches. These are common families of still and slow-flowing waters. The 16 rare families included several aquatic insect families associated with faster flowing, cooler waters. For example, the mayfly *Coloburiscoides* was rare in the Macquarie due to the lack of these habitats.

### Macroinvertebrate Condition Index



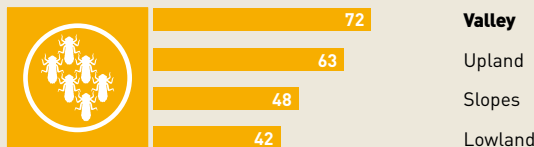
### Expectedness



### SIGNAL OE Score



### Number of families



## Hydrology



The Macquarie Valley was in Moderate to Good hydrological Condition overall (Lowland, Slopes Zones: Moderate; Upland Zone: Good). Hydrology Index scores (HI) for the 41 sites were 55–100, ranging from Poor (one site only) to Good Condition.

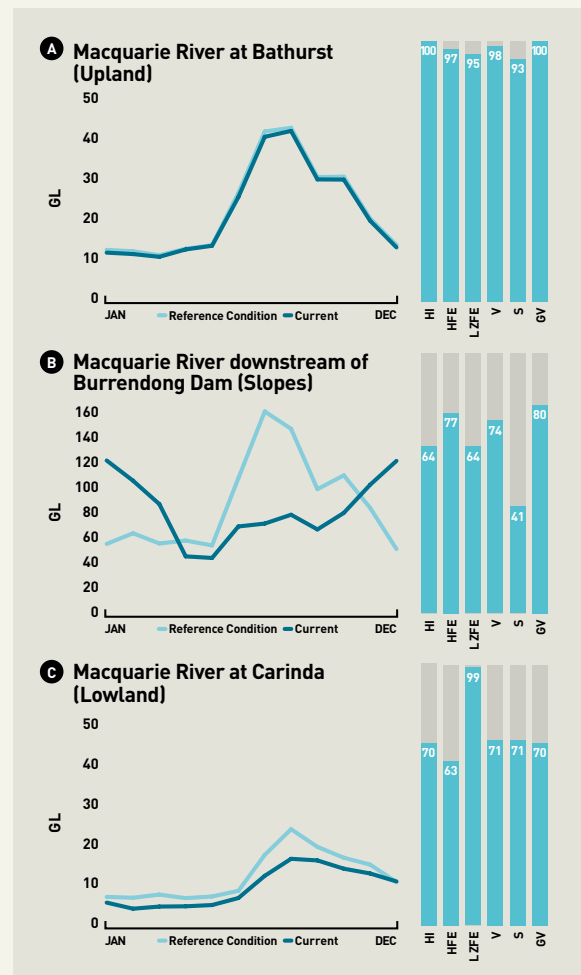
Lowland sites ranged from Large Differences from Reference to Near Reference Condition. Slopes and Upland Zone sites showed Moderate Differences from Reference to Near Reference Condition.

High-flows were Near Reference Condition for all Upland and most Slopes Zone sites, but reduced by 30–55% in Lowland reaches of the Bogan and Macquarie rivers. Annual flow volumes were reduced by 5–30% from Reference in several Lowland Zone streams, by 5–25% in the Slopes Zone and by 10–15% in the Cudgegong River

Flow variability and seasonality and the incidence and duration of low- and zero- flows were Near Reference Condition for most sites, but showed a Large to Moderate Difference in some Lowland streams, the Macquarie Slopes and Cudgegong River. Gross Volume declined from Upland to Lowland Zones, reflecting diversions.

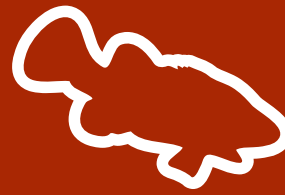
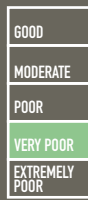
High flows and annual flows for the Macquarie at Carinda had decreased by 25% and 40%, respectively, relative to Reference Condition, indicating substantial changes to the hydrology of the Macquarie Marshes.

### Selected Hydrology sites

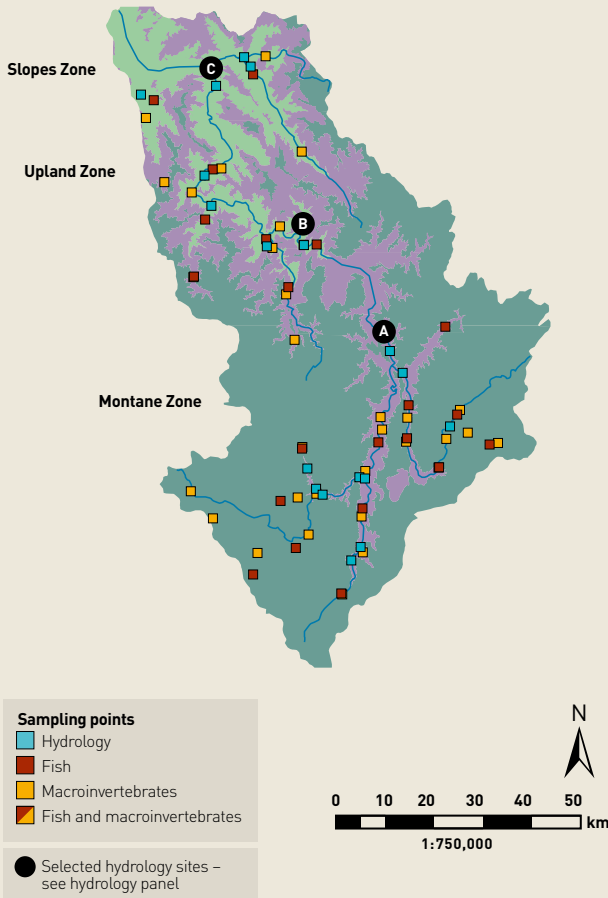




# Mitta Mitta Valley Ecosystem Health



## Fish



## The Mitta Mitta Valley

The Mitta Mitta River rises east of Falls Greek township, Victoria, near the Kiewa headwaters, where four tributaries (Big, Bundara and Cobungra rivers, Livingstone Creek) join. The river flows north-west to meet the Murray via the south arm of Lake Hume. Tallangatta Creek, formerly a Mitta Mitta tributary, enters Lake Hume nearby. Other tributaries are Snowy Creek and Little Snowy Creek. The Mitta Mitta Valley is narrow and steep for most of its length, forming a floodplain only as it approaches Lake Hume. It includes the largest instream storage in the Basin, Lake Dartmouth (3,900 GL).

The Mitta Mitta Valley covers 6,200 km<sup>2</sup>, less than 1% of the Basin area.

## River Ecosystem Health

The Mitta Mitta Valley river ecosystem was in Very Poor Health (Slopes Zone: Very Poor; Upland Zone: Poor; Montane Zone: Very Poor).

The Mitta Mitta Valley fish community was in Extremely Poor Condition (FI = 10) (Slopes and Upland Zones: Very Poor Condition; Montane Zone: Extremely Poor); the third lowest score for the Basin.

Twenty-one sites yielded 717 fish. Few fish were collected, and total biomass was low. The native biomass proportion was extremely low (8%). Only 43% of the expected native species were caught. For each Zone the number of species observed never exceeded 50% of predicted.

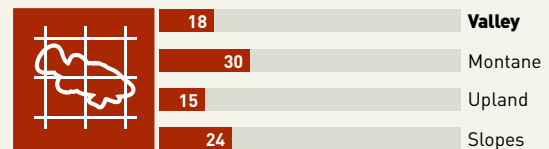
Alien species were 50% of total fish abundance. Brown trout dominated, and there were substantial numbers of Rainbow trout. Common carp and Redfin perch. Gambusia and Goldfish occurred sparsely. Releases from Dartmouth Dam cause severe cold-water pollution in mainstem Slopes Zone sites, favouring trout at the expense of native fish. Communities at cold-polluted sites were in Extremely Poor Condition, with only one native species per site and up to five alien species.

Macquarie perch and *Galaxias* 'species 2' were not caught in the Zones where they were expected to be common. Other species not caught but expected to occur occasionally included Golden perch, Macquarie perch, Murray cod, Trout cod and River blackfish.

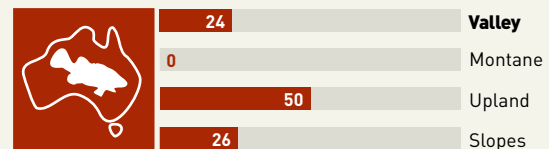
## Fish Condition Index



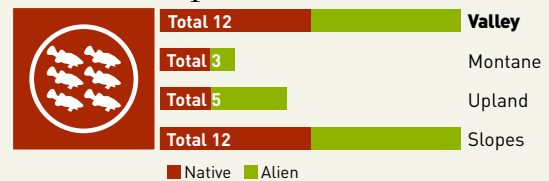
## Expectedness



## Nativeness



## Number of species



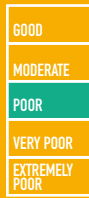
## Biomass







# Macroinvertebrates



The Mitta Mitta Valley macroinvertebrate community had a condition index (MI) of 59 and was in Poor Condition (Upland Zone: Moderate Condition; Slopes and Montane Zones: Poor).

Thirty-two sites were sampled yielding 82 families (57% of all Basin families).

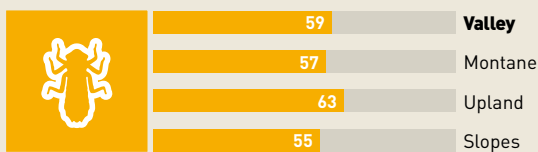
Most sites had an impoverished fauna, but unlike many Valleys, retained most disturbance-sensitive families.

Eighty percent of families expected in the Valley were recorded. Family richness was less than Reference Condition at all sites bar one. Diversity was moderate to high (average 29 families per site), with Slopes Zone sites being most diverse (30 families per site). Most (83%) of the range of Valley fauna was observed in the Upland Zone (compared to around 70% for the other Zones).

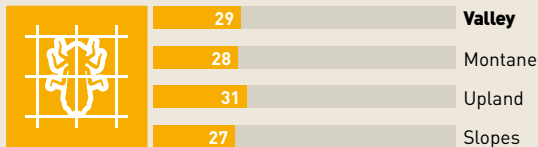
The entire stream length had a low proportion of expected families. However, 66% of stream length had a good SIGNAL OE score, indicating that changes in the Valley are not causing major losses of disturbance- or pollution-sensitive families.

The 18 common families included 14 insect families (eg mayflies, stoneflies, caddisflies, beetles, dragonflies) typical of cool, fast-flowing water. Many of the 24 rare families favour slow-flowing water habitats.

## Macroinvertebrate Condition Index



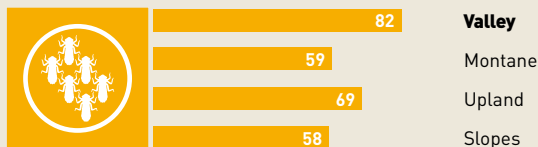
## Expectedness



## SIGNAL OE Score



## Number of families



# Hydrology



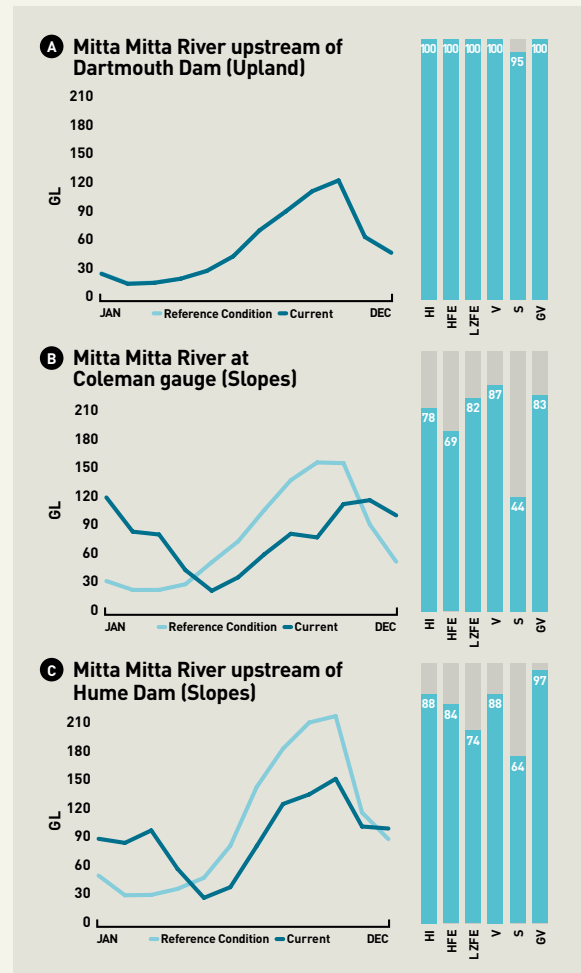
The Mitta Mitta Valley was in Good hydrological Condition (Slopes Zone: Moderate to Good Condition; Upland Zone: Good). Hydrology Index scores (HI) at the 18 sites were 78–100.

Only one site in the Slopes Zone (downstream of Dartmouth Dam) showed a Moderate Difference from Reference Condition. All other Slopes sites and all sites in the Upland Zone were in Near Reference Condition.

Storage and release patterns at Dartmouth Dam resulted in High-flow Events showing a Moderate Difference from Reference Condition, and Seasonality showing a Large Difference from Reference Condition at some downstream sites. Little water is diverted from the Mitta Mitta, so that Gross Volume is Near Reference Condition over the length of the river.

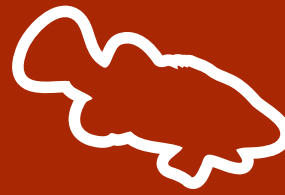
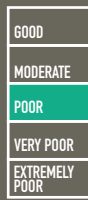
Overall, the flow regime is little changed from Reference Condition, apart from changes in seasonality and high- and low-flows below Dartmouth Dam. All indicators in tributaries and upstream of Dartmouth Dam were Near Reference Condition.

## Selected Hydrology sites

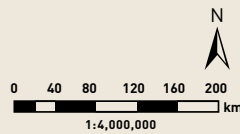
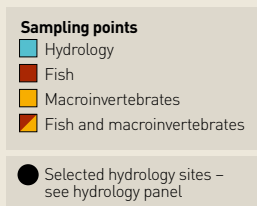




# Murray Valley, Lower Ecosystem Health



## Fish



## The Lower Murray Valley

In its lower reaches, the Murray flows westward through a broad floodplain from Wentworth to Morgan, where the river enters a limestone gorge extending south to about Mannum. An offstream storage, Lake Victoria (677 GL), regulates flows from the Murray and Darling. The Lower Murray Valley begins at Lock 9, below the Murray-Darling confluence, and ends with the river's entry to Lake Alexandrina, hence Lake Albert and the Coorong. It includes a number of small tributaries draining the eastern slopes of the Mt Lofty Ranges. There are Ramsar-listed wetlands at Chowilla, near Renmark, and the Lower Lakes and Coorong. Water levels are closely controlled by a series of weirs, and by barrages along the seaward margins of Lake Alexandrina.

The Lower Murray Valley covers 100,000 km<sup>2</sup>, about 9% of the Basin area.

