Sustainable Rivers Audit 2

The ecological health of rivers in the Murray–Darling Basin at the end of the Millennium Drought (2008–2010)

Summary

The second **Sustainable Rivers Audit** (SRA) is the most comprehensive assessment of river health undertaken for the Murray–Darling Basin. This MDBA summary is based on the report prepared by ISRAG, an independent panel of ecology experts. This report is a significant advance on the first report by including additional assessment themes of physical form and vegetation, refinement of components within themes, and improved data sources and analyses.

Australian Government

MURRAY–DARLING
BASIN AUTHORITY

www.mdba.gov.au

Acknowledgement of the Traditional Owners of the Murray–Darling Basin

The Murray–Darling Basin Authority acknowledges and pays its respect to the Traditional Owners and their Nations of the Murray–Darling Basin. The contributions of earlier generations, including the Elders, who have fought for their rights in natural resource management are also valued and respected.

The Authority recognises and acknowledges that the Traditional Owners and their Nations in the Murray–Darling Basin have a deep cultural, social, environmental, spiritual and economic connection to their lands and waters. The Authority understands the need for recognition of Traditional Owner knowledge and cultural values in natural resource management associated with the Basin. Further research is required to assist in understanding and providing for cultural flows. The Authority supports the belief of the Northern Murray–Darling Basin Aboriginal Nations and the Murray Lower Darling Rivers Indigenous Nations that cultural flows will provide beneficial outcomes for Traditional Owners.

The approach of Traditional Owners to caring for the natural landscape, including water, can be expressed in the words of Ngarrindjeri elder Tom Trevorrow: 'our traditional management plan was don't be greedy, don't take any more than you need and respect everything around you. That's the management plan—it's such a simple management plan, but so hard for people to carry out.[1]

This traditional philosophy is widely held by Traditional Owners and respected and supported by the Murray–Darling Basin Authority.

1. Tom Trevorrow (2010) Murrundi Ruwe Pangari Ringbalin 'River Country Spirit Ceremony: Aboriginal Perspectives on River Country'.

Australian Government

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ABOUT THIS REPORT

The Sustainable Rivers Audit (SRA) is an initiative of Basin governments, coordinated on their behalf by the Murray–Darling Basin Authority. 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 *Sustainable Rivers Audit 2: The ecological health of rivers in the Murray–Darling Basin at the end of the Millennium Drought (2008–2010) (Volume 1, technical report; and Volumes 2 and 3, valleys)* submitted to the Murray–Darling Basin Ministerial Council in 2012.

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. Each of the valleys was sampled once for Vegetation and Physical Form, twice for Fish, three times for Macroinvertebrates and four times for Hydrology.

The report cards include icons, indicators and indices for five themes—Fish, Macroinvertebrates, Vegetation, Physical Form and Hydrology—representing 'windows' on the ecosystem. A more detailed explanation of the various indicators and indices can be found on pages 10–21.

The results presented in this report should be interpreted in the context of the SRA sampling regime and the prevailing climate conditions, which included severe drought until late in 2010.

The full SRA report 2 is available through the Murray–Darling Basin Authority's website: www.mdba.gov.au.

FOREWORD

It is with pleasure that I present, on behalf of the Basin governments, the second Basin-wide assessment of river health in the Murray–Darling Basin.

Under the Sustainable Rivers Audit, the six Basin jurisdictions—Queensland, New South Wales, Victoria, South Australia, Australian Capital Territory and the Australian Government—and an independent group of river ecologists (the Independent Sustainable Rivers Audit Group) have collaborated to answer the question, 'What is the condition of our Basin's rivers?'

This report summarises the Independent Audit group's findings on river health over the period 2008 to 2010, the last years of the Millennium Drought. This was the most severe drought experienced in Australia since the start of the 20th century, and it is perhaps no surprise that the Independent Audit group found river health to be poor overall—with six of the Basin's 23 valleys in 'Very Poor health' and 15 valleys in 'Poor health'. This report shows an overall picture of degraded ecosystems with little resilience, a consequence of the cumulative impacts of over a century of intensive land and water development. The findings support the decision of all Basin jurisdictions to commit to the 2008 Intergovernmental Agreement on Murray–Darling Basin Reform and ongoing initiatives to manage the Basin sustainably.

The Sustainable Rivers Audit created the opportunity for the Authority and its partners to make major advances in environmental monitoring methodology and analysis. The consistent, robust methodologies and sampling design behind this report mean that its findings can be used as a benchmark of the rivers' condition for many years to come.

As this report is going to press, sampling programs are underway to monitor river health during the years of high rainfall following the Millennium Drought. This will complete a cycle of basin-wide assessment and will provide baseline information on river conditions during the recent wet phase.

As the Basin Plan is implemented, it will be critical to measure progress in rebuilding environmental resilience and achieving the Basin Plan's primary goal: a healthy working river system. The lessons learned from the Sustainable Rivers Audit will make a significant contribution to the design of any future monitoring programs.

I commend this report to all who have an interest in the ecological health of the rivers in the Murray–Darling Basin.

Dr Rhondda Dickson

Chief Executive
Murray–Darling Basin Authority

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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 River Murray. Considerable volumes of water are lost as the rivers flow from their upper tributaries to the sea. Total run-off averages around 32,553 GL/year, but only about 5,100 GL/year reaches the sea—a very low annual discharge by world standards.

Over the decade up to late 2010, the discharge had fallen even lower as a result of a sustained drought, and the Murray mouth was kept open by constant dredging. Since then, the Basin has seen heavy rain and flooding. Although erratic droughts and floods are part of the character of rivers in the Basin, this report is based upon data from 2008 to 2010—reflecting the end phase of the recent drought—which placed agricultural systems, rural communities and the natural river environment under severe stress. Annual rainfall deficits for the Basin during the Audit period (2006–09) are shown in Figure 2.

The main rivers in the Basin are the Darling (2,740 km) and the Murray (2,530 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 2, 23 major valleys in the Basin, designated by the Australian Water Resources Council, are the basis for reporting. These are shown in Figure 3.

Land use

- ■ Conservation and natural environments
- ■ Intensive uses
- ■ Production from dryland agriculture and plantations
- ■ Production from irrigated agriculture and plantations
- ■ Production from relatively natural environments
- ■ Water
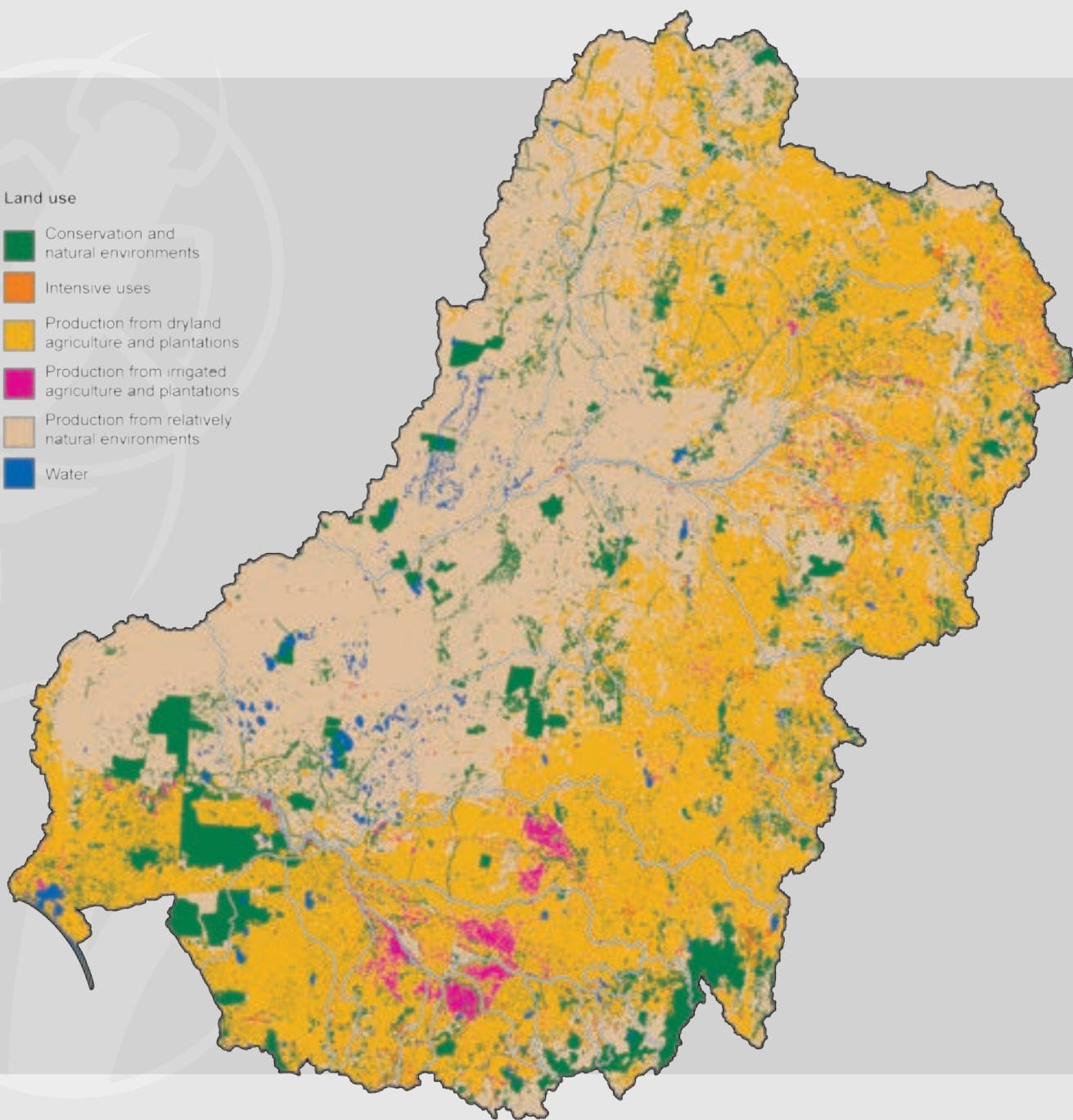
Figure 1: Pattern of land use across the Murray–Darling Basin in 2004
(Source: Bureau of Rural Sciences).

2006 Annual Rainfall Anomaly

2007 Annual Rainfall Anomaly

2008 Annual Rainfall Anomaly

2009 Annual Rainfall Anomaly

rainfall anomaly

< -500	0 - 50
-500 - -400	50 - 100
-400 - -300	100 - 200
-300 - -200	200 - 300
-200 - -100	300 - 400
-100 - -50	400 - 500
-50 - 0	>500

N

0 100 200 300 400 500
km

Data source: Bureau of Meteorology
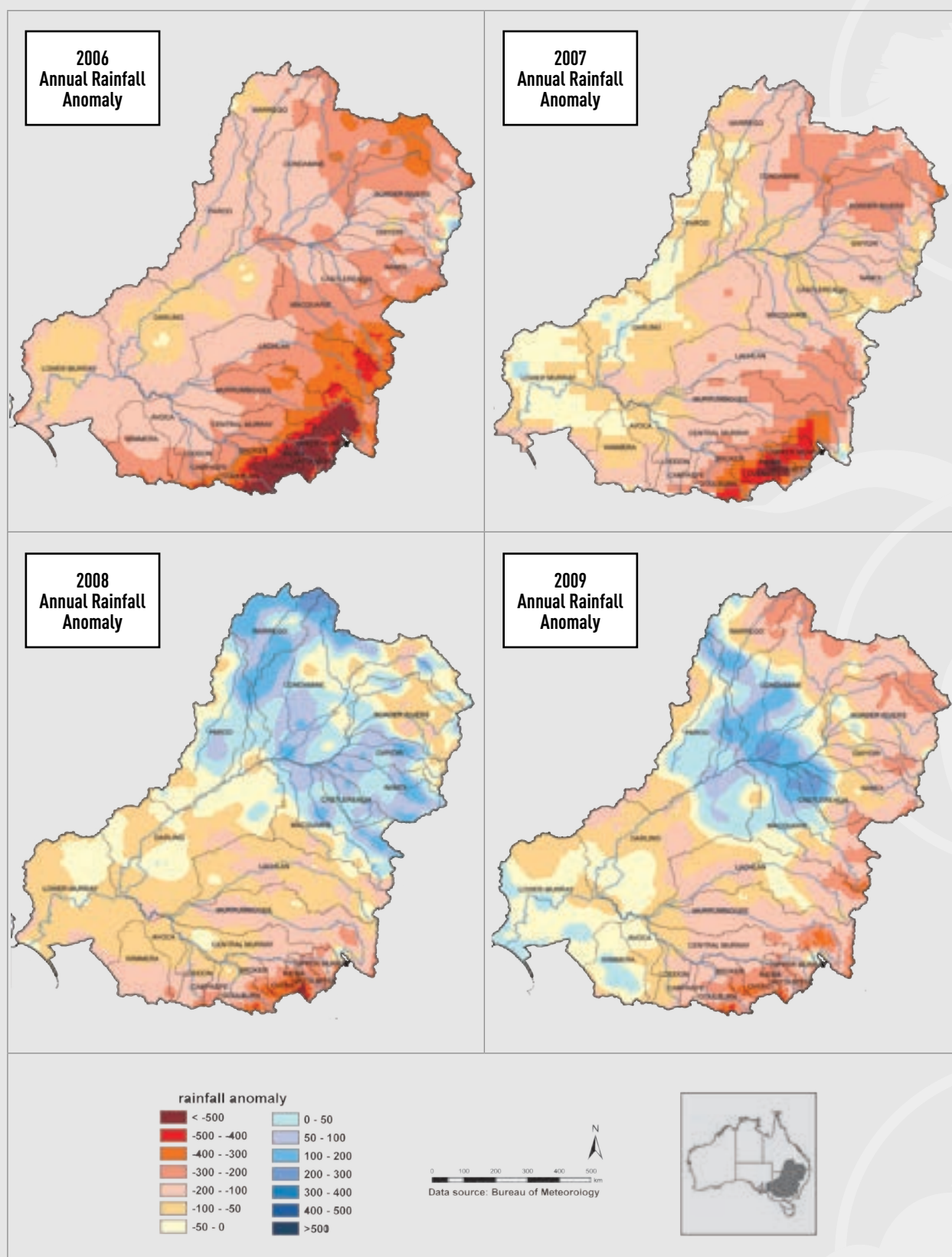
Figure 2: Annual rainfall deficits from long-term average, during the Audit period (2006–2009)

(Source: Bureau of Meteorology).

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 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 2*, the second in a series of three-yearly reports, the SRA has utilised five themes: Fish, Macroinvertebrates, Vegetation, Physical Form and Hydrology. SRA reporting can now 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 1–6 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 Basin governments coordinated on their behalf by the Murray–Darling Basin Authority (MDBA). 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 Joint Venture Committee* (SRAJVC), and employs staff to conduct field sampling and data collection. The SRAJVC provides technical advice to program management and oversees field and laboratory work. There are also specialist *Technical Advisory Groups*, responsible for refinement and implementation of the themes. The MDBA 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 About SRA report 2

This report (titled *Sustainable Rivers Audit 2: The ecological health of rivers in the Murray–Darling Basin at the end of the Millennium Drought (2008–2010) (Summary)*) presents a summary of the results from the second three years of monitoring under the Sustainable Rivers Audit, which are contained in the full *SRA report 2 (three volumes).* The full report can be accessed through the Murray–Darling Basin Authority website (www.mdba.gov.au).

SRA ASSESSMENT REPORT

Stakeholders
(community, government agencies, academia, commercial interests)

Murray–Darling Basin Ministerial Council

Murray–Darling Basin Authority

Natural Resources Management Committee

Independent Sustainable Rivers Audit Group

Sustainable Rivers Audit (SRA) program

SRA MANAGEMENT

SRA Team (Murray–Darling Basin Authority office)

SRA Joint Venture Committee

Implementation partner government agencies

SRA DATA USERS

Murray–Darling Basin Authority internal user groups
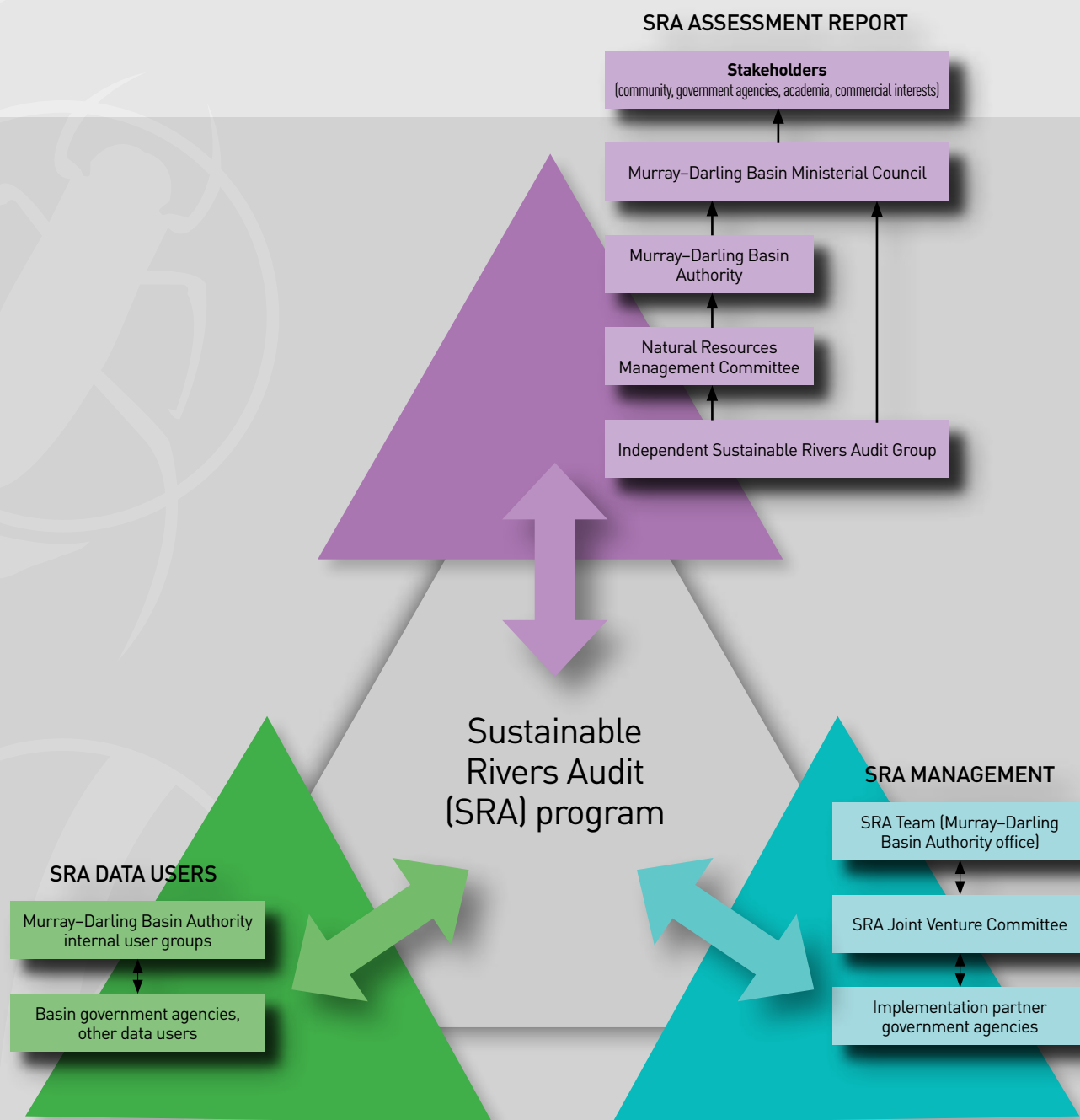
Basin government agencies, other data users

Figure 4: SRA partners and interrelationships

4. EXPERT RULES METHODS

Indicators and indices are calculated from metrics by *integration* (see Box 2) using a computational process called *expert systems*. This integration approach allows the inclusion of ecological insights, rather than relying only on simple mathematical operators such as weighted averaging.

Input values (e.g. metrics) are weighted and combined by ISRAG into rule sets (high or low score combinations relative to reference condition). These rule sets are based on ecological insight, and define the score values of the integrated outputs (e.g. indicators) in a way that cannot be achieved by simple mathematical methods. The combinations are arranged in *expert system definition tables* and are then used to mathematically define a decision calculation surface.

A simplified example of an expert system definition table looks like this:

Table 1: Example expert system definition table

FLOW SEASONAL PERIOD METRIC	FLOW SEASONAL AMPLITUDE METRIC	FLOW SEASONALITY INDICATOR
GOOD	GOOD	100
GOOD	EXT'LY POOR	50
EXT'LY POOR	GOOD	20
GOOD	EXT'LY POOR	20
EXT'LY POOR	EXT'LY POOR	10
EXT'LY POOR	EXT'LY POOR	0

The decision calculation surface for the example definition table looks like Figure 5. Note that the 'pinpoints' defined by the definition table are circled in red: they shape the calculation surface so that for any given combination of the two metrics, and indicator output can be defined.

Expert systems are tolerant of uncertainty in input and output values, a useful feature because the relationship between observed inputs and outputs is not always known with high accuracy.

The expert systems were used to integrate information at three levels:

1. *Indicator expert systems* determine the values of indicators (or sub-indicators) from metrics, within each of the themes.

2. *Index expert systems* determine the values of a theme's condition index from indicators, within each of the themes.

3. *Ecological condition expert systems* determine the values of the Ecological Condition Index from values of three theme indices: Fish, Macroinvertebrates and Vegetation. This index forms the primary basis for rating the Ecological Health of a valley or a zone.

This approach requires judgements, based on expert opinion, of the relative contributions of each metric, indicator or index to the integrated result. In particular, assessments of Ecosystem Health require judgements about the conceptual links between themes (see Box 3 'Themes, data, metrics, indicators, indices').

In reporting on Ecosystem Health the emphasis is primarily on the results of an integrated assessment of biological condition. Information on the condition of Hydrology and Physical Form is reported as supporting and contextual information.

Metric, indicator and index values are derived at both zone and valley scale by spatial *aggregation* (see Box 2) of information from smaller spatial scales e.g. sites (fish, macroinvertebrates, physical form), reaches (hydrology) or domains (vegetation). The aggregation uses weighting by stream length to derive a mean zone score.

Detailed information on expert systems is available in SRA report 2 (Chapter on themes and Appendix 1).
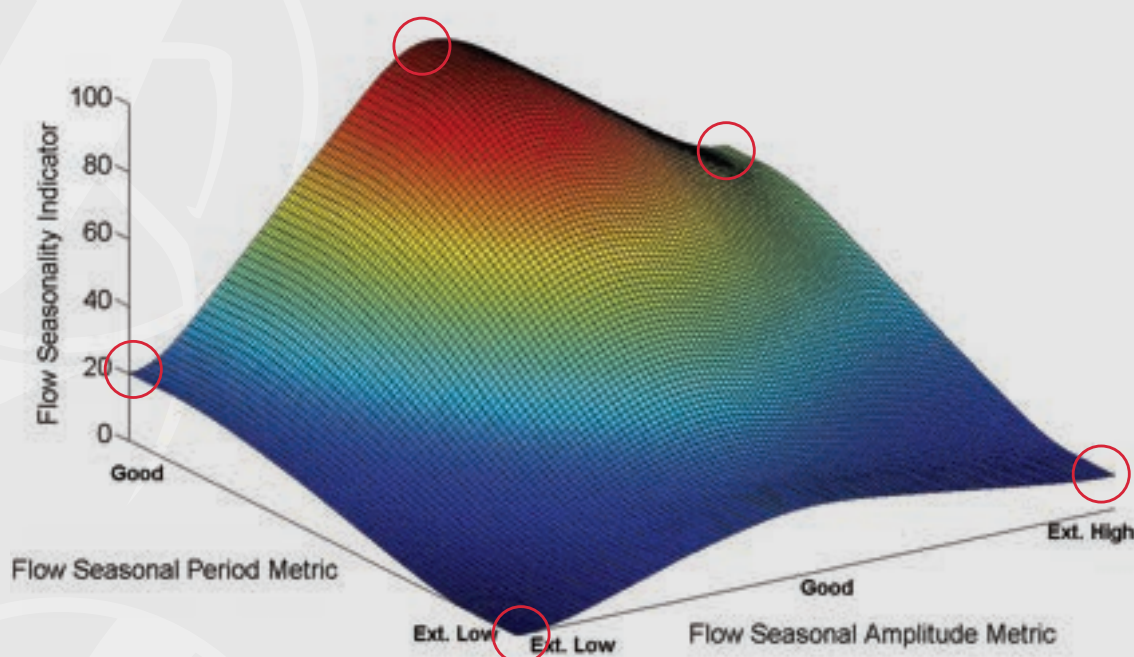
Figure 5: Example Expert Rules decision calculation surface

BOX 2 Aggregation and integration

Aggregation is here defined as the process of combining data from two or more spatial locations. Thus, data collected from sites can be combined to provide information at zone level, which can be combined to give information at valley level. This is done by calculating the mean of all site scores, and providing confidence intervals or minimum/maximum values.

Integration is defined as the process of combining two or more metrics into an indicator, or two or more indicators into a theme index. It summarises more detailed information into a score at a higher level.

Integration occurs within themes to provide the theme Index. The Fish, Macroinvertebrate and Vegetation themes are integrated to provide an Ecosystem Health rating for a valley or zone (Lowland, Slopes, Upland or Montane areas; or geomorphically defined zones for the Central and Lower Murray and the Darling valleys).

BOX 3 Themes, 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 Ecosystem Health *rating* places a valley or zone into one of five bands: Good (scores 80–100), Moderate (scores 60–79), Poor (scores 40–59), Very Poor (scores 20–39) and Extremely Poor (scores 0–19). This is done by integrating theme indices for Fish, Macroinvertebrates and Vegetation into an Ecological Condition score using an expert system.
- A *theme* represents an ecological window on ecosystem health or some of its drivers. Each theme consists of a *theme index*, which is the integrated product of indicators and metrics.
- An *index* of condition is an integrated condition score, delivered by integrating two or more indicators, using *expert rules*, and aggregated for reporting at valley and zone scales.

- *Metrics* represent the difference between an observation and its estimated value under reference condition, typically as a ratio. They are calculated from primary and/or derived data from both observed (current) and 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).

INTEGRATION OF INFORMATION ⟩⟩

**Overall
Health Index
Theme indices**
Ministerial Council
MDBA
Community

Indicators, metrics
Managers

Primary data
Scientists
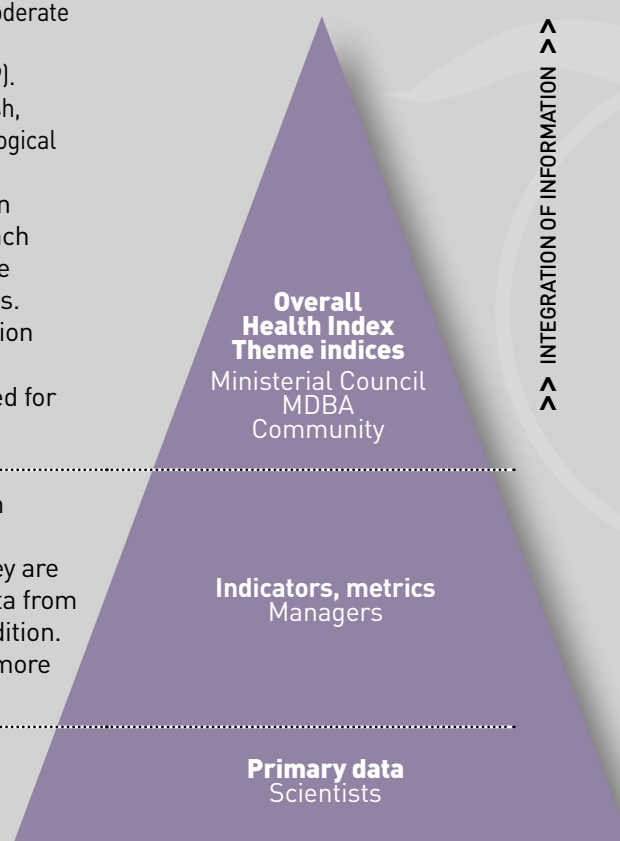
LEVEL OF DETAIL
Stages in integrating information in the SRA—from primary data to health assessments— and the main audiences

5. THEMES FOR MONITORING RIVER HEALTH

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

For example, information might be gathered about algae, fish, invertebrates and water plants; about floodplain vegetation, amphibians, birds, mammals, reptiles and microbial communities (see Figure 6). Ecological processes could be monitored, including carbon and nutrient cycling, primary production and recruitment. The physical landscape could also be monitored for signs of change.

All of these are 'windows' on river 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 the set of chosen themes should represent a range of ecosystem components.

Active themes

Five themes—Fish, Macroinvertebrates, Vegetation, Physical Form and Hydrology— are active in this second 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.

> ## BOX 4 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.
>
> For all metrics a score of 1 indicates no change from or equivalence to reference condition values, while a score of 0 indicates extreme change or total loss (see Box 3 for more information).
>
> For metrics with an unbounded upper limit, such as Number of Patches or Vegetation Height, a score greater than 1 also indicates change from reference condition, usually an increase. This occurs in the Vegetation, Physical Form and Hydrology themes. For these cases, a more complex set of expert rules is required.

This second Audit covers both river channels and floodplains, where applicable. The new *Physical Form* theme assesses geomorphic condition at the scale of the drainage network and of individual river reaches, and the *Vegetation* theme assesses channel and floodplain vegetation at catchment and reach scales.

The addition of these two new themes means this Audit presents an integrated biophysical assessment of river health in channel–floodplain systems throughout the Basin.

RIVER CHANNEL

FLOODPLAIN

Clarity Turbidity

Nutrient status
TN, FRP, TN, NOx, NH4

Benthic algae MPB
Benthic R, GPP

Phytoplankton
& microbes
Water Column R, GPP

Macrophytes

Zooplankton

Temperature

Dissolved
organic matter

Particulate
organic matter

Large woody
debris

Seed bank

Litter

Invertebrates,
terrestrial
and aquatic

Microbes

Birds and bats

Frogs

Reptiles

Mammals

MACRO-INVERTEBRATES

Littoral/Riffle

FISH

Recruitment

**Native and
exotic fish**

VEGETATION

Large trees

Understorey

Ground cover

PHYSICAL FORM

Channel–floodplain types:
Diversity; location; extent; dynamics

Floodplain condition:
Sedimentation; form

Channel condition:
bed & bank dynamics; channel form

HYDROLOGY

In-channel flows:
Volumes; Seasonality; Variability;
High, Low and Zero Flows

Floodplain watering:
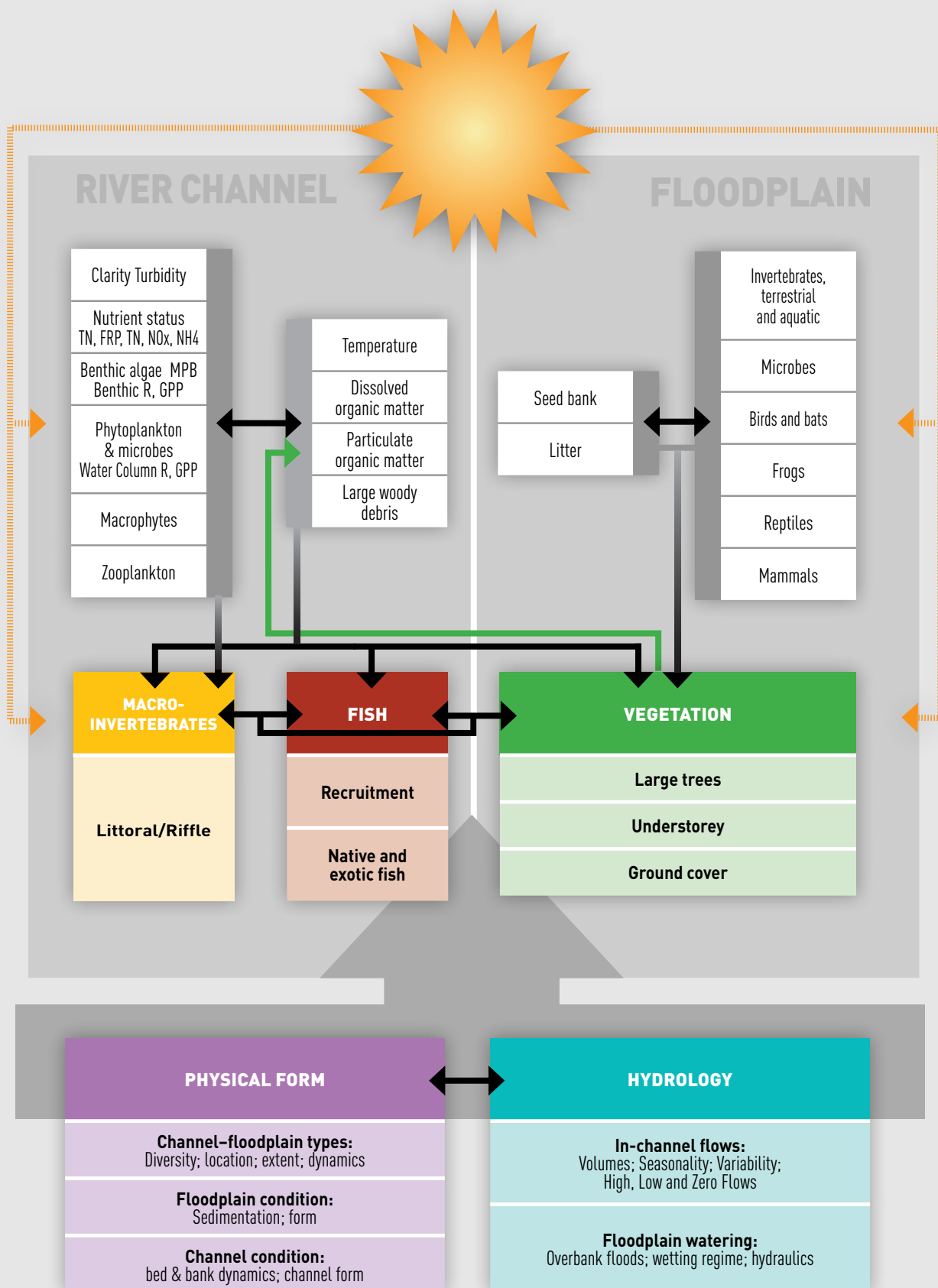Overbank floods; wetting regime; hydraulics

Figure 6: **River Ecosystem Function Model showing components and processes in a
channel–floodplain ecosystem.**

(Components addressed at least in part by the SRA themes are overlaid as 'windows' [titled and in grey] on the ecosystem.
Interactions between components are shown as arrows).