## River Ecosystem Health

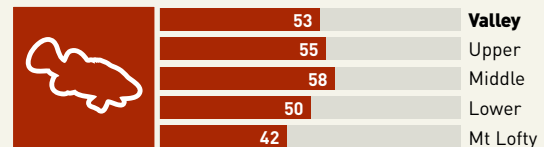
The Lower Murray Valley river ecosystem was in Poor Health (Lower Zone: Very Poor; Middle Zone: Very Poor; Upper Zone: Poor; Mt Lofty Zone: Poor).

The Lower Murray Valley fish community was in Poor Condition (FI = 53) (all four Zones: Poor Condition). The Mt Lofty Zone community was different from those in the weir-pool environments of the Murray.

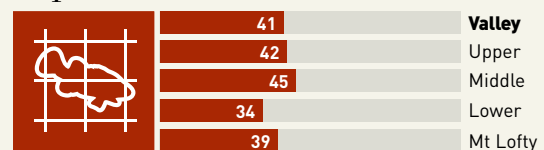
Twenty-two sites were surveyed, yielding 6,128 fish. Fish were abundant, but only 40% of expected species were caught. Bony herring, Un-specked hardyhead, Mountain galaxias, Australian smelt, Southern pygmy perch, Murray-Darling rainbowfish and Carp gudgeons dominated the native fish. Thirteen expected species that require access to the estuary were missing due to the barrages. Only six of the 16 species expected in the Mt Lofty Zone were recorded. Strictly riverine fishes including Silver perch, Murray cod and Freshwater catfish were not caught in Zones where they were expected to be common. Some other species expected to be occasional or rare were also not caught.

Gambusia and Common carp dominated the alien species. Goldfish and Redfin perch also were common. Rainbow trout and Brown trout occurred occasionally, especially in the Mt Lofty Zone.

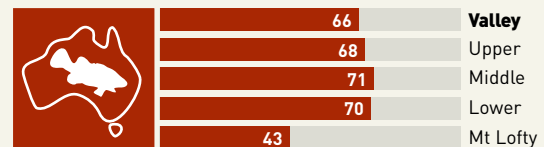
## Fish Condition Index



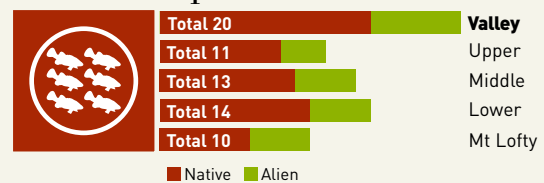
## Expectedness



## Nativeness



## Number of species

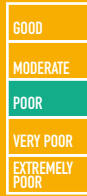


## Biomass





## Macroinvertebrates



## Hydrology



The Lower Murray Valley macroinvertebrate community had a condition index (MI) of 48 and was in Poor Condition (Lower, Middle Zones: Very Poor Condition; Upper and Mt Lofty Zones: Poor).

Thirty-three sites were sampled yielding 58 families (47% of all Basin families). Most sites were impoverished but retained many of their disturbance-sensitive families.

Most (82%) of the families expected in the Valley were recorded, although family richness was less than Reference Condition at all but a few sites. Diversity ranged from moderate (Mt Lofty Zone) to low (Murray sites).

The 15 common families, of which several inhabited all Zones, included shrimp, mites, worms and midges, caenid mayflies, hydroptilid caddisflies and little basket shells (family Corbiculidae). These are generally associated with silty, still-water habitats or arid-zone intermittent streams.

Six families were very common in both the Upper and Mt Lofty Zones, but less frequent in the Middle and Lower Zones. These were nemertean worms, aquatic moths, brine flies and moth flies and velvet water bugs. Many are typical of slightly saline water.

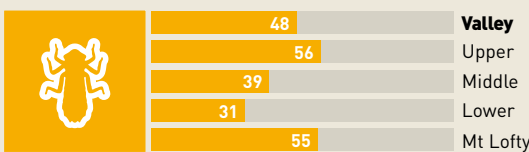
The Lower Murray Valley was in Poor hydrological Condition throughout (all Zones: Poor Condition), Hydrology Index scores from the 13 sites were 16–61. Flows are highly modified by diversions, regulation and inter-valley transfers upstream. Nine instream weirs have had profound effects on the river and floodplain.

Mean annual volumes were half of Reference Condition values, and median annual volumes reduced by 60–70%. Reductions in high-flow magnitudes were 69–88%, 66% and 68–69% in the Upper, Middle and Lower Zones, respectively. Although the duration of zero-flows changed little, there were substantial reductions in the magnitude of low flows, particularly in winter–spring, by 45–58% across all Zones.

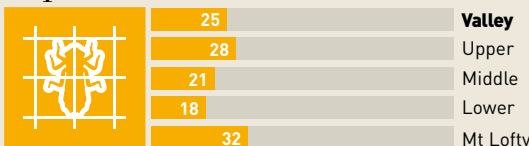
Seasonality is less modified in the Lower than the Central Murray Valley. All sites showed a 31–40% decline in flow variability

Overall, the flow regime has experienced substantial reductions in magnitudes of mean and median annual flows and high-flows, substantial changes in variability and moderate changes in seasonality.

### Macroinvertebrate Condition Index



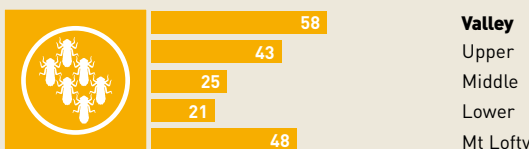
### Expectedness



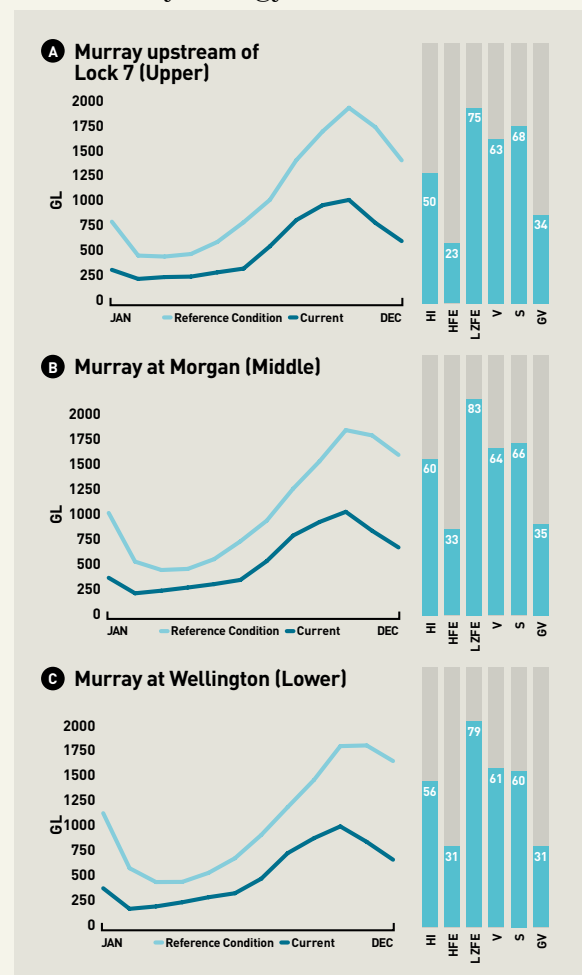
### SIGNAL OE Score



### Number of families

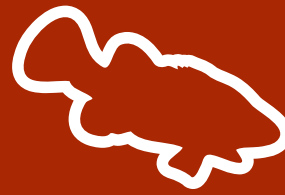
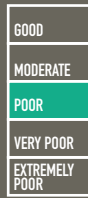


### Selected Hydrology sites

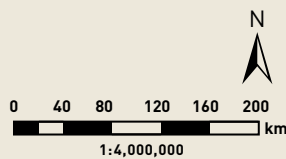
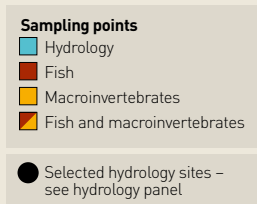
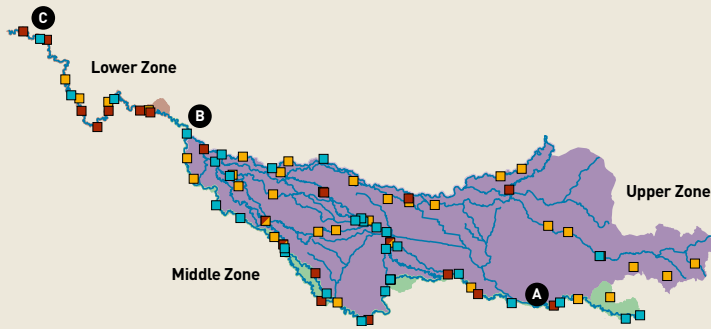




# Murray Valley, Central Ecosystem Health



## Fish



### The Central Murray Valley

The Central Murray Valley extends from below Lake Hume to Lock 9, below the Murray–Darling junction at Wentworth. Tributaries include the Murrumbidgee, Darling, Kiewa, Ovens, Goulburn, Campaspe and Loddon rivers. In addition to Lake Hume, there are smaller instream storages at Yarrowonga, Torrumbarry, Mildura and Wentworth weirs.

The Central Murray Valley covers just over 30,000 km<sup>2</sup>, or 3% of the Basin area.

### River Ecosystem Health

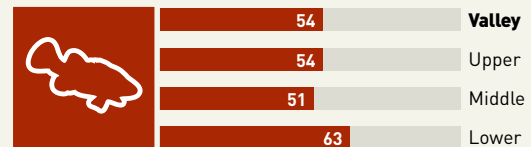
The Central Murray Valley river ecosystem was in Poor Health (Lower Zone: Moderate, Middle Zone: Very Poor; Upper Zone: Poor).

The Central Murray Valley fish community was in Poor Condition (FI = 54) (Lower Zone: Moderate Condition; Middle and Upper Zones: Poor).

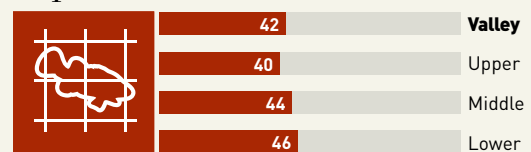
Twenty-one sites were sampled, yielding 3,117 fish. Fish were abundant, and 93% were native, but the alien fish were much larger and accounted for roughly half of the biomass. The diversity of native fish was much less than expected under Reference Condition; only 40% of predicted native species were caught. There were 9–10 native species in each Zone, with 3–4 alien species.

Common carp dominated the alien species, although Goldfish and Gambusia were common and occasional Redfin perch were caught. Species not caught in Zones where they were expected to be common included Trout cod, Freshwater catfish and Murray hardyhead. Other species not caught but expected to be rare or moderately rare included Macquarie perch, Freshwater catfish, River blackfish, Trout cod and Southern purple-spotted gudgeon.

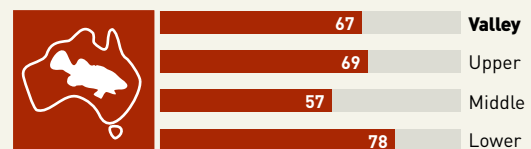
### Fish Condition Index



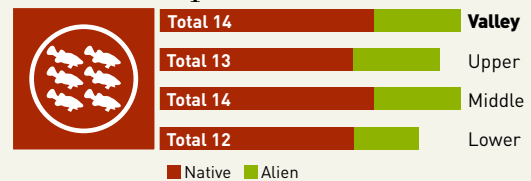
### Expectedness



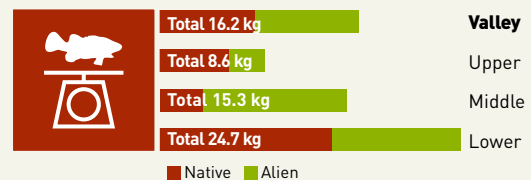
### Nativeness



### Number of species

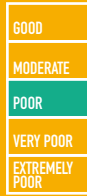


### Biomass





## Macroinvertebrates



The Central Murray Valley macroinvertebrate community had a condition index (MI) of 46 and was in Poor Condition (Lower, Upper Zones: Poor Condition; Middle Zone: Very Poor).

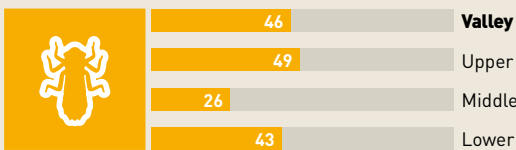
Thirty-five sites were sampled yielding 57 families (40% of all Basin families). Most sites had impoverished faunas, lacking some disturbance-sensitive families.

Only 59% of the families expected in the Valley were recorded, and family richness was less than Reference Condition at all sites. Diversity was moderate to low (average 17 families per site), with substantial variation among sites. Most (89%) of the range of Valley fauna was observed in the Upper Zone (compared to 51% and 67% for the Lower and Middle Zones).

The Expectedness indicator scores indicated substantial to severe loss of expected families. No sites had a high Expectedness score, and eight (19% of stream length) had a low score.

The five common families, all of which favour still or slow-flowing habitats, were water bugs, shrimps, semi-aquatic beetles and an aquatic millipede. The 17 rare families included diving beetles and midges, and several families associated with faster-flowing habitats.

### Macroinvertebrate Condition Index



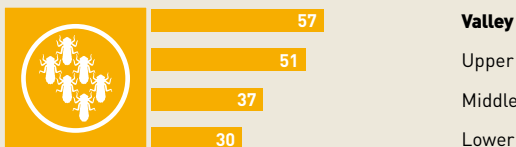
### Expectedness



### SIGNAL OE Score



### Number of families



## Hydrology



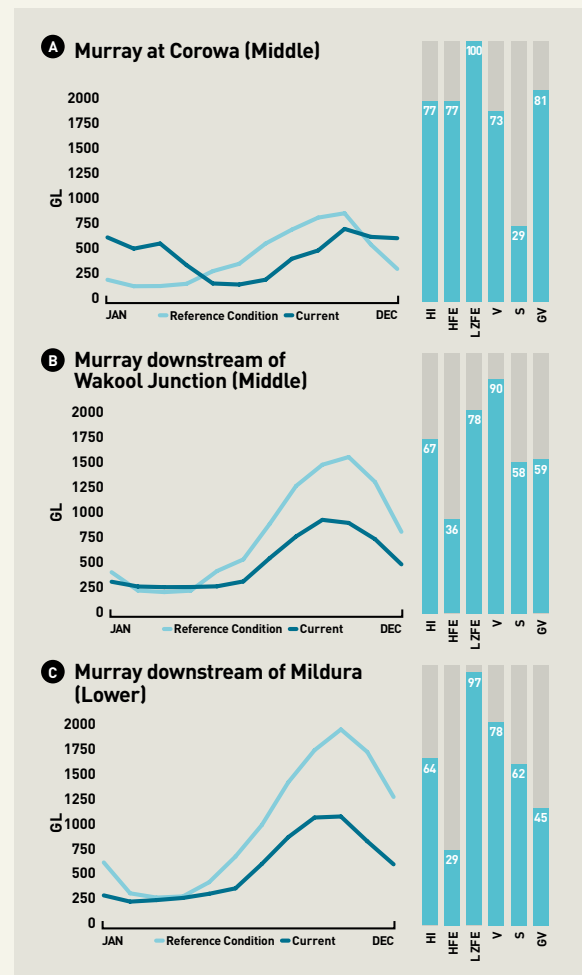
The Central Murray Valley was in Moderate hydrological Condition throughout, based on data from 32 sites. Hydrology Index scores (HI) for the mainstem were 36–100, declining gradually along the Valley.

High-Flow Events were reduced by 20–70% throughout. Low- and Zero-Flow Events showed a Moderate Difference from Reference Condition downstream of the Wakool Junction; elsewhere they were Near Reference Condition.

Mean and median annual flow volumes were reduced relative to Reference Condition by about 40% and 55–60%, respectively, in the Lower Zone, and 10–40% and 20–50%, respectively, at most Upper and Middle Zone sites.

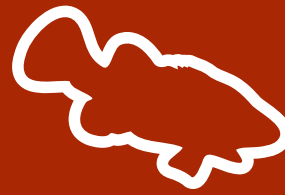
There were reductions of 5–25% in flow variability at most sites. Flow Seasonality was shifted by 1–2 months at most sites.

### Selected Hydrology sites

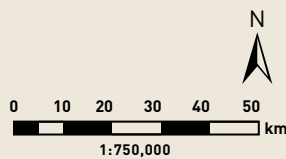
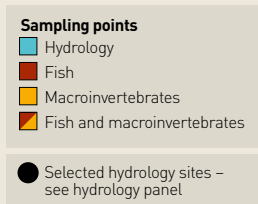
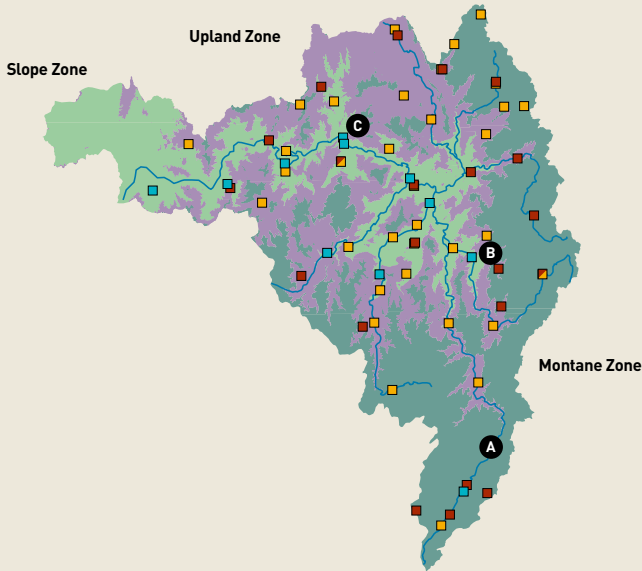




# Murray Valley, Upper Ecosystem Health



## Fish



## The Upper Murray Valley

The Murray rises east of Albury, NSW, and Wodonga, Victoria. The headwater tributaries include the Swampy Plain River, Corryong, Cudgewa, Limestone, Burrowye, Koetong, Walwa and Johnston creeks. From the Junction of Cudgewa Creek, the Murray continues westward to enter the 'Murray Arm' of Lake Hume. Inter-valley transfers occur via the Snowy Mountains Scheme, discharging into the Upper Murray near Khancoban. The lower reaches are impounded as part of Lake Hume.

The Upper Murray Valley covers 9,100 km<sup>2</sup>, less than 1% of the Basin area.

## River Ecosystem Health

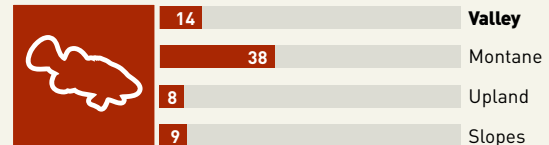
The Upper Murray Valley river ecosystem was in Very Poor Health (Slopes Zone: Very Poor; Upland Zone: Very Poor; Montane Zone: Poor).

The Upper Murray Valley fish community was in Extremely Poor Condition (FI = 14) (Slopes and Upland Zones: Extremely Poor Condition; Montane Zone: Very Poor).

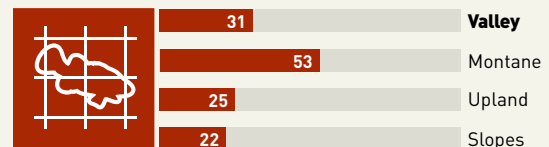
Twenty-one sites were surveyed, yielding few (881) fish. Few fish were collected. Alien species—trout, Redfin perch and Common carp, plus occasional Gambusia and Goldfish—formed 96% of total biomass and 74% of total abundance. Seven alien species were found in the Slopes Zone, and three in each of the others.

Only half (47%) of the expected native species were caught. Three of the four expected species were recorded from Montane Zone sites, producing a higher proportion of caught-to-expected species than in other Zones. Macquarie perch and Galaxias 'species 2' were not caught in the Zones where they were expected to be common. Other species not caught but expected to occur rarely or occasionally included Golden perch, Murray cod, Trout cod and Silver perch.

## Fish Condition Index



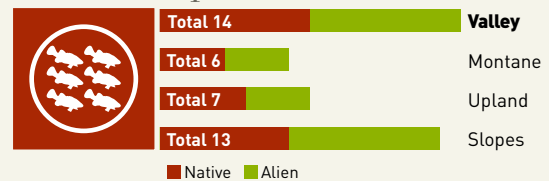
## Expectedness



## Nativeness



## Number of species

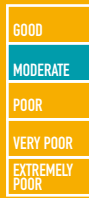


## Biomass





# Macroinvertebrates



# Hydrology



The Upper Murray Valley macroinvertebrate community had a condition index (MI) of 65, the second highest score of all Valleys, and was in Moderate Condition (Slopes Zone: Poor Condition; Upland, Montane Zones: Moderate).

Thirty-four sites were sampled yielding 86 families (60% of all Basin families).

Eighty-three percent of families expected in the Valley were recorded. Family richness was less than Reference Condition at all sites except one. Diversity was moderate to high (average 32 families per site). Most (91%) of the range of Valley fauna was found in the Upland (compared to 71% and 76% for the Slopes and Montane Zones).

Expectedness scores indicated moderate to substantial loss of expected families. A high proportion of sites (71% of stream length) had a high SIGNAL OE score, so although most sites had low diversity, they still retained most disturbance-sensitive families.

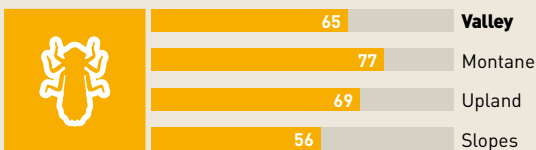
The 33 common families were dominated by 28 aquatic insect families that favour fast-flowing, cool habitats. In contrast, the 19 rare families included many associated with slow-flowing or still waters.

The Upper Murray Valley was in Moderate to Good hydrological Condition (Slopes Zone: Moderate to Good Condition; Upland and Montane Zones: Good), Hydrology Index scores (HI) at the 12 sites were 47–100.

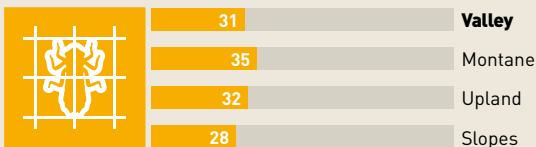
All sites but one (Montane) were in the Slopes Zone. Condition at all sites in tributaries was Near Reference Condition except for the Swampy Plain River, immediately downstream of the Snowy hydroelectric scheme inter-valley transfer near Khancoban. There were substantial changes in volumes, variability and the magnitudes of high- and low-flows in the Swampy Plain River below Khancoban, and the flow regimes exhibited a Large Difference from Reference Condition (HI = 47).

Overall, the flow regime showed substantial changes in volumes, variability and the magnitudes of high and low flows in the Swampy Plain River and the Murray downstream of Khancoban Pondage, but elsewhere little difference from Reference Condition.

## Macroinvertebrate Condition Index



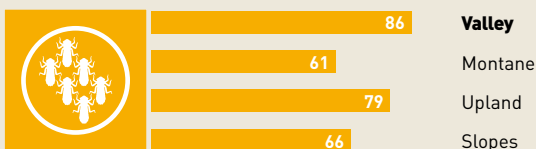
## Expectedness



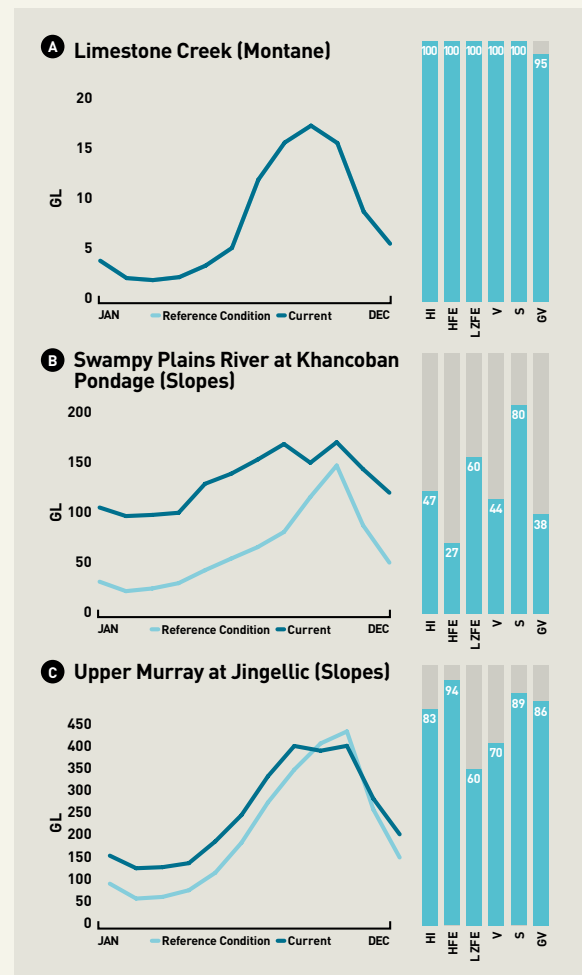
## SIGNAL OE Score



## Number of families

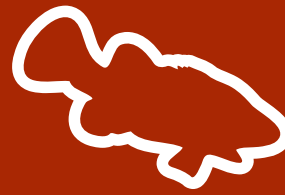


## Selected Hydrology sites

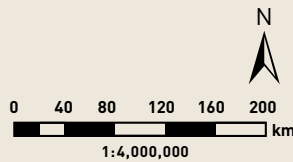
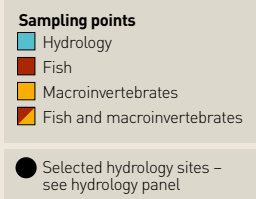
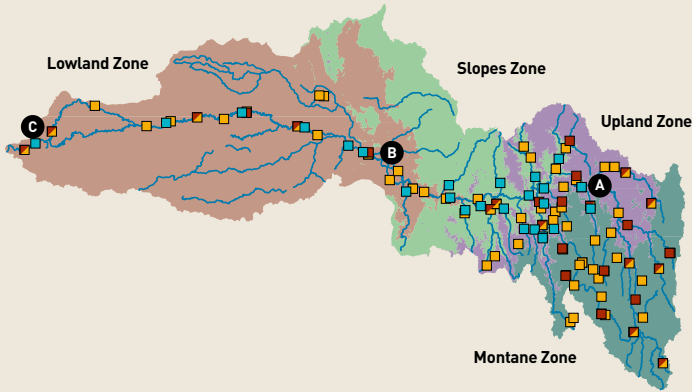




# Murrumbidgee Valley Ecosystem Health



## Fish



## The Murrumbidgee Valley

The Murrumbidgee River and its major tributary, the Tumut River, rise in the Snowy Mountains. Other tributaries include the Queanbeyan, Yass and Cotter rivers in the upper reaches, and Tarcutta and Mirrool Creeks downstream of the Tumut junction. From here westward the river enters a broad floodplain. In big floods, water from the Lachlan River enters the lower Murrumbidgee via the Great Cumbung Swamp. Major dams are Burrinjuck on the Murrumbidgee (1,025 GL) and Blowering on the Tumut (1,631 GL). Smaller dams (Googong, Corin, Bendoura, Cotter) supply the Australian Capital Territory, and there is a series of storages on the upper Tumut, including Talbingo reservoir. Inter-valley transfers occur as part of the Snowy Mountains Scheme.

The Murrumbidgee Valley covers 88,000 km<sup>2</sup>, or about 7.5% of the Basin.

## River Ecosystem Health

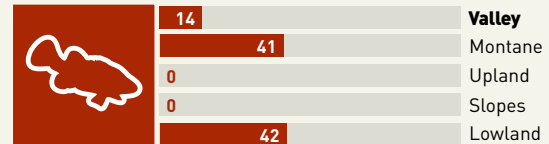
The Murrumbidgee Valley river ecosystem was in Very Poor Health (Lowland Zone: Poor; Slopes Zone: Very Poor; Upland Zone: Very Poor; Montane Zone: Very Poor).

The Murrumbidgee Valley fish community was in Extremely Poor Condition (FI = 14) (Lowland and Montane Zones: Poor Condition; Slopes and Upland Zones: Extremely Poor).

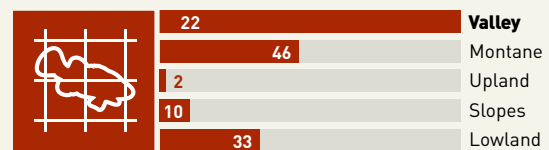
Twenty-eight sites were surveyed, yielding 1,536 fish. Thirteen of 22 expected native species were caught, but alien fish accounted for more than 87% of biomass (largely Rainbow trout, Common carp and Redfin perch) and 71% of abundance. Gambusia, Rainbow trout, Redfin perch and Common carp dominated, with fewer Goldfish, Oriental weatherloach and Brown trout. The Slopes and Upland Zones had an extremely low percentage of native biomass, with numbers averaging 17% and 6% per site. Only three of five expected species were recorded in the Montane Zone.

Freshwater catfish, Silver perch and Macquarie perch were not caught at any sites, although they were expected to be common. Other species not caught but expected to be rare or moderately rare in one or more Zones included Murray cod, Golden perch, Southern pygmy perch, Olive perchlet, River blackfish, Southern purple-spotted gudgeon and Trout cod.

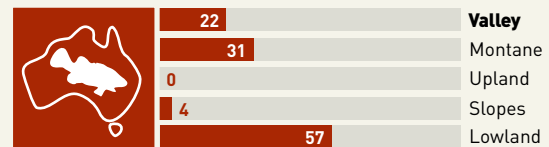
## Fish Condition Index



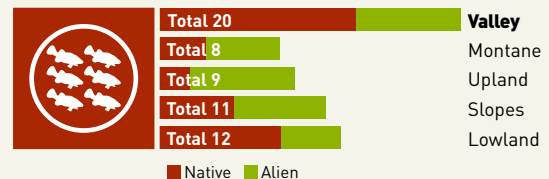
## Expectedness



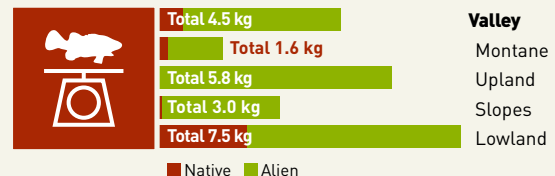
## Nativeness



## Number of species



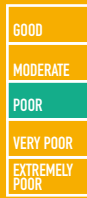
## Biomass







## Macroinvertebrates



The Murrumbidgee Valley macroinvertebrate community had a condition index (MI) of 48 and was in Poor Condition (Lowland Zone: Moderate Condition; Slopes and Upland Zones: Poor; Montane Zone: Very Poor).