Ecosystem Health

The condition of each ecosystem component (theme) is assessed by integrating all indicators for that theme to a condition index and rating. In all themes, the condition indices vary from 0 to 100, where 100 is reference (or 'Good') condition, and 0 is Extremely Poor.

For each of the five themes, a condition index was calculated for each valley and zone, reported as both the index value (0–100) and as a rating (Extremely Poor – Good).

The Ecosystem Health rating for each zone and valley is derived by integrating the condition index scores and ratings for the three biological themes (Fish, Macroinvertebrates and Vegetation) using expert rules. The condition indices for Physical Form and Hydrology are reported alongside the Ecosystem Health rating, to provide further information on some of the drivers of river health.

The process of assessment leads to five rating categories (Bands) that express the condition of ecosystem components (themes) in terms of differences from reference condition. Ecosystem Health is also reported as falling within one of these bands, from *Good* through *Moderate*, *Poor, Very Poor* to *Extremely Poor*.

| GOOD |
| MODERATE |
| POOR |
| VERY POOR |
| EXTREMELY POOR |
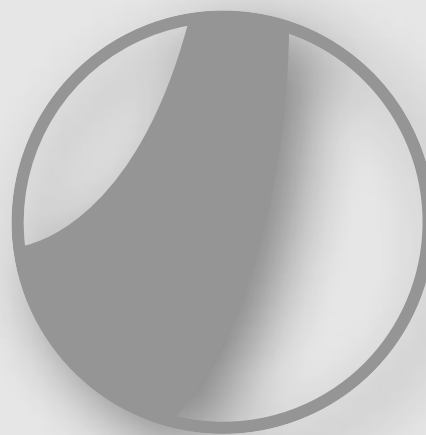
BOX 5 What is 'Ecosystem Health?'

In the SRA, *ecosystem health* is indicated primarily by the condition of key biological components and processes. Thus in this report, Vegetation, Fish and Macroinvertebrate condition are used as component indicators of Ecosystem Health, which already reflect the effects of human impacts, including changes in the hydrological regime, physical form and processes.
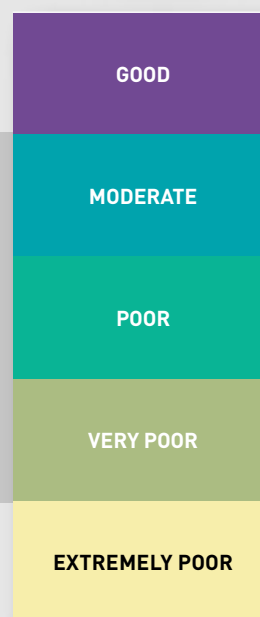
Fish

The Fish theme reports on changes in key characteristics of fish communities in river channels across the Murray–Darling Basin. More than 60 fish species are known from the Basin, including a complex of species (*Hypseleotris* spp.) awaiting formal description. The total also includes 10 species that are alien to Australia, and seven marine or estuarine species that are capable of entering and surviving in fresh water.

SRA methods for using fish as indicators rely on information about the composition of native fish assemblages, the presence of alien species and the level of recruitment.

In each zone, seven fish sampling sites were chosen using a stratified-random procedure, with a minimum of 18 sites per valley. Each was the centre point of a one-kilometre stream reach. This design was adopted following power and benefit–cost analyses of species-accretion data from the SRA Pilot Audit. Fish were sampled by boat-mounted or backpack electrofishing, using standardised effort and methods.

Fish were returned alive to the water after examination, except for voucher specimens needed for laboratory confirmation and alien pest species that, in some jurisdictions, must be humanely destroyed.

reference condition for Fish (SR–FI) estimates community composition, in terms of the species present and their probability of occurrence, 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.

Eight metrics were derived from field data. These were integrated as three indicators that measure community composition, relative dominance of alien species and the level of native fish recruitment, relative to reference condition. These were then merged to provide the *Fish Condition Index* (FI).
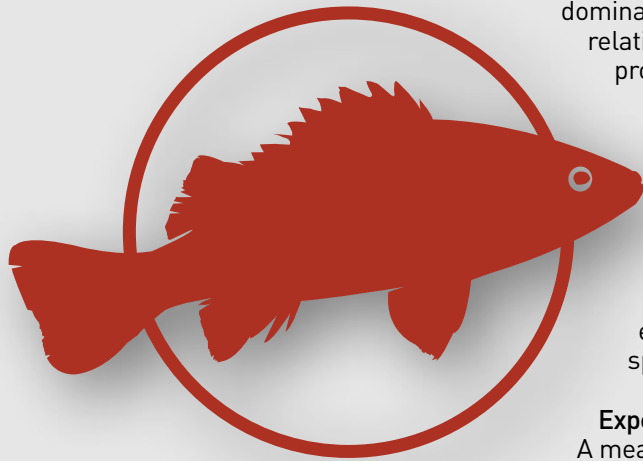
SR–FI—Fish Condition Index

Integrates the three fish indicators using Expert Rules. A high score would mean abundant expected native species recruiting satisfactorily relative to their existing populations and few alien species being present. A very low SR–FI score would indicate loss of expected native species, very low levels of recruitment of the species present and dominance by 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 and low scores indicate that many are missing.

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

Recruitment indicator
Quantifies the degree to which native fish species are maintaining recruitment—the accrual of potentially reproductive individuals to populations. It does this at zone scale, using three variables: proportion of native species with recruits, proportion of sites with recruits present and the proportion of total native abundance represented by recruits. It ranges from 0 (representing the complete absence of recruitment) to 1, (representing the presence of recruitment at reference levels).

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.

Trends
Temporal changes in the SR–FI (measure of fish community condition) comparing 2004–2007 with 2008–2010.

Macroinvertebrates

The Macroinvertebrate theme describes the occurrence of macroinvertebrate families at each site as a measure of community composition. Macroinvertebrates are bottom-dwelling invertebrates visible to the naked eye. They form a major component 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 and freshwater mussels were not included in this Audit but are being considered for future sampling.

Samples were taken at 797 sites, including approximately 35 sites per valley and at least three sites per zone. Sampling was in spring or autumn under base-flow conditions and only in the river channel (including both riffle- and edge-habitats where possible). Floodplain wetlands and some ephemeral pools and streams were not sampled for logistical reasons, although these are significant habitats.

Each valley has been sampled every two years—with each valley and zone sampled three times since 2004. In the second and all subsequent sampling events, approximately one-quarter of sites were 'fixed sites', re-sampled each year if they were available (not dry) and the remaining 'roving sites' randomly re-allocated annually.

reference condition for Macroinvertebrates (SR–MI) is the estimated composition of macroinvertebrate communities that would occur now, at a given site, in the absence of significant human intervention. It is derived using a novel 'Bayesian' modelling technique relating the occurrence of families to environmental and human-disturbance variables.

Assessments were made using one indicator (simOE) based on the composition of communities relative to reference condition. The simOE score (equivalent to the Sorensen [Bray–Curtis] similarity measure) is based on the difference in a site's observed community composition from its 'expected' reference communities. This was used to derive the *Macroinvertebrate Condition Index* (SR–MI).

SR–MI—Macroinvertebrate Condition Index

A low score of this Index indicates the loss of most expected macroinvertebrate families, coupled with reduction and decline in the frequency of occurrence of the remaining taxa.

Additional information reported

Number of families
The numbers of macroinvertebrate families found across all sites in the valley or zone.

Trends
Data from SRA report 1 were re-analysed using new methods developed for SRA report 2 and trends emerging over the three sampling cycles of 2004–2006, 2006–2008 and 2008–2010 are reported.

Vegetation

The Vegetation theme measures the condition of riverine vegetation (connected to, or part of, streams and rivers) in near-riparian and floodplain areas. Both sampled and census data were used for this assessment—these differ in scale, detail and currency. Census data were based on vegetation mapping of Major Vegetation Groups (MVGs) within the Near Riparian and Lowland Floodplain domains. Sampled data derived from aerial surveys using Light Detection and Ranging (LiDAR) at sites randomly located across the SRA stream drainage network within the Near Riparian domain.

At the catchment scale, the notable attributes of riverine vegetation are its extent and continuity, its structural integrity and its heterogeneity. The two indicators that have been developed for the Vegetation theme, **Diversity & Abundance** and **Quality & Integrity**, focus on these attributes. Related characteristics such as the capacity of vegetation to persist in the riverine landscape, and its functional importance for stream health are not addressed in this assessment.

As with other themes, this assessment of condition is referential. Contemporary riverine vegetation is compared with its reference. Reference condition for riverine vegetation is intended to represent its status under 'minimally disturbed' conditions. The method for determining this, and its precise definition, varies across the Basin. As this was the first assessment of riverine vegetation for the Sustainable Rivers Audit, there is no analysis of trend.

This assessment recognises two areas, here called spatial domains: Near Riparian and Lowland Floodplain. Future assessments could expand the number of domains; for example by considering channels, riverbanks and wetlands.

The Near Riparian domain is the area beside or parallel to the channel. The Near Riparian spatial domain is assessed in all valleys and zones. For metrics based on mapping, this domain is the area within 200 m either side of all drainage lines in the SRA stream network. This is the minimum width practicable for detecting MVG boundaries in the vegetation mapping resources available for this assessment.

For variables based on LiDAR data, the Near Riparian domain is that area lying within a LiDAR survey plot, which was centred on the channel, but more than 50 m from the top of the bank. This is to allow for distinctiveness in channel side vegetation that is not recorded in the reference condition or vegetation mapping.

The Lowland Floodplain domain was selected from those areas on the floodplain inundated by major over bank flooding (for example, by a 1:100 Average Recurrence Interval [ARI] flood).

SR–VI—Vegetation Condition Index

Integrates information on vegetation condition by combining the two indicators described below, based on data and metrics from the two spatial domains already described: Near Riparian and Lowland Floodplain. A high score indicates abundant MVGs in reference (natural) condition—with little evidence of clearing or MVG replacement, intact structure and a distribution and patchiness similar to reference condition.

Abundance and Diversity indicator
Addresses the heterogeneity characteristic of riverine vegetation at a landscape scale, by using MVG as a high-level taxonomic unit.

Quality and Integrity indicator
Focuses on changes that alter riverine vegetation characteristics at the landscape scale.

Physical Form

The Physical Form theme measures the condition of river system geomorphology based on channel form and the dynamics of river banks, beds and floodplains. River morphology governs the type, abundance, diversity and availability of physical habitat, and influences the transfer of energy and organisms, within and through the riverine landscape. The physical character of the riverine landscape therefore provides a template upon which ecological structures and functions develop.

This theme provides a comparison of current physical form data with reference condition. Reference values were specifically derived for each physical form variable using both novel and established modelling techniques.

The comparison between current and reference condition is relatively precise in time because the current physical form data were collected over a short time span of several months in 2010.

This theme is new in SRA 2 and, as such, no trends can yet be provided. It is envisaged that this SRA 2 dataset will represent a starting point for reporting on trends.

Three types of data were used for this assessment: data obtained from a single, full wave-form Light Detection and Ranging (LiDAR) survey; data from the Sediment Network Model (SedNet) of the Murray–Darling Basin; and data derived from novel 'Bayesian' models of reference physical variables.

SR–PI—Physical Form Condition Index

Combines the four indicators below. A high score would mean that channel and floodplain form, dimensions and dynamics are essentially intact and comparable to reference conditions.

A very low SR–PI score would indicate extreme changes in channel form, bank dynamics and bed dynamics (reflected in substantial decreases and/or increases in mean channel depths, channel and floodplain sediment loads and depths, variability in channel width and bank angles and in channel wavelength and sinuosity).

Channel Form indicator
Quantifies differences in overall form of the river channel relative to reference condition, based on measures of the mean and variability of channel depth and width, and of the sinuosity of the channel.

Bank Dynamics indicator
Quantifies changes in the variability of riverbanks relative to reference condition, based on longitudinal bank variability and mean bank complexity.

Bed Dynamics indicator
Quantifies changes in the riverbed sediment regime relative to reference condition, based on the modelled sediment load entering a reach and accumulated sediment depth in the channel.

Floodplain indicator
Quantifies changes in sediment deposition depth on the floodplain relative to reference condition.

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, 'drives' the form of the riverine environment and sustains aquatic and terrestrial organisms in both channel and floodplain environments. The pattern of flow (the hydrological regime) is sensitive to short- and long-term human interventions.

For *SRA report 2*, hydrological assessment has been broadened to cover most of the river network, not just individual locations within the regulated components, as in SRA report 1. Reach-based data has been aggregated, with some limitations, to quantitatively assess the hydrological condition of the network at zone and valley scale. Flow regime alteration was assessed throughout the major rivers in the Basin and scores developed for mainstem rivers (defined as rivers explicitly represented in the water resource models used for development of the Basin Plan). The effect of farm dams and tree cover change on the flow regime was also assessed for all smaller headwater streams (defined as those with an upper catchment area threshold of 100 km^2).

Hydrological condition was assessed using Murray–Darling Basin Plan model run #580 (for the Current Scenario) and Basin Plan model run #566 (Reference Scenario). *Reference condition for Hydrology* (SR–HI) was estimated using models that simulate conditions with no direct human influence within the Basin (storages, diversions and inter-valley transfers set to zero).

Four data sources have been used in this Hydrology theme assessment: water resource modelling; farm dam modelling; 'forest' (woody plant) cover modelling; and streamflow gauge records (for trend analysis).

The SRA uses Flow Stressed Ranking (FSR) hydrology metrics, with some additions and modifications. This characterises the degree of hydrologic 'regime change' relative to 'unimpacted' reference flow conditions.

Current and reference condition data records for Hydrology account for both wet and dry periods. The condition assessments therefore reflect the overall effects of water resource development on the entire flow regime rather than just the recent prevailing drought, whose effects are separately evaluated by the Trend assessment.

SR–HI—Hydrology Condition Index

This index integrates two sub-indices (In-Channel Flow Regime and Over Bank Flow Regime), which are derived by combining the four indicators below. A high score would mean that the in-channel flow and floodplain flooding regimes are essentially intact and comparable to reference conditions under the existing climatic conditions. A very low SR–HI score would indicate extreme changes in flow volumes, seasonality, variability, timing and occurrence of key high- and low-flow events, coupled with extreme changes in patterns of floodplain watering and channel-floodplain connections.
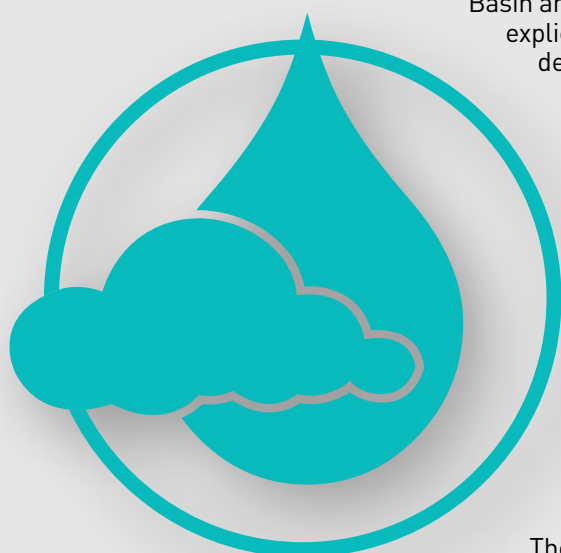
In-Channel Flow Regime A (Volume and Flow Events)
Derived by integrating the following six metrics: Mean Annual Flow; High Flow; High Flow Spells; Low Flow; Low Flow Spells and Zero Flow Proportion.

In-Channel Flow Regime B (Seasonality and Variability)
Derived by integrating the following three metrics: Flow Seasonal Amplitude; Flow Seasonal Period and Flow Variation.

Over Bank Floods, Low
Derived by integrating the Over Bank Flow Duration (for events of ARI of 1 year) and Over bank Flow Spells (ARI 1 yr) metrics.

Over Bank Floods, High
Derived by integrating the Over Bank Flow Duration (ARI 8 yr) and Over Bank Flow Spells (ARI 8 yr) metrics

Additional information reported

Mean monthly flows
Current and reference condition mean monthly flows (GL) are presented for a sample of sites in each valley.

Trends
This second SRA report also reports on fluctuations in the Hydrology Index and indicators over the past twelve years (1998 to 2009)—describing temporal patterns or trends.

Trends in hydrology metrics were evaluated at 45 streamflow gauging stations, all located on mainstem rivers of the Basin. These sites were unevenly distributed across the SRA valleys with some valleys having no sites—sites were selected for their ability to contribute reference flow series (derived from water resource models), reliable streamflow records and to be representative of good coverage across the SRA valleys.

6. OVERALL ASSESSMENTS
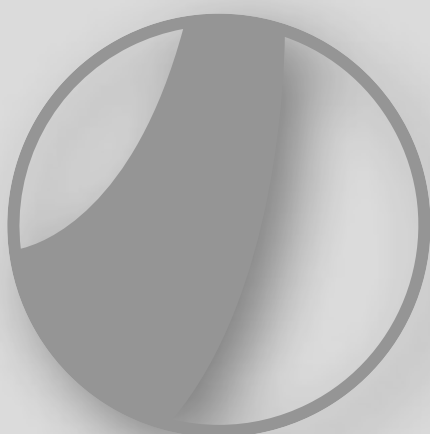
Ecosystem Health

Only the Paroo valley was found to be in Good Ecosystem Health and only the Warrego was rated in Moderate health. Most valleys were rated in Poor (15 valleys) or Very Poor health (6 valleys). None was rated in Extremely Poor health.

Of the Basin's 68 zones, only one zone was rated in Good health—the Paroo Lowland zone (which accommodates the entire river). Two zones (Lowland and Slopes) from the Warrego were rated in Moderate health. Other zones in Moderate health included: Lowland of the Condamine; the Upper of the Darling; Upper of the Lower Murray; Slopes of the Castlereagh, Upland of the Ovens and the Montane of the Upper Murray.

Most zones were rated as Poor (38 zones) or Very Poor (21 zones). No zones were rated in Extremely Poor health.

Overall, Upland and Montane zones rated in similar Ecosystem Health to the Lowland and Slopes zones. Nineteen of 21 (90%) of the former were rated in Poor or Very Poor health, compared to 40 of 47 (85%) of the latter. A higher proportion of Slopes zones were rated in Very Poor health (50%) than for any of the other zones (5–30%).

Northern (Darling River catchment) valleys generally were in better health than southern (River Murray catchment) valleys. Only one of the nine northern valleys was rated as in Very Poor health, compared to six of the 14 southern valleys. In addition, both valleys rated as being in Moderate or Good health were in the northern Basin, as were the three highest ranked valleys in Poor health. All except two of the 21 zones rated in Very Poor health were in southern valleys.

Table 2: Ecosystem Health assessment by valley, 2008–2010
Valleys are arranged in rank order of health ratings.

HEALTH RATING	VALLEY	GROUP RANK
GOOD	PAROO	1
MODERATE	WARREGO	2
POOR	CASTLEREAGH CONDAMINE DARLING	3
	BORDER RIVERS GWYDIR MURRAY (CENTRAL) MURRAY (LOWER) MURRAY (UPPER) NAMOI OVENS WIMMERA	4
	AVOCA KIEWA MITTA MITTA MURRUMBIDGEE	5
VERY POOR	CAMPASPE LODDON	6
	BROKEN GOULBURN LACHLAN MACQUARIE	7
EXTREMELY POOR		

Table 3: Sustainable Rivers Ecosystem Health and theme condition (SR–HI etc.) ratings for all valleys, in order of declining Ecosystem Health.

Ecosystem Health was determined based on the biological themes: Fish, Macroinvertebrates and Vegetation.

VALLEY	ECOSYSTEM HEALTH	FISH	MACRO-INVERTEBRATES	VEGETATION	PHYSICAL FORM	HYDROLOGY
PAROO	GOOD	GOOD	GOOD	GOOD	GOOD	GOOD
WARREGO	MODERATE	POOR	GOOD	GOOD	GOOD	GOOD
CASTLEREAGH	POOR	VERY POOR	MODERATE	GOOD	GOOD	GOOD
CONDAMINE	POOR	MODERATE	MODERATE	GOOD	MODERATE	MODERATE
DARLING	POOR	POOR	POOR	GOOD	MODERATE	MODERATE
BORDER RIVERS	POOR	MODERATE	MODERATE	POOR	MODERATE	GOOD
LOWER MURRAY	POOR	POOR	MODERATE	POOR	MODERATE	VERY POOR
OVENS	POOR	POOR	MODERATE	POOR	GOOD	GOOD
GWYDIR	POOR	POOR	MODERATE	MODERATE	MODERATE	POOR
CENTRAL MURRAY	POOR	VERY POOR	POOR	GOOD	MODERATE	POOR
UPPER MURRAY	POOR	EXT'LY POOR	GOOD	MODERATE	GOOD	POOR
WIMMERA	POOR	POOR	MODERATE	POOR	GOOD	MODERATE
NAMOI	POOR	VERY POOR	MODERATE	POOR	MODERATE	GOOD
KIEWA	POOR	EXT'LY POOR	GOOD	POOR	GOOD	GOOD
MITTA MITTA	POOR	EXT'LY POOR	GOOD	MODERATE	GOOD	GOOD
AVOCA	POOR	VERY POOR	MODERATE	POOR	MODERATE	GOOD
MURRUMBIDGEE	POOR	EXT'LY POOR	MODERATE	MODERATE	GOOD	POOR
CAMPASPE	VERY POOR	VERY POOR	MODERATE	EXT'LY POOR	MODERATE	MODERATE
LODDON	VERY POOR	VERY POOR	MODERATE	EXT'LY POOR	MODERATE	MODERATE
GOULBURN	VERY POOR	EXT'LY POOR	POOR	POOR	GOOD	POOR
MACQUARIE	VERY POOR	EXT'LY POOR	MODERATE	MODERATE	MODERATE	MODERATE
BROKEN	VERY POOR	EXT'LY POOR	GOOD	VERY POOR	GOOD	GOOD
LACHLAN	VERY POOR	EXT'LY POOR	MODERATE	POOR	GOOD	MODERATE
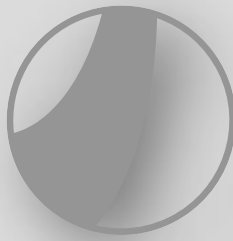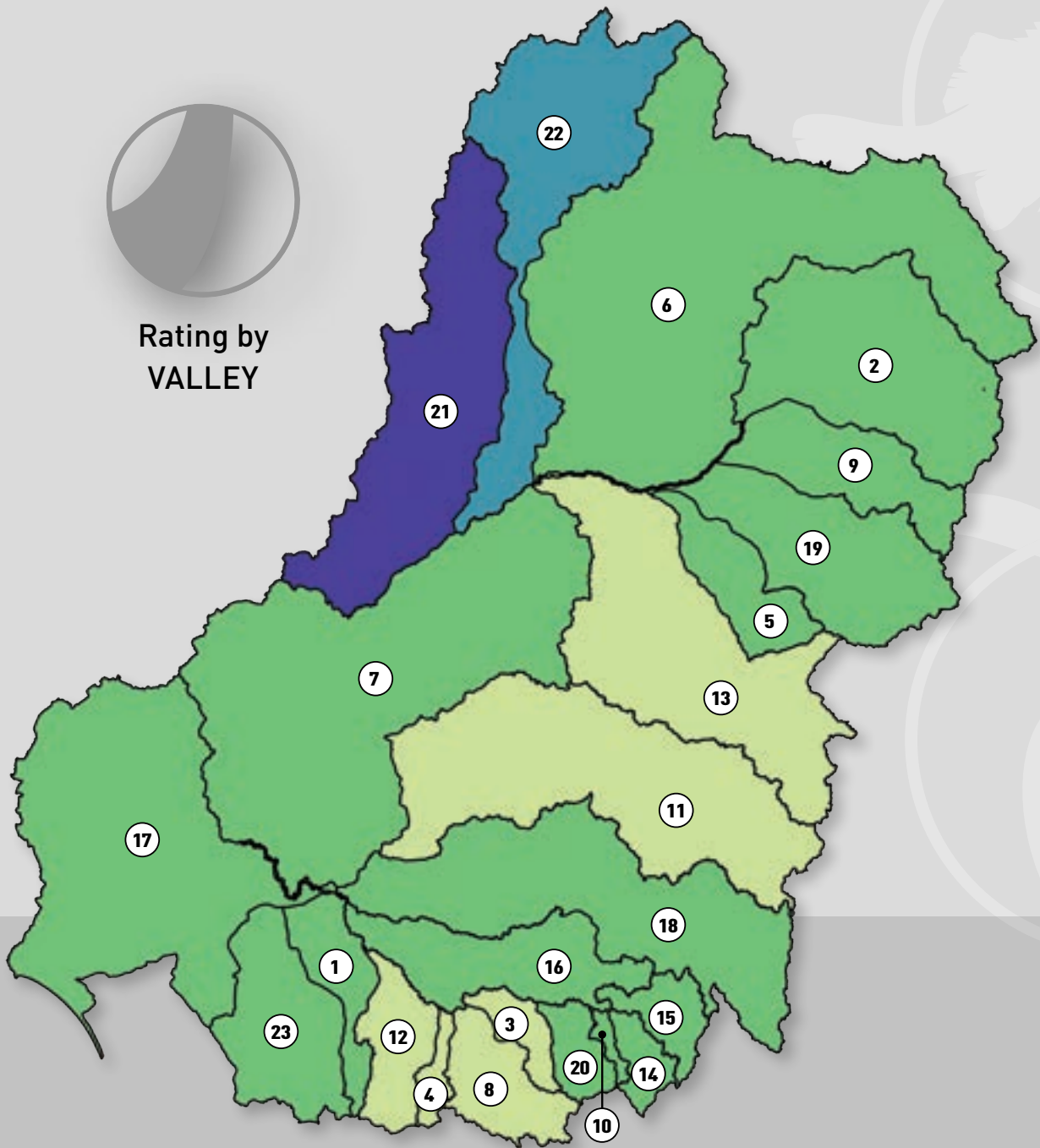
Figure 7: Ecosystem Health rating

1	Avoca	9	Gwydir	17	Murray Lower
2	Border Rivers	10	Kiewa	18	Murrumbidgee
3	Broken	11	Lachlan	19	Namoi
4	Campaspe	12	Loddon	20	Ovens
5	Castlereagh	13	Macquarie	21	Paroo
6	Condamine	14	Mitta Mitta	22	Warrego
7	Darling	15	Murray Upper	23	Wimmera
8	Goulburn	16	Murray Central		

Rating by ZONE

The zone ratings (which correspond to the colours in the map) for each valley can be found in Section 7 of this Summary document.

100	
80	Good
60	Moderate
40	Poor
20	Very Poor
0	Extremely Poor

N

0	100	200	300
			km
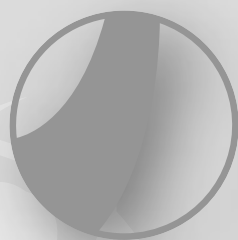
Fish theme

All valleys (510 sites) were sampled for fish, involving 36 (27 native, nine alien) species and more than 63,000 individual specimens with a total biomass of nearly 4.5 tonnes.

Fish Condition (SR–FI) was in Good health in the Paroo valley. Two other valleys (Condamine and Border Rivers) were in Moderate condition. Though the three valleys (Group A) supported very different fish densities, their fish communities were characterised by high proportions of native species. Group B includes eight valleys (Castlereagh, Darling, Gwydir, Murray [Lower], Ovens, Warrego, Namoi and Wimmera) in Poor or Very Poor Condition. All of the valleys from the northerly, summer–rainfall region of the Basin fall into either Group A or Group B.

The remaining 12 valleys have a condition rating from Very Poor to Extremely Poor. Alien species made up more than half the fish biomass in every case. All valleys in Group C are situated in the southern part of the Basin.

Alien species are a major part of the Basin fish fauna. Goldfish were caught in 22 valleys. Redfin perch were also abundant and widespread, especially in warm, lowland areas; and brown trout and rainbow trout were common in cooler upland streams.

Alien species made up more than half the numbers of fish in ten valleys—with more than 75% of fish numbers in the Campaspe, Kiewa and Murrumbidgee valleys comprised of alien species. At the other end of the scale, the Border Rivers, Condamine, Central Murray, Darling, Paroo, and Warrego valleys all had native species contributing more than 75% of their total fish numbers.

Of the total catch of 4.49 tonnes: 3.01 tonnes were alien species, of which 2.71 tonnes–90% (or 60% of the total catch biomass)–were common carp. A major part of the native fish biomass (1.48 tonnes) came from large-bodied species–Murray cod (0.53 tonnes) and golden perch (0.39 tonnes)–and the smaller but more numerous bony herring (0.42 tonnes).