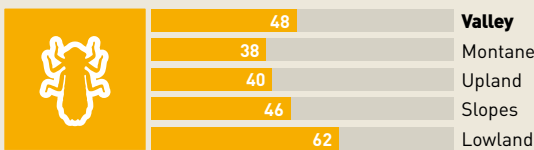
Thirty-five sites yielded 76 families (53% of all Basin families). Upland and Montane Zone communities had low diversity and had lost many disturbance-sensitive families.

Seventy-two percent of families expected in the Valley were recorded. Family richness was less than Reference Condition at over 40% of sites. Diversity was moderate (average 22 families per site), although Upland Zone sites were highly variable. Most of the range of Valley families (80–83%) was in the Upland and Montane Zones, compared with 59–68% for the Lowland and Slopes Zones.

One Lowland site had a high Expectedness score, indicating that many expected families were present, but 16% of sites in the Slopes to Montane Zones had low scores.

The four common families present included damselflies, pond snails, 'pill' clams and isopods. These are all families of still and slow-flowing aquatic habitats. The 15 rare families included particular families of bugs, beetles and molluscs, many of which are associated with still or slow-flowing habitats, but are uncommon.

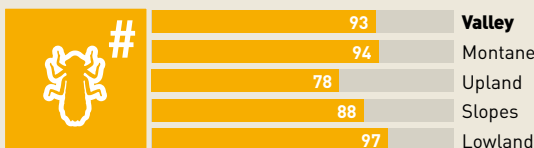
### Macroinvertebrate Condition Index



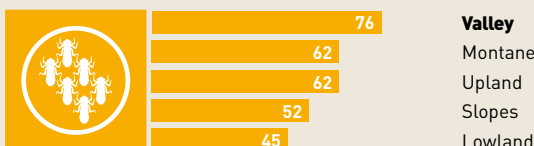
### Expectedness



### SIGNAL OE Score



### Number of families



## Hydrology



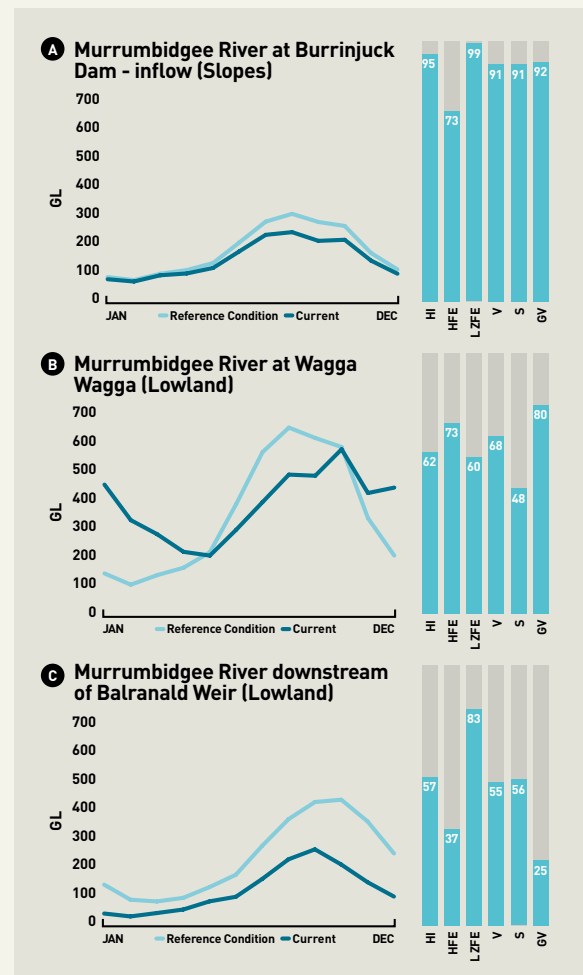
The Murrumbidgee Valley was in Poor to Moderate hydrological Condition (Lowland Zone: Poor to Moderate Condition; Slopes Zone: Poor to Good; other Zones unrated), Hydrology Index scores (HI) from the 26 sites were 36–100.

Lowland Zone sites showed a Moderate to Large Difference from Reference Condition. Slopes Zone sites ranged from Near Reference Condition to a Very Large Difference from Reference (in the Tumut downstream of Blowering Dam).

Murrumbidgee and Tumut River flow regimes were affected by major changes in annual volume and high flow magnitudes (GV, HFE), and Seasonality (S). Mean annual volume in the lower mainstream, downstream of Balranald Weir is halved under current conditions, despite an approximate doubling of annual flows in the Tumut through inter-valley transfer from the Snowy Scheme

Overall, the flow regime was typified by major changes in the magnitude of annual volumes and high flows and seasonality in the Murrumbidgee and Tumut Rivers, but little or no change from Reference Condition elsewhere.

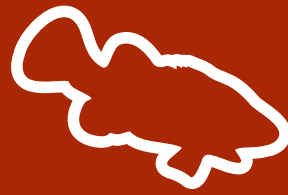
### Selected Hydrology sites



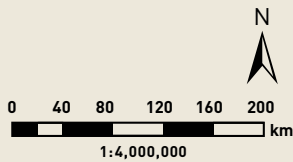
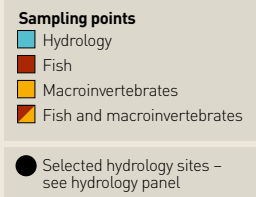
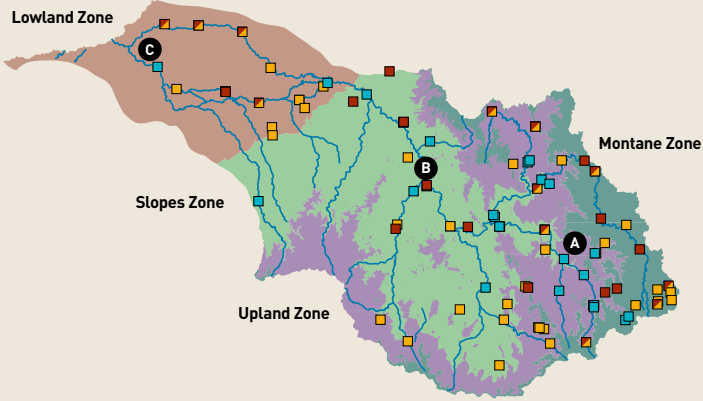
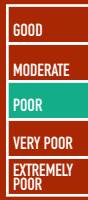


# Namoi Valley

## Ecosystem Health



# Fish



## The Namoi Valley

The Namoi River rises in the Great Dividing Range and flows westward to join the Barwon River near Walgett. The main tributary is the Peel River, joining the Namoi at Gunnedah; others include the Manilla and McDonald rivers and Coxs Creek. From Wee Waa to Walgett, the channel branches across a broad floodplain. There are instream storages at Keepit Dam on the Namoi (423 GL), Split Rock Dam at the junction of the Manilla and McDonald (397 GL) and Chaffey Dam on the Peel (62 GL). Weirs on the Namoi provide urban, stock and domestic supplies, and the larger Mollee and Gunidgera weirs provide irrigation water.

The Namoi Valley covers 42,000 km<sup>2</sup>, about 4% of the total Basin area.

## River Ecosystem Health

The Namoi Valley river ecosystem was in Poor Health (Lowland Zone: Moderate; Slopes Zone: Moderate; Upland Zone: Moderate; Montane Zone: Poor).

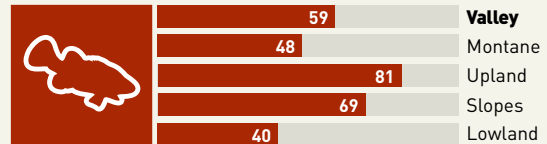
The Namoi fish community was in Poor Condition (FI = 59) (Lowland and Montane Zones: Poor Condition; Slopes Zone: Moderate; Upland: Good), but was in the upper range of Valley scores.

Twenty-eight sites were surveyed, yielding 2,453 fish. Twelve native species (80% of expected) were recorded. Five alien species were abundant, constituting 61% of biomass and 37% of numbers.

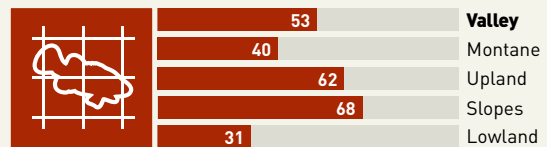
Few Lowland sites recorded more than two native species, while most Slopes sites had four or more. Native fish comprised over half of the catch in each Zone, but their proportion of biomass varied greatly—from 91% (Montane) to 20% (Slopes), where large Common carp were numerous.

Larger native fish such as Murray cod and Bony herring were recorded among large alien species like Common carp, Goldfish and trout. Medium-sized native fish including Spangled perch and River blackfish were common. Gambusia were abundant. Murray cod were caught at two Montane Zone sites, where they were not expected, probably as the result of stocking.

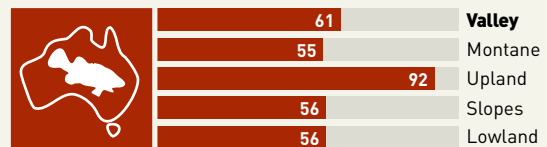
## Fish Condition Index



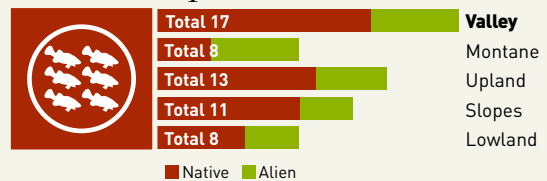
## Expectedness



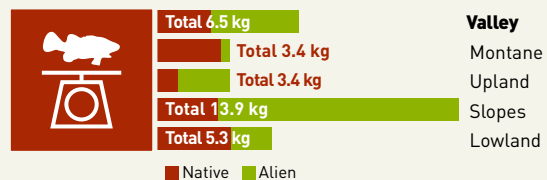
## Nativeness



## Number of species

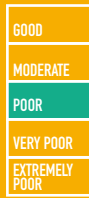


## Biomass





## Macroinvertebrates



The Namoi Valley macroinvertebrate community had a condition index (MI) of 52 and was in Poor Condition (Lowland Zone: Moderate Condition; Upland Zone, Slopes and Montane Zones: Poor).

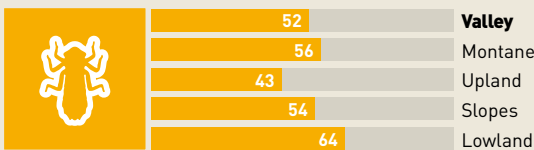
Twenty-five sites were sampled yielding 73 families (50% of all Basin families).

Seventy-two percent of families expected in the Valley were recorded. Family richness was less than Reference Condition at over 40% of sites. Diversity was moderate (average 24 families per site), with Montane Zone sites being most diverse (33 families per site). A moderate proportion (54%) of the range of Valley fauna was found in the Lowland Zone, compared with 66–74% for other Zones.

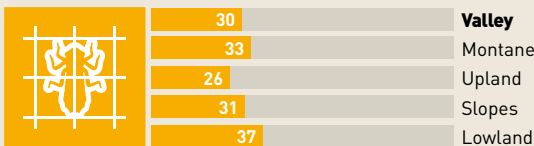
Low Expectedness scores indicated substantial loss of expected families for 92% of stream length, with significant variation among sites in the Lowland Zone. The communities in all Zones were impoverished and lacking disturbance-sensitive families.

Six common families included freshwater shrimp, long-horned and ecnomid caddisflies and velvet water bugs. Five rare families included hawkers and emerald dragonflies and midges.

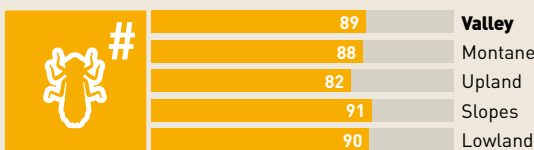
### Macroinvertebrate Condition Index



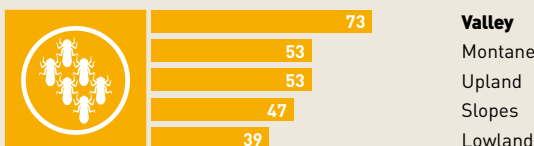
### Expectedness



### SIGNAL OE Score



### Number of families



## Hydrology

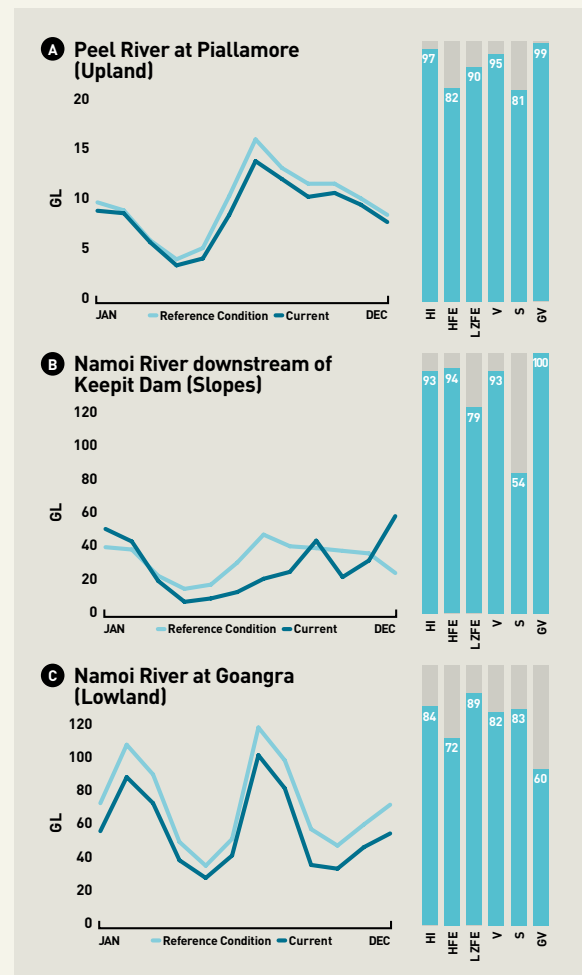


The Namoi Valley was in Good hydrological Condition throughout (all Zones: Good Condition), Hydrology Index scores (HI) at the 22 sites were 59–100, indicating Good Condition in all but one Upland site.

High-Flow Events were Near Reference Condition at most sites, but with a decrease of up to 62% for some Lowland sites. Low- and Zero-Flow Events were also Near Reference Condition at most sites. Seasonality of flows was Near Reference Condition for most sites, but had Moderate to Large Differences from Reference Condition for the Namoi and tributaries downstream of storages. Gross Volume indicator values were Near Reference Condition for all sites except Dungowan Creek.

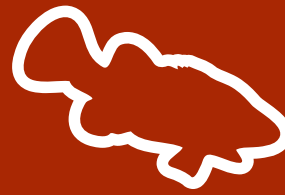
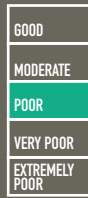
In general, the flow regime was Near Reference Condition, but with changes in volume, seasonality and high flows in response to regulation (upstream) by storages and diversions (downstream).

### Selected Hydrology sites

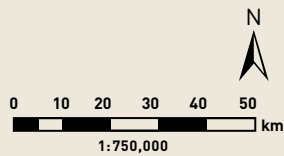
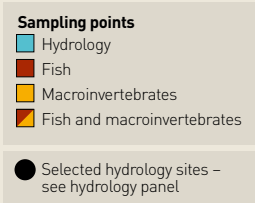
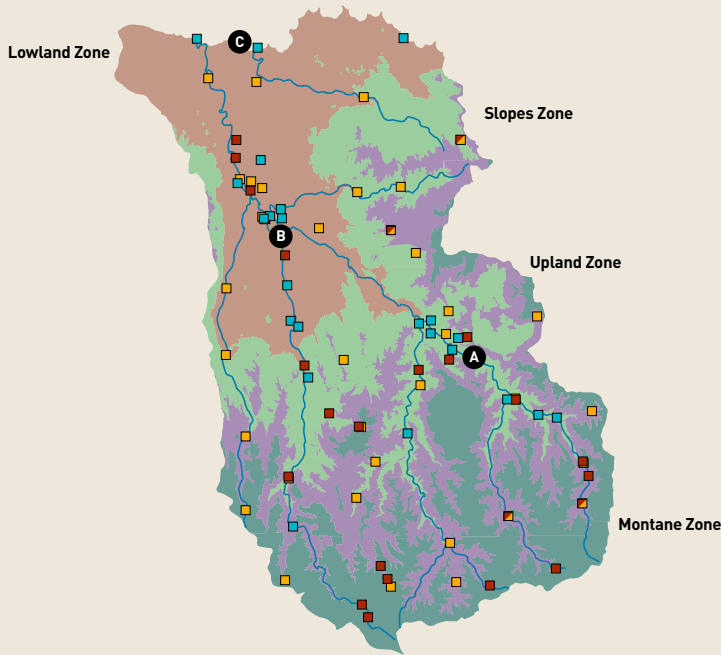




# Ovens Valley Ecosystem Health



# Fish



## The Ovens Valley

The Ovens River rises near Mount Buffalo, Victoria, and flows north-west to Wangaratta then north to join the Murray at Lake Mulwala, impounded by Yarrawonga Weir. The tributary King River rises near the Goulburn catchment and flows north to join the Ovens at Wangaratta. Other tributaries include the Buckland and Buffalo rivers and Reedy and Fifteen Mile creeks. Between the Buffalo and the King junctions, the Ovens branches across a wide floodplain, part-shared with the King, and then continues through a confined floodplain to meet the Murray. There are two instream storages, Lake Buffalo (24 GL) on the Buffalo and Lake William Hovell (14 GL) on the King.

The Ovens Valley covers 7,900 km<sup>2</sup>, less than 1% of the Basin area.

## River Ecosystem Health

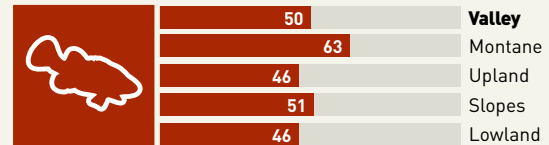
The Ovens Valley river ecosystem was in Poor Health (Lowland Zone: Poor; Slopes Zones: Poor; Upland Zone: Very Poor; Montane Zone: Moderate).

The Ovens Valley fish community was in Poor Condition (FI = 47) (Lowland, Slopes, Upland Zones: Poor Condition; Montane: Moderate).

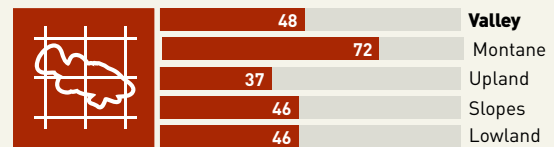
Twenty-six sites were surveyed, yielding 1,975 fish. Thirteen native species, or 59% of the expected species, were caught. These comprised 53% of the total numbers and 23% of the biomass. Six alien species were caught; Rainbow trout and Brown trout appeared in Montane and Upland sites, but more species were caught in other Zones. Gambusia were sometimes abundant and there were moderate numbers of Redfin perch, Common carp and the two trout species.

No Macquarie perch, Mountain galaxias or Galaxias 'species 1' (a new species), and only a single Southern pygmy perch, were caught in Zones where they were expected to be common. Other species not caught but expected to occur rarely or occasionally included Bony herring, Freshwater catfish, Silver perch, Golden perch and Trout cod.

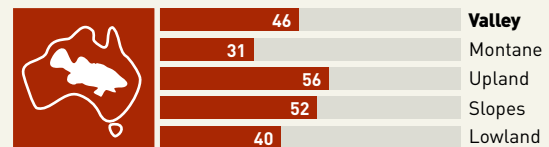
## Fish Condition Index



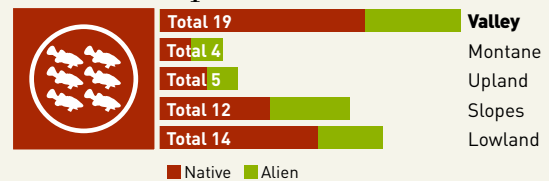
## Expectedness



## Nativeness



## Number of species

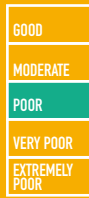


## Biomass





## Macroinvertebrates



## Hydrology



The Owens Valley macroinvertebrate community had a condition index (MI) of 57 and was in Poor Condition (Lowland, Slopes and Montane Zones: Poor Condition; Upland Zone: Moderate).

Thirty-five sites were sampled yielding 86 families (62% of all Basin families).

Most communities in the Valley were impoverished but had lost few of their disturbance-sensitive families.

Eighty-three percent of families expected in the Valley were recorded. Family richness was less than Reference Condition at over 40% of sites. Diversity was moderate to high (average 28 families per site), with Upland Zone sites having highest diversity (33 families per site). A moderate proportion (60–77%) of the range of Valley families was found in the Lowland to Upland Zones, compared to 38% for the Montane Zone.

Expectedness scores indicated substantial loss of expected families.

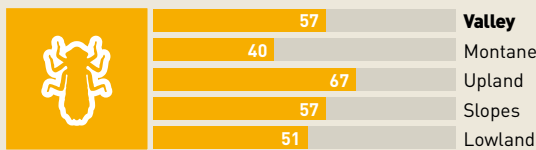
Nine common families included mayflies, three subfamilies of midges, water scavenger beetles and broad-shouldered water striders. The 15 rare families included a range of families normally found in lowland reaches. The apparent scarcity of the prawn *Macrobrachium australiense* is noteworthy, as it is common elsewhere in the Basin.

The Owens Valley was in Good hydrological Condition, with Hydrology Index scores (HI) for the 23 sites ranging 81–100 (all Zones: Good Condition).

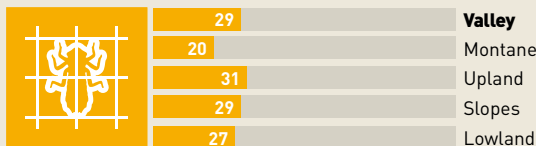
High-Flow Events were Near Reference Condition throughout. Low- and Zero-Flow Events on the Owens and King Rivers in the Lowland Zone, however, showed a Large Difference from Reference Condition, reflecting diversions from naturally low summer flows.

In general, the flow regime of the Owens Valley showed little change from Reference Condition, other than changes to low flows in the mid-Lowland Zone.

### Macroinvertebrate Condition Index



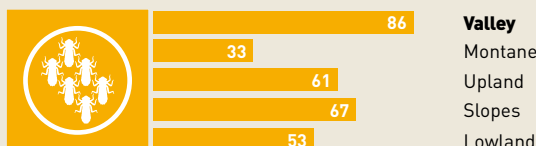
### Expectedness



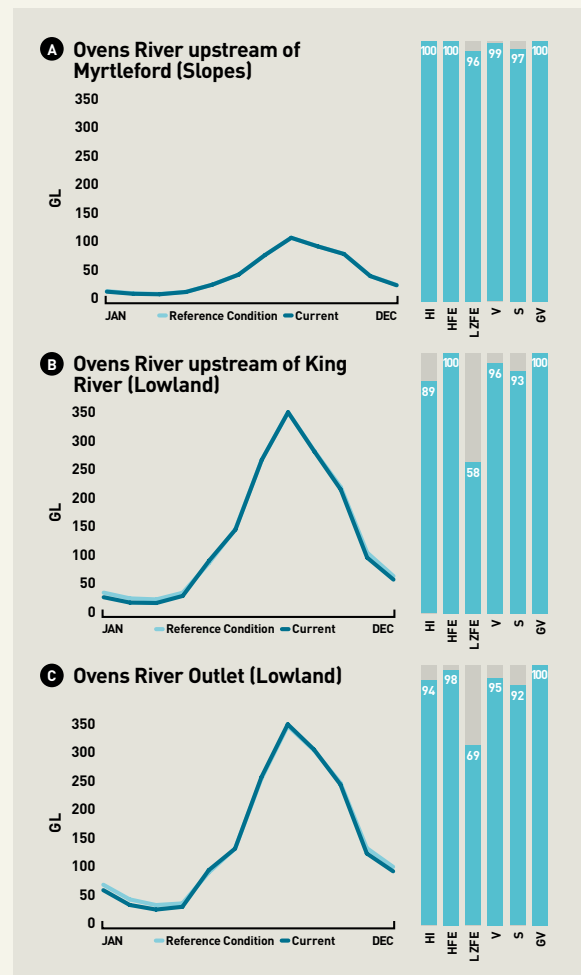
### SIGNAL OE Score



### Number of families



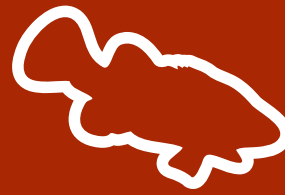
### Selected Hydrology sites



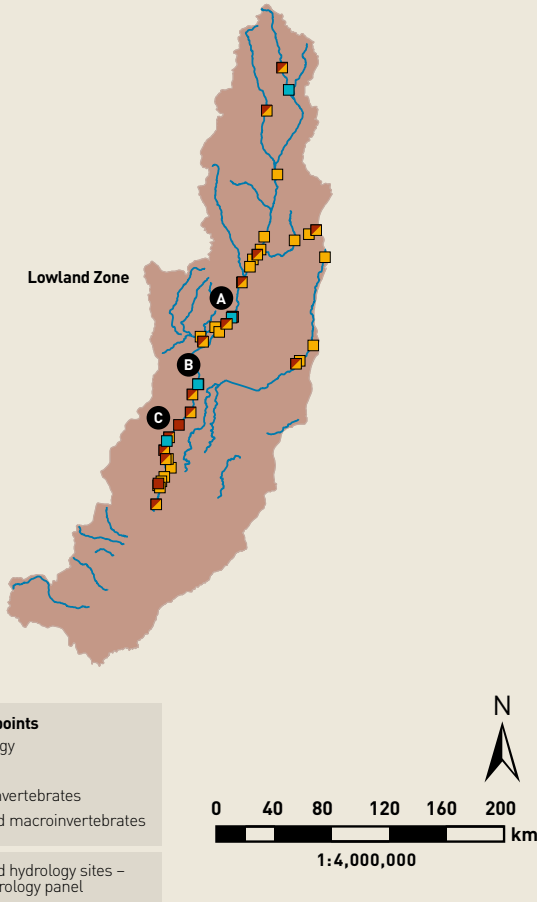


# Paroo Valley

## Ecosystem Health



# Fish



The Paroo Valley fish community was in Moderate Condition (FI = 78) and had the highest Fish Index score among all Valleys.

Eighteen sites were sampled, yielding 1047 fish. Nativeness was extremely high (97% of all fish were native), with only a few individuals from three alien species recorded. Most sites yielded three to four native species. Bony herring were widespread and abundant, and Golden perch, Murray–Darling rainbowfish, Spangled perch and Hyrtl’s tandan also were widespread, in smaller numbers.

Native fish comprised a high proportion (78%) of total biomass, though only seven of 12 expected native species were caught. A single Carp gudgeon was caught, although this small species was expected to occur commonly. Species not caught but expected to occur rarely or occasionally included Murray cod and Freshwater catfish.

The few alien fish were substantially larger than the small native species. Common carp and Goldfish were sparsely distributed and in low abundance. Only one Gambusia was caught.

### Fish Condition Index



### The Paroo Valley

The Paroo is an ephemeral river that rises in the gorge country of western Queensland, and flows south into western NSW. Flows from the Paroo reach the Darling only rarely, typically dissipating in the vast floodplains of the Paroo Overflow. The Paroo region contains many important wetlands, including several Ramsar-listed sites. There are no instream storages.

The Paroo Valley covers 73,000 km<sup>2</sup> or nearly 7% of the Basin area.

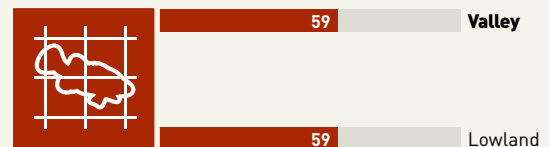
### River Ecosystem Health

The Paroo Valley river ecosystem was in Good Health.

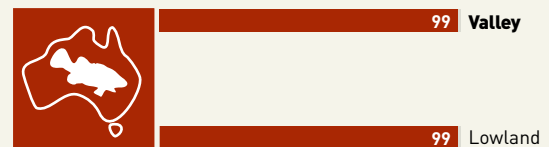
Paroo Valley comprises only one zone, the Lowland Zone.

The condition and health assessments for the Valley and Zone are therefore the same.

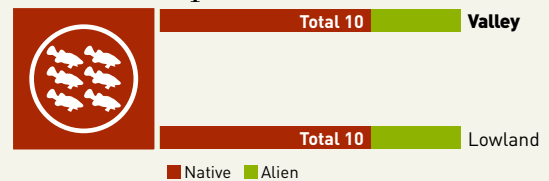
### Expectedness



### Nativeness



### Number of species

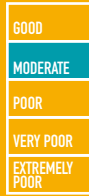


### Biomass





# Macroinvertebrates



# Hydrology



The Paroo Valley macroinvertebrate community had a condition index (MI) of 64, the third highest score for all Valleys, and was in Moderate Condition.

Thirty-five sites were sampled across the Valley yielding 42 families (31% of all Basin families).

Nearly all (93%) macroinvertebrate families expected in the Valley were recorded. Family richness at site level was Near or slightly reduced compared to Reference Condition. Diversity was low to moderate (average 15 families per site).