Condition assessments (valley and zone maps) for the Fish theme are shown in Figure 9.
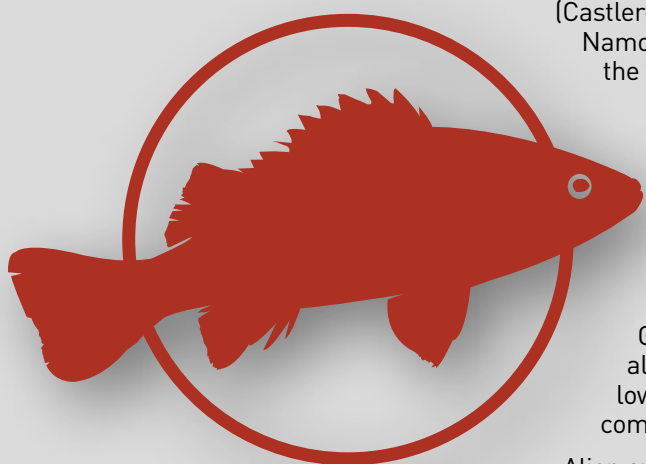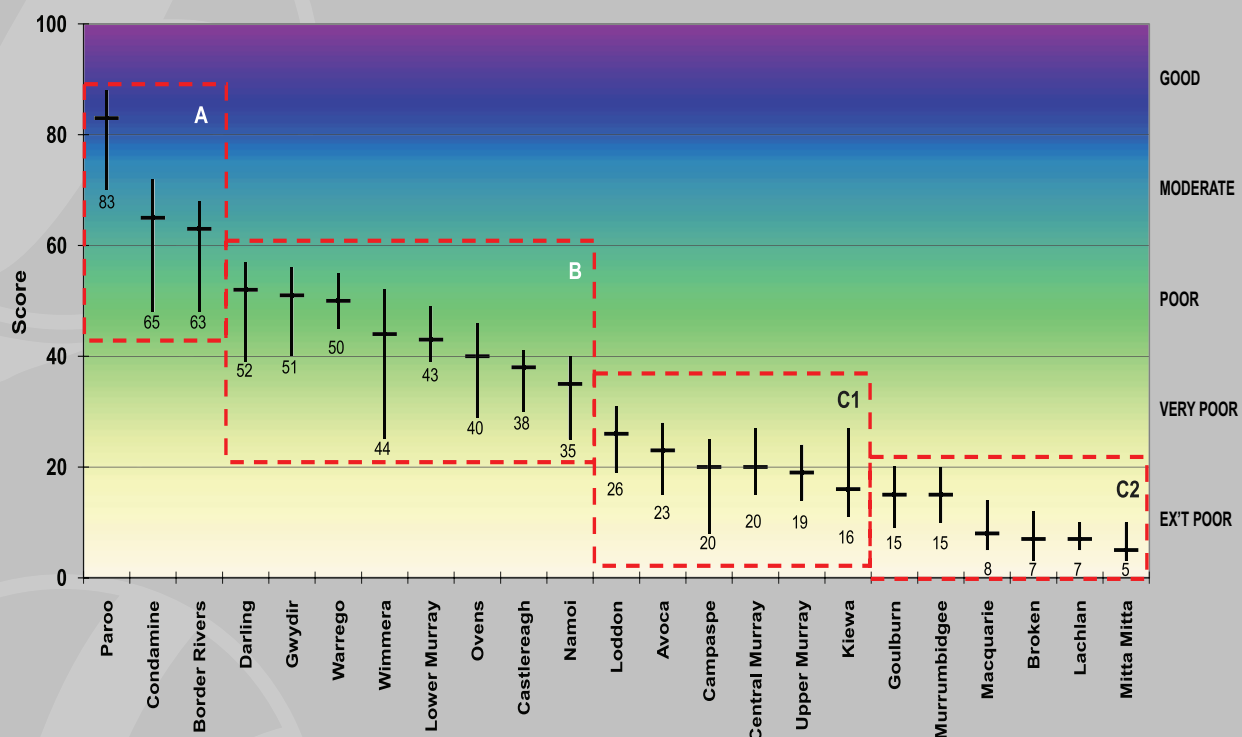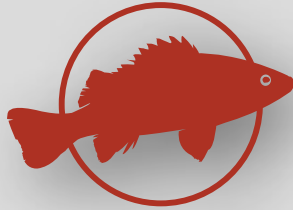
Figure 8: Valleys ranked by Fish Condition Index (SR–FI) scores

Short horizontal bars are means; vertical lines show the associated 95% confidence limits.
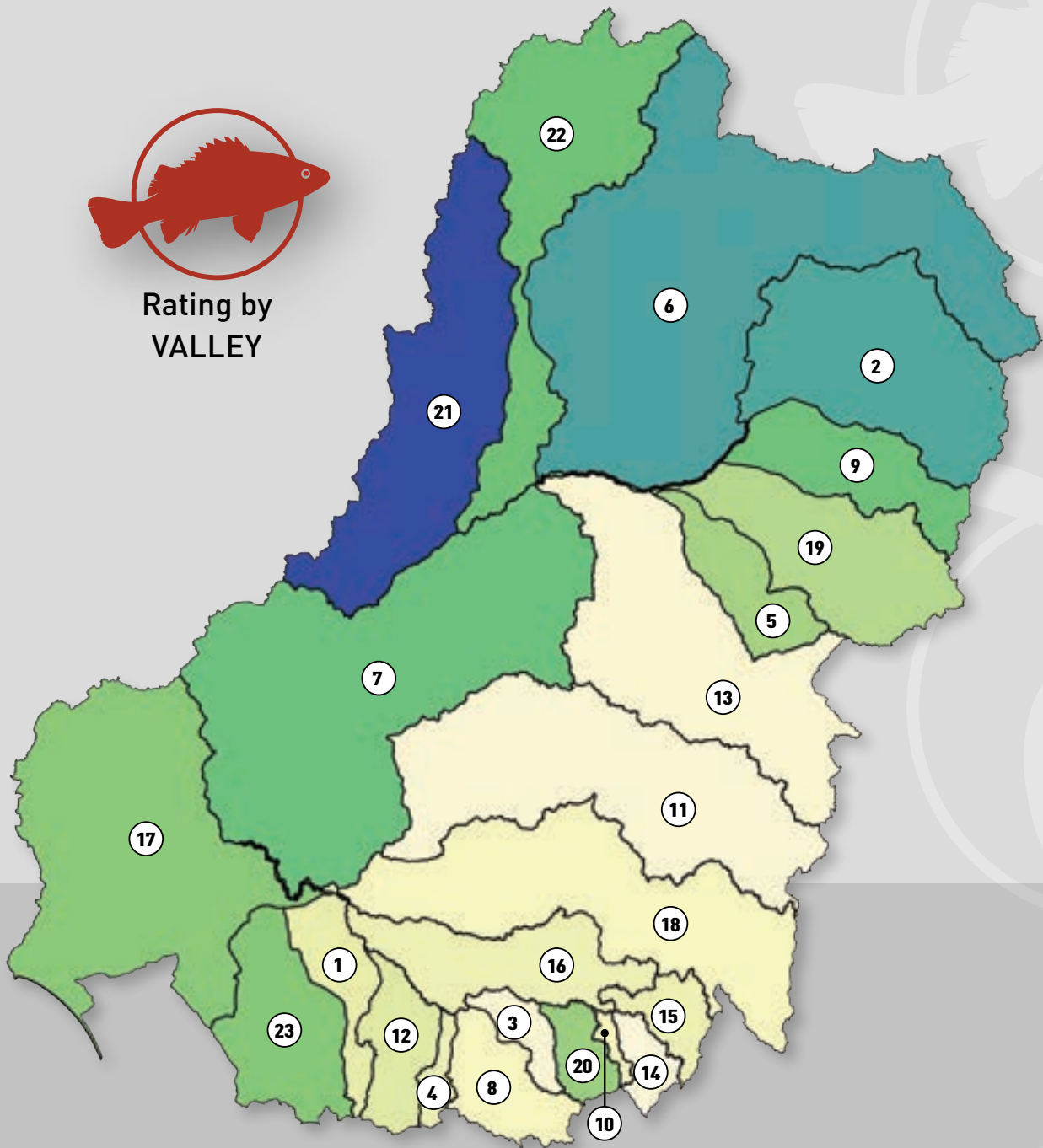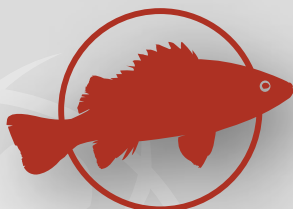The SRA condition band colour standard is shown.
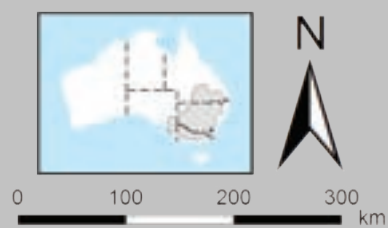
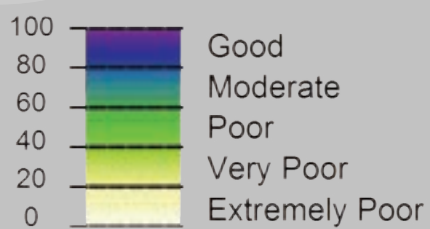**Rating by VALLEY**

Figure 9: Fish Condition rating

1	Avoca	9	Gwydir	17	Murray Lower
2	Border Rivers	10	Kiewa	18	Murrumbidgee
3	Broken	11	Lachlan	19	Namoi
4	Campaspe	12	Loddon	20	Ovens
5	Castlereagh	13	Macquarie	21	Paroo
6	Condamine	14	Mitta Mitta	22	Warrego
7	Darling	15	Murray Upper	23	Wimmera
8	Goulburn	16	Murray Central		

Rating by ZONE

The zone ratings (which correspond to the colours in the map) for each valley can be found in Section 7 of this Summary document.

100	Good
80	Moderate
60	Poor
40	Very Poor
20	Extremely Poor
0	

N

0	100	200	300
			km

Macroinvertebrate theme

All valleys were sampled for macroinvertebrates at 797 sites, yielding over 216,454 specimens in 116 families.

The mean Macroinvertebrate condition rating for valleys ranged from Good (for the Kiewa, Mitta Mitta, Murray [Upper], Paroo and Warrego) through Moderate to Poor (Darling, Goulburn and Central Murray).

Twenty-two 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.

There were substantial differences in the condition of macroinvertebrate communities between southern and northern valleys. In the Slopes, Upland and Montane zones, macroinvertebrate communities in the northern region are more frequently in Good condition, 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.

Condition assessments for the Macroinvertebrate theme (valley and zone maps) are shown in Figure 11.
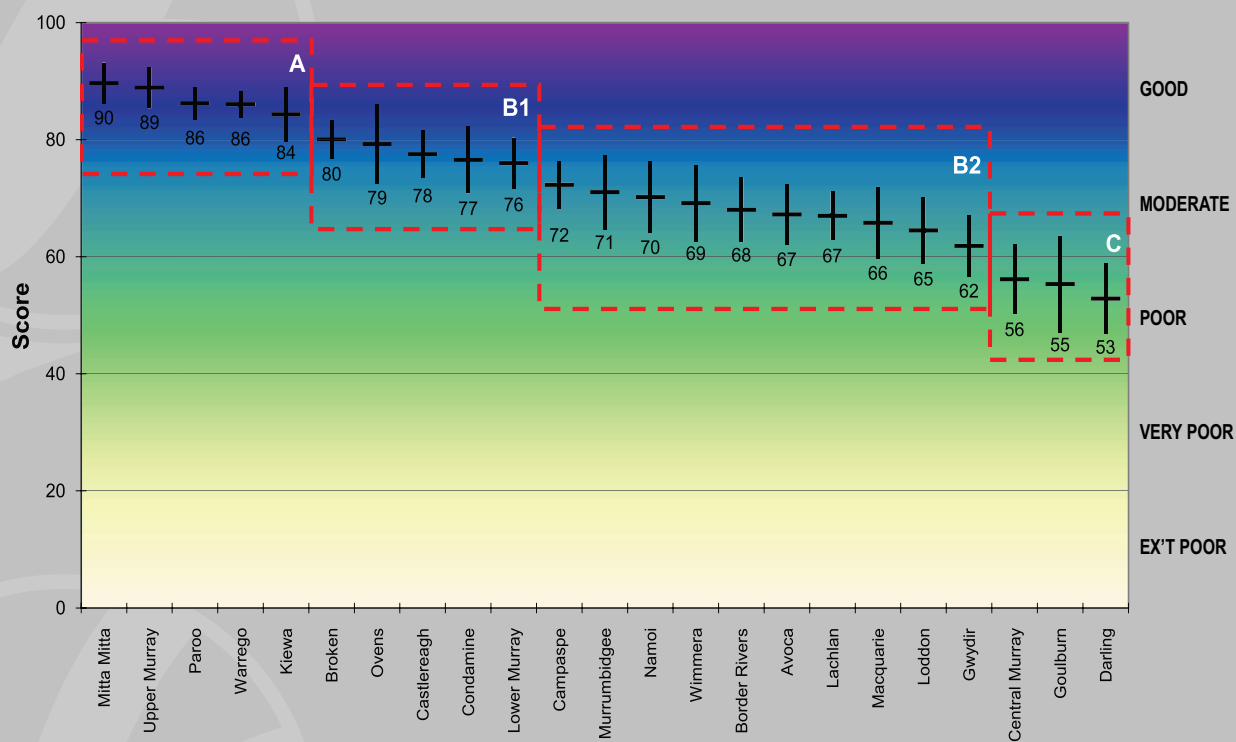
Figure 10: Valleys ranked by Macroinvertebrate Condition Index (SR–MI) scores

Short horizontal bars are means; vertical lines show the associated 95% confidence limits.
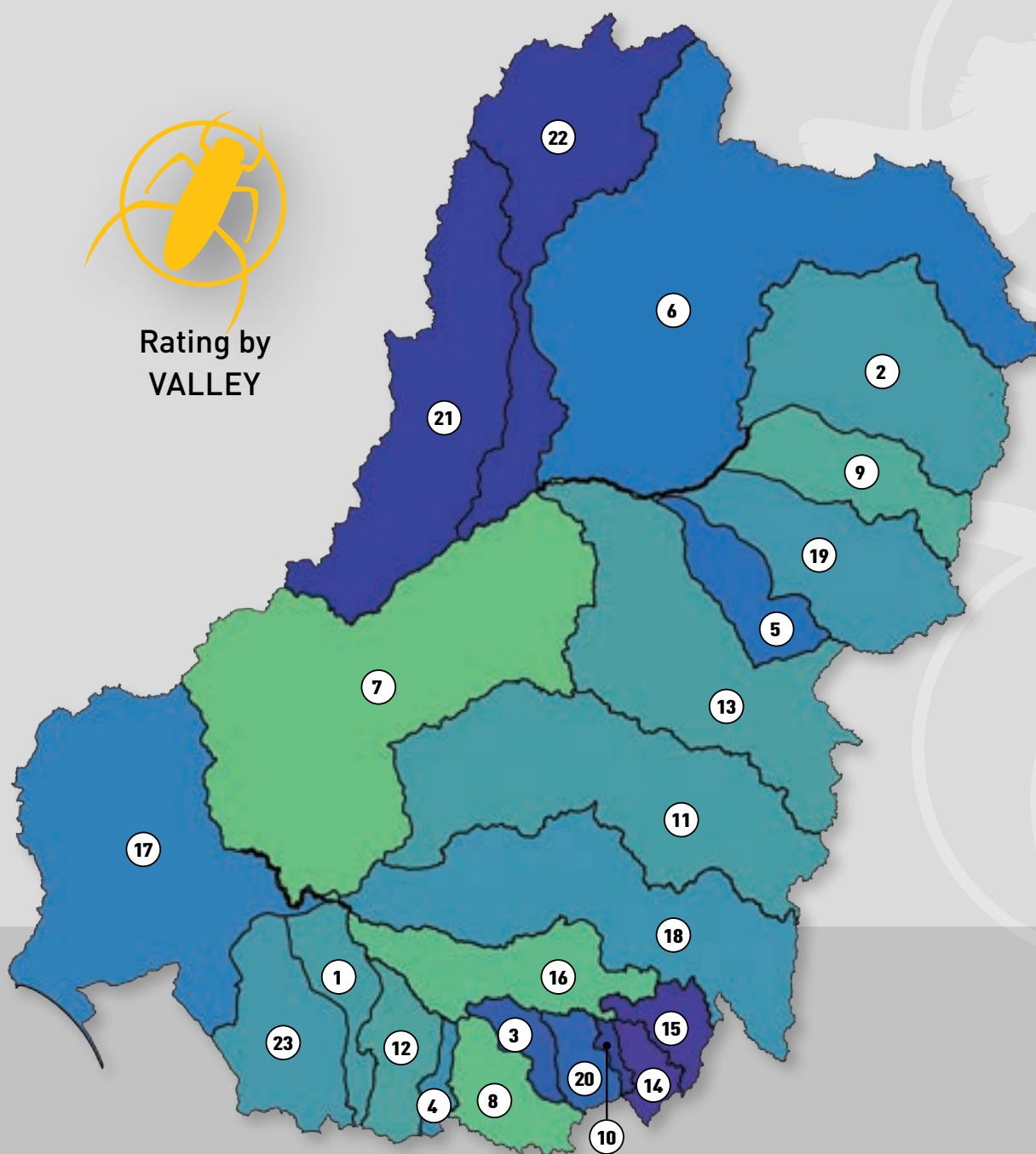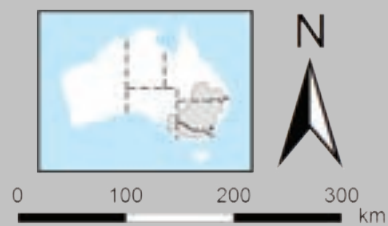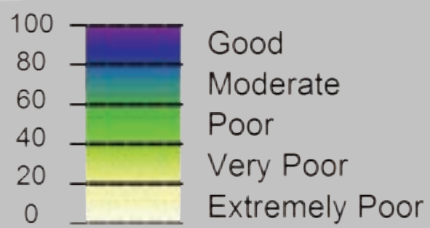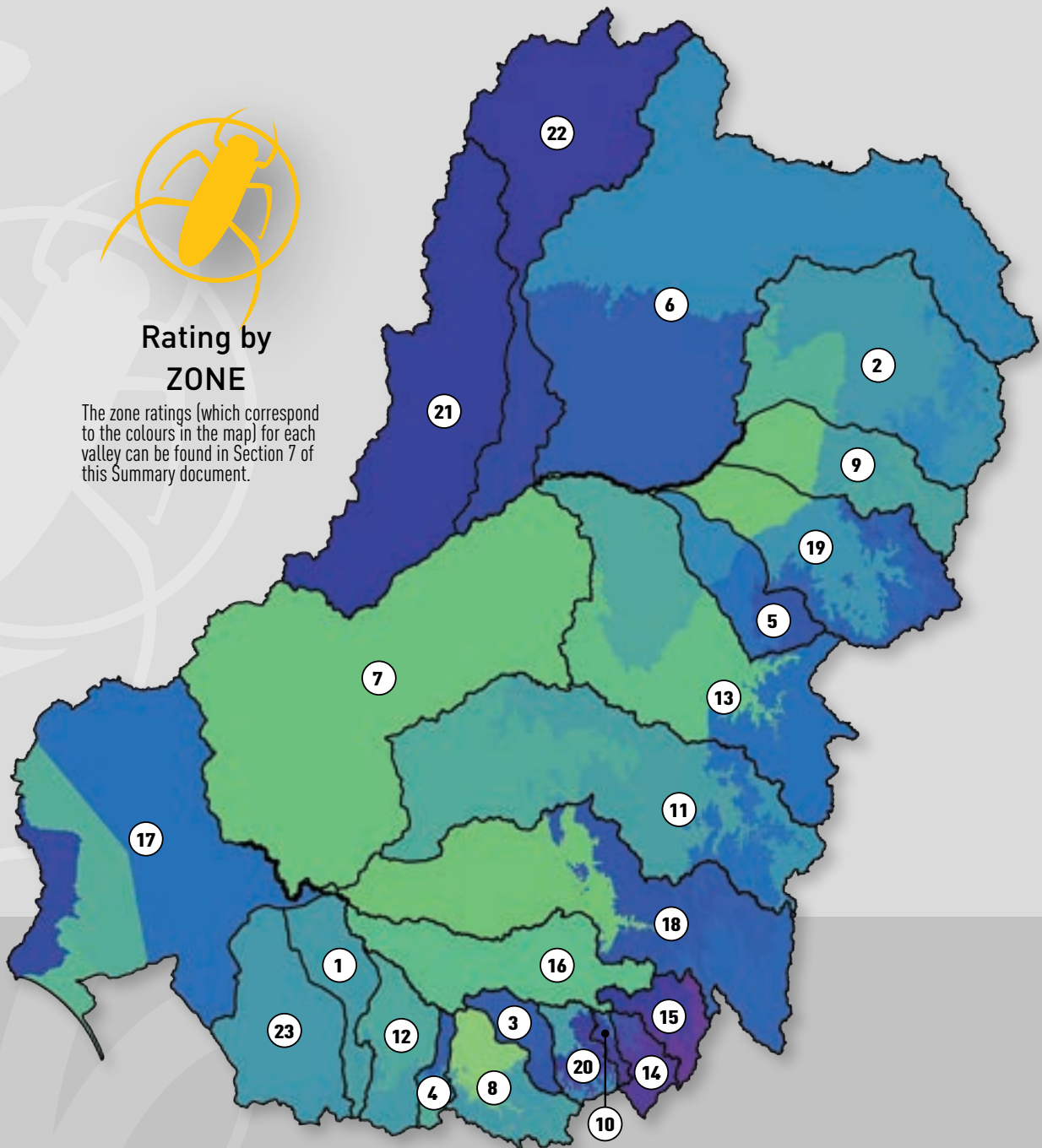The SRA condition band colour standard is shown.

Rating by VALLEY

Figure 11: Macroinvertebrate Condition rating

1	Avoca	9	Gwydir	17	Murray Lower
2	Border Rivers	10	Kiewa	18	Murrumbidgee
3	Broken	11	Lachlan	19	Namoi
4	Campaspe	12	Loddon	20	Ovens
5	Castlereagh	13	Macquarie	21	Paroo
6	Condamine	14	Mitta Mitta	22	Warrego
7	Darling	15	Murray Upper	23	Wimmera
8	Goulburn	16	Murray Central		

Rating by ZONE

The zone ratings (which correspond to the colours in the map) for each valley can be found in Section 7 of this Summary document.

100	Good
80	Moderate
60	Poor
40	Very Poor
20	
0	Extremely Poor

N

0   100   200   300
km

Vegetation theme

This is the first Vegetation theme assessment reported by the SRA.

Figure 15 shows indices of riverine Vegetation Condition (SR–VI) for all valleys, arranged in descending order. The valleys fall into four groups (A–D), based on valley scores and rankings.

Six valleys (Castlereagh, Central Murray, Condamine, Darling, Paroo, and Warrego) have very high SR–VI scores, and the riverine vegetation is in near reference condition. Five of these are in the northern sub-basin. Three valleys (Broken, Campaspe and Loddon), all in the southern sub-basin, are in Very Poor to Extremely Poor condition.

A marked difference in riverine vegetation condition scores is evident between the northern and southern valleys of the Basin. The northern sub-basin average is Moderate condition; while the southern valleys' average is Poor condition.

Richness in the lowland floodplain domain—with 15 main vegetation groups (MVGs) across the Basin—is higher in the northern sub-basin than the southern (which has 12).

Out of 19 valleys with metric values for both domains (lowland floodplain and near-riparian), 13 have no loss of any MVG, five have lost an MVG from one domain, and one (the Ovens) lost MVGs from both domains. Nearly all instances of MVG loss are for southern valleys.

MVG abundance in the Near Riparian domain varies across the Basin. At valley scale, abundance ranges from Very Poor to Good. It is higher in the northern sub-basin than in the southern (mean = 0.71 and 0.43), and lowest in the Slopes zone (mean = 0.36).

Fragmentation has a broadly similar geographic pattern to abundance, with higher scores (i.e. closer to reference condition) in the northern sub-basin (mean score = 85.7, range 57–98) than in the southern (mean = 67.8, range 40–97).

Valley scores for structure range from 66 to 85, and valley zone scores range from 44 to 94, with all except four valley zones being equivalent to Moderate or Good condition. This indicates relatively little variation across the Basin.

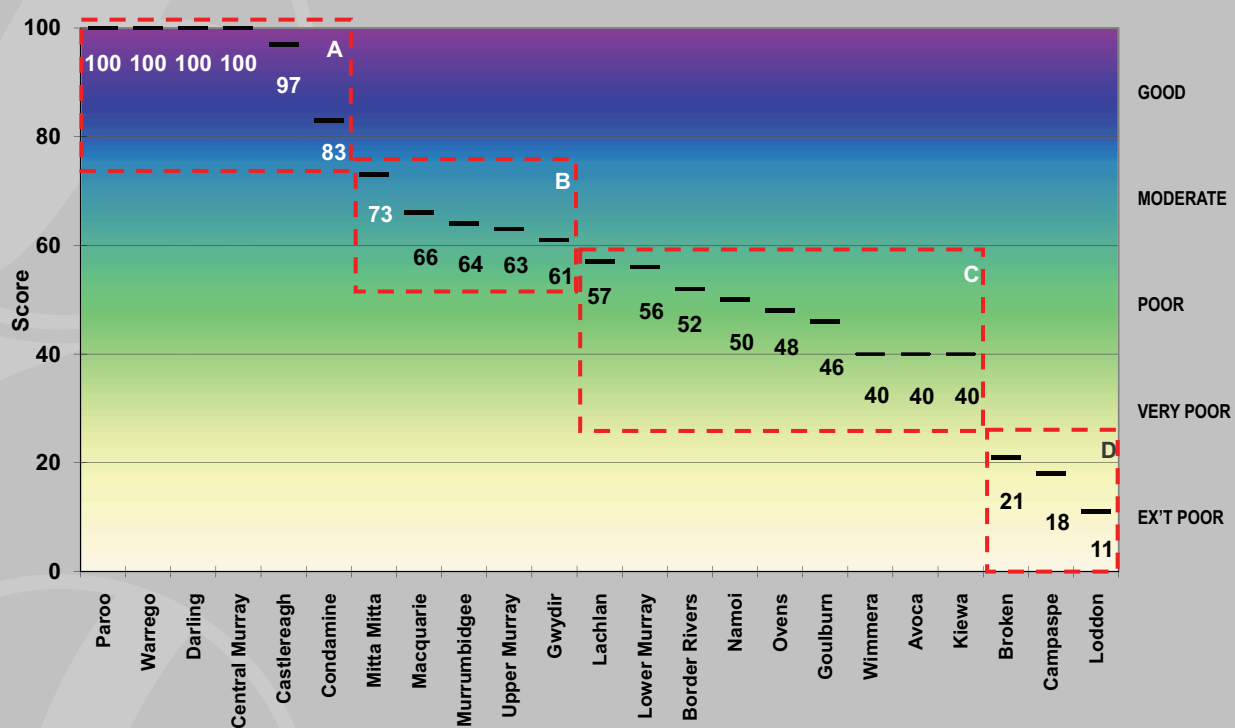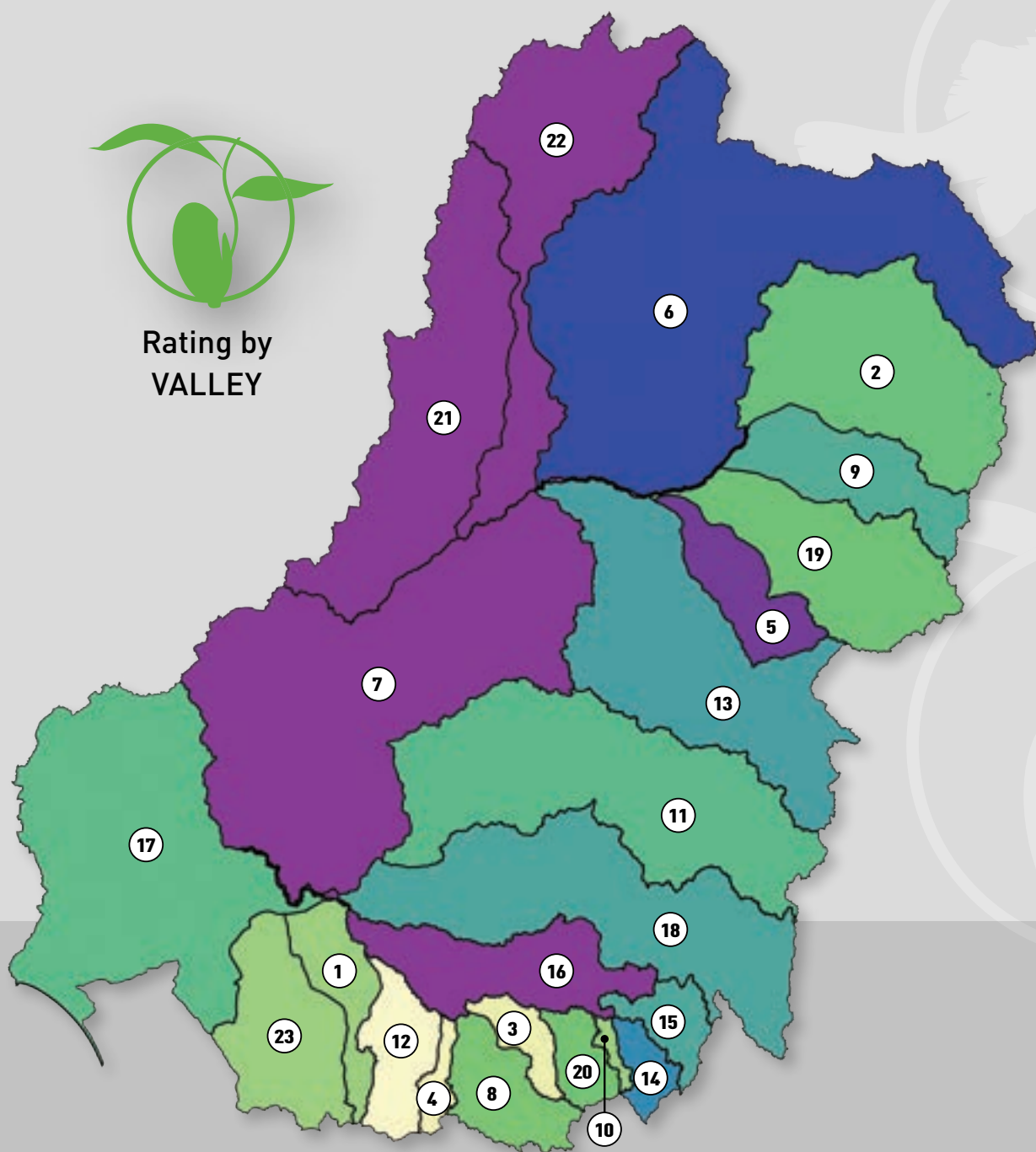Condition assessments for the Vegetation theme (valley and zone maps) are shown in Figure 13.
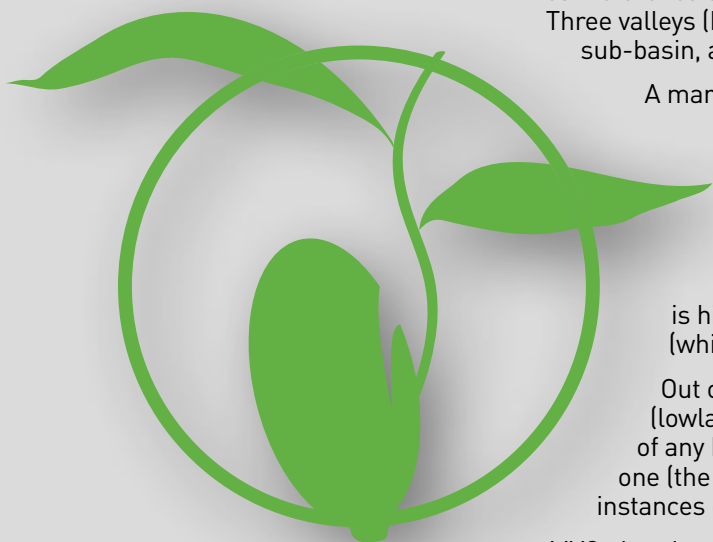
Figure 12: Valleys ranked by Vegetation Condition Index (SR–VI) scores

Short horizontal bars are means; vertical lines show the associated 95% confidence limits.
The SRA condition band colour standard is shown.

Rating by VALLEY

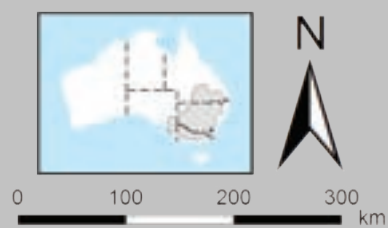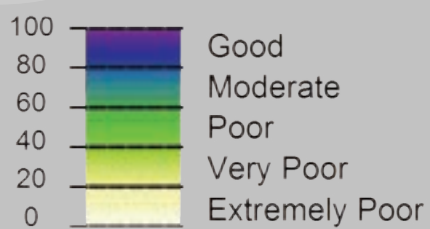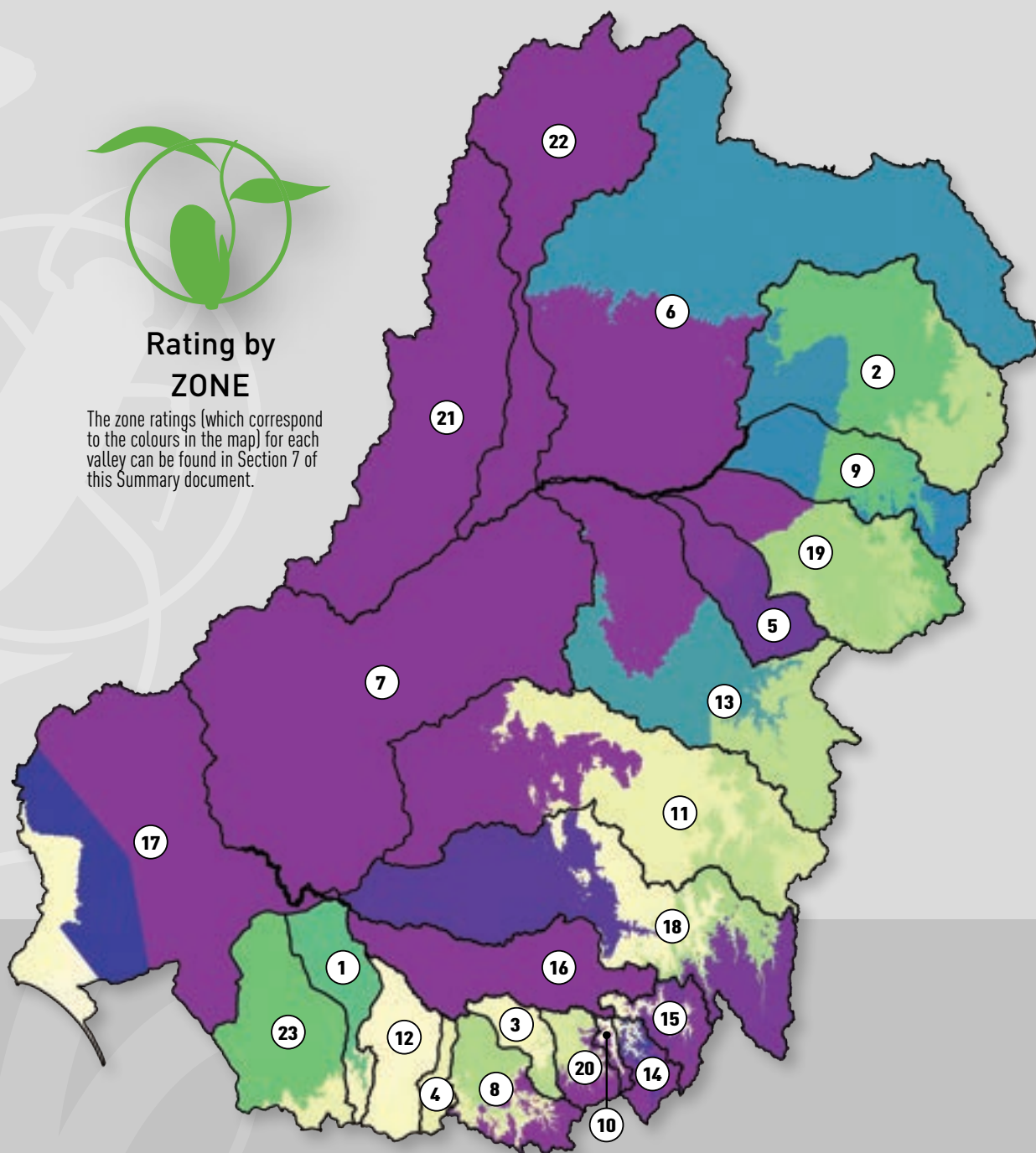**Figure 13:** Vegetation Condition rating

1	Avoca	9	Gwydir	17	Murray Lower
2	Border Rivers	10	Kiewa	18	Murrumbidgee
3	Broken	11	Lachlan	19	Namoi
4	Campaspe	12	Loddon	20	Ovens
5	Castlereagh	13	Macquarie	21	Paroo
6	Condamine	14	Mitta Mitta	22	Warrego
7	Darling	15	Murray Upper	23	Wimmera
8	Goulburn	16	Murray Central		

Rating by
ZONE

The zone ratings (which correspond to the colours in the map) for each valley can be found in Section 7 of this Summary document.

100	
80	Good
60	Moderate
40	Poor
20	Very Poor
0	Extremely Poor

N

0	100	200	300
			km

Physical Form theme

This is the first Physical Form theme assessment reported by the SRA.

Valleys across the Murray–Darling Basin were rated as either in Moderate condition (11 valleys) or Good condition (12 valleys) (Figure 15).

Of the Basin's 68 zones, none were rated as Extremely Poor for Physical Form. Only five were rated as Very Poor or Poor and these were all Lowland zones. Other zones were rated as either in Moderate condition (21 zones) or Good condition (42 zones). All the Montane zones were in Good condition (Figure 15).

The Lowland zones generally had lower condition than either the Slopes or Upland zones.

Human impacts on Physical Form are widespread across the Basin. Of the 1,385 sites surveyed, there are indications of channel simplification at 63% of sites, channel enlargement at 53% of sites and channel contraction at 21% of sites.

Increased sediment load and floodplain deposition rates throughout the Basin since European settlement are apparent. In-channel sedimentation is elevated along 41% of the river length.

As this includes periods of high catchment disturbance immediately following settlement, these results are not necessarily indicative of sediment loads and sedimentation in recent years.
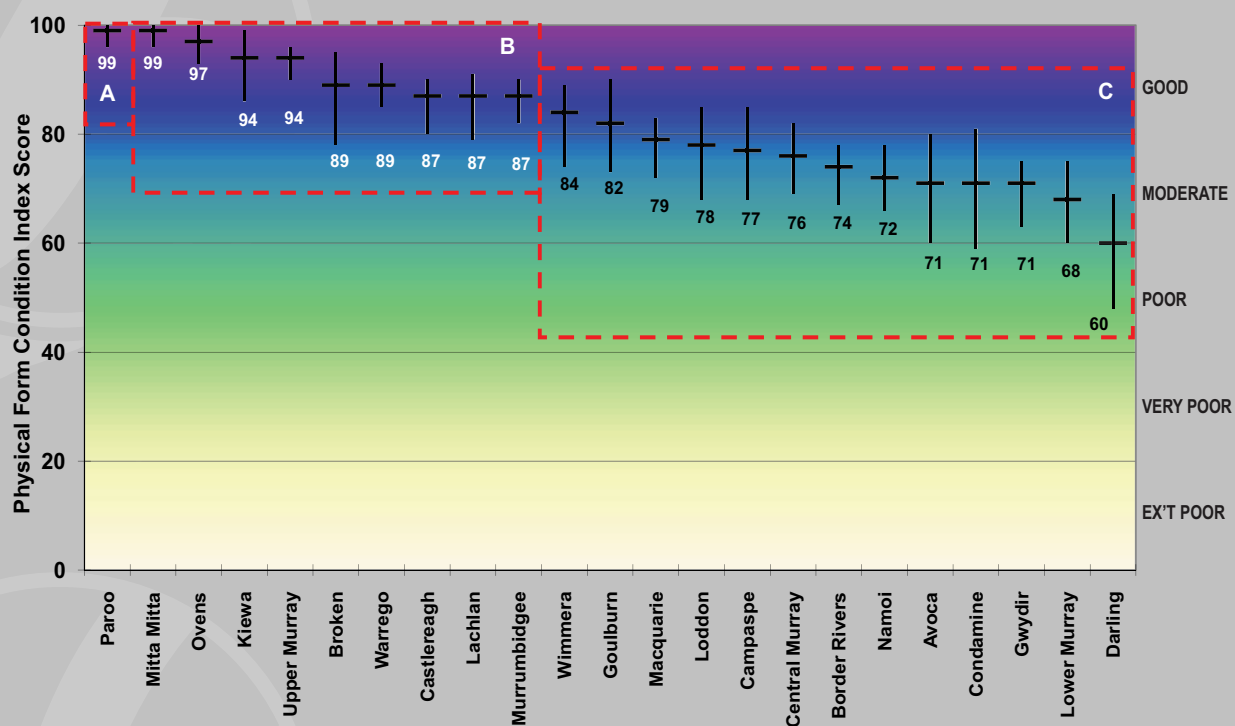
Figure 14: Valleys ranked by Physical Form Condition Index (SR–PI)

Short horizontal bars are means; vertical lines show the associated 95% confidence limits.
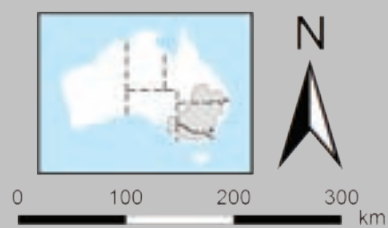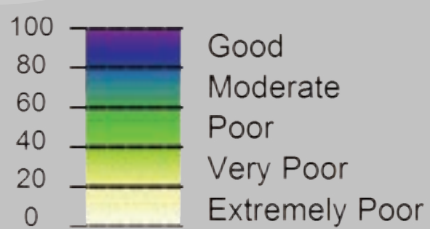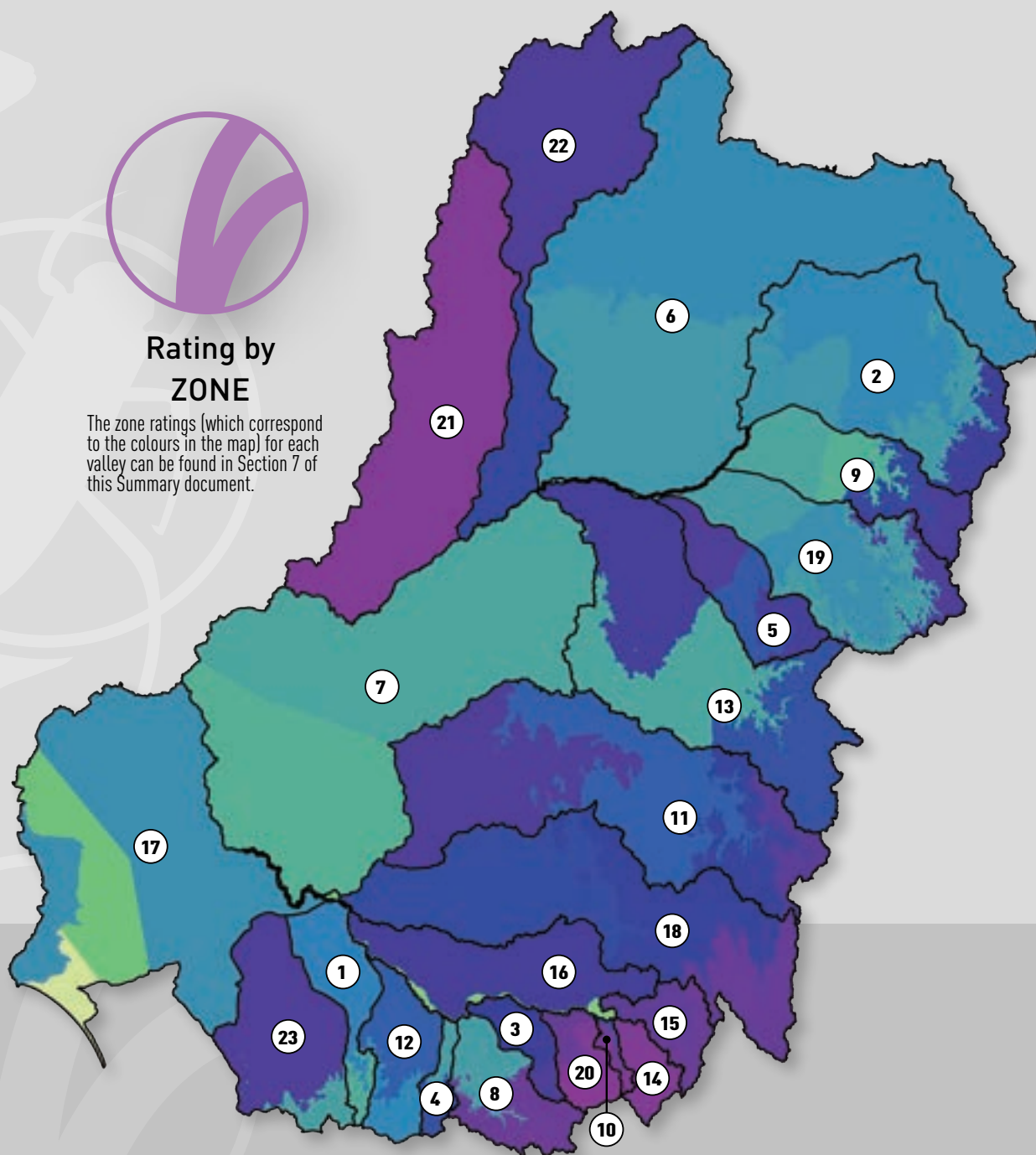The SRA condition band colour standard is shown.
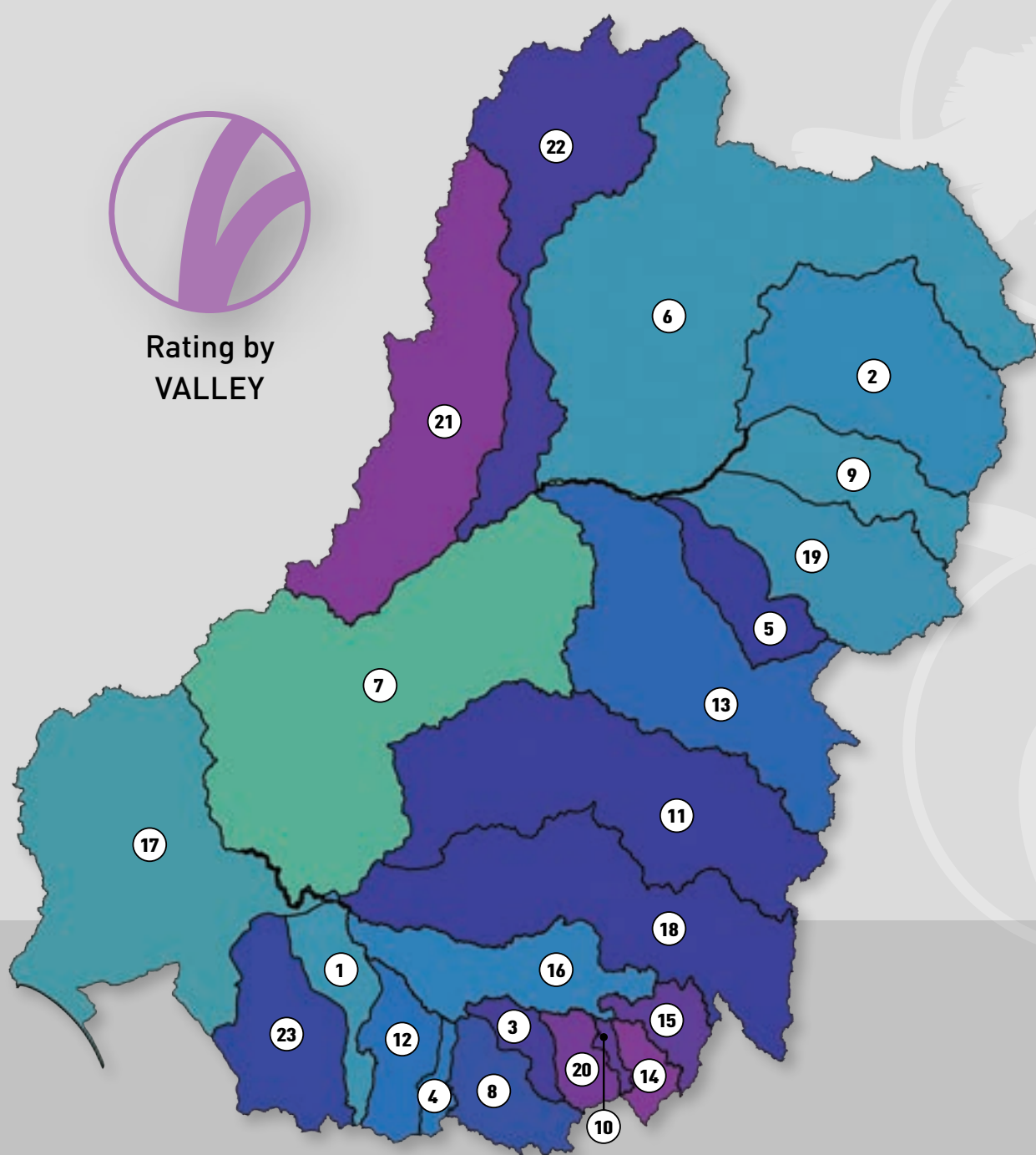
Rating by
VALLEY

Figure 15: Physical Form Condition rating

1	Avoca	9	Gwydir	17	Murray Lower
2	Border Rivers	10	Kiewa	18	Murrumbidgee
3	Broken	11	Lachlan	19	Namoi
4	Campaspe	12	Loddon	20	Ovens
5	Castlereagh	13	Macquarie	21	Paroo
6	Condamine	14	Mitta Mitta	22	Warrego
7	Darling	15	Murray Upper	23	Wimmera
8	Goulburn	16	Murray Central		

Rating by
ZONE

The zone ratings (which correspond to the colours in the map) for each valley can be found in Section 7 of this Summary document.

100	Good
80	Moderate
60	Poor
40	Very Poor
20	Extremely Poor
0	

N

0   100   200   300
km

Hydrology theme

The Hydrology theme has been broadened and refined since SRA 1. In this SRA report 2, reach-based assessment results for mainstem rivers and headwater streams were aggregated to quantitatively assess the hydrological condition of the network at zone and valley scales.

The theme assessments included:

• significantly improved hydrological modelling
• hydrological effects of farm dams
• historical changes to landcover
• measures of hydrological condition of both the channel and near and far floodplain environments
• assessments of temporal changes over the past 12 years
• condition assessment based on a 30-year record.

Over the entire Basin, 56% of the mainstem river length is rated as being in Poor, Very Poor or Extremely Poor hydrological condition. Ten valleys were rated in Good condition, seven were in Moderate condition and five were in Poor condition. The lowest rating valleys were the Upper and Lower Murray valleys, rated Very Poor and Poor respectively (Figure 17).

Variation in overall valley condition was largely determined by the mainstem river condition as the headwater stream condition did not vary greatly between valleys (except in the Darling and Central Murray valleys, which only include lowland zones).

Mainstem rivers could be assessed in all the SRA valleys except the Avoca and Kiewa. The total length of mainstem rivers assessed in this SRA report is 18,300 km. Modifications to all aspects of the flow regime are widespread across the mainstem river network. The greatest human impacts are on flow seasonality and flow variability. However, alterations to high- and low-flow events as well as the total volume of flow are also widespread and severe in many cases.

Headwater streams could be assessed in all the SRA valleys. The total length of headwater streams assessed in the SRA is 94,200 km. Note that in headwater streams, the SRA only considers impacts of farm dams and altered tree cover. Based on this assessment, 99% of the Basin's headwater streams are rated in Good condition. There are some restricted areas (less than 5% of the total headwater stream length) where there are moderate alterations to headwater stream flow seasonality and variability relative to reference conditions.

A classification of Good or Moderate does not mean that all river reaches within a valley conform to this rating. There is variation in hydrological condition throughout each valley and zone.
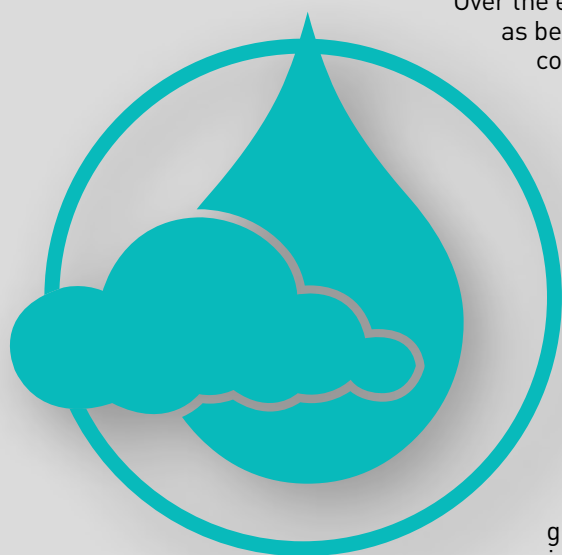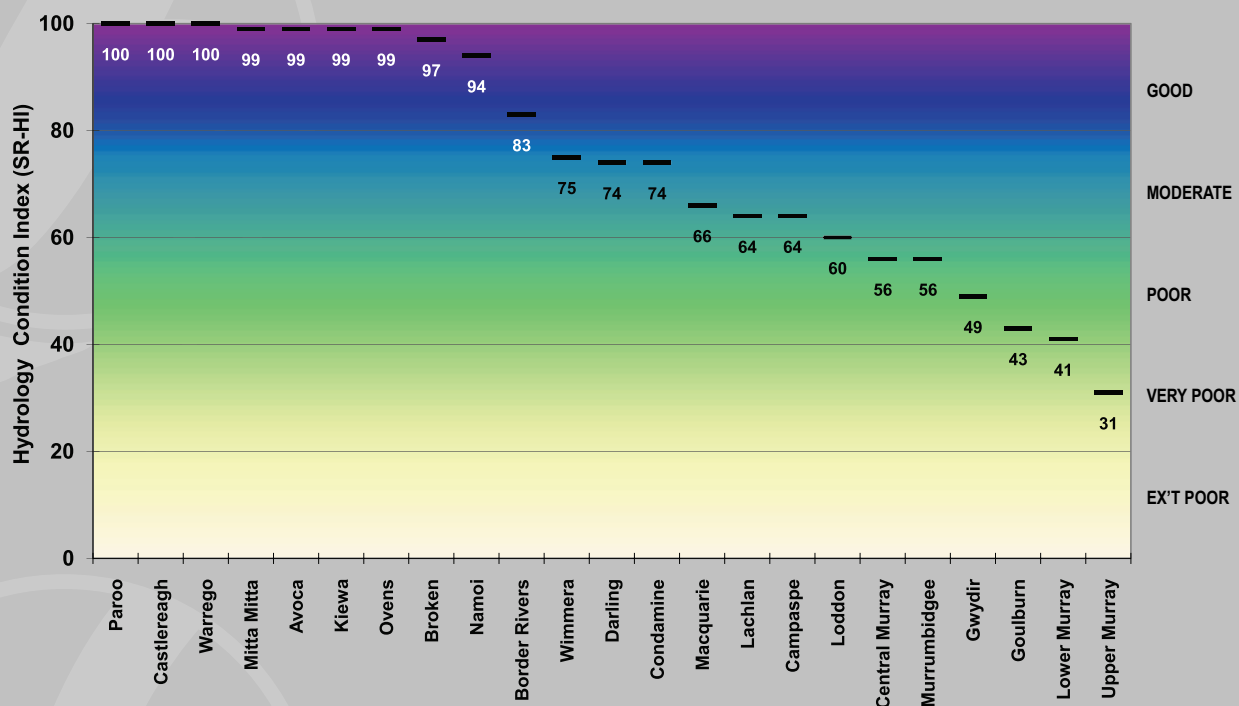
Figure 16: Hydrology Condition Index (SR–HI) scores for each Basin valley.

In decreasing order of Index value. Derived by combination (aggregation) of mainstem river and headwater stream results.
Short horizontal bars are means. The SRA condition band colour standard is shown.
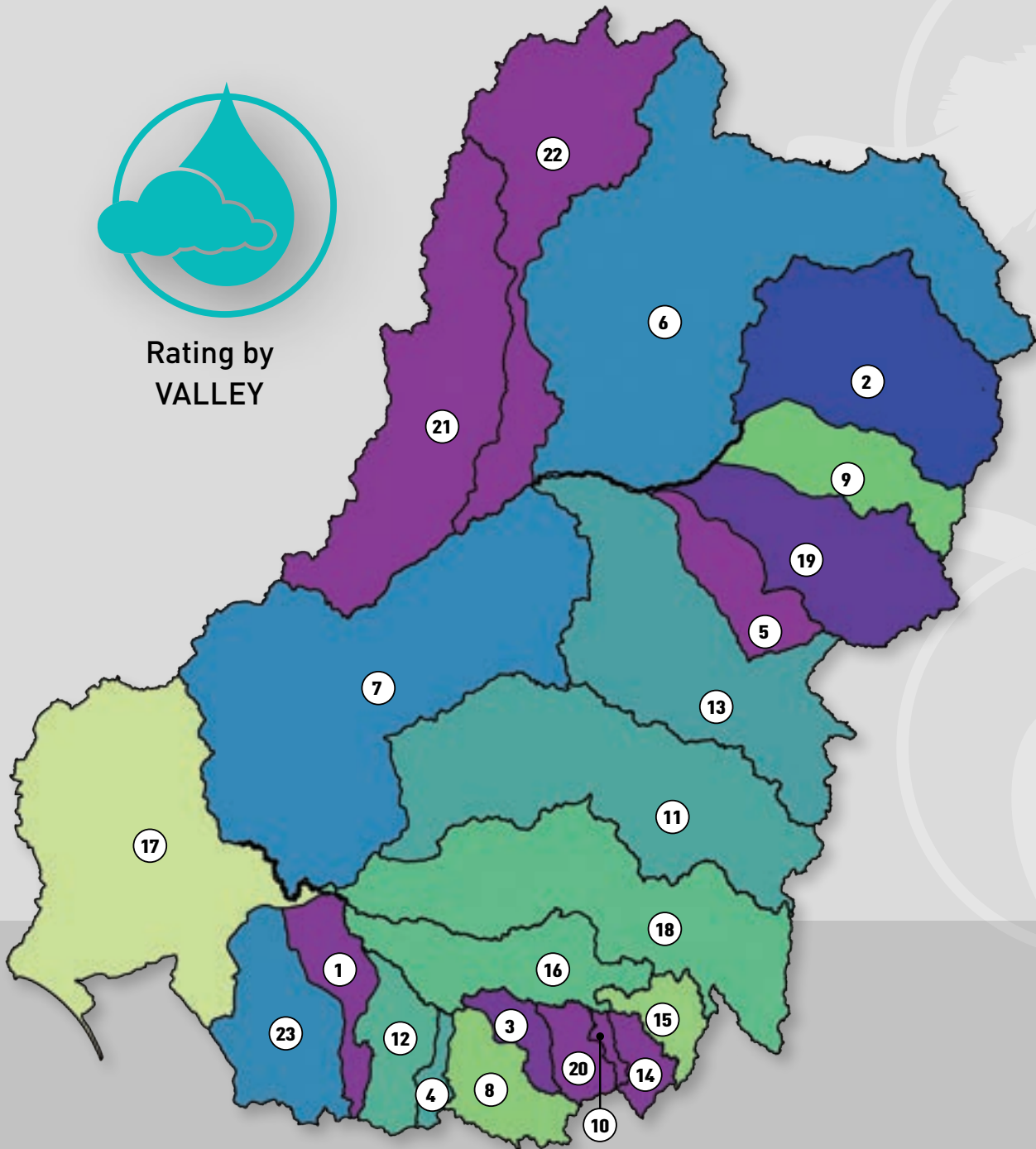
Rating by VALLEY

Figure 17: Hydrology Condition rating

1	Avoca	9	Gwydir	17	Murray Lower
2	Border Rivers	10	Kiewa	18	Murrumbidgee
3	Broken	11	Lachlan	19	Namoi
4	Campaspe	12	Loddon	20	Ovens
5	Castlereagh	13	Macquarie	21	Paroo
6	Condamine	14	Mitta Mitta	22	Warrego
7	Darling	15	Murray Upper	23	Wimmera
8	Goulburn	16	Murray Central		

Rating by ZONE

The zone ratings (which correspond to the colours in the map) for each valley can be found in Section 7 of this Summary document.

Please note that the lowland zone of Avoca and Kiewa are white as no mainstem river reaches could be assessed for this zone of these valleys (see SRA report 2, vol. 2 for more information).

100	
80	Good
60	Moderate
40	Poor
20	Very Poor
0	Extremely Poor

N

0   100   200   300
km
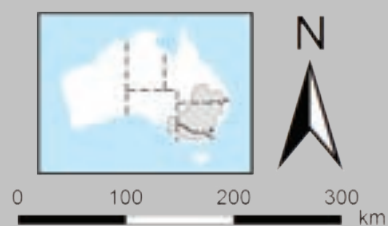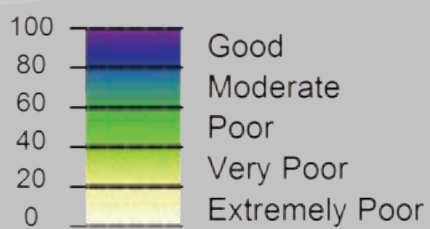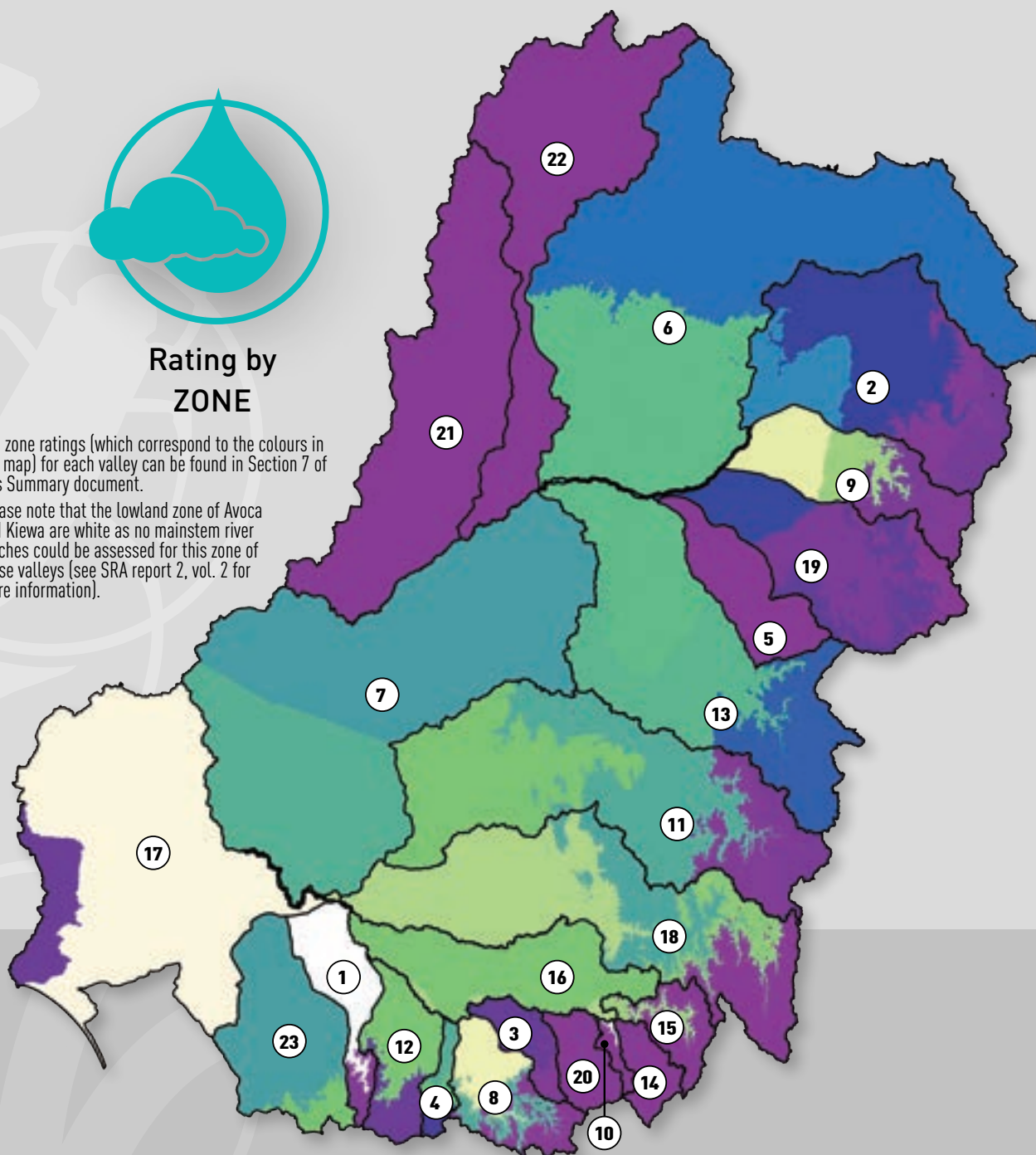
7. REPORT CARDS FOR VALLEYS

Overview

Using the valley- and zone-level condition assessments for Fish, Macroinvertebrates and Vegetation, each valley and its constituent zones was assigned a river Ecosystem Health rating.