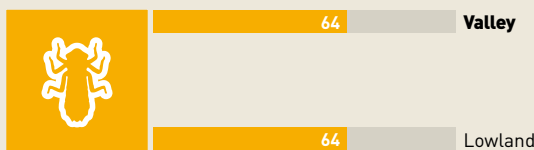
Expectedness and SIGNAL OE scores were relatively high and near Reference Condition, with slight variation among sites. Eleven sites in the Valley (31% of stream length) had a high Expectedness score, and only one site had a low score. Most communities were only slightly impaired; the reduced SIGNAL OE scores may be a result of the sustained dry conditions prior to sampling leading to reduced habitat quality.

Nine common families included diving and water scavenger beetles, clam shrimps, emerald dragonflies and midges. Clam shrimps are typical of temporary rainwater pools rather than permanent habitats. The 16 rare families included crustaceans, longhorn caddis and pond damselflies.

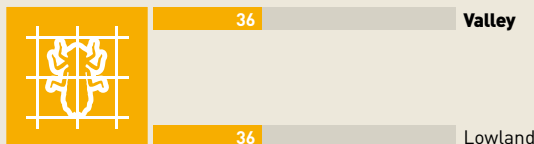
The Paroo Valley was in Good hydrological Condition throughout. Hydrology Index scores (HI) for all four sites were 100, indicating Near Reference Condition.

Very high values of both the index and all hydrology indicators reveal that hydrology in the Paroo is little changed from its natural flow regime.

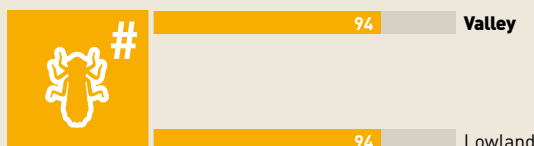
## Macroinvertebrate Condition Index



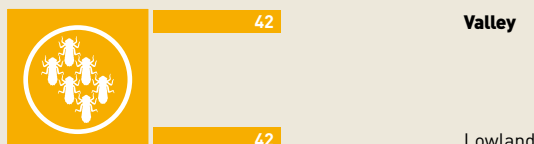
## Expectedness



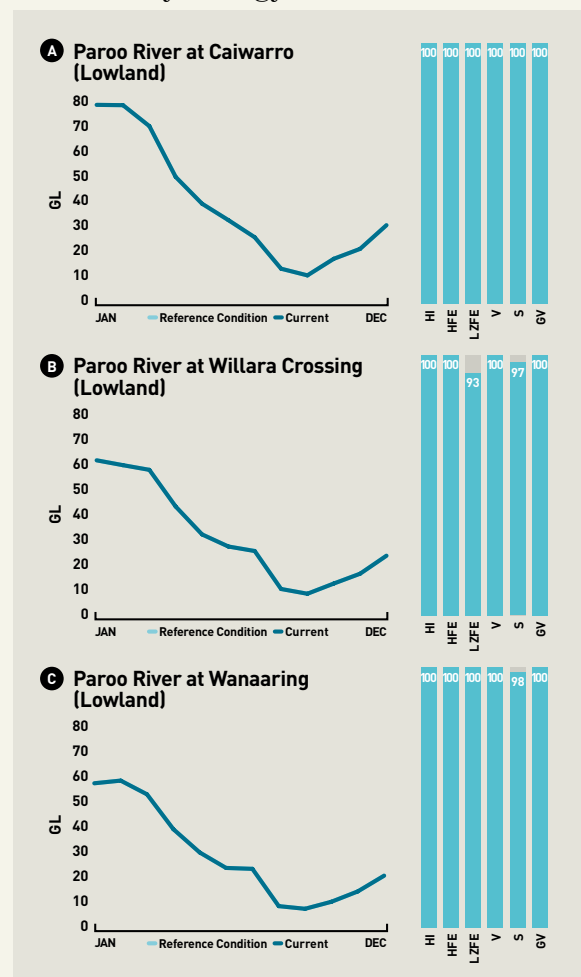
## SIGNAL OE Score



## Number of families

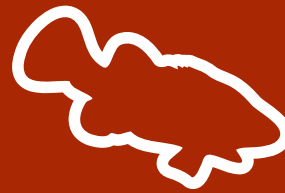
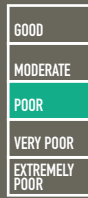


## Selected Hydrology sites

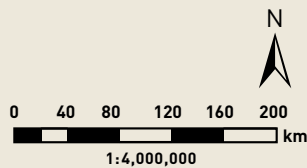
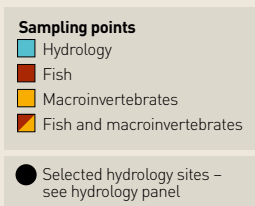
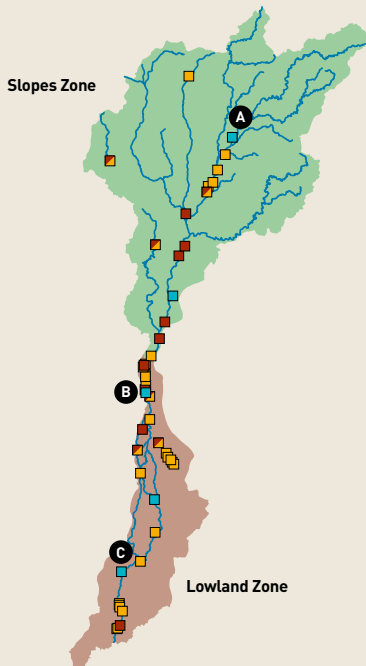




# Warrego Valley Ecosystem Health



## Fish



## The Warrego Valley

The headwaters of the Warrego River rise near the Warrego and Chesterton Ranges in the northernmost part of the Basin, converge near Augathella and Charleville and flow southward as the Warrego, meeting the Darling downstream of Bourke. Below Cunnamulla the river breaks into distributaries, some feeding the Yantabulla Swamp in the Cuttaburra Basin, which may deliver flood flows to the Paroo system. Water reaches the Darling from the Warrego only during floods. There are no instream storages other than weirs.

The Warrego Valley covers almost 63,000 km<sup>2</sup>, or 6% of the Basin area.

## River Ecosystem Health

The Warrego Valley river ecosystem was in Poor Health (Lowland Zone: Poor; Slopes Zone: Moderate).

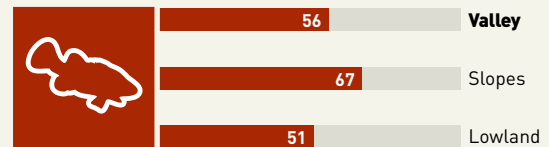
The Warrego fish community was in Poor Condition (FI = 56) (Lowland Zone: Poor Condition; Slopes Zone: Moderate), slightly above the average score for all Valleys.

Sixteen sites were sampled, yielding 1,126 fish. Only seven of 14 expected native species were recorded. Native fish were numerically dominant but small, and alien species comprised half of the biomass.

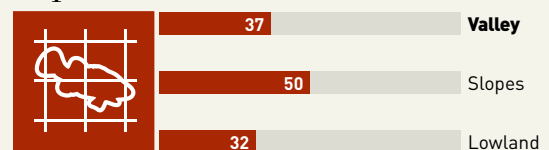
Bony herring, Golden perch and Australian smelt were widespread and abundant. Most sites had three to four native species. Carp gudgeons and Murray-Darling rainbowfish were recorded occasionally, as were Spangled perch and Murray cod.

Freshwater catfish, Silver perch and Spangled perch were not caught in Zones where they were expected to be common. Other species not caught, but expected to occur rarely or occasionally, included Hyrtl's tandan and Murray cod. Common carp were widespread and Goldfish and Gambusia were caught occasionally.

## Fish Condition Index



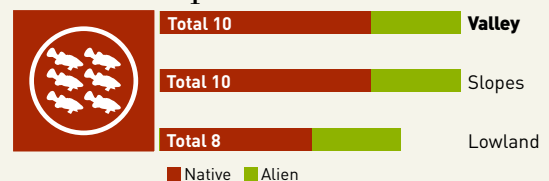
## Expectedness



## Nativeness



## Number of species



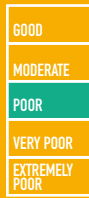
## Biomass







## Macroinvertebrates



## Hydrology



The Warrego Valley macroinvertebrate community had a condition index (MI) of 49, in the lower mid-range of all Valley scores, and was in Poor Condition throughout (both Zones: Poor Condition).

Thirty-five sites were sampled yielding 45 families (33% of all Basin families).

There were few expected and disturbance-sensitive families in both Lowland and Slopes Zones. Family richness was significantly less than Reference Condition at all sites. Diversity was low (average 13 families per site), especially at Lowland Zone sites (12 families per site). Most of the range of Valley families (77–89%) was found in both Zones.

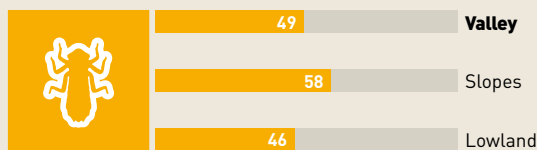
Expectedness scores indicated substantial losses of expected families, with some variation among sites. Most communities (89% of stream length) were impoverished and missing some disturbance-sensitive families.

Six common families included waterboatmen, mosquitoes, small water beetles and variegated mud-loving beetles and, in the Lowland Zone, clam shrimps and leeches. The 21 rare families included aquatic insect families such as caddis, mayflies, beetles, damselflies and midges, as well as bugs (Veliidae, Mesoveliidae), water measurers and snails.

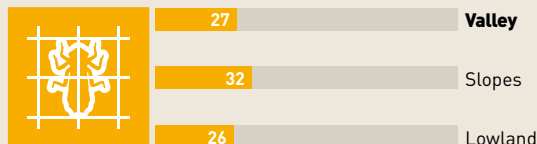
The Warrego Valley was in Good hydrological Condition (both Zones: Good Condition). Hydrology Index scores across all five hydrology sites were 93–100, with most indicators in Near Reference Condition at the majority of sites. Data from the most downstream reaches of the Warrego River indicate moderate declines in high flow and median annual flow volumes, and changes in duration of zero flow days. The magnitudes of mean annual volumes and of low flows are little changed throughout the Warrego River, along with flow variability and seasonality, which remain Near Reference Condition.

The values suggest that the flow regime in the Warrego is only slightly changed from the natural regime, though changes in the lower reaches are of ecological significance. There are no regulating storages on the Warrego and the in-stream weirs and limited diversions for irrigation have had little effect on the Hydrology Index.

### Macroinvertebrate Condition Index



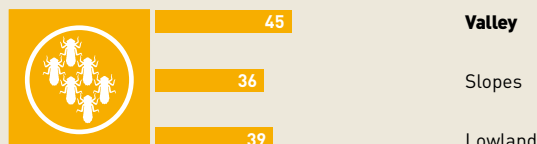
### Expectedness



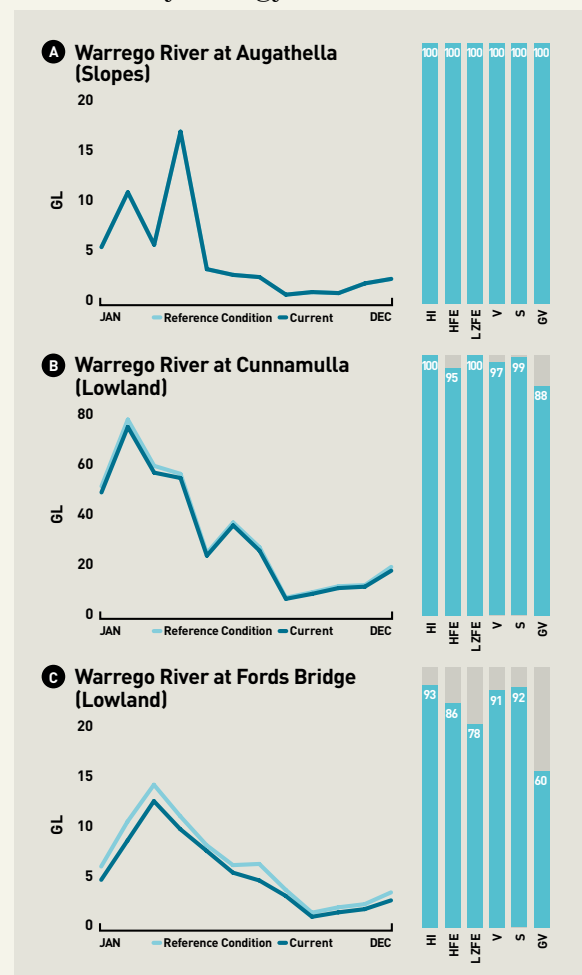
### SIGNAL OE Score



### Number of families

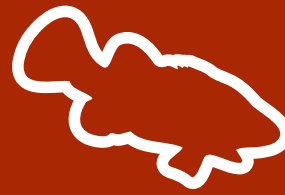
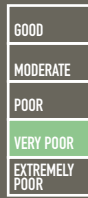


### Selected Hydrology sites

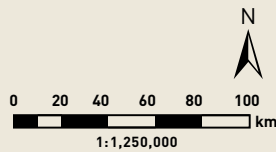
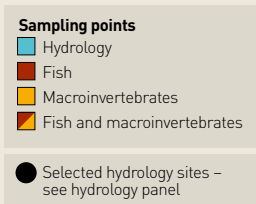
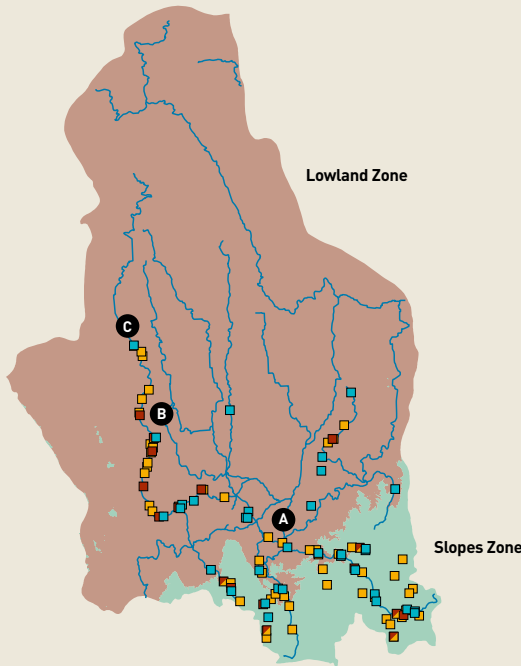




# Wimmera Valley Ecosystem Health



## Fish



## The Wimmera Valley

The Wimmera River rises in the hills in the south of the catchment and terminates in wetlands that include Ramsar-listed sites at Lakes Hindmarsh and Albacutya, two of the largest natural freshwater lakes in Victoria. There are seven storages (>15 GL) on tributaries but only one small storage, Mount Cole Dam, on the Wimmera channel.

The Wimmera Valley covers about 30,000 km<sup>2</sup>, or nearly 3% of the Basin area.

## River Ecosystem Health

The Wimmera Valley river ecosystem was in Very Poor Health (Lowland Zone: Very Poor; Slopes Zone: Poor).