The Paroo was the only valley rated in Good ecosystem health. Only the Warrego was rated in Moderate health. Most Valleys rated in Poor (15 valleys) or Very Poor health (six valleys). No valley was rated in Extremely Poor health.

Northern 'summer rainfall' river system valleys were generally in better health than southern 'winter–spring rainfall' valleys. Of the nine northern valleys, only the Macquarie was rated in Very Poor health, compared to six of the 14 southern valleys. Both the valleys rated in Moderate to Good health were situated in the northern Basin.
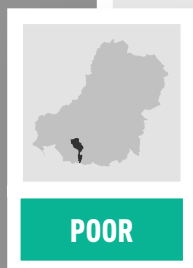
River Ecosystem Health assessments by valley are shown in Table 2 and Figure 7.

These assessments of Ecosystem Health were undertaken during the very dry conditions that have prevailed in the Basin until recently. The results therefore do not reflect the changes in ecosystem condition or health that have occurred since major rains and flooding began in 2010–11. Rather, ISRAG considers that they form a sound basis for assessing these changes in the near future. 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. Based on their health ratings, the 23 valleys are grouped into Good, Moderate, Poor and Very Poor in Table 2. The Ecosystem Health and condition assessments (by theme) for each valley in the Basin are summarised in Table 3 on page 25.

Report cards

Individual report cards for the 23 SRA valleys, covering Ecosystem Health and condition of five environmental components—Fish, Macroinvertebrates, Vegetation, Physical Form and Hydrology—are provided in the following section of this report.
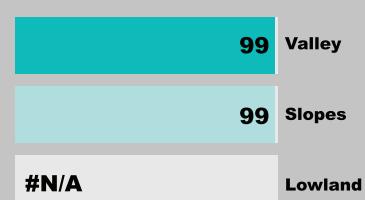
Avoca Valley

Lowland Zone

Slopes Zone

SR–EH
- 100 — Good
- 80
- 60 — Moderate
- 40 — Poor
- 20 — Very Poor
- 0 — Extremely Poor

0 20 40 60 80 100 km

N

23	Valley
63	Slopes
8	Lowland

67	Valley
66	Slopes
68	Lowland

40	Valley
15	Slopes
55	Lowland

71	Valley
62	Slopes
76	Lowland

|	
99	Valley
99	Slopes
#N/A	Lowland

#N/A

The Avoca River flows from the Great Dividing Range northward to the Murray, terminating in the Avoca Marshes and Lake Bael Bael, at the edge of the Kerang Wetlands.

The Avoca Valley covers 14,000 km² (about 1.5% of the Basin area).

River Ecosystem Health

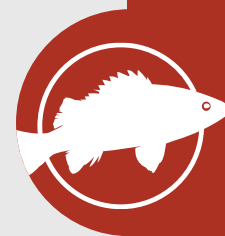The Avoca Valley river ecosystem was rated in **poor health.**

(Lowland zone: Very Poor; Slopes zone: Poor).
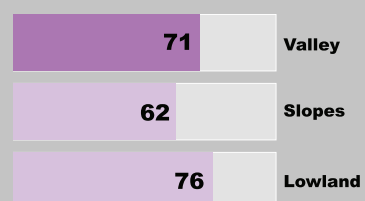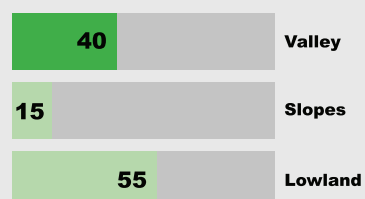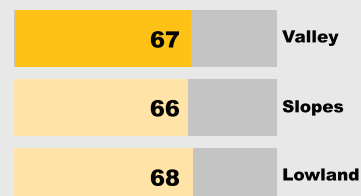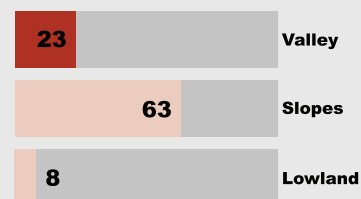
The Fish community of the Avoca Valley river system was rated in very poor condition, with an aggregate Fish Index score (SR–FI) of 23. (Lowland zone: Extremely Poor condition; Slopes zone: Moderate condition).

Overall, the fish community of the Avoca had reduced numbers of expected native species and a very small biomass of native fish (the second lowest biomass of all the 23 valleys). In the Lowland zone, native species contributed only 2.4% of the total fish biomass. The alien species, common carp, dominated the fish biomass in both zones. Expectedness, nativeness and recruitment were all very poor and indicated a very large difference from reference condition.

Fish

The Macroinvertebrate community of the Avoca Valley river system was rated in moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 67. (Lowland and Slopes zones: Moderate condition).

The proportion of sites in moderate condition was high across both zones, and four sites (13%) were in good condition. Expectedness was moderate for both presence and frequency of occurrence of expected families in samples from edge and riffle habitats. Family richness was generally reduced compared to reference condition. The valley contained 46% of all families found across the Basin, with the Lowland zone having the lowest representation of Basin-wide fauna. Most (>80%) of the fauna of the valley was found in each of the two zones.

Macroinvertebrates

The riverine Vegetation of the Avoca Valley river system was rated in poor condition, with an aggregate Vegetation Index score (SR–VI) of 40. (Lowland zone: Poor condition; Slopes zone: Extremely Poor condition).

The abundance and diversity of Avoca Valley riverine vegetation is in poor condition overall, with a large difference from reference in near riparian and lowland floodplain areas. There was also a large difference from reference condition for the structure, nativeness and fragmentation of vegetation communities and groups within near riparian and lowland floodplain areas. The Lowland Floodplain domain is moderately affected by clearing. The riverine Vegetation condition of the Avoca Valley ranked eighteenth among the 23 SRA valleys, equal with that of the Kiewa and Wimmera Valleys.

Vegetation

The Physical Form of the Avoca Valley river system was rated in moderate condition, with an aggregate Physical Form Index score (SR–PI) of 71. (Lowland and Slopes zones: Moderate condition).

The valley's river channel form and bank dynamics were in good condition. However, bed dynamics were in poor condition. Overall, the valley's riverine physical form was characterised by elevated sediment loads since European settlement, resulting in sedimentation on the floodplain and within the channel. Channel width, channel width variability, sinuosity and meander wavelength were largely unmodified from reference condition in the Slopes zone. Together with the Condamine and Gwydir, the Avoca Valley ranked equal nineteenth among the 23 SRA valleys for physical form.

Physical Form

The Hydrology of the Avoca Valley river system was rated in good condition, with an aggregate Hydrology Index (SR–HI) score of 99. (Lowland zone: un-rated; Slopes zone: Good condition).

The headwater streams were generally characterised by near reference condition in flow variability, flow seasonality, low- and zero-flow events, high-flow and flow gross volume. There is no mainstem river represented in the hydrological models for the Avoca Valley, and the assessment was limited to headwater stream reaches. Noting this limitation, hydrological condition of the Avoca Valley ranked equal fourth, with the Kiewa, among the 23 SRA valleys.
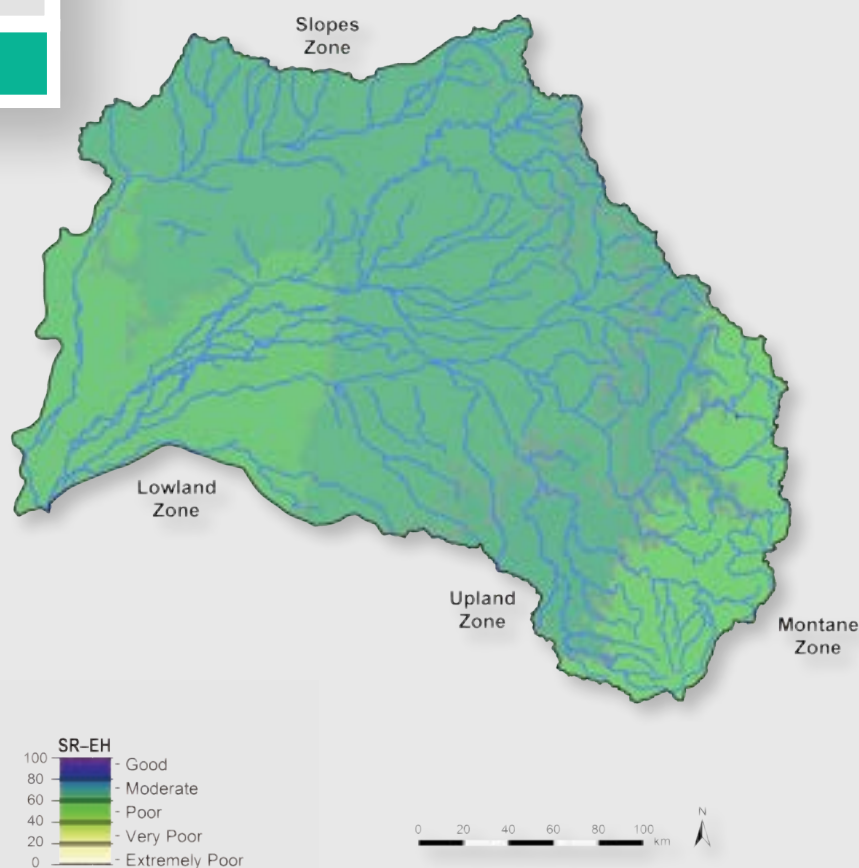
Hydrology

Border Rivers Valley

63	Valley
39	Montane
83	Upland
75	Slopes
47	Lowland

68	Valley
71	Montane
75	Upland
69	Slopes
60	Lowland

52	Valley
34	Montane
34	Upland
51	Slopes
72	Lowland

74	Valley
88	Montane
68	Upland
74	Slopes
70	Lowland

83	Valley
97	Montane
99	Upland
85	Slopes
75	Lowland

Map zones: Slopes Zone, Lowland Zone, Upland Zone, Montane Zone

SR–EH
- Good
- Moderate
- Poor
- Very Poor
- Extremely Poor

The Border Rivers catchment is 62,500 km², or about 6% of the Basin area, bounded by the Queensland border on the north and west. The rivers rise on the western slopes of the Great Dividing Range 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 then 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 New South Wales. In-stream storages include the Coolmunda, Glenlyon, Pindara and Rangers valley dams (combined volume 641 GL).

River Ecosystem Health

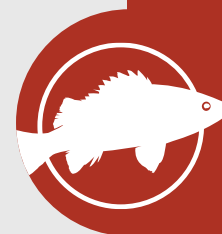The Border Rivers Valley river ecosystem was rated in **poor health**.

(Lowland, Slopes, Upland and Montane zones: Poor).
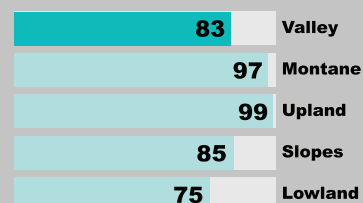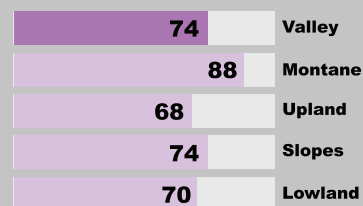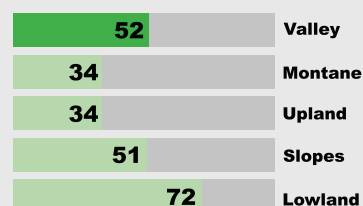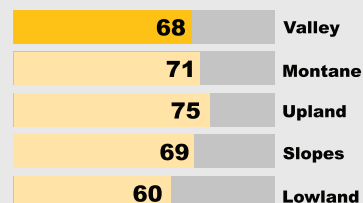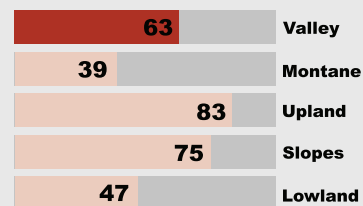
The Fish community of the Border Rivers Valley river system was rated in moderate condition, with an aggregate Fish Index score (SR–FI) of 63. (Lowland zone: Poor condition; Slopes zone: Moderate; Upland zone: Good; Montane zone: Very Poor).

The fish community was characterised by a moderate score for expected native fish species, nativeness and for native fish recruitment. Overall the valley had retained much of its native species richness, though the Lowland zone in particular had fewer fish and lacked almost 50% of the predicted native species. Native fish outnumbered alien species and contributed more than 63% of total fish biomass in the valley. Native fish recruitment was poor in the Montane zone (only four of the seven native species observed in the Montane zone showed evidence of recruitment in at least one site). Recruitment was moderate in the other three zones.

Fish

The Macroinvertebrate community of the Border Rivers Valley river system was rated in moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 68. (All zones: Moderate condition).

The proportion of sites in moderate condition was high (50%), especially in the Slopes to Montane zones, and eight sites (22%) were rated in good condition. Expectedness was low to moderate and varied by up to 23 points among sites. Family richness generally was high though reduced compared to reference condition. The number of families found was lowest in the Lowland zone (38 families) and highest in the Slopes zone (55 families), though the Montane zone had the highest average number of families per site (35).

Macroinvertebrates

The riverine Vegetation of the Border Rivers Valley river system was rated in poor condition, with an aggregate Vegetation Index score (SR–VI) of 52. (Lowland zone: Moderate condition; Slopes zone: Poor condition; Upland and Montane zones: Very Poor condition).

The abundance and diversity of valley riverine vegetation is in poor condition overall, with a large difference from reference in the Montane, Upland and Slopes zones, and a moderate difference in the Lowland zone. The poor rating for the abundance and diversity indicator is largely due to the extent (abundance) of the major vegetation groups as given in NVIS 3.0. Valley-wide abundance in both the near riparian and lowland floodplain domains shows a large difference from reference. MVG richness is maintained as no MVG has been completely reduced. Vegetation in the Lowland Floodplain domain has 54% stability.

Vegetation

The Physical Form of the Border Rivers Valley river system was rated in moderate condition, with an aggregate Physical Form Index score (SR–PI) of 74. (Lowland, Slopes and Upland zones: Moderate condition; Montane zone: Good condition).

The valley's river channel form was rated as Moderate. Bank dynamics was rated as good. Bed dynamics was rated as moderate. Floodplain dynamics was rated as poor. The valley's riverine physical form was characterised by elevated sediment loads since European settlement, resulting in sedimentation on the floodplain and within the channel. Channels were simplified, with reduced variability in channel width, particularly in the Upland zone, and increased meander wavelength.

Physical Form

The Hydrology of the Border Rivers Valley river system was rated in good condition, with an aggregate Hydrology Index (SR–HI) score of 83. (Slopes, Upland and Montane zones: Good condition, Lowland zone: Moderate condition).

Mainstem river reaches were generally characterised by moderate alteration from reference in high over bank floods, flow seasonality and near reference condition for low- and zero-flow events, low over bank floods, flow variability, high-flow and flow gross volume. The headwater streams were rated in good condition. Throughout some of the headwater streams the magnitude of low flows were reduced and the amplitude of seasonal flow variations was increased.
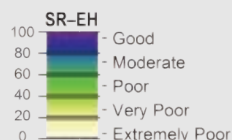
Hydrology

Broken Valley

VERY POOR

7	Valley
6	Slopes
8	Lowland

80	Valley
81	Slopes
80	Lowland

21	Valley
34	Slopes
15	Lowland

89	Valley
91	Slopes
87	Lowland

|	
97	Valley
99	Slopes
95	Lowland

The Broken River rises east of Mansfield, Victoria. It flows west to Lake Nillahcootie, then north to Benalla, then west again to join the Goulburn River above Shepparton. 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 6,800 km^2 — less than 1% of the Murray–Darling Basin.
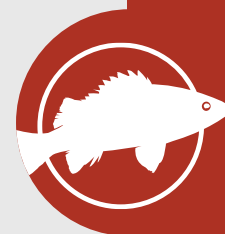
River Ecosystem Health

The Broken Valley river ecosystem was rated in **very poor health.**
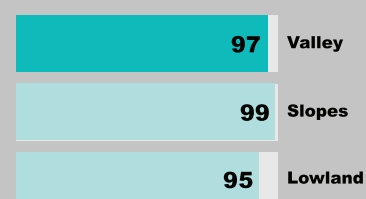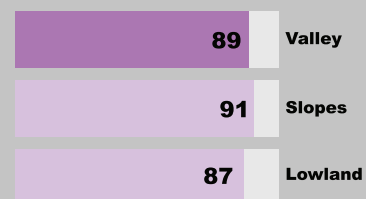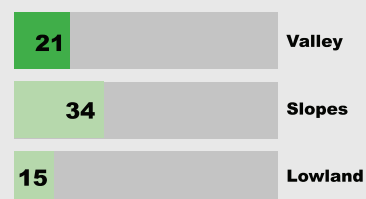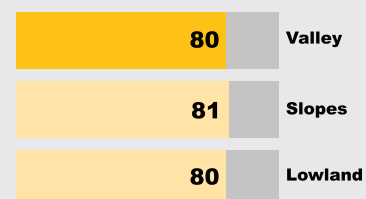
(Lowland and Slopes zones: Very Poor).

The Fish community of the Broken Valley river system was rated in extremely poor condition, with an aggregate Fish Index score (SR–FI) of 7. (Lowland and Slopes zones: Extremely Poor condition).

Overall, the fish community had reduced numbers of expected native species and low population densities. Only five of the 11 native species recorded showed any evidence of recruitment. There was an extreme difference from reference condition for expectedness and very large differences from reference for nativeness and recruitment. Broken Valley was equal 2nd lowest of the Basin's valleys for fish condition.

Fish

The Macroinvertebrate community of the Broken Valley river system was rated in good condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 80. (Lowland and Slopes zone: Good condition).

The proportion of sites in good condition was high across both zones (59%). Expectedness showed a minor difference from reference condition for both presence and frequency of occurrence of expected families in samples from edge and riffle habitats. Family richness was generally high, and showed minor reductions from reference condition.

Macroinvertebrates

The riverine Vegetation of the Broken Valley river system was rated in very poor condition, with an aggregate Vegetation Index score (SR–VI) of 21. (Lowland zone: Extremely Poor condition; Slopes zone: Very Poor condition).

The abundance and diversity of riverine vegetation was in very poor condition in near riparian and lowland floodplain areas. There was also a very large difference from reference condition for vegetation quality and integrity; and also for structure, nativeness and fragmentation—indicating very poor condition—in these same areas, resulting in the Broken Valley ranking equal lowest for this theme. This is, in part, reflecting the degree of rural development throughout the valley, with grazing and cereal cropping for much of the river's length and fruit and dairy irrigation in the lower reaches.

Vegetation

The Physical Form of the Broken Valley river system was rated in good condition, with an aggregate Physical Form Index score (SR–PI) of 89. (Lowland and Slopes zones: Good condition).

The valley's river channel form and bank dynamics were in good condition (near reference). Bed dynamics and floodplain form were in moderate condition. Overall, the valley's riverine physical form was characterised by widespread channel enlargement, particularly in the Slopes zone. Elevated sediment loads since European settlement are associated with sedimentation of river channels within the Lowland zone.
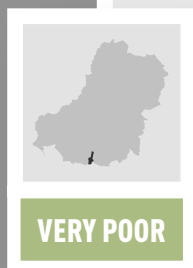
Physical Form

The Hydrology of the Broken Valley river system was rated in good condition, with an aggregate Hydrology Index (SR–HI) score of 97. (Lowland and Slopes zones: Good condition).

Both mainstem and headwater streams were generally characterised by near reference condition in flow variability, flow seasonality, low- and zero-flow events, high-flow and flow gross volume.

Hydrology

Campaspe Valley

20	Valley
34	Upland
26	Slopes
3	Lowland

72	Valley
61	Upland
72	Slopes
80	Lowland

18	Valley
22	Upland
13	Slopes
21	Lowland

77	Valley
82	Upland
82	Slopes
67	Lowland

|	
64	Valley
90	Upland
51	Slopes
61	Lowland

The Campaspe River rises near Woodend, Victoria and flows north for 50 km to the main instream storage, Lake Eppalock (304 GL) near Bendigo. From Lake Eppalock, the Campaspe joins the Murray near Echuca.

The Campaspe Valley covers 4,000 km^2 (about 0.4% of the Basin area).

River Ecosystem Health

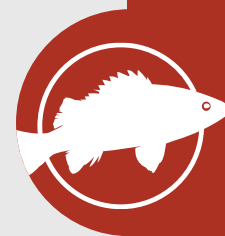The Campaspe Valley river ecosystem was rated in **very poor health**.

(Upland zone: Poor; Slopes and Lowland zones: Very Poor).
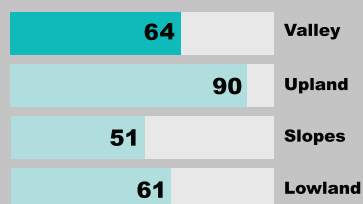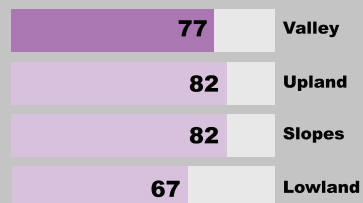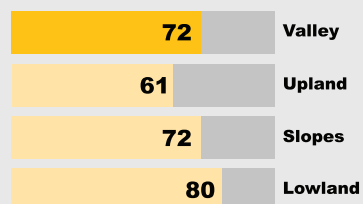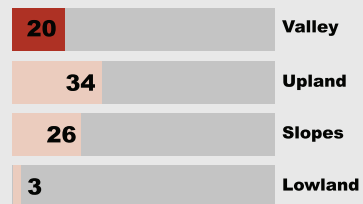
The Fish community of the Campaspe Valley river system was rated in very poor condition, with an aggregate Fish Index score (SR–FI) of 20. (Lowland zone: Extremely Poor condition; Slopes and Upland zones: Very Poor condition).

The fish community of the Campaspe had reduced numbers of expected native species and low biomass of those native fish populations present. Alien species comprised over 90% of the biomass. Native fish recruitment was poor, moderate and extremely poor in the Upland, Slopes and Montane zones respectively. Large-bodied native fish were few, and showed no evidence of recruitment.

Fish

The Macroinvertebrate community of the Campaspe Valley river system was rated in moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 72. (Lowland zone: Good condition; Slopes and Upland zones: Moderate condition).

The Campaspe Valley ranked 11th of 23 Basin valleys for this theme. There was a moderate difference from reference condition for presence and frequency of occurrence of expected families in samples from edge and riffle habitats. The proportion of sites in moderate condition was high (57%) across all zones, and eight of the 33 sites (23%) were rated in good condition. Family richness was moderate and reduced compared to reference condition, with Lowland zone site communities being the most diverse.

Macroinvertebrates

The riverine Vegetation of the Campaspe Valley river system was rated in extremely poor condition, with an aggregate Vegetation Index score (SR–VI) of 18. (Lowland zone and Upland zones: Very Poor condition; Slopes zone: Extremely Poor condition).

The abundance and diversity of Campaspe Valley riverine vegetation was in very poor condition overall and is notable for the extremely poor condition of the Slopes zone. The Quality and Integrity of valley riverine vegetation is in very poor condition overall, with no difference between zones: Upland, Slopes and Lowland zones all show a very large difference from reference condition. Valley-wide abundance in the Near Riparian domain shows a very large difference from reference. Main vegetation group richness is moderately different from reference.

Vegetation

The Physical Form of the Campaspe Valley river system was rated in moderate condition, with an aggregate Physical Form Index score (SR–PI) of 77. (Lowland zone: Moderate condition; Slopes and Upland zones: Good condition).

Overall, the valley's riverine physical form was characterised by channel enlargement and simplification. There was also indication of elevated sediment loads since European settlement and associated sedimentation within the Lowland zone river channel and floodplain. Channel form, bed dynamics and floodplain form indicators were all moderate and showed minor differences from reference condition. Bank dynamics were in good (near reference) condition.

Physical Form

The Hydrology of the Campaspe Valley river system was rated in moderate condition, with an aggregate Hydrology Index (SR–HI) score of 64. (Lowland zone: Moderate condition; Slopes zone: Poor condition; Upland zone: Good condition).

The mainstem river reaches were generally characterised by a large difference from reference condition in flow seasonality, moderate alteration in flow variability and low- and zero-flow events and near to reference condition in high-flow and flow gross volume. The headwater streams were generally characterised by little or no alteration in any of these indicators. There was a large difference from reference condition for the flow regime within channels.
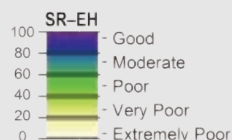
Hydrology

Castlereagh Valley

POOR

38		Valley
28		Upland
53		Slopes
28		Lowland

78		Valley
81		Upland
78		Slopes
74		Lowland

97		Valley
96		Upland
97		Slopes
99		Lowland

87		Valley
89		Upland
81		Slopes
91		Lowland

100		Valley
100		Upland
100		Slopes
100		Lowland

The Castlereagh River rises south-west of Coonabarabran, New South Wales 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.

The Castlereagh catchment covers 17,500 km^2 (17% of the Basin area).

River Ecosystem Health

The Castlereagh Valley river ecosystem was rated in **poor health**.

(Lowland and Upland zones: Poor; Slopes zone: Moderate).
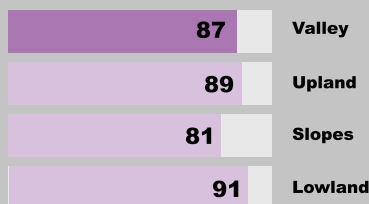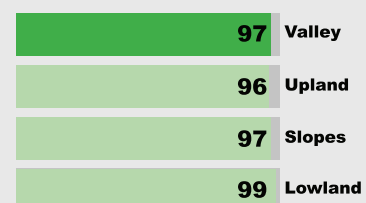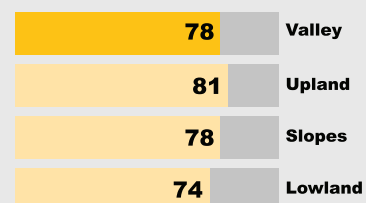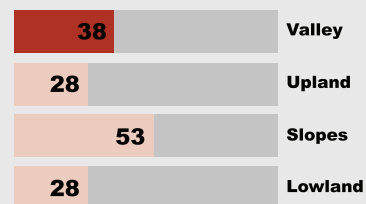
The Fish community of the Castlereagh Valley river system was rated in very poor condition, with an aggregate Fish Index score (SR–FI) of 38. (Lowland and Upland zones: Very Poor condition; Slopes zone: Poor condition).

In general, the fish community of the Castlereagh Valley had greatly reduced numbers of expected native species (with a very large difference from reference condition). The Lowland zone in particular had few fish and lacked almost 75% of predicted native species. Most species showed signs of recruitment. Carp comprised almost half of the fish biomass in the valley. Larger native species were particularly lacking and recruitment was very poor, good and good in the Upland, Slopes and Lowland zones respectively.
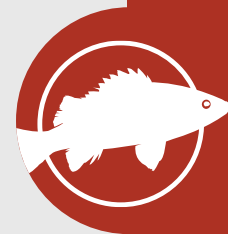
Fish

The Macroinvertebrate community of the Castlereagh Valley river system was rated in moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 78. (Lowland and Slopes zone: Moderate condition; Upland zone: Good condition).

There was a moderate difference from reference condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats. The proportion of sites in good condition was 14 out of 35 rated sites, or 40%) across all zones. No site was in poor or extremely poor condition. Family richness generally was moderate and reduced compared to reference condition.

Macroinvertebrates

The riverine Vegetation of the Castlereagh Valley river system was rated in good condition, with an aggregate Vegetation Index score (SR–VI) of 97. (Lowland, Slopes and Upland zones: Good condition).

The vegetation abundance and diversity was in good condition and showed only minor differences from reference condition within near riparian and lowland floodplain areas. Vegetation quality and integrity were also in good condition with only a minor difference from reference condition for the structure, nativeness and fragmentation of vegetation communities. The lowland floodplain domain is little affected by clearing.

Vegetation

The Physical Form of the Castlereagh Valley river system was rated in good condition, with an aggregate Physical Form Index score (SR–PI) of 87. (Lowland, Slopes and Upland zones: Good condition).

Overall, the valley's riverine physical form was characterised by elevated sediment loads since European settlement and associated sedimentation in the Slopes and Lowland zones. There were also indications of bed aggradation and channel narrowing in the Lowland zone. Channel form and bank dynamics were in good (near reference) condition. Bed dynamics and floodplain form indicators were moderate and showed minor differences from reference condition.

Physical Form

The Hydrology of the Castlereagh Valley river system was rated in good condition, with an aggregate Hydrology Index (SR–HI) score of 100. (Lowland, Slopes and Upland zones: Good condition).

Both the mainstem river and headwater streams were characterised by little or no alteration from reference condition for any indicators. Results for high over bank flow duration and high over bank flow spells showed near to reference condition throughout the mainstem river length (mostly associated with increased flows).
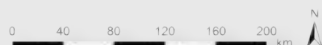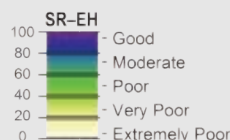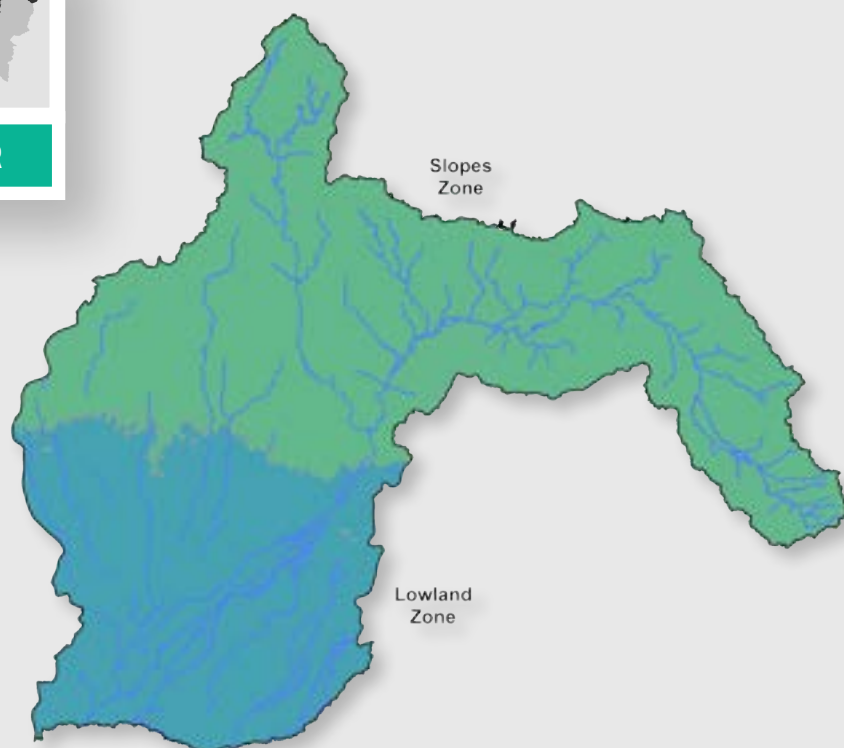
Hydrology
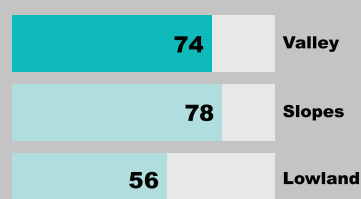
Condamine Valley

POOR

Slopes Zone

Lowland Zone

SR–EH
- Good
- Moderate
- Poor
- Very Poor
- Extremely Poor

65		Valley
69		Slopes
58		Lowland

77		Valley
74		Slopes
80		Lowland

83		Valley
71		Slopes
100		Lowland

71		Valley
73		Slopes
69		Lowland

|		
74		Valley
78		Slopes
56		Lowland

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 River (Leslie Dam: 106 GL; Chinchilla Weir: 10 GL) and by 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 km², or about 15% of the Basin area.