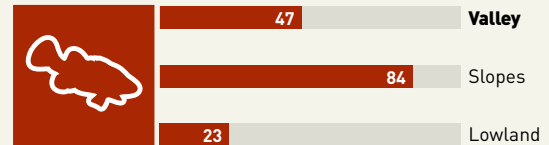
The Wimmera Valley fish community was in Poor Condition (FI = 47) (Lowland Zone: Very Poor Condition; Slopes Zone: Good).

Seventeen sites were surveyed, yielding 1,009 fish. Fish abundance was dominated by native species but alien species dominated biomass. Fish were abundant, averaging 59 per site. In some Lowland sites, only one or two native species were caught.

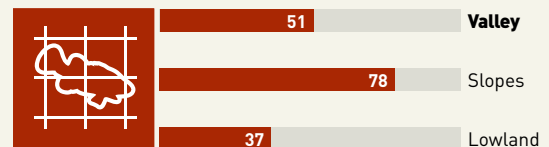
Flathead gudgeon and Southern pygmy perch were abundant. Common jollytail were numerous, having been introduced through inter-basin water transfers from the Glenelg River. Dominant alien species included Redfin perch, Common carp and Gambusia.

Species not caught, although expected to occur under Reference Condition, included River blackfish and three smaller, less well-known species.

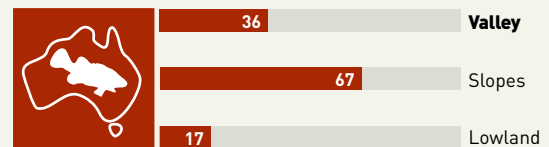
## Fish Condition Index



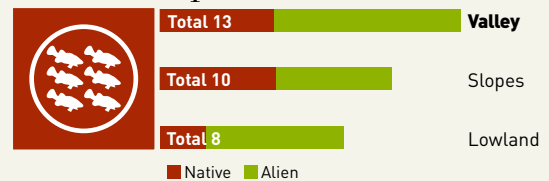
## Expectedness



## Nativeness



## Number of species

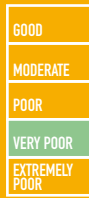


## Biomass





## Macroinvertebrates



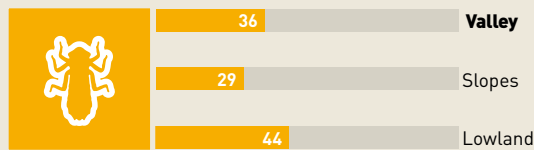
The Wimmera Valley macroinvertebrate community had a condition index (MI) of 36 and was in Very Poor Condition (Lowland Zone: Poor Condition; Slopes Zone: Very Poor). The Valley score was the second lowest value for all Valleys (higher only than that for the Avoca).

Thirty-four sites were surveyed across the two Zones yielding 75 families (52% of all Basin families). Most communities were impoverished, lacking disturbance-sensitive families.

Seventy-six percent of families expected in the Valley were recorded. Family richness was substantially less than Reference Condition at all sites. Diversity was moderate (average 22 families per site), with substantial variation among Lowland Zone sites. Most of the range of Valley fauna was found in both Zones. There was significant variation in Condition among sites in the Slopes Zone.

The 13 common families found in the Wimmera valley included diving beetles, snails, pond damselflies, amphipods and midges. Twenty rare families were found, and included many associated with flowing water habitats, including several aquatic insect families.

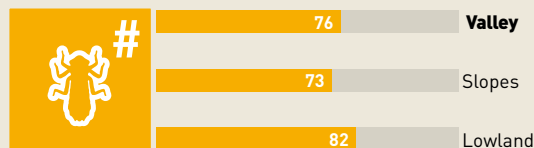
### Macroinvertebrate Condition Index



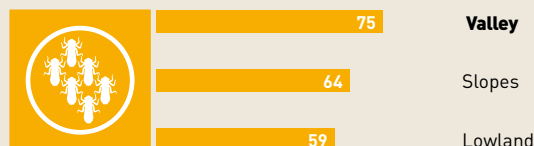
### Expectedness



### SIGNAL OE Score



### Number of families



## Hydrology



The Wimmera Valley was in Poor hydrological Condition (Lowland Zone: Poor to Very Poor Condition; Slopes Zone: Good). Hydrology Index scores (HI) for the 34 sites were 13–100.

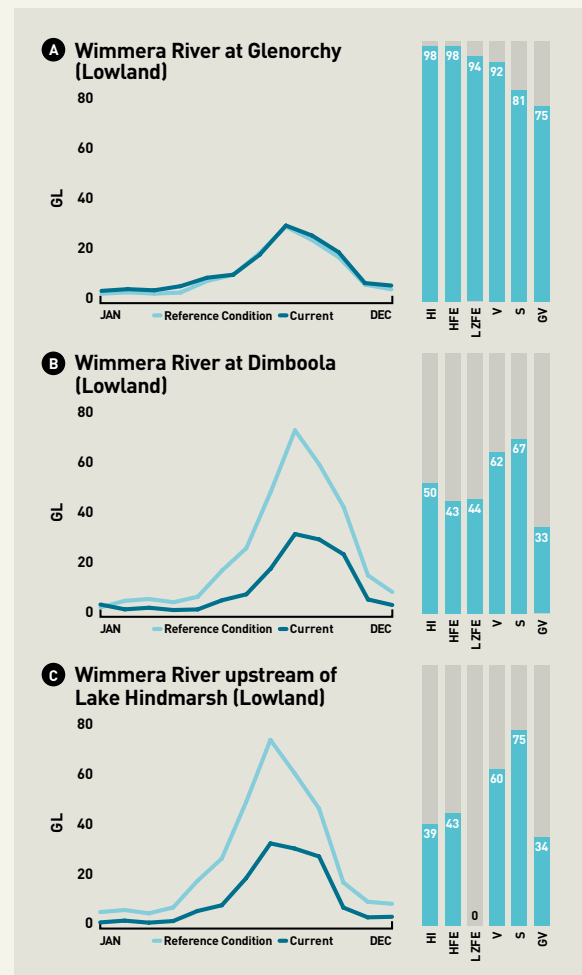
Of 23 Lowland Zone sites, 14 were in Near Reference Condition. The remainder showed Extreme to Moderate Differences from Reference Condition. Two Slopes Zone sites showed a Moderate Difference from Reference and the remainder were in Near Reference Condition.

Mean and median annual flow volumes were reduced by up to 85% and 60%, respectively in the Slopes Zone; and in the Lowland Zone by 45–60% and 85–95%, respectively—strongly affecting the terminal lakes.

Gross annual flow volumes decline along the Wimmera due to diversions. Low- and zero-flow magnitude and duration were Near Reference Condition upstream, but extremely reduced downstream. Flow variability was reduced in the lower Wimmera, unchanged elsewhere. Flow seasonality showed Moderate to Large Differences from Reference Condition, with diversions changing minimum flows.

The Valley's flow regime had reduced high flow magnitudes, annual volumes and variability. Flow seasonality showed Moderate to Large Differences from Reference, with diversions changing minimum flows.

### Selected Hydrology sites



## 6. Assessments by Theme

### Fish Theme

All Valleys (487 sites) were sampled for fish, involving 38 species and more than 60,600 individual specimens with a total biomass of over 4 tonnes. All fish (except pest species in some states) were returned to the water after measurement.

Fish Condition Index scores indicated Very Poor Condition in most Valleys. Communities in the northern Basin often were in better condition than those in the southern Basin. Many native fish species expected to occur in Valleys under Reference Condition were not recorded. Overall, species were found in only 43% of Valley Zones where they were predicted. This confirms the well-known decline of native fish in the Basin.

Alien species are a major part of the Basin fish fauna. They rivalled or out-numbered native fish in nine of the 23 Valleys, especially the Macquarie, Campaspe, Gwydir and Murrumbidgee Valleys. Twenty-eight of the species caught were native, contributing 57% of individual fish but only 32% of the biomass. In other words, 10 alien species contributed 43% of abundance and 68% of biomass.

Three alien species—Common carp, *Gambusia* and Goldfish—were present in all rivers. Redfin perch and trout species also were widespread. Common carp were overwhelmingly dominant, being 87% of alien biomass and 58% of total fish biomass.

Native fish were numerically dominant (90% or more of individuals) in the Lower and Central Murray, Paroo and Warrego Valleys. High proportions of native fish biomass were recorded for the Paroo (78%), Darling (62%) and Border Rivers Valleys (60%).

Golden perch were common and present in 21 of the 23 Valleys. Other native species included Murray cod (16 Valleys), Freshwater catfish (7 Valleys), Silver perch (5 Valleys) and Trout cod (3 Valleys).

The Darling Valley had the greatest combined biomass of alien and native fish (16.8 kg/site) and the greatest native fish biomass (10 kg/site). The Central Murray Valley was the next most productive. Least productive was the Paroo Valley, yielding only 0.75 kg/site of combined alien and native biomass, although 78% of this was native.

Condition assessments for the Fish Theme are shown in Figure 7 and Table 3. The Fish Condition Indices, ranked by Valley, are shown in Figure 8.

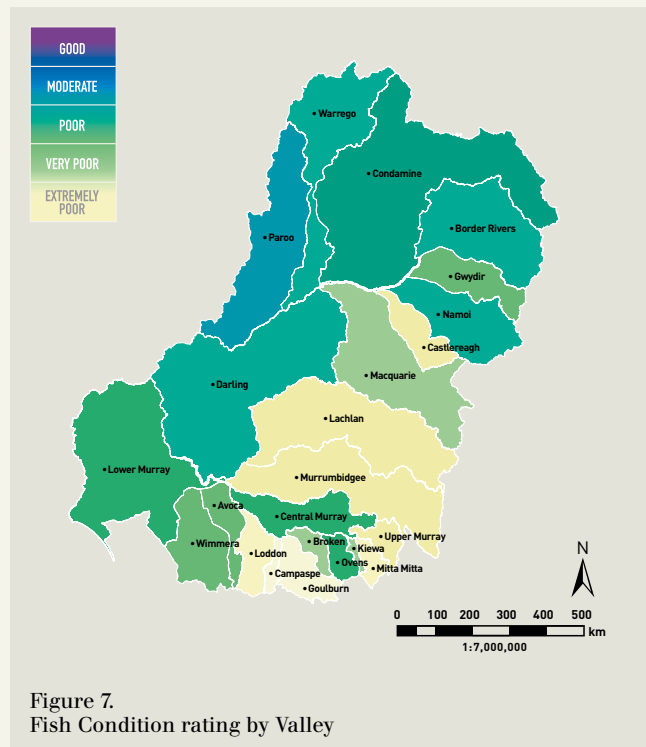
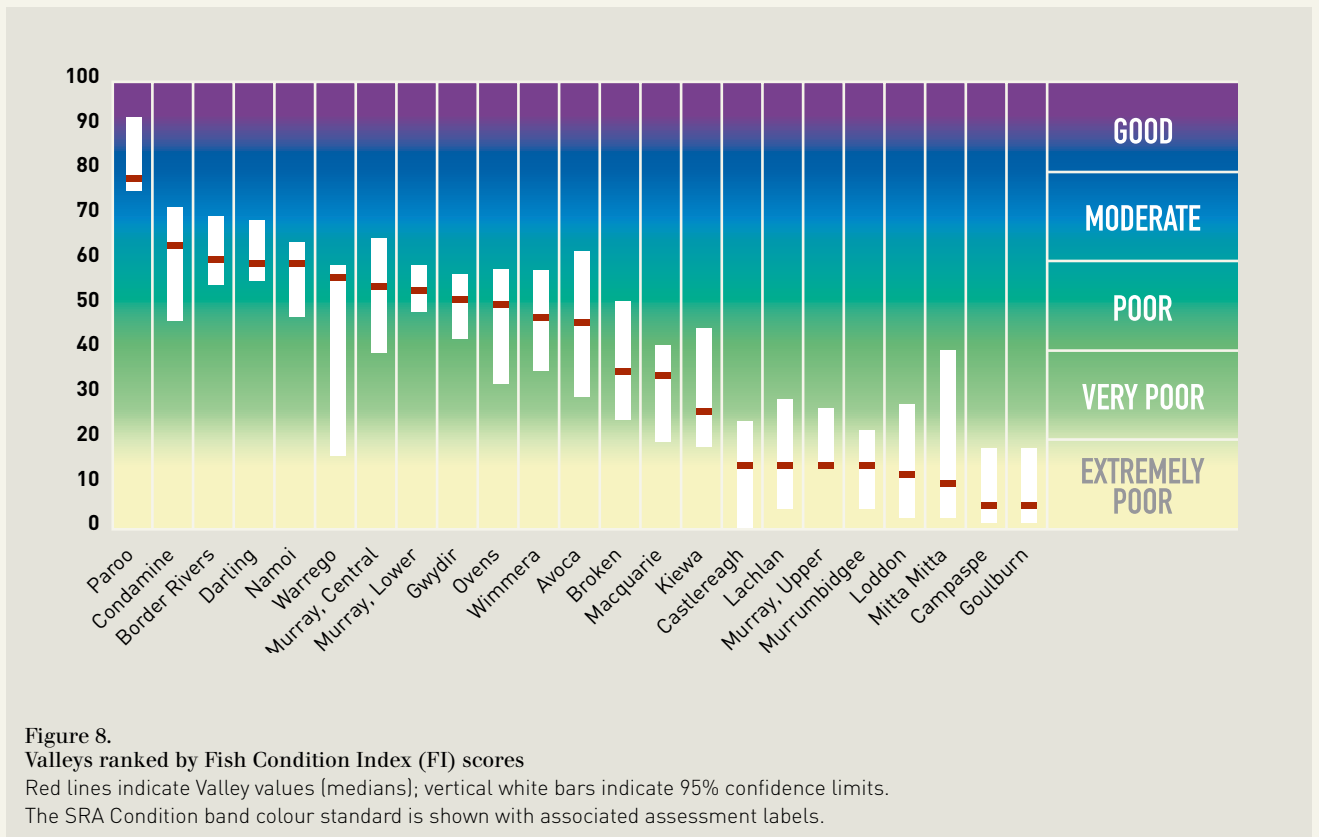


Figure 7. Fish Condition rating by Valley



### Macroinvertebrate Theme

All Valleys (773 sites) were sampled for macroinvertebrates, yielding over 209,100 specimens in 124 families.

Twenty three families were present in all 23 Valleys. Many are typical of edge and slow-flowing river habitats throughout eastern Australia, and are tolerant to pollution and other human disturbance. In contrast, some families were rare, with 14 each found at only one site.

There were distinct differences in the Condition of macroinvertebrate communities between southern and northern Valleys, and between upland and lowland Zones, with changes in representation of families tolerant of slow flow and high temperatures.

Most communities showed lower diversity (fewer families) than expected under Reference Condition, especially those of the Avoca, Castlereagh, Central and Lower Murray, and Wimmera valleys.

Overall, the Avoca and Wimmera communities were in worst (Very Poor) Condition and the Border Rivers, Upper Murray and Paroo communities were in best (Moderate) Condition.

Condition assessments for the Macroinvertebrate Theme are shown in Figure 9 and Table 3. Macroinvertebrate Condition Indices, ranked by Valley, are shown in Figure 10.