River Ecosystem Health

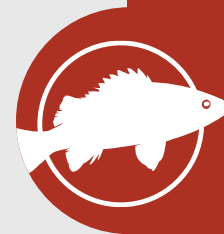The Condamine Valley river ecosystem was rated in **poor health.**

(Lowland zone: Moderate; Slopes zone: Poor).
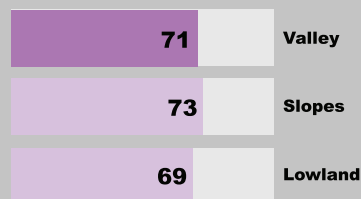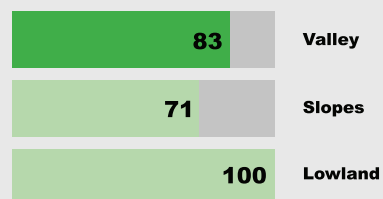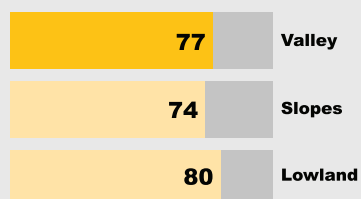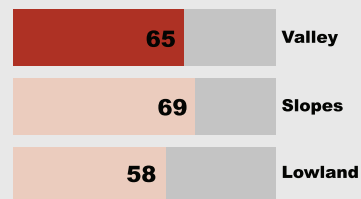
The Fish community of the Condamine Valley river system was rated in moderate condition, with an aggregate Fish Index score (SR–FI) of 65.
(Lowland zone: Poor condition; Slopes zone: Moderate condition).

The fish community was characterised by a poor score for expected native fish species, a good score for nativeness and a moderate score for native fish recruitment. The Slopes zone in particular lacked 50% of the predicted native species. The valley had reduced native species richness. Alien species contributed 43% of the biomass in samples. Native fish recruitment was moderate in both the Slopes and Lowland zones and in the valley overall.

Fish

The Macroinvertebrate community of the Condamine Valley river system was rated in moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 77.
(Lowland zone: Good condition; Slopes zone: Moderate condition).

The proportion of sites in good condition was high across all zones (21 of 35 rated sites, 60%); only 6 (17%) were in poor or very poor condition. Family richness generally was low, and was reduced compared to reference condition.

Macroinvertebrates

The riverine Vegetation of the Condamine Valley river system was rated in good condition, with an aggregate Vegetation Index score (SR–VI) of 83.
(Lowland zone: Good condition; Slopes zone: Moderate condition).

The riverine vegetation of the Condamine Valley is notable for being in near reference condition, especially in the Lowland zone. Most of the metrics are based on vegetation mapping that is not current and can be variable in quality. The condition of either or both the near riparian and lowland floodplain domains, and hence of the valley itself, may have changed since the source mapping was compiled. Within the Lowland zone, the abundance and nativeness are noticeably higher in the near riparian domain than in the lowland floodplain.

Vegetation

The Physical Form of the Condamine Valley river system was rated in moderate condition, with an aggregate Physical Form Index score (SR–PI) of 71.
(Lowland and Slopes zones: Moderate condition).

Overall, the valley's riverine physical form was characterised by enlarged channels with evidence of channel widening and bed degradation. There was also indication of elevated sediment loads since European settlement. The valley's river channel form was rated as moderate. Bank dynamics and floodplain dynamics were rated as good, while bed dynamics was rated as moderate.

Physical Form

The Hydrology of the Condamine Valley river system was rated in moderate condition, with an aggregate Hydrology Index (SR–HI) score of 74.
(Lowland zone: Poor condition; Slopes zone: Moderate condition).

The Condamine Valley river system was characterised by a mainstem river in moderate condition and headwater streams in good condition. The mainstem river reaches were generally characterised by a moderate change to reference condition in high over bank floods, flow variability, flow seasonality, low- and zero-flow events, high-flow and flow gross volume and near to reference condition in low over bank floods. The headwater streams were generally characterised by little or no alteration in any indices.
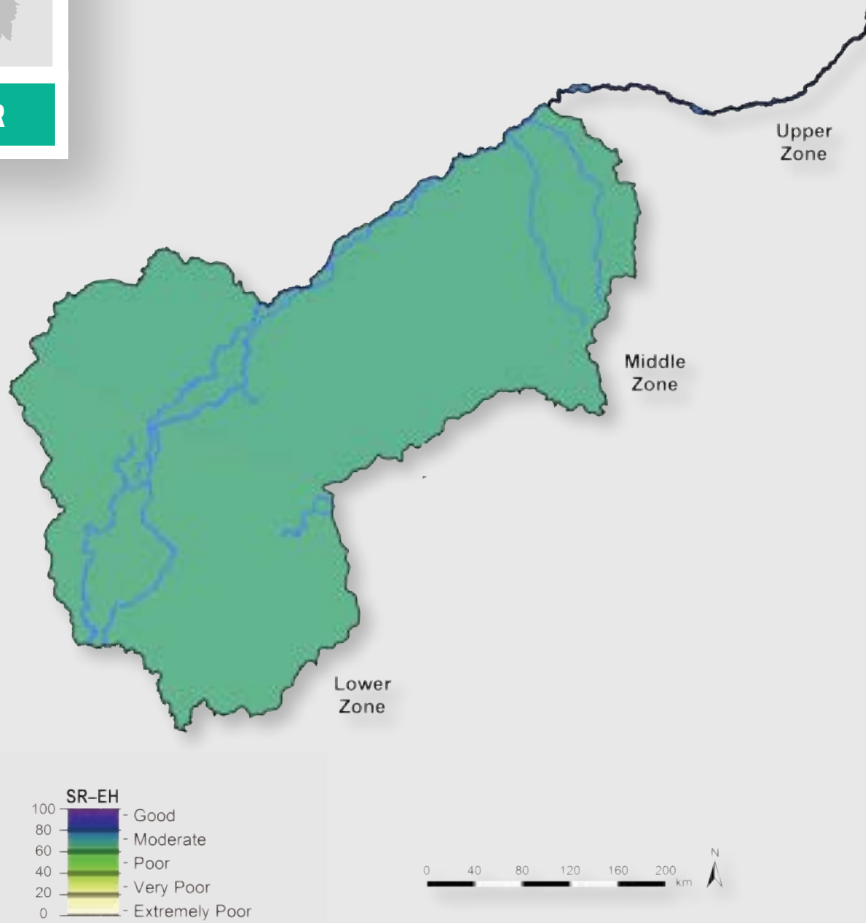
Hydrology

Darling Valley

52			Valley
63			Upper
48			Middle
47			Lower

53			Valley
56			Upper
52			Middle
52			Lower

100			Valley
100			Upper
100			Middle
100			Lower

SR–EH
- Good
- Moderate
- Poor
- Very Poor
- Extremely Poor

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. 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^2 (about 13% of the Basin).

River Ecosystem Health

The Darling Valley river ecosystem was rated in **poor health**.

(Lower and Middle zones: Poor; Upper zone: Moderate).

60			Valley
48			Upper
64			Middle
60			Lower

75			Valley
68			Upper
67			Middle
60			Lower
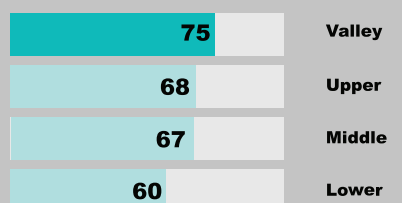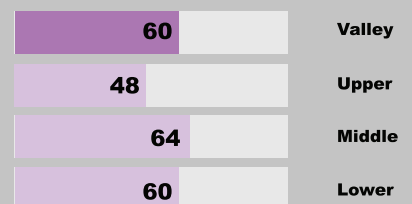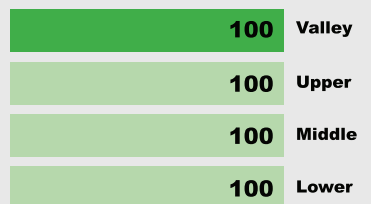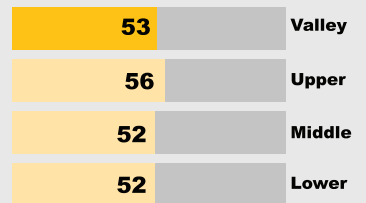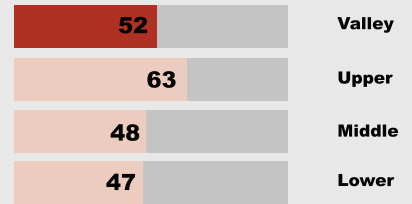
The Fish community of the Darling Valley river system was rated in poor condition, with an aggregate Fish Index score (SR–FI) of 52. (Lower and Middle zones: Poor condition; Upper zone: Moderate condition).

The fish community was characterised by a poor score for expected native fish species, a good score for nativeness and a poor score for native fish recruitment. The fish communities were similar in all three zones, each with 7 of the 15 predicted native species represented in the samples and each with a similar proportion of native individuals in the total fish community (Upper zone: 89%, Middle zone: 82%, and Lower zone: 87%). The valley had lost half of its native species richness, but alien species contributed 35% of the biomass in samples.
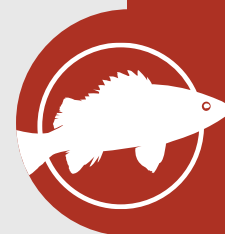
Fish

The Macroinvertebrate community of the Darling Valley river system was rated in poor condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 53. (Lower, Middle and Upper zones: Poor condition).

All zones showed large differences from reference condition. A wide confidence interval for the Lower zone value indicated more variability there, though most sites showed a moderate to large difference from reference condition. The proportion of sites in poor to extremely poor condition was high across all zones (66%). Family richness generally was very low, and was also low compared to reference.

Macroinvertebrates

The riverine Vegetation of the Darling Valley river system was rated in good condition, with an aggregate Vegetation Index score (SR–VI) of 100. (Lower, Middle and Upper zones: Good condition).

The riverine vegetation of the Darling Valley is notable for being in near reference condition in all three zones, with little evidence of clearing, loss, turnover or fragmentation of the main vegetation groups. The structure sub-indicator implies modifications close to the main river channels. Most of the metrics are based on vegetation mapping that is not up to date and can be of variable quality. The condition of either or both the Near riparian and Lowland Floodplain domains, and hence of the valley itself, may have changed since the source mapping was compiled.

Vegetation

The Physical Form of the Darling Valley river system was rated in moderate condition, with an aggregate Physical Form Index score (SR–PI) of 60. (Lower and Middle zones: Moderate condition; Upper zone: Poor condition).

Overall, the valley's physical form was characterised by accelerated floodplain sediment deposition in the Upper zone since European settlement and evidence of enlarged channels in the Lower zone. Bank dynamics was rated as good. Bed dynamics and floodplain dynamics were rated as moderate.

Physical Form

The Hydrology of the Darling Valley river system was rated in moderate condition, with an aggregate Hydrology Index (SR–HI) score of 75. (Lower, Middle and Upper zones: Moderate condition).

The Darling Valley river system was characterised by a mainstem river in moderate condition and headwater streams in good condition. The mainstem river reaches were generally characterised by a large difference from reference condition in flow variability and flow gross volume, moderate alteration from reference in low over bank floods and flow seasonality, and a large difference from reference in high-flow events. There was little or no alteration in high over bank floods and low- and zero-flow events. The headwater streams were generally characterised by little or no alteration in any indices.
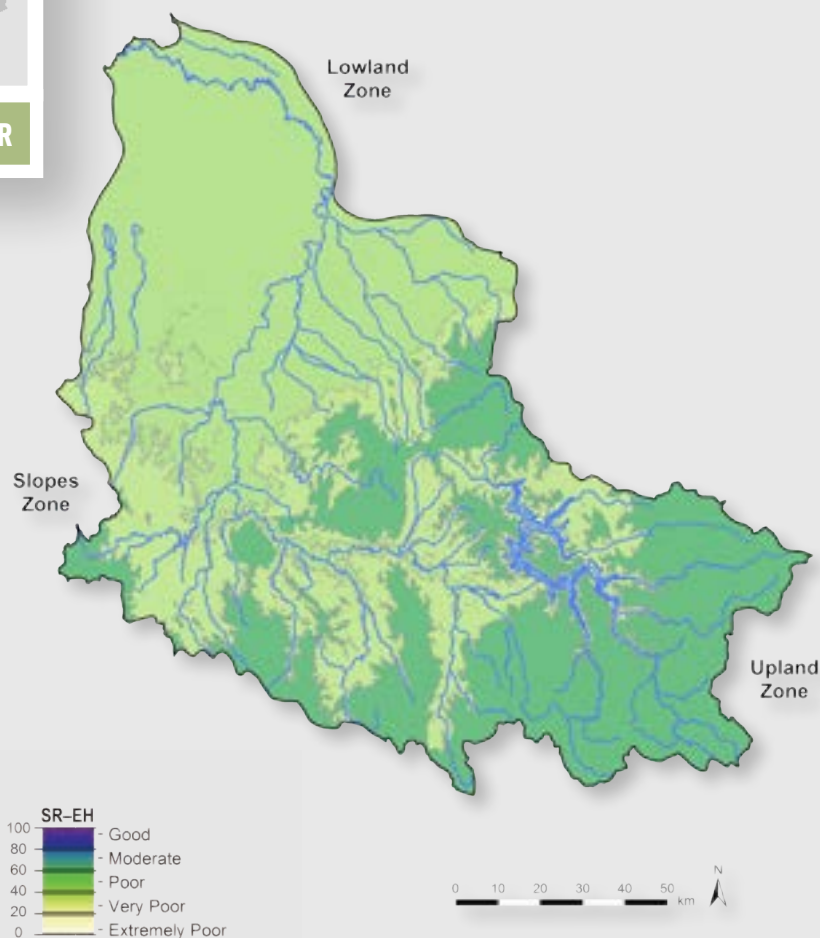
Hydrology

Goulburn Valley

VERY POOR

Lowland Zone

Slopes Zone

Upland Zone

	Value
Valley	15
Upland	21
Slopes	8
Lowland	18

	Value
Valley	55
Upland	66
Slopes	69
Lowland	43

	Value
Valley	46
Upland	100
Slopes	24
Lowland	36

	Value
Valley	82
Upland	96
Slopes	95
Lowland	67

	Value
Valley	43
Upland	100
Slopes	62
Lowland	20

SR–EH
- 100 / 80 — Good
- 60 — Moderate
- 40 — Poor
- 20 — Very Poor
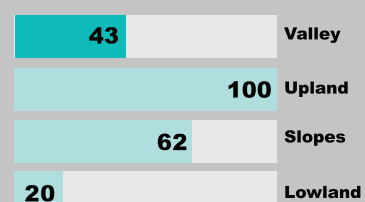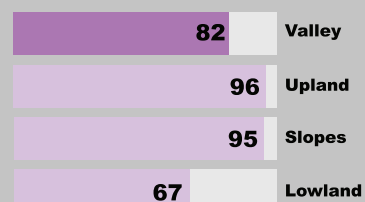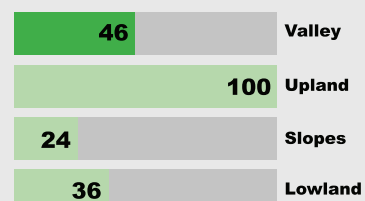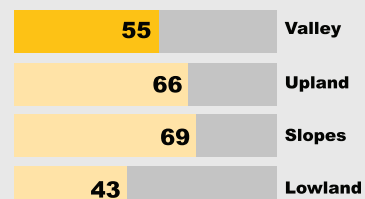- 0 — Extremely Poor

0 10 20 30 40 50 km

The Goulburn River rises in the Great Dividing Range and joins the River Murray upstream of Echuca. Headwater streams join the Goulburn at Lake Eildon (3,334 GL), upstream of Shepparton. A second instream storage is Goulburn Reservoir (25.5 GL) and an offstream storage is Greens Lake (28 GL).

The Goulburn Valley covers 16,800 km^2 (less than 2% of the Basin area).
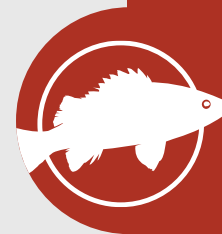
River Ecosystem Health

The Goulburn Valley river ecosystem was rated in **very poor health.**

(Lowland and Slopes zones: Very Poor; Upland zone: Poor).

The Fish community of the Goulburn Valley river system was rated in extremely poor condition, with an aggregate Fish Index score (SR–FI) of 15. (Lowland and Slopes zones: Extremely Poor condition; Upland zone: Very Poor condition).

The fish community of the Goulburn had reduced numbers of expected native species and with an extreme difference from reference. There were very large differences from reference for recruitment and nativeness. In general, the fish community of the Goulburn had lost much of its native species richness and alien species contributed over 60% of the biomass in samples. The Upland zone in particular had few native fish and lacked 83% of the predicted species.

Fish

The Macroinvertebrate community of the Goulburn Valley river system was rated in poor condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 55. (Lowland zone: Poor condition; Slopes and Upland zones: Moderate condition).

The proportion of sites in poor to extremely poor condition was high overall (57%), especially in the Lowland zone. Family richness was generally high, though low compared to reference condition. The Goulburn Valley contained 87% of the families found across the Basin. Diversity was low (average 16 families per site), with the Upland zone being most diverse at site scale (average 18 families per site).

Macroinvertebrates

The riverine Vegetation of the Goulburn Valley river system was rated in poor condition, with an aggregate Vegetation Index score (SR–VI) of 46. (Lowland and Slopes zones: Very Poor condition, Upland zone: Good condition).

The abundance and diversity of Goulburn Valley riverine vegetation was in moderate condition overall, with a moderate difference from reference in near riparian and lowland areas. There was a large difference from reference condition for the structure and nativeness of vegetation communities and groups within near riparian and lowland areas.

Vegetation

The Physical Form of the Goulburn Valley river system was rated in good condition, with an aggregate Physical Form Index score (SR–PI) of 82. (Lowland zone: Moderate condition: Slopes and Upland zones: Good condition).

Overall, the valley's riverine physical form was characterised by channel enlargement and simplification, particularly in the Lowland zone. There was also indication of elevated sediment loads since European settlement and associated sedimentation within the Lowland zone river channel and floodplain. Channel form, bed dynamics and floodplain form indicators were all moderate and showed minor differences from reference condition. Bank dynamics were in good (near reference) condition.

Physical Form

The Hydrology of the Goulburn Valley river system was rated in poor condition, with an aggregate Hydrology Index (SR–HI) score of 43. (Lowland zone: Very Poor condition; Slopes zone: Moderate condition; Upland zone: Good condition).

The Goulburn Valley river system was characterised by a mainstem river in very poor condition and headwater streams (with little or no alteration from reference) in good condition. The mainstem river reaches were generally characterised by a large difference from reference condition in flow seasonality and flow variability. A large difference from reference was also found for low- and zero-flow events, a moderate difference in high-flow events and near reference for flow gross volume.
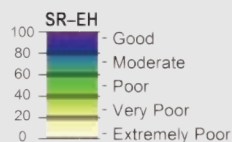
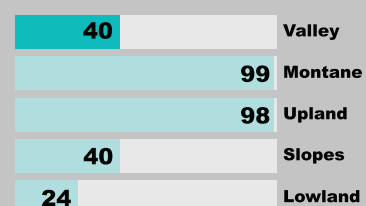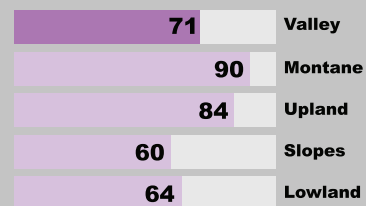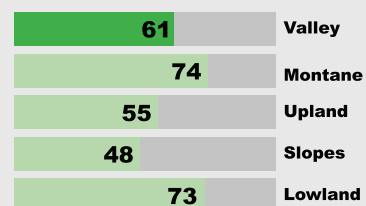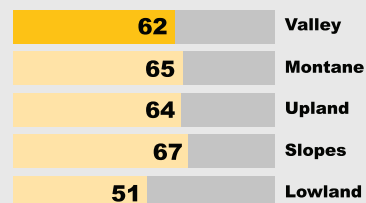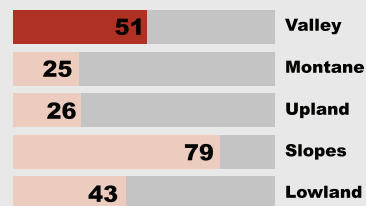*Hydrology*

Gwydir Valley

POOR

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

The Gwydir Valley covers 26,500 km² (about 2.5% of the Basin area).

River Ecosystem Health

The Gwydir Valley river ecosystem was rated in **poor health.**

(Lowland, Slopes, Upland and Montane zones: Poor).

51	Valley
25	Montane
26	Upland
79	Slopes
43	Lowland

62	Valley
65	Montane
64	Upland
67	Slopes
51	Lowland

61	Valley
74	Montane
55	Upland
48	Slopes
73	Lowland

71	Valley
90	Montane
84	Upland
60	Slopes
64	Lowland

40	Valley
99	Montane
98	Upland
40	Slopes
24	Lowland

The Fish community of the Gwydir Valley river system was rated in poor condition, with an aggregate Fish Index score (SR–FI) of 51. (Lowland zone: Poor condition; Slopes zone: Moderate condition; Montane and Upland zones: Very Poor condition).

The Gwydir Valley had the fifth highest biomass of all the Basin valleys (11.7 kg/site), but the fish community composition was highly variable among zones. The Gwydir had reduced numbers of expected native species (assessed as very poor in the Upland zone). Nativeness varied across zones, being moderate in the Slopes zone, but extremely poor in the Montane zone. Recruitment was very poor in the Montane zone, with evidence only for the gudgeon. However, recruitment of the alien species gambusia and redfin perch was observed at six of the seven sampling sites.

Fish

The Macroinvertebrate community of the Gwydir Valley river system was rated in moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 62. (Lowland zone: Poor condition; Montane, Slopes and Upland zones: Moderate condition).

The communities of the Montane, Upland and Slopes zones showed moderate differences from reference condition, but the Lowland zone showed large differences. Expectedness was moderate overall and variation among sites was minor. Family richness was generally low compared to reference condition. Diversity was moderate (average 23 families per site), with the Montane and Upland zones being most diverse at site scale (average 36 and 32 families respectively).

Macroinvertebrates

The riverine Vegetation of the Gwydir Valley river system was rated in moderate condition, with an aggregate Vegetation Index score (SR–VI) of 61. (Lowland zone: Moderate condition; Slopes and Upland zones: Poor condition; Montane zone: Moderate condition).

The abundance and diversity of Gwydir Valley riverine vegetation was in moderate condition overall (and a moderate difference from reference in all four zones). Valley-wide abundance in both the near riparian domain and the lowland floodplain shows a moderate difference from reference condition. The quality and integrity of valley riverine vegetation is in moderate condition overall, strongly influenced by nativeness in the near-riparian domain, which shows a large difference from reference in the Montane, Upland and Slopes zones.

Vegetation

The Physical Form of the Gwydir Valley river system was rated in moderate condition, with an aggregate Physical Form Index score (SR–PI) of 71. (Lowland and Slopes zones: Moderate condition; Upland and Montane zones: Good condition).

Overall, the valley's physical form was characterised by elevated sediment loads since European settlement and associated sedimentation within the Lowland zone river channel and floodplain. Channel form and bank dynamics were rated as good, but bed dynamics were poor and floodplain dynamics were very poor. There was also evidence of adjustments in channel dimensions in the Upland and Lowland zones and widespread channel straightening and simplification.

Physical Form

The Hydrology of the Gwydir Valley river system was rated in poor condition, with an aggregate Hydrology Index (SR–HI) score of 49. (Lowland zone: Very Poor condition; Slopes zone: Poor condition; Upland and Montane zones: Good condition).

The Gwydir Valley river system was characterised by a mainstem river in very poor condition and headwater streams (with little or no alteration from reference) in good condition. The mainstem river reaches were generally characterised by a large difference from reference condition in low over bank floods, flow variability and low- and zero-flow events. The headwater streams showed little or no alteration in any indices.
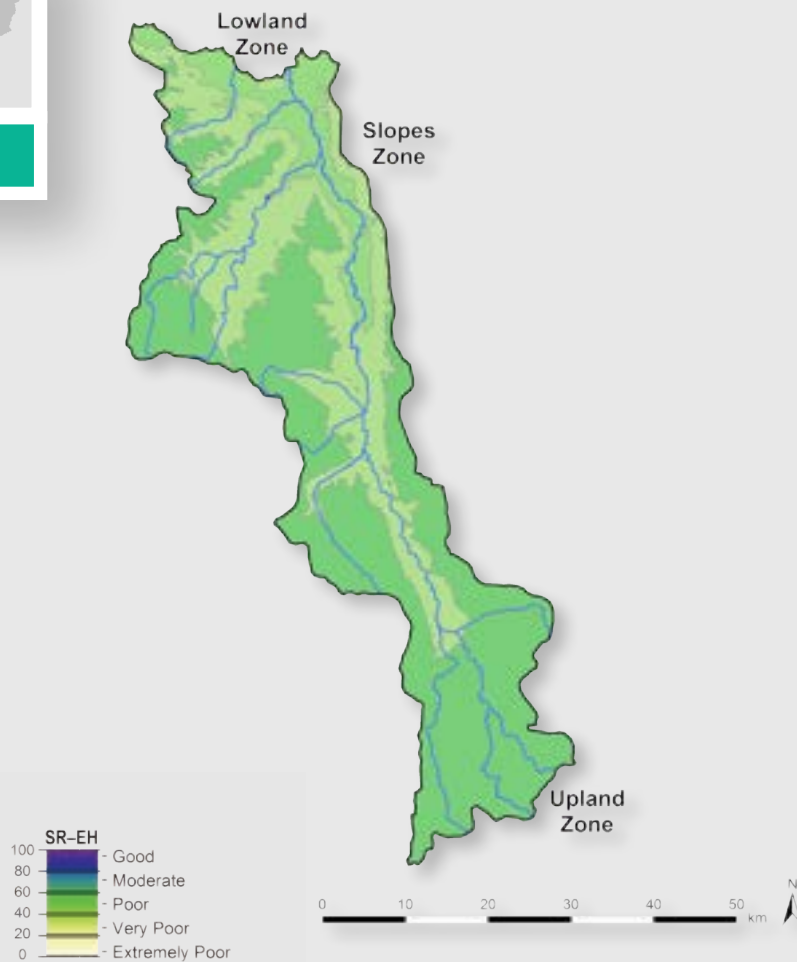
Hydrology

Kiewa Valley

POOR

16	Valley
0	Upland
10	Slopes
45	Lowland

84	Valley
91	Upland
84	Slopes
75	Lowland

40	Valley
99	Upland
12	Slopes
3	Lowland

SR–EH
- 100–80 Good
- 80–60 Moderate
- 60–40 Poor
- 40–20 Very Poor
- 20–0 Extremely Poor

|	
94	Valley
99	Upland
96	Slopes
82	Lowland

The west Kiewa River rises near Mt Hotham, Victoria and the East Kiewa River rises above Falls Creek township. They join near Mt Beauty and flow northward to meet the River Murray below Lake Hume. 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^2, the smallest of the valleys in the Basin.

River Ecosystem Health

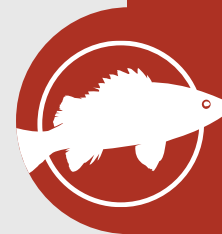The Kiewa Valley river ecosystem was rated in **poor health.**

(Upland zone: Poor; Slopes and Lowland zones: Very Poor).

99	Valley
100	Upland
100	Slopes
#N/A	Lowland
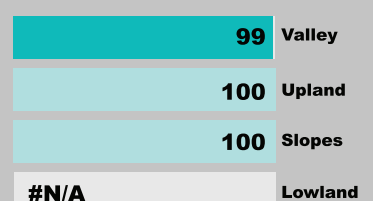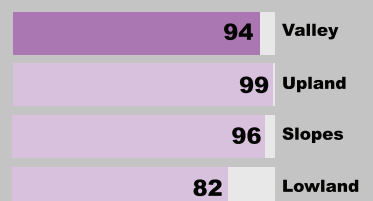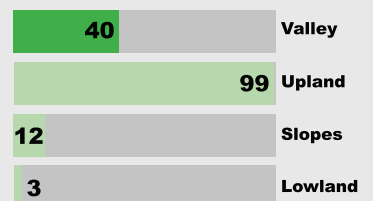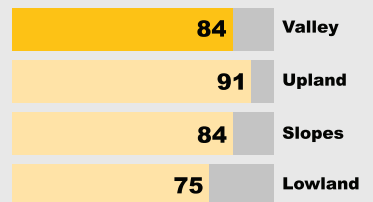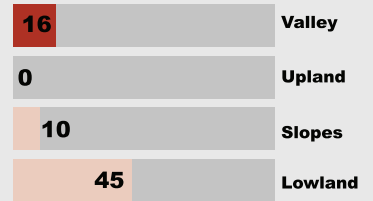
The Fish community of the Kiewa Valley river system was rated in extremely poor condition, with an aggregate Fish Index score (SR–FI) of 16. (Lowland zone: Poor condition; Upland and Slopes zones: Extremely Poor condition).

The fish community of the Kiewa had a very large difference from reference (41% of expected native species were recorded). There was a very large difference from reference for recruitment and nativeness. The proportion of expected native fish caught per zone was 16% for the Upland; 24% for the Slopes and 21% for the Lowland zone. The equivalent data for biomass were 8.6%, 6.1% and 35% respectively. The only native fish caught in the Upland zone (two-spined blackfish) showed no evidence of recruitment; however, all six native species caught in the Lowland zone showed recruitment.

Fish

The Macroinvertebrate community of the Kiewa Valley river system was rated in good condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 84. (Lowland zone: Moderate condition; Slopes and Upland zones: Good condition).

Seventy-eight per cent of the Basin's macroinvertebrate families were found in the Kiewa Valley. The proportion of sites in good condition was high overall (69%), especially in the Upland zone. Only one site was rated poor and none lower. Family richness was generally high and was also high compared to reference condition at most sites except in the Lowland zone. Diversity was also high (average 28 families per site). However, the Upland and Lowland zones had the highest and lowest representations of Basin-wide fauna (69 and 40% respectively).

Macroinvertebrates

The riverine Vegetation of the Kiewa Valley river system was rated in poor condition, with an aggregate Vegetation Index score (SR–VI) of 40. (Lowland and Slopes zones: Extremely Poor condition; Upland zone: Good condition).

Overall, there was a large difference from reference condition for the structure and nativeness of vegetation communities and groups within near riparian and lowland areas. There was a large difference from reference condition in the Slopes and Lowland zones for abundance and diversity; quality and integrity; and for nativeness. However, for the Upland zone, metrics for abundance, nativeness, richness and structure have moderate- to near-reference scores.

Vegetation

The Physical Form of the Kiewa Valley river system was rated in good condition, with an aggregate Physical Form Index score (SR–PI) of 94. (Lowland, Slopes and Upland zones: Good condition).

Overall, the valley's riverine physical form was characterised by elevated sediment loads since European settlement and associated sedimentation within the Lowland zone river channel and floodplain. Channel sediment and floodplain sediment deposition were modified from reference throughout most of the Upland zone, with the channel sediment ratio generally increased (many sites having large increases). Sinuosity was modified from reference in most of the Upland zone. However, channel form, floodplain form and bank dynamics were rated in good condition (close to reference), and bed dynamics as moderate.

Physical Form

The Hydrology of the Kiewa Valley river system was rated in good condition, with an aggregate Hydrology Index (SR–HI) score of 99. (Slopes and Upland zones: Good condition).

No mainstem river reaches were assessed. Headwater streams were generally in good condition, with little or no alteration from reference condition in flow Variability, flow seasonality, low- and zero-flow events, high-flow events or flow gross volume.
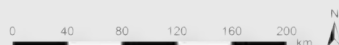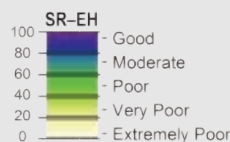
Hydrology

Lachlan Valley

7	Valley
9	Montane
4	Upland
2	Slopes
12	Lowland

67	Valley
71	Montane
78	Upland
66	Slopes
62	Lowland

57	Valley
27	Montane
34	Upland
22	Slopes
100	Lowland

87	Valley
93	Montane
85	Upland
80	Slopes
91	Lowland

64	Valley
98	Montane
99	Upland
62	Slopes
46	Lowland

SR–EH
- 100 / 80 — Good
- 60 — Moderate
- 40 — Poor
- 20 — Very Poor
- 0 — Extremely Poor

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^2 (about 8% of the Basin area).
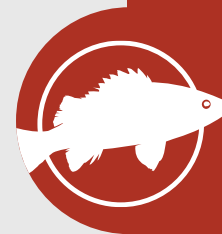
River Ecosystem Health

The Lachlan Valley river ecosystem was rated in **very poor health.**

(Lowland zone: Poor; Slopes, Upland and Montane zones: Very Poor).
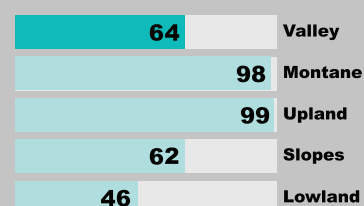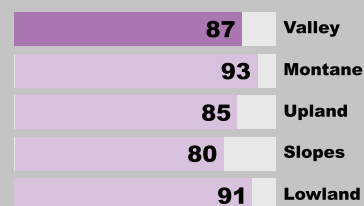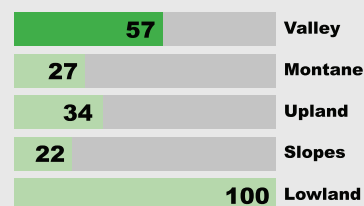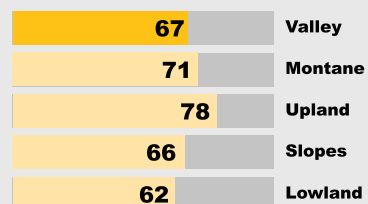
The Fish community of the Lachlan Valley river system was rated in extremely poor condition, with an aggregate Fish Index score (SR–FI) of 7. (Lowland, Slopes, Upland and Montane zones: Extremely Poor condition).

The Lachlan Valley has lost much of its native species richness and alien species contributed over 71% of fish biomass. Of the 18 native species expected to occur in the valley under reference condition, only six were captured. Native fish recruitment was also extremely poor in the Montane and Upland zones, and very poor in the Slopes and Lowland zones. There was a significant decline in the condition of the fish community since SRA 1 and also in the expectedness indicator, implying further loss of native species. Sampling took place during continuing severe drought conditions.

Fish

The Macroinvertebrate community of the Lachlan Valley river system was rated in moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 67. (Lowland, Slopes, Upland and Montane zones: Moderate condition).

The communities of the Montane, Upland, Slopes and Lowland zones all showed moderate differences from reference condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats. The proportion of sites in moderate or good condition was high across all zones (66% overall), including seven sites (20%) in good condition. Family richness was generally high, but was reduced compared to reference condition. Diversity was high (average 27 families per site), with the Montane and Upland zones being most diverse at site scale (average 46 and 47 families respectively).

Macroinvertebrates

The riverine Vegetation of the Lachlan Valley river system was rated in poor condition, with an aggregate Vegetation Index score (SR–VI) of 57. (Lowland zone: Good condition; Slopes, Upland and Montane zones: Very Poor condition).

The lowland floodplain domain is little affected by clearing. The abundance, nativeness and degree of fragmentation of major vegetation groups in the sampled floodplain area is near reference. There was a moderate difference from reference for the structure and nativeness of vegetation communities and groups within near riparian areas.

Vegetation

The Physical Form of the Lachlan Valley river system was rated in good condition, with an aggregate Physical Form Index score (SR–PI) of 87. (Lowland, Slopes and Upland zones: Moderate, Montane zone: Good condition).

Overall, the valley's physical form was characterised by evidence of adjustments in channel size and channel simplification and in particular, channel enlargement in the Slopes zone. Sediment loads to the floodplain have also been elevated since European settlement. Channel form and bank dynamics were rated as good, but bed and floodplain dynamics were moderate There was also evidence of adjustments in channel dimensions in the Upland and Lowland zones with widespread channel straightening and simplification and channel enlargement in the slopes zone.

Physical Form

The Hydrology of the Lachlan Valley river system was rated in moderate condition, with an aggregate Hydrology Index (SR–HI) score of 64. (Lowland zone: Poor condition; Slopes zone: Moderate condition; Upland and Montane zones: Good condition).

The Lachlan Valley river system was characterised by a mainstem river in very poor condition and headwater streams (with little or no alteration from reference) in good condition. The mainstem river reaches were generally characterised by close to reference condition for low over bank floods and flow variability, and a very large difference from reference in low- and zero-flow events. The headwater streams showed little or no alteration in any indices.

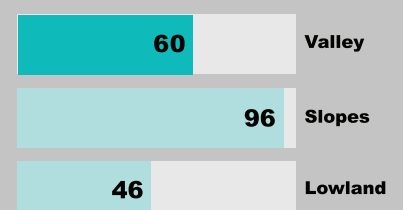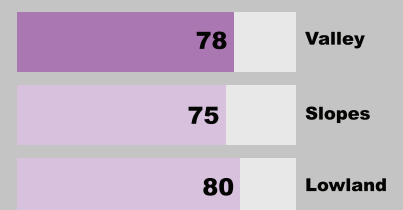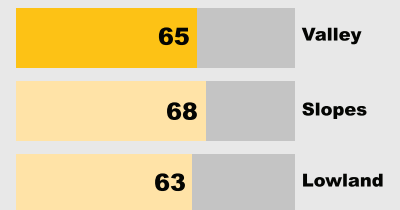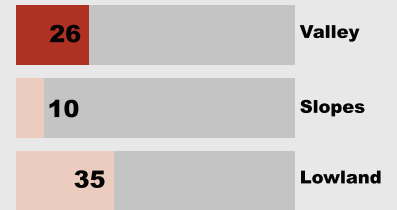**Hydrology**

Loddon Valley

VERY POOR
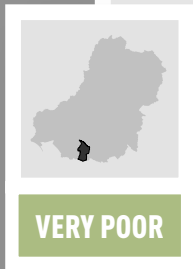
The Loddon River flows northward through central Victoria to join the Murray near Kerang, downstream of Torrumbarry Weir. Instream storages include Cairn Curran and Tullaroop dams and Laanecoorie Reservoir (total 228 GL). Inter-valley transfers from the Murray and Goulburn (via the Waranga Basin) enter 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^2, or about 1.5% of the Basin area.

River Ecosystem Health

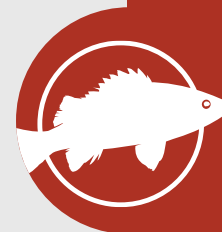The Loddon Valley river ecosystem was rated in **very poor health**.

(Lowland and Slopes zones: Very Poor).

	Value	Slopes	Lowland
	26	10	35
	65	68	63
	11	13	10
	78	75	80
	60	96	46

The Fish community of the Loddon Valley river system was rated in very poor condition, with an aggregate Fish Index score (SR–FI) of 26. (Lowland zone: Very Poor condition; Slopes zone: Extremely Poor condition).

The Loddon Valley has lost much of its native species richness and alien species contributed over 75% of fish biomass. There was a moderate score for nativeness and a very poor score for fish recruitment. The Slopes zone in particular had few fish and lacked 73% of the predicted native species. Native fish recruitment was very poor in both zones.

Fish

The Macroinvertebrate community of the Loddon Valley river system was rated in moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 65. (Lowland and Slopes zones: Moderate condition).

There was a large difference from reference condition in the presence and frequency of occurrence of expected families in samples from edge and riffle habitats. The proportion of sites in moderate condition was 57% across both zones and four of the 33 rated sites were in good condition. Family richness generally was very low, and was also low compared to reference condition.

Macroinvertebrates

The riverine Vegetation of the Loddon Valley river system was rated in extremely poor condition, with an aggregate Vegetation Index score (SR–VI) of 11. (Lowland and Slopes zones: Extremely Poor condition).

Riverine vegetation was in extremely poor condition overall, with reduced abundance, stability, structure and nativeness in the near riparian and lowland floodplain areas. There was also considerable fragmentation in the lowland floodplain (which is significantly affected by clearing). The abundance and degree of fragmentation of major vegetation groups in the sampled floodplain area were substantially different from reference condition.

Vegetation

The Physical Form of the Loddon Valley river system was rated in moderate condition, with an aggregate Physical Form Index score (SR–PI) of 78. (Lowland zone: Good condition; Slopes zone: Moderate condition).

Overall, the valley's physical form was characterised by elevated sediment loads since European settlement and associated sedimentation within the river channel and floodplain. There is also evidence of channel enlargement and channel simplification. Bed dynamics were in poor condition but channel form and bank dynamics both ranked in good condition (near reference).

Physical Form

The Hydrology of the Loddon Valley river system was rated in moderate condition, with an aggregate Hydrology Index (SR–HI) score of 60. (Lowland zone: Poor condition; Slopes zone: Good condition).

The Loddon Valley river system was characterised by a mainstem river reaches with a very large difference from reference condition in flow seasonality, and moderate alteration in flow variability and low- and zero-flow events. High-flow events and flow gross volume were near to reference condition. The headwater streams showed little or no alteration in any indices.
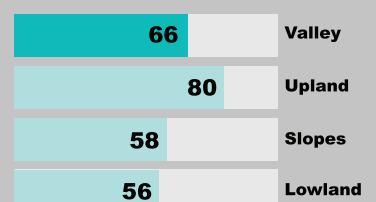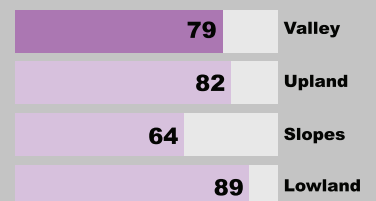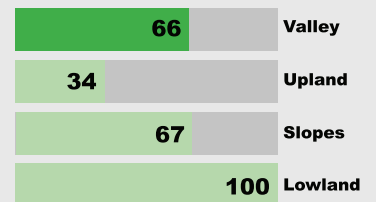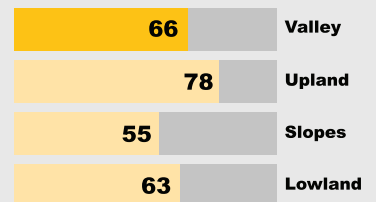
Hydrology

Macquarie Valley

POOR

8	Valley
6	Upland
14	Slopes
6	Lowland

66	Valley
78	Upland
55	Slopes
63	Lowland

66	Valley
34	Upland
67	Slopes
100	Lowland

79	Valley
82	Upland
64	Slopes
89	Lowland

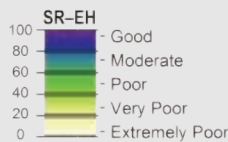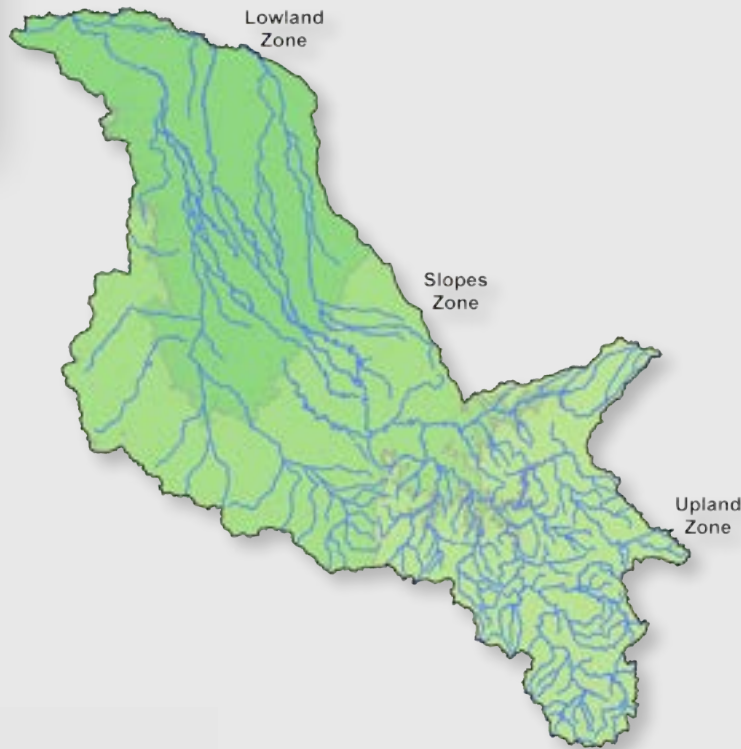|	
66	Valley
80	Upland
58	Slopes
56	Lowland

SR–EH
- 100 / 80 — Good
- 60 — Moderate
- 40 — Poor
- 20 — Very Poor
- 0 — Extremely Poor

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^2, 7% of the Basin area.
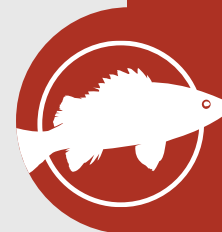
River Ecosystem Health

The Macquarie Valley river ecosystem was rated in **very poor health**.

(Lowland zone: Poor; Slopes and Upland zones: Very Poor).

The Fish community of the Macquarie Valley river system was rated in extremely poor condition, with an aggregate Fish Index score (SR–FI) of 8. (Lowland, Slopes and Upland zones: Extremely Poor condition).

The fish community of the Macquarie had reduced numbers of expected native species (53%), with an extreme difference from reference. There was a very large difference from reference for recruitment, which was extremely poor in the Upland zone and very poor in the Slopes and Lowland zones. Nativeness also showed a very large difference from reference. In general, the fish community of the Macquarie had lost much of its native species richness and alien species contributed over 70% of the biomass in samples. Native fish numbers were high but dominated by small- to medium sized species.

Fish

The Macroinvertebrate community of the Macquarie Valley river system was rated in moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 66. (Lowland zone: Moderate condition; Slopes zone: Poor condition, Upland zone: Moderate condition).

The valley contained 71% of the families found across the Basin although most of this was in the Upland and Slopes zones (82% and 67% respectively). Family richness was generally low compared to reference condition. Diversity was moderate (average 21 families per site) with the Upland zone being most diverse at a site scale (average 25 families per site).

Macroinvertebrates

The riverine Vegetation of the Macquarie Valley river system was rated in moderate condition, with an aggregate Vegetation Index score (SR–VI) of 66. (Lowland zone: Good condition; Slopes zone: Moderate condition; Upland zone: Very Poor condition).

The abundance and diversity of Macquarie Valley riverine vegetation was in moderate condition overall, with a moderate difference from reference in near riparian and lowland areas. There was a moderate difference from reference condition for the structure and nativeness of vegetation communities and groups within near riparian and lowland areas.

Vegetation

The Physical Form of the Macquarie Valley river system was rated in moderate condition, with an aggregate Physical Form Index score (SR–PI) of 79. (Lowland zone: Good condition; Slopes zone: Moderate condition; Upland zone: Good condition).

Overall, the valley's riverine physical form was characterised by channel simplification and adjustments in channel size. There was also indication of elevated sediment loads since European settlement and associated minor sedimentation within the river channel and moderate to high sedimentation on the floodplain. Channel form, bed dynamics and floodplain form indicators were all moderate and showed minor differences from reference condition. Bank dynamics were in good (near reference) condition.
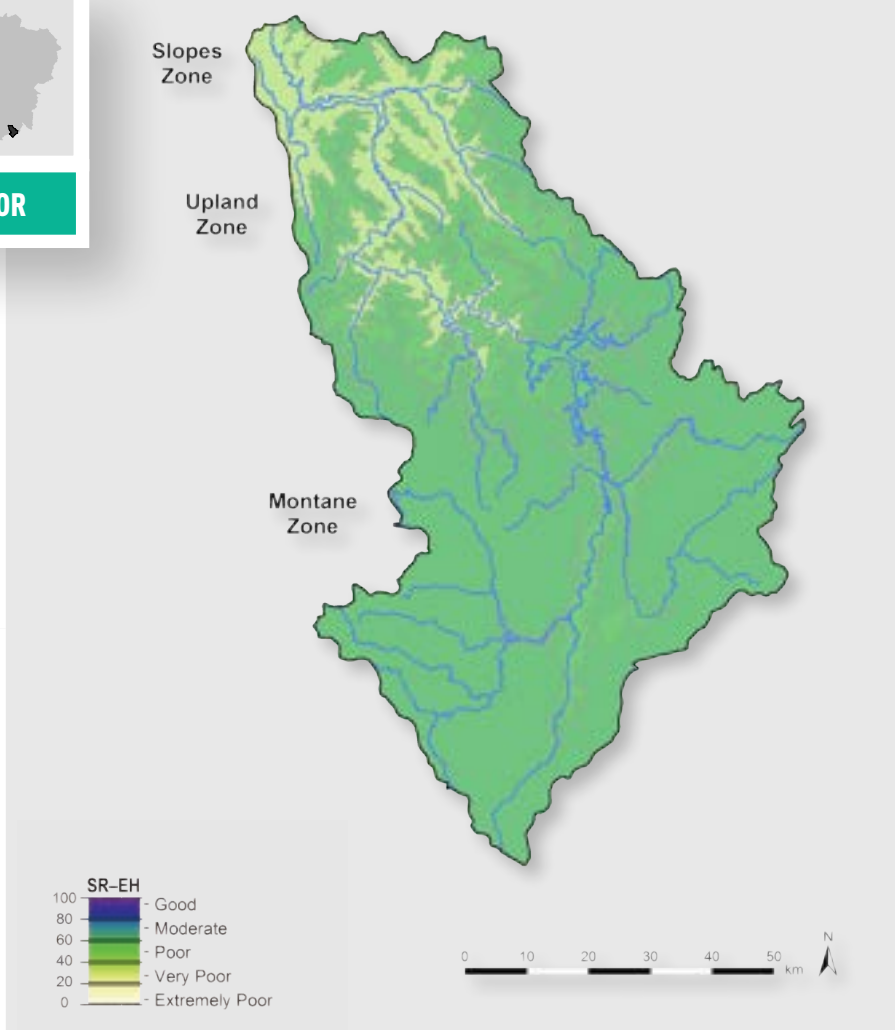
Physical Form

The Hydrology of the Macquarie Valley river system was rated in moderate condition, with an aggregate Hydrology Index (SR–HI) score of 66. (Lowland and Slopes zones: Poor condition; Upland zone: Good condition).

The Macquarie Valley river system was characterised by a mainstem river in poor hydrological condition, with a large difference from reference condition in low- and zero-flow events; moderate alteration in high over bank floods, low over bank floods, flow variability and flow seasonality; and little or no alteration in high-flow events and flow gross volume. The headwater streams were generally characterised by little or no alteration in any of these indicators.

Hydrology

Mitta Mitta Valley

Slopes Zone

Upland Zone

Montane Zone

SR–EH
100 — Good
80
60 — Moderate
40 — Poor
20 — Very Poor
0 — Extremely Poor

0 10 20 30 40 50
km

N

5	Valley
4	Montane
7	Upland
5	Slopes

90	Valley
92	Montane
93	Upland
81	Slopes

73	Valley
100	Montane
87	Upland
14	Slopes

99	Valley
99	Montane
99	Upland
98	Slopes

99	Valley
100	Montane
100	Upland
99	Slopes
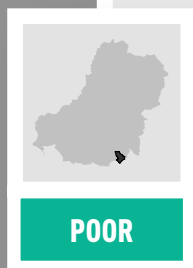
The Mitta Mitta River rises east of Falls Creek township, Victoria, near the Kiewa headwaters, where four tributaries (Big, Bundara and Cobungra rivers, Livingstone Creek) join. The river flows north-west to meet the Murray via the south arm of Lake Hume. Tallangatta Creek, formerly a Mitta Mitta tributary, 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^2, less than 1% of the Basin area.

River Ecosystem Health

The Mitta Mitta Valley river ecosystem was rated in **poor health.**
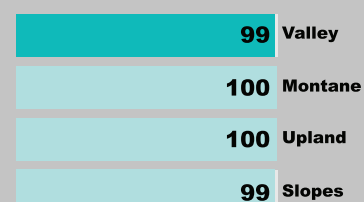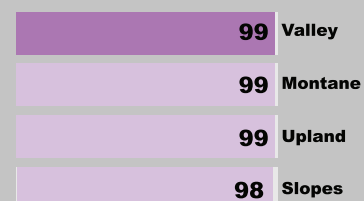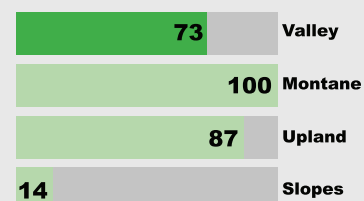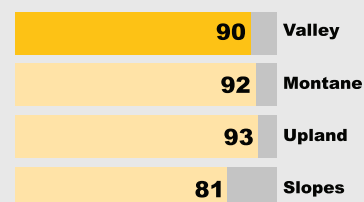
(Slopes zone: Very Poor; Upland and Montane zones: Poor).
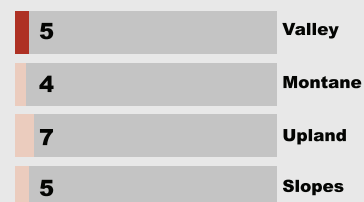
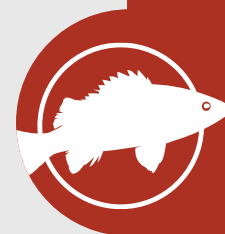**The Fish community of the Mitta Mitta Valley river system was rated in extremely poor condition, with an aggregate Fish Index score (SR–FI) of 5.**
(Slopes, Upland and Montane zones: Extremely Poor condition).

The fish community of the Mitta Mitta received the lowest score of the SRA valleys. Most expected species were absent and species counts, abundance and biomass were dominated by alien species (which contributed over 96% of the biomass). Recruitment was observed in only three of the observed eight native species. The Mitta Mitta had the third lowest expectedness score of the 23 SRA valleys, out-scoring only the Campaspe and Lachlan. Nativeness was poorest in the Montane zone.

Fish

The Macroinvertebrate community of the Mitta Mitta Valley river system was rated in good condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 90.
(Slopes, Upland and Montane zones: Good condition).

The proportion of sites in good condition was high (85%). Family richness was generally high and comparable to reference condition. Diversity was also high (average 29 families per site) with the Upland zone being the most diverse at site scale (average 31 families per site). The valley contained 78% of the families found across the Basin, with the Slopes zone having the lowest representation of Basin-wide fauna. Most (77–81%) of the fauna of the valley was found in the Montane and Upland zones.

Macroinvertebrates

The riverine Vegetation of the Mitta Mitta Valley river system was rated in moderate condition, with an aggregate Vegetation Index score (SR–VI) of 73.
(Slopes zone: Extremely Poor condition; Upland and Montane zones: Good condition).

The abundance and diversity of Mitta Mitta Valley riverine vegetation was in moderate condition overall, with a moderate difference from reference in near riparian and lowland areas. There was a moderate difference from reference condition for the structure and nativeness of vegetation communities and groups within near riparian and lowland areas.

Vegetation

The Physical Form of the Mitta Mitta Valley river system was rated in good condition, with an aggregate Physical Form Index score (SR–PI) of 99.
(Slopes, Upland and Montane zones: Good condition).

Overall, the valley's riverine physical form was characterised by channel simplification and adjustments in channel size. There was also indication of elevated sediment loads since European settlement and associated minor sedimentation within the river channel and moderate to high sedimentation on the floodplain. Channel form, bed dynamics, bank dynamics and floodplain form indicators were in good condition and showed minor differences from reference condition.

Physical Form

The Hydrology of the Mitta Mitta Valley river system was rated in good condition, with an aggregate Hydrology Index (SR–HI) score of 99.
(Slopes, Upland and Montane zones: Good condition).

The Mitta Mitta Valley river system was characterised by a mainstem river with near to reference condition in low- and zero-flow events. The river system showed a large difference from reference in flow seasonality and little or no alteration in high-flow events and flow gross volume. The headwater streams were generally characterised by little or no alteration in any of these indicators.

Hydrology

Murray Valley – upper

POOR

Upland Zone

Slopes Zone

Montane Zone

SR–EH
- Good
- Moderate
- Poor
- Very Poor
- Extremely Poor

19	Valley
22	Montane
12	Upland
24	Slopes

89	Valley
95	Montane
88	Upland
86	Slopes

63	Valley
100	Montane
97	Upland
14	Slopes

94	Valley
96	Montane
95	Upland
94	Slopes

41	Valley
100	Montane
100	Upland
40	Slopes
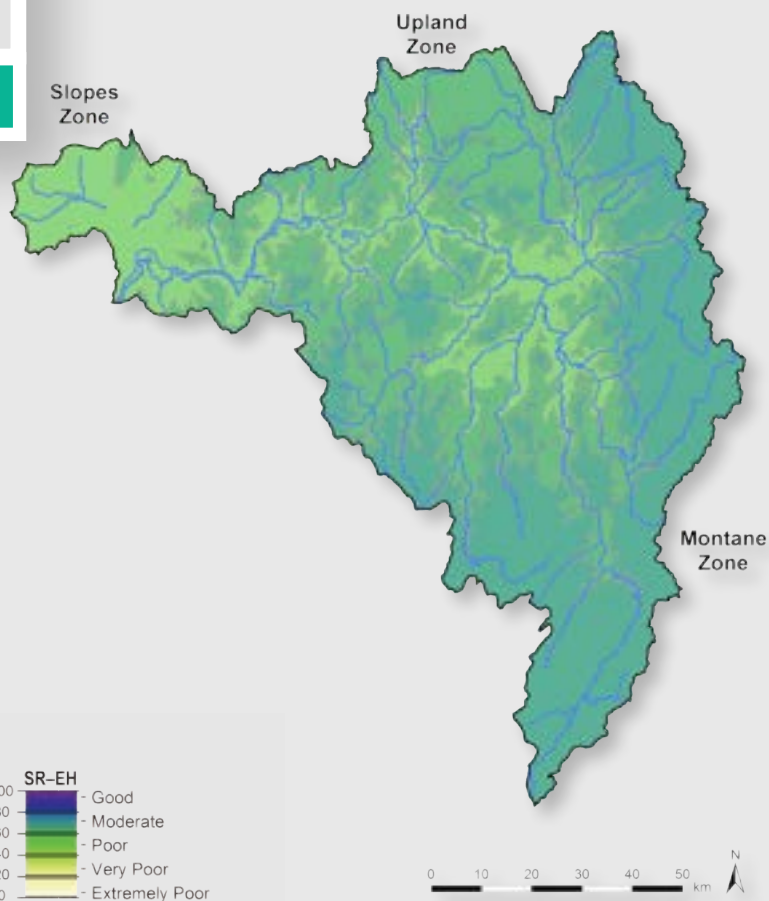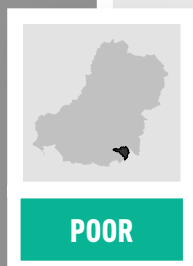
The Murray rises east of Albury, NSW and Wodonga, Victoria. The headwater tributaries include the Swampy Plain River and the Corryong, Cudgewa, Limestone, Burrowye, Koetong, Walwa and Johnston creeks. From the junction of Cudgewa Creek, the Murray continues westward to enter the 'Murray Arm' of Lake 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^2, less than 1% of the Basin area.

River Ecosystem Health

The Upper Murray Valley river ecosystem was rated in **poor health.**

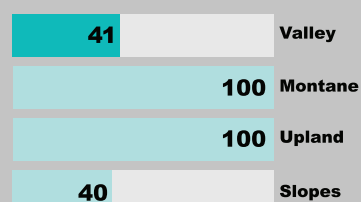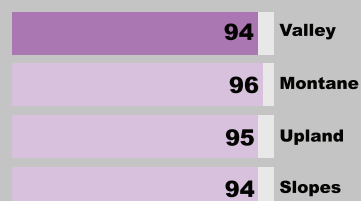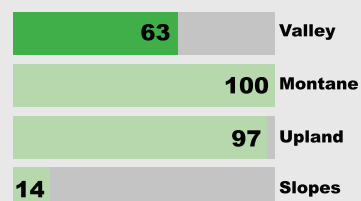(Upland and Slopes zones: Poor; Montane zone: Moderate).
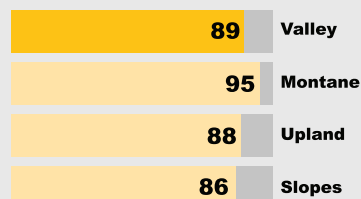
The Fish community of the Upper Murray Valley river system was rated in extremely poor condition, with an aggregate Fish Index score (SR–FI) of 19. (Slopes zone: Very Poor condition; Upland zone: Extremely Poor condition; Montane zone: Very Poor condition).

In general, the fish community of the Upper Murray had reduced numbers of native species and a low biomass of native fish. Expectedness was very poor in the Upland and Slopes zones and moderate in the Montane zone (reflecting that three of the four expected species were caught). Native fish recruitment was extremely poor; in the Slopes zone the Murray cod was the only large-bodied native species recorded as recruiting. Six alien species were recorded, most of which were actively recruiting. The valley had the fourth lowest total fish biomass per site of the 23 valleys and, of this, only 8.5% came from native species.
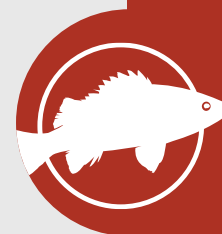
Fish

The Macroinvertebrate community of the Upper Murray Valley river system was rated in good condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 89. (Slopes, Upland and Montane zones: Good condition).

The valley contained 79% of the families found across the Basin although most of this was in the Upland zone (93%). Family richness was generally high compared to reference condition. Diversity was high (average 34 families per site) with the Montane and Upland zones being most diverse at a site scale (average 36 and 38 families per site respectively).

Macroinvertebrates

The riverine Vegetation of the Upper Murray Valley river system was rated in moderate condition, with an aggregate Vegetation Index score (SR–VI) of 63. (Slopes zone: Extremely Poor condition; Upland and Montane zones: Good condition).

Only one spatial domain was considered (near riparian), with most (42%) of the stream length in the Slopes zone. The condition of riverine vegetation is highly variable, from near reference in the Montane and Upland zones to extremely poor in the Slopes zone. The quality and integrity was in moderate condition overall, and near reference in the Montane and Upland zones. There was a moderate difference from reference condition for the structure and nativeness of vegetation communities and groups.

Vegetation

The Physical Form of the Upper Murray Valley river system was rated in good condition, with an aggregate Physical Form Index score (SR–PI) of 94. (Slopes, Upland zone and Montane zones: Good condition).

Overall, the valley's riverine physical form was characterised by elevated sediment loads since European settlement. There was low- to moderate sediment deposition on the floodplain. Channel form, bank dynamics and floodplain dynamics were all rated as good. Bed dynamics were in moderate condition.

Physical Form

The Hydrology of the Upper Murray Valley river system was rated in poor condition, with an aggregate Hydrology Index (SR–HI) score of 41. (Slopes zone: Poor condition; Upland and Montane zones: Good condition).