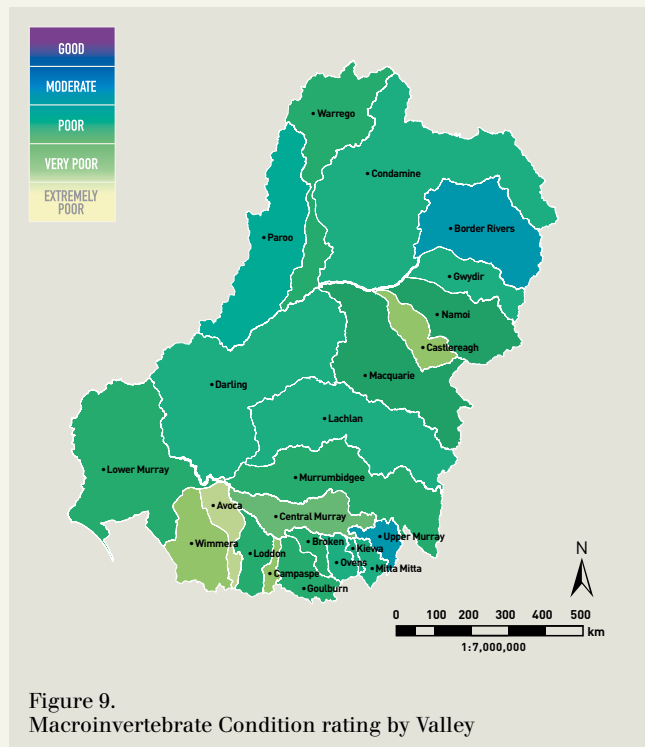
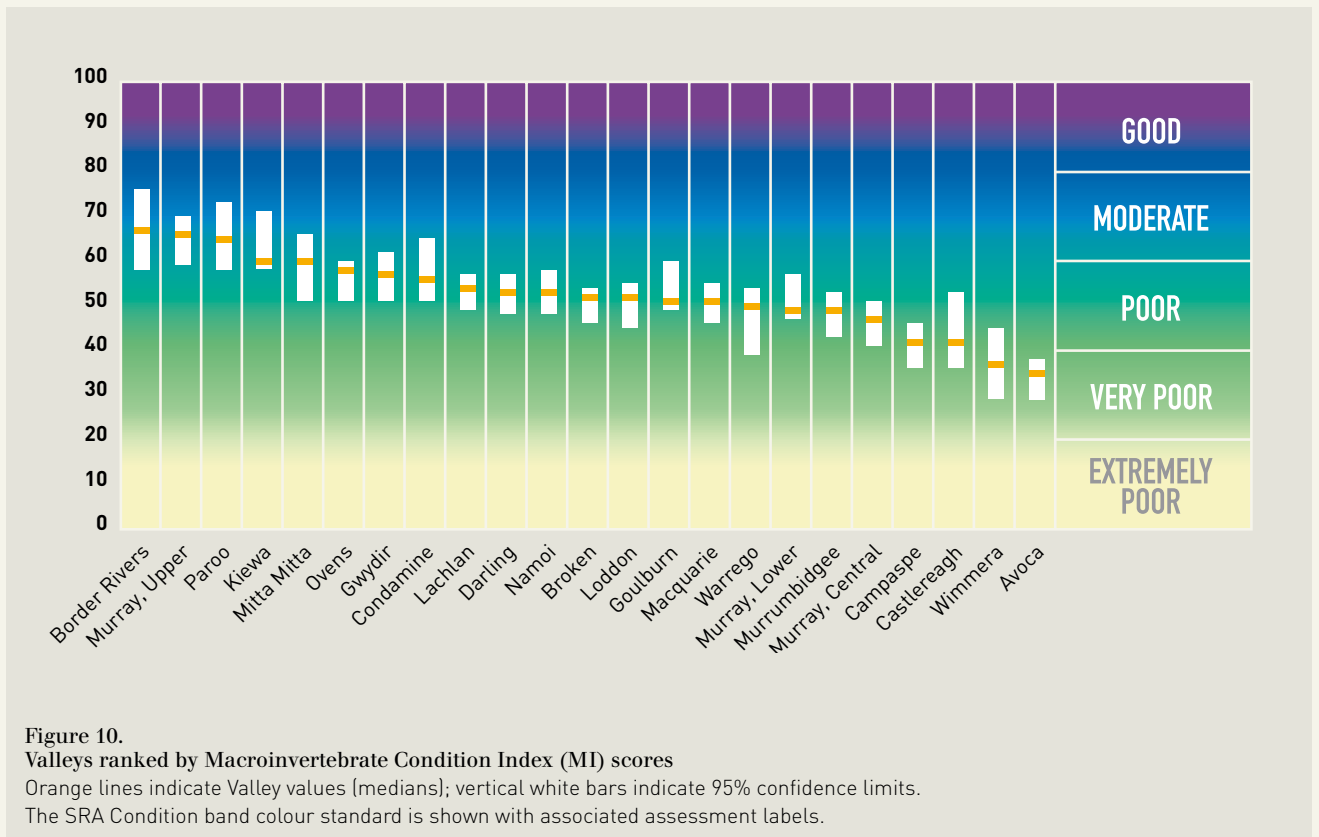


Figure 9. Macroinvertebrate Condition rating by Valley



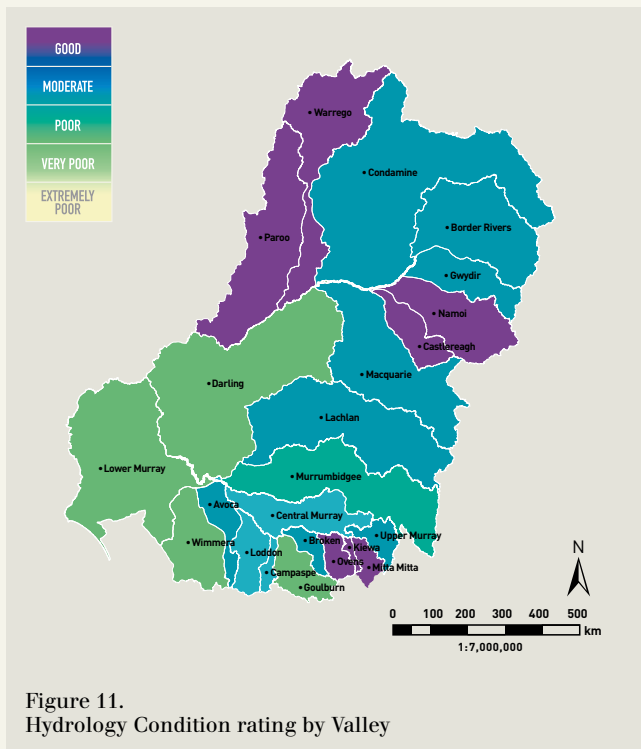


Figure 11. Hydrology Condition rating by Valley

### Hydrology Theme

The Hydrology Theme assessments encountered several problems, including data limitations, some analysis and reporting inconsistencies within and between States; and incomplete quality assurance procedures. Overall Condition ratings were made based on the data available, though the non-random distribution of sample sites prevented fully quantitative assessments at the Zone- and Valley-scale.

One-third of all Valleys were rated in Good Condition, and another third were in Moderate to Good Condition. Of 469 sites examined, 179 (38%) had a Hydrology Condition Index (HI) of 100, and values for another 128 sites were greater than 79. Thus, about two-thirds of the sites were Near Reference Condition. An additional 107 sites (23%) showed a Moderate Difference from Reference Condition, 40 sites (8.5%) showed a Large Difference, 12 sites (2.6%) showed a Very Large Difference and three sites (0.6%) showed an Extreme Difference.

Many sites were rated in Good Condition. However, most sites that fell short of Reference Condition were in the channels of the Basin’s principal rivers. Most sites rated in Poor Condition were in the Lowland Zones of these major rivers.

Factors that affect Hydrological Condition include regulation (storage and release of water), diversions and transfers of water between Valleys. The five indicators reflect these impacts. At about one-third of sites, High Flow Events showed a spread of Moderate, Large and Very Large Differences from Reference Condition. Metrics of Low- and Zero-Flow Events, Variability, Seasonality and Gross Volume tended to have low values at about a quarter of the sites.

Results for all indicators, except Seasonality, showed Extreme Differences from Reference Condition at a few sites.

It is important to note that the flow models used for Hydrological Condition assessments calculate Reference and Current flows over identical periods, accounting for the effects of prolonged wet and dry periods. Results reflect the effects of water resource development on the flow regime rather than the recent prevailing drought.

Condition assessments for the Hydrology Theme are shown in Table 2 and Figure 11.



**Table 2.**  
**Hydrology Index (HI) values and Condition rating for all Valleys**  
 Minima and maxima of HI values for sites in the data set are shown.

VALLEY	NUMBER OF SITES	CONDITION RATING	SR HYDROLOGY INDEX	
			MINIMUM	MAXIMUM
AVOCA	11	MODERATE TO GOOD	75	100
BORDER RIVERS	34	MODERATE TO GOOD	70	100
BROKEN	18	MODERATE TO GOOD	41	100
CAMPASPE	18	MODERATE	58	100
CASTLEREAGH	3	GOOD	100	100
CONDAMINE	22	MODERATE TO GOOD	44	100
DARLING	8	POOR	47	74
GOULBURN	41	POOR	34	100
GWYDIR	19	MODERATE TO GOOD	37	99
KIEWA	14	GOOD	90	100
LACHLAN	21	MODERATE TO GOOD	66	100
LODDON	30	MODERATE	34	100
MACQUARIE	41	MODERATE TO GOOD	55	100
MITTA MITTA	18	GOOD	78	100
MURRAY, LOWER	13	POOR	16	61
MURRAY, CENTRAL	32	MODERATE	36	100
MURRAY, UPPER	12	MODERATE TO GOOD	47	100
MURRUMBIDGEE	26	POOR TO MODERATE	36	100
NAMOI	22	GOOD	59	100
OVENS	23	GOOD	81	100
PAROO	4	GOOD	100	100
WARREGO	5	GOOD	93	100
WIMMERA	34	POOR	13	100

## 7. Key findings and recommendations

### Ecosystem health

- Only the Paroo Valley was found to be in Good Ecosystem Health. The Border Rivers and Condamine Valleys were in Moderate Health. Seven other Valleys were in Poor Health and 13 in Very Poor Health. No Valley was rated in Extremely Poor Health.
- Of 62 Zones in 23 Valleys, two were in Good Health, eleven were in Moderate Health and 46 were in either Poor Health (19 Zones) or Very Poor Health (27 Zones). Three Zones, the Slopes and Upland Zones of the Campaspe Valley and the Slopes Zone of the Castlereagh were rated in Extremely Poor Health.
- Valleys in the northern Basin were generally in better health than those in the south. Two of nine northern Valleys were in Very Poor Health, compared to nine of 14 southern Valleys. The three Valleys rated in Moderate or Good Health were in the northern Basin.
- When all Valleys were ranked by Ecosystem Health rating, the Lower Murray and Darling valleys were toward the middle. This indicates that impacts are not simply cumulative from headwaters to the mouth of the Murray.
- Many Upland and Montane zones were rated Poor or Very Poor, and these can contribute significantly to their overall Valley scores. These low ratings were often related to the dominance of alien fish in upper catchments.
- Extreme drought in some Valleys before and during sampling will have affected the sampled communities but it is too soon to judge the magnitude of the effect.

### Fish

- Twenty-eight of the 38 fish species found were native, contributing 57% of fish numbers but only 32% of the biomass; the 10 alien species formed 43% of abundance and weighed 68% of biomass.
- Three alien species: Common carp, Gambusia and Goldfish were present in all rivers. Redfin perch and trout species were also widespread across the Basin.
- Common carp were overwhelmingly dominant, being 58% of the total fish biomass.
- Numbers and biomass of alien and native fish varied widely among Valleys; alien fish rivalled or out-numbered native fish in nine of the 23 Valleys.

### Macroinvertebrates

- Most Valleys show reduced macroinvertebrate diversity relative to Reference Condition. This was especially striking for the Avoca, Lower Murray and Warrego Valleys.

### Hydrology

- One-third of sites (162 of 468) fell short of hydrology Reference Condition—these were mostly in the main channels of the Basin's principal rivers.
- Sites in the Lowland Zones of the major rivers formed a high proportion of those in Poor Condition for hydrology.
- No hydrology indicators showed frequent extreme shortfalls from Reference Condition.
- About two-thirds of sites were Near Reference Condition for all hydrology indicators.
- The hydrological assessments account for the effects of climatic conditions, including wet and dry periods. Assessment results therefore reflect long-term water resource development impacts on the flow regime rather than the recent prevailing drought. Thus, even for sites rated as Near Reference Condition for hydrology, the ecosystem may still have been under stress from drought.
- Further improvement is needed in the hydrological assessment to account for the effects of changes in groundwater and vegetation, and of farm dams, and to fully standardise the basis for modelling and analyses across the Basin.

### Recommendations

- ISRAG recommends that the SRA be expanded to include floodplain and terminal wetland systems, including those declared as Wetlands of International Importance under the Ramsar Convention and The Living Murray Icon Sites. These include the Lower Lakes and Coorong and major floodplain and terminal wetland-lake systems of the northern and southern Basin.
- ISRAG urges the establishment of quantitative management goals for river health, at Valley and smaller scales, across the Murray-Darling Basin. The SRA could play a valuable role in monitoring progress against them.

**Table 3.**  
Summary of Ecosystem Health and Condition assessments for each Valley in the Murray–Darling Basin

VALLEY	ECOSYSTEM HEALTH	FISH	MACROINVERTEBRATES	HYDROLOGY
PAROO	Good	Moderate	Moderate	Good
BORDER RIVERS	Moderate	Moderate	Moderate	Moderate to Good
CONDAMINE	Moderate	Moderate	Poor	Moderate to Good
NAMOI	Poor	Poor	Poor	Good
OVENS	Poor	Poor	Poor	Good
WARREGO	Poor	Poor	Poor	Good
GWYDIR	Poor	Poor	Poor	Moderate to Good
DARLING	Poor	Poor	Poor	Poor
LOWER MURRAY	Poor	Poor	Poor	Poor
CENTRAL MURRAY	Poor	Poor	Poor	Moderate
UPPER MURRAY	Very Poor	Extremely Poor	Moderate	Moderate to Good
WIMMERA	Very Poor	Poor	Very Poor	Poor
AVOCA	Very Poor	Poor	Very Poor	Moderate to Good
BROKEN	Very Poor	Very Poor	Poor	Moderate to Good
MACQUARIE	Very Poor	Very Poor	Poor	Moderate to Good
CAMPASPE	Very Poor	Extremely Poor	Poor	Moderate
CASTLEREAGH	Very Poor	Extremely Poor	Poor	Good
KIEWA	Very Poor	Very Poor	Poor	Good
LACHLAN	Very Poor	Extremely Poor	Poor	Moderate to Good
LODDON	Very Poor	Extremely Poor	Poor	Moderate
MITTA MITTA	Very Poor	Extremely Poor	Poor	Good
MURRUMBIDGEE	Very Poor	Extremely Poor	Poor	Poor to Moderate
GOULBURN	Very Poor	Extremely Poor	Poor	Poor