The Upper Murray Valley river system is ranked second lowest (before the Goulburn) of the 23 SRA valleys for hydrological condition. This ranking resulted from the effect of inter-valley transfers on the condition of the slopes zone. Stream discharge from the Upper Murray catchment (excluding inter-valley transfers) was very low in the period 2001–2009. Headwater streams were in good condition, but mainstem river reaches were characterised as extremely poor, showing a very large difference from reference condition in flow variability and low- and zero-flow events; and moderate difference from reference in flow seasonality.
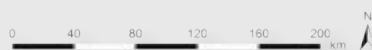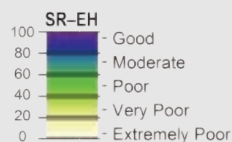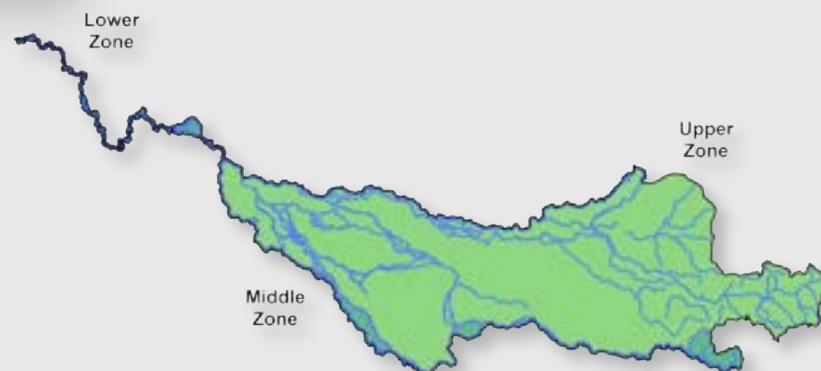
Hydrology
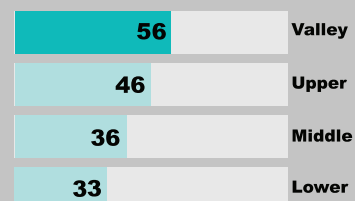
Murray Valley – central

POOR

	Valley
20	Valley
9	Upper
38	Middle
49	Lower

56	Valley
56	Upper
57	Middle
55	Lower

100	Valley
100	Upper
100	Middle
100	Lower

Lower Zone

Upper Zone

Middle Zone

SR–EH
- 100 — Good
- 80
- 60 — Moderate
- 40 — Poor
- 20 — Very Poor
- 0 — Extremely Poor

0 40 80 120 160 200 km

N

76	Valley
89	Upper
44	Middle
48	Lower

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 Yarrawonga, Torrumbarry, Mildura and Wentworth weirs.

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

River Ecosystem Health

The Central Murray Valley river ecosystem was rated in **poor health**.

(Upper, Middle and Lower zones: Poor).
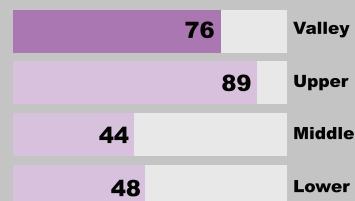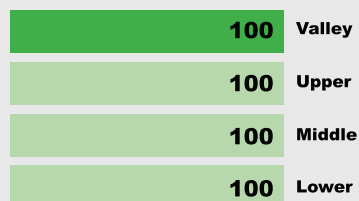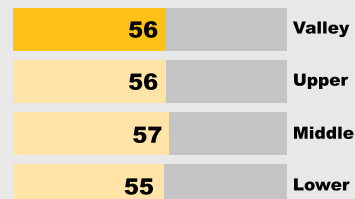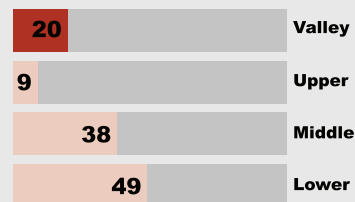
56	Valley
46	Upper
36	Middle
33	Lower

The Fish community of the Central Murray Valley river system was rated in very poor condition, with an aggregate Fish Index score (SR–FI) of 20. (Lower zone: Poor condition; Middle zone: Very Poor condition; Upper zone: Extremely Poor condition).

Although there were substantially reduced numbers of native species compared to reference condition, the valley had the seventh largest number of fish caught per site (127.2) of the 23 SRA valleys. Of the fish caught, 84% were native species. Total fish biomass (16.6 kg/site) was the se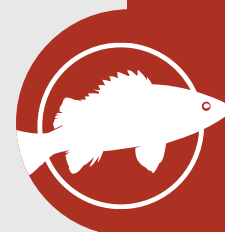cond largest of the valleys. Forty-four per cent of this biomass was native species, reflecting the numerical dominance of small-bodied species such as gudgeon, Australian smelt and unspecked hardyhead, although small numbers of larger-bodies species were also caught.

Fish

The Macroinvertebrate community of the Central Murray Valley river system was rated in poor condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 56. (Lower, Middle and Upper zones: Poor condition).

The proportion of sites in poor condition was high (47%), especially in the Upper zone. Only two of the 34 rated sites (6%) were in good condition. Family richness generally was moderate and reduced compared to reference condition. Diversity was moderate (average 22 families per site) with the Upper zone scoring highest. The valley contained 55% of the families found across the Basin.

Macroinvertebrates

The riverine Vegetation of the Central Murray Valley river system was rated in good condition, with an aggregate Vegetation Index score (SR–VI) of 100. (Lower, Middle and Upper zones: Good condition).

The riverine vegetation of the Central Murray Valley is notable for being in near reference condition in all three zones and both the near riparian and lowland floodplain domains. However, the condition of riverine vegetation of the Upper zone scored less than the other two zones on all metrics except fragmentation in both the near riparian and lowland floodplain domains. Notable differences were in a lower score for structure and loss of one vegetation group: Mallee woodlands and shrublands.

Vegetation

The Physical Form of the Central Murray Valley river system was rated in moderate condition, with an aggregate Physical Form Index score (SR–PI) of 76. (Lower and Middle zones: Poor condition; Upper zone: Good condition).

Overall, the valley's riverine physical form was characterised by high rates of floodplain sediment deposition since European settlement and elevated sediment loads. There was also evidence of channel simplification, particularly in the Middle zone. Channel form, bed dynamics and floodplain dynamics were all rated as moderate. Bank dynamics were in good condition.

Physical Form

The Hydrology of the Central Murray Valley river system was rated in poor condition, with an aggregate Hydrology Index (SR–HI) score of 56. (Lower and Middle zones: Very Poor condition; Upper zone: Poor condition).

The Central Murray Valley river system was characterised by mainstem river reaches in very poor condition with a very large difference from reference condition in flow seasonality, a large difference in high-flow events and moderate alteration in high over bank floods, low over bank floods, flow variability and low- and zero-flow events. Headwater streams were in good condition.
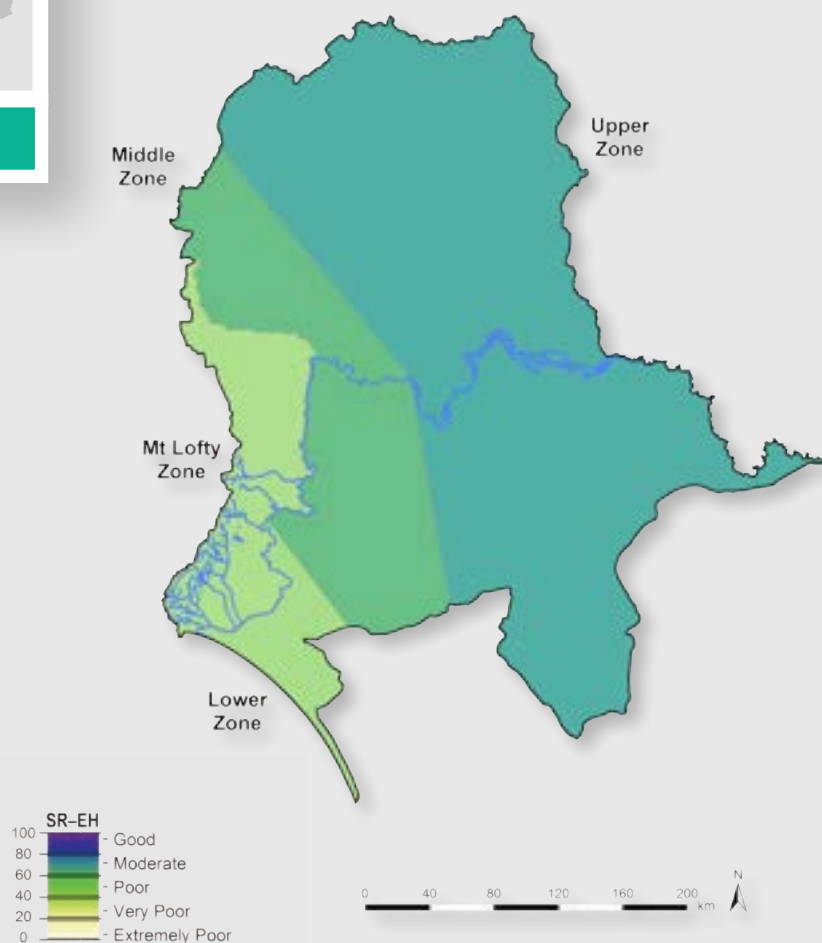
**Hydrology**

Murray Valley – lower

POOR

43	Valley
48	Upper
45	Middle
42	Lower
11	Mt Lofty

76	Valley
78	Upper
61	Middle
59	Lower
83	Mt Lofty

56	Valley
100	Upper
87	Middle
6	Lower
12	Mt Lofty

68	Valley
72	Upper
51	Middle
29	Lower
72	Mt Lofty

31	Valley
3	Upper
3	Middle
2	Lower
96	Mt Lofty

SR–EH
100 – Good
80
60 – Moderate
40 – Poor
20 – Very Poor
0 – Extremely Poor

In its lower reaches, the Murray flows westward through a broad floodplain from Wentworth, New South Wales, to Morgan, South Australia, 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 rivers. The Lower Murray Valley begins at Lock 9, below the Murray–Darling confluence, and ends with the river's entry to Lake Alexandrina, 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^2, about 9% of the Basin area.

River Ecosystem Health

The Lower Murray Valley river ecosystem was rated in **poor health**.

(Lower and Mt Lofty zones: Very Poor; Upper zone: Moderate and Middle zone: Poor).
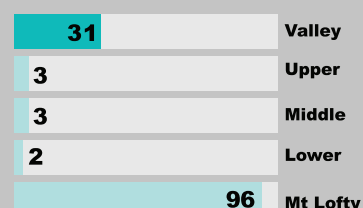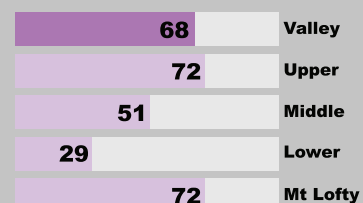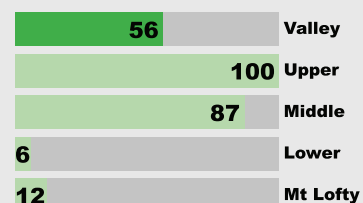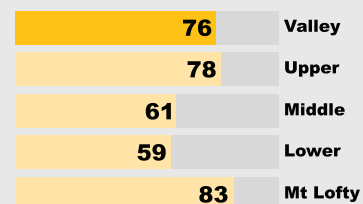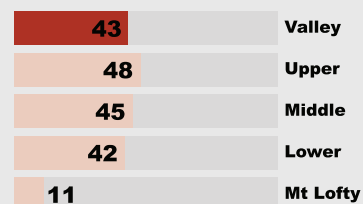
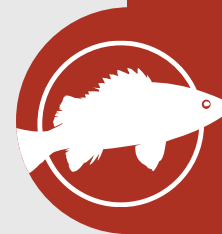**The Fish community of the Lower Murray Valley river system was rated in poor condition, with an aggregate Fish Index score (SR–FI) of 43.**
(Lower, Middle and Upper zones: Poor condition; Mt Lofty: Extremely Poor condition).

Overall, the valley had lost much of its native species richness and alien species contributed over 69% of fish biomass. Sixty-six percent of the total fish caught were native species (mostly small-bodied species) but overall there were lower than expected numbers of native species. In the three main-channel zones, native fish were more than 88% of the catch, but in the Mt Lofty zone native species contributed only 18% of the catch. Native fish recruitment was very poor in the Mt Lofty zone and poor to moderate for the Upper, Middle and Lower zones. All five alien species were recorded as recruiting.

Fish

The Macroinvertebrate community of the Lower Murray Valley river system was rated in moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 76.
(Lower zone: Poor condition; Middle and Upper zones: Moderate condition; Mt Lofty: Good condition).

The proportion of sites in moderate condition was high (51%); ten of the 32 rated sites (31%) were in good condition (mostly in the Upper zone). The number of families found was lowest in the Lower zone (14 families) and highest in the Upper and Mt Lofty zones (36 and 37 families respectively).

Macroinvertebrates

The riverine Vegetation of the Lower Murray Valley river system was rated in poor condition, with an aggregate Vegetation Index score (SR–VI) of 56.
(Middle and Upper zones: Good condition; Mt Lofty and Lower zones: Extremely Poor condition).

The riverine vegetation of the Lower Murray Valley is notable for the extremely poor condition of the Mt Lofty and Lower zones; for the contrast in condition between these and the Upper and Middle zones, and for the moderate abundance and nativeness in the near riparian domain. Only the Upper and Middle zones have a lowland floodplain domain—its condition is similar to their near riparian domains. In the valley and in these two zones, characterised by a large main channel inset into the landscape, these two domains refer to similar parts of the landscape. Condition in the four zones is variable and changes down the valley. There was an unusually low score for structure in the Lower zone.

Vegetation

The Physical Form of the Lower Murray Valley river system was rated in moderate condition, with an aggregate Physical Form Index score (SR–PI) of 68.
(Lower zone: Very Poor condition; Middle zone: Poor condition; Upper zone and Mt Lofty: Moderate condition).

Overall, the valley's riverine physical form was rated as moderate. Bank dynamics was rated as good. Bed dynamics and floodplain form were moderate. The valley's riverine physical form was characterised by channel straightening and enlargement. There was also indication of elevated sediment loads since European settlement, particularly in the Mt Lofty zone, and associated sedimentation.

Physical Form

The Hydrology of the Lower Murray Valley river system was rated in very poor condition, with an aggregate Hydrology Index (SR–HI) score of 31.
(Lower, Middle and Upper zones: Extremely Poor condition; Mt Lofty: Good condition).

Mainstem river reaches were in extremely poor condition, characterised by a very large difference from reference condition in flow variability, flow seasonality and high-flow; and considerable alteration in flow gross volume. The in-channel and over bank flow regimes were in extremely poor condition. The headwater streams were generally characterised by little or no alteration in any hydrology indicators relative to reference condition.
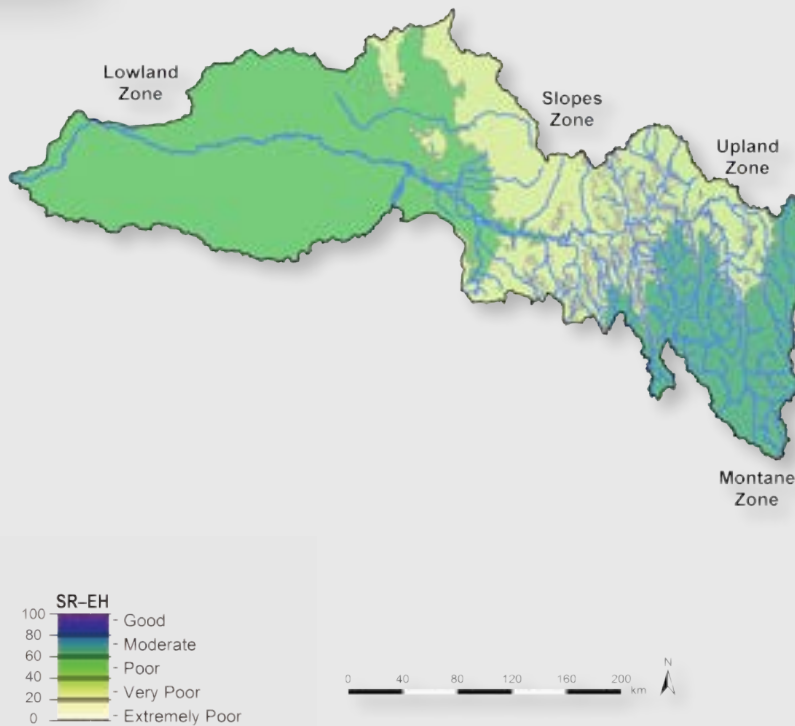
Hydrology

Murrumbidgee Valley

VERY POOR

Lowland Zone • Slopes Zone • Upland Zone • Montane Zone

SR–EH
- 100
- 80 — Good
- 60 — Moderate
- 40 — Poor
- 20 — Very Poor
- 0 — Extremely Poor

15	Valley
26	Montane
0	Upland
0	Slopes
24	Lowland

71	Valley
79	Montane
80	Upland
81	Slopes
50	Lowland

64	Valley
98	Montane
37	Upland
13	Slopes
93	Lowland

87	Valley
95	Montane
85	Upland
85	Slopes
83	Lowland

|	
56	Valley
100	Montane
43	Upland
64	Slopes
36	Lowland

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^2, or about 7.5% of the Basin.
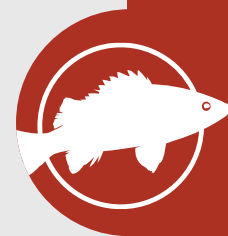
River Ecosystem Health

The Murrumbidgee Valley river ecosystem was rated in **poor health.**

(Lowland zone: Poor; Slopes zone: Very Poor; Upland zone: Very Poor; Montane zone: Poor).
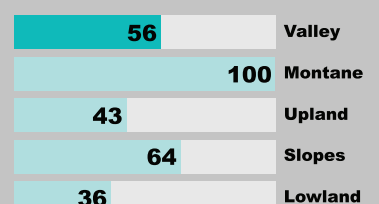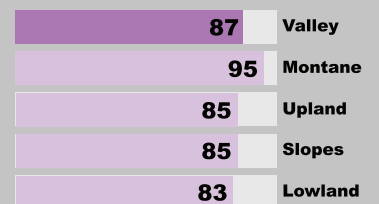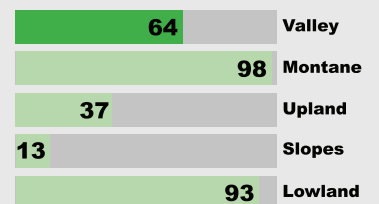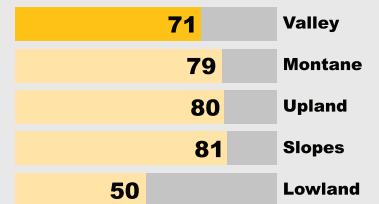
The Fish community of the Murrumbidgee Valley river system was rated in extremely poor condition, with an aggregate Fish Index score (SR–FI) of 15. (Lowland zone: Very Poor condition; Slopes and Upland zones: Extremely Poor condition; Montane zone: Very Poor condition).

In general, the fish community of the Murrumbidgee had reduced numbers of expected native species, low numbers of native fish, and low native biomass. The Upland and Slopes zones in particular had few fish and lacked 67% and 72% of the predicted native species respectively. Alien species contributed 84% of the biomass in samples. Evidence of recruitment was observed for 10 of the 12 native species observed in the valley. Only one of the four native species in the Upland zone showed evidence of recruitment. Golden perch, present in three zones, showed no evidence of recruitment. All alien species were recorded as recruiting in all or almost all zones in which they were found.

Fish

The Macroinvertebrate community of the Murrumbidgee Valley river system was rated in moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 71. (Lowland zone: Poor condition; Slopes and Upland zones: Good condition; Montane zone: Moderate condition).

Overall, family richness was reduced compared to reference condition. Diversity was moderate (average 23 families per site). The valley contained 78% of the families found across the Basin with the Lowland zone having the lowest representation of Basin-wide fauna. Most (79 - 81%) of the fauna of the valley was found in the Montane and Upland zones.

Macroinvertebrates

The riverine Vegetation of the Murrumbidgee Valley river system was rated in moderate condition, with an aggregate Vegetation Index score (SR–VI) of 64. (Lowland zone: Good condition; Slopes zone: Extremely Poor condition, Upland zone: Very Poor condition; Montane zone: Good condition).

The riverine vegetation of the Murrumbidgee Valley is notable for the range of conditions among the zones. The zones in the best condition are the Montane and Lowland, both rated near reference condition. The Slopes zone is in extremely poor condition with extremely low abundance of major vegetation groups and nativeness in the near riparian domain. In the Lowland zone, the lowland floodplain domain is in better condition than the near riparian.

Vegetation

The Physical Form of the Murrumbidgee Valley river system was rated in good condition, with an aggregate Physical Form Index score (SR–PI) of 87. (Lowland, Slopes, Upland and Montane zones: Good condition).

Overall, the valley's riverine physical form was characterised by elevated sediment loads since European settlement and associated sedimentation within the river channel and floodplains of the Lowland and Slopes zones. The valley's river channel form and bank dynamics were rated as good. Bed dynamics and floodplain dynamics were rated as moderate.

Physical Form

The Hydrology of the Murrumbidgee Valley river system was rated in poor condition, with an aggregate Hydrology Index (SR–HI) score of 56. (Lowland zone: Very Poor condition; Slopes zone: Moderate condition; Upland zone: Poor condition; Montane zone: Good condition).

The Murrumbidgee Valley river system was characterised by a mainstem river in very poor condition and headwater streams in good condition. The mainstem river reaches were generally characterised by a very large difference from reference condition in flow variability and low- and zero-flow events and flow gross volume; a moderate difference in flow seasonality; near reference for high-flow and a moderate difference in high over bank floods. The headwater streams were generally characterised by little or no alteration in any indicators.
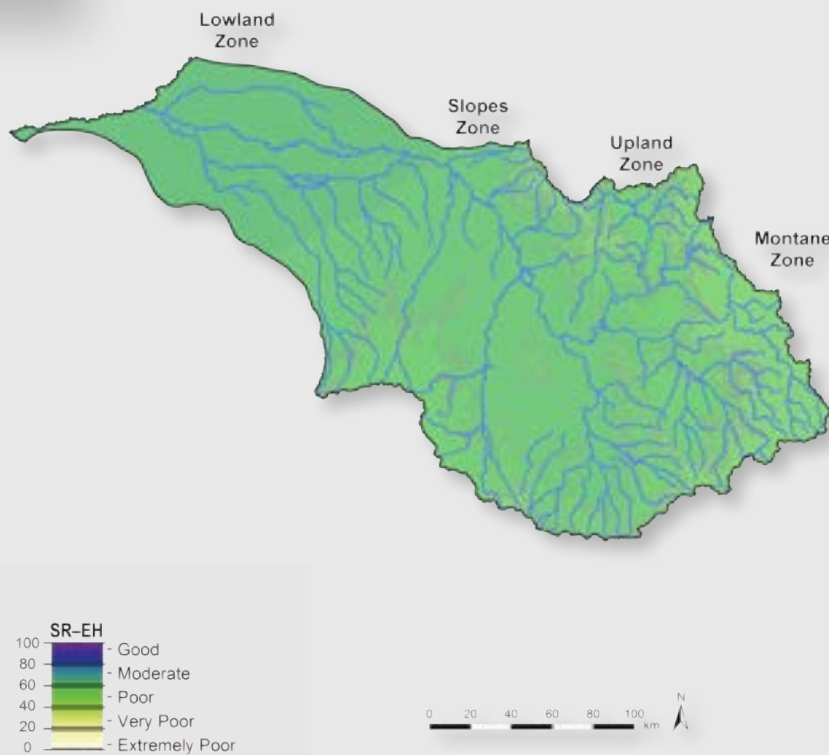
Hydrology

Namoi Valley

POOR

35	Valley
19	Montane
30	Upland
44	Slopes
28	Lowland

70	Valley
81	Montane
79	Upland
71	Slopes
49	Lowland

50	Valley
47	Montane
34	Upland
38	Slopes
100	Lowland

72	Valley
91	Montane
67	Upland
72	Slopes
67	Lowland

94	Valley
100	Montane
94	Upland
98	Slopes
84	Lowland

Map labels: Lowland Zone, Slopes Zone, Upland Zone, Montane Zone

SR–EH
- 100 / 80 – Good
- 60 – Moderate
- 40 – Poor
- 20 – Very Poor
- 0 – Extremely Poor

0 20 40 60 80 100 km

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 Cox's 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^2, about 4% of the total Basin area.

River Ecosystem Health

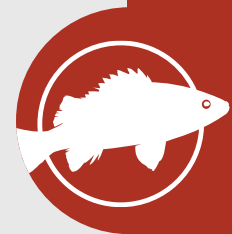The Namoi Valley river ecosystem was rated in **poor health**.

(Lowland, Slopes, Upland and Montane zones: Poor).
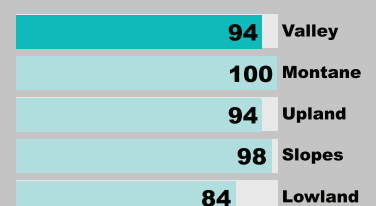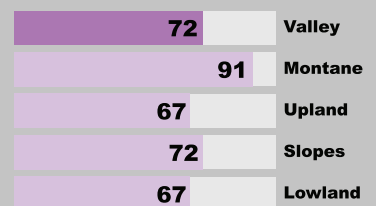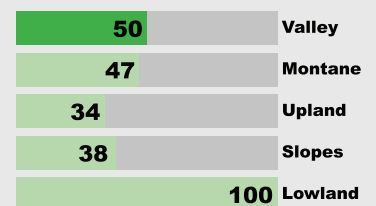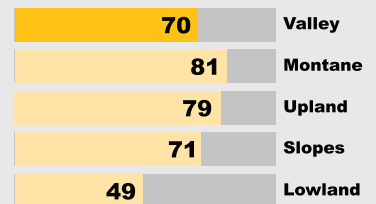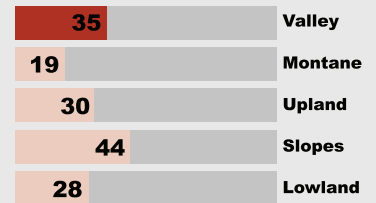
The Fish community of the Namoi Valley river system was rated in very poor condition, with an aggregate Fish Index score (SR–FI) of 35. (Lowland and Upland zones: Very Poor condition; Slopes zone: Poor condition; Montane zone: Extremely Poor condition).

The fish community was characterised by a poor score for expected native fish species and for nativeness, and a very poor score for native fish recruitment. The Montane zone in particular had few fish and lacked three out of six predicted native species. The valley had reduced native species richness and alien species contributed over 67% of the biomass in samples.

Fish

The Macroinvertebrate community of the Namoi Valley river system was rated in moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 70. (Lowland zone: Poor condition; Slopes and Upland zones: Moderate condition; Montane zone: Good condition).

Family richness generally was reduced or low relative to reference condition. Diversity was moderate (average 23 families per site), with the Montane and Upland zones being most diverse at site scale. Twelve of the 35 rated sites were in good condition. The valley contained 71% of the families found across the Basin, however, most of this fauna was found in the Slopes, Upland and Montane zones.

Macroinvertebrates

The riverine Vegetation of the Namoi Valley river system was rated in poor condition, with an aggregate Vegetation Index score (SR–VI) of 50. (Lowland zone: Good condition; Slopes and Upland zones: Very Poor condition; Montane zone: Poor condition).

The riverine vegetation of the Namoi Valley is notable for the marked contrast in condition between the Lowland zone and zones further up the valley, for the low abundance of main vegetation groups and low nativeness in the near riparian domain in the Montane, Upland and Slopes zones; and for the contrast between this and the lowland floodplain domain, which has moderate scores for abundance, stability, nativeness, fragmentation and structure, and is in better condition. With more stream length than other zones, the Slopes zone has more influence on the valley score.

Vegetation

The Physical Form of the Namoi Valley river system was rated in moderate condition, with an aggregate Physical Form Index score (SR–PI) of 72. (Lowland, Slopes and Upland zones: Moderate condition; Montane zone: Good condition).

Overall, the valley's riverine physical form was characterised by elevated sediment loads since European settlement and associated sedimentation of floodplain areas. There was also evidence of widespread channel enlargement and channel simplification. The valley's river channel form and bed dynamics were rated as moderate. Bank dynamics were rated as good. Floodplain dynamics was rated as poor.
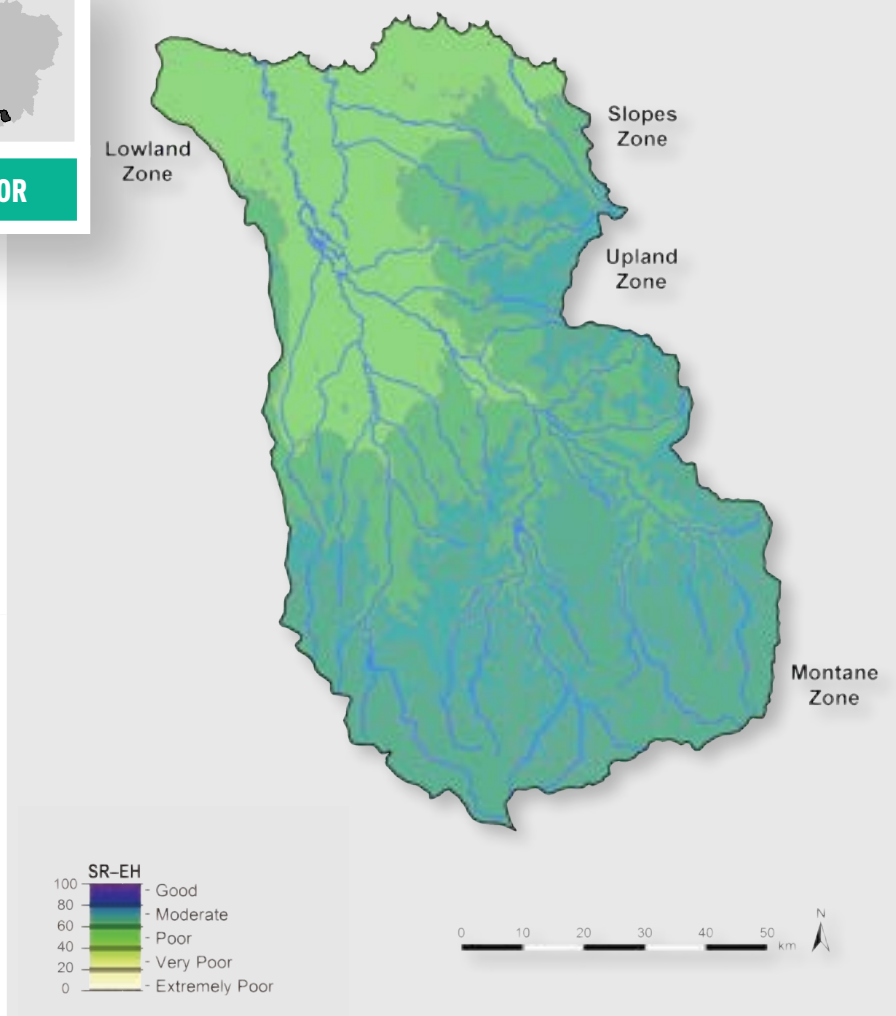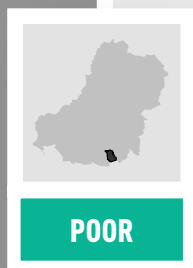
Physical Form

The Hydrology of the Namoi Valley river system was rated in good condition, with an aggregate Hydrology Index (SR–HI) score of 94. (Lowland, Slopes, Upland and Montane zones: Good condition).

The Namoi valley river system was characterised by its mainstem river and headwater streams in good condition. The mainstem river reaches showed minor alteration from reference condition in flow variability and low- and zero-flow events and little or no alteration in any other indices. The headwater streams were generally characterised by little or no alteration in any indices.

Hydrology

Ovens Valley

40	**Valley**
35	**Montane**
34	**Upland**
52	**Slopes**
29	**Lowland**

79	**Valley**
73	**Montane**
92	**Upland**
86	**Slopes**
67	**Lowland**

48	**Valley**
100	**Montane**
100	**Upland**
30	**Slopes**
27	**Lowland**

97	**Valley**
100	**Montane**
100	**Upland**
98	**Slopes**
95	**Lowland**

|	
99	**Valley**
100	**Montane**
100	**Upland**
99	**Slopes**
100	**Lowland**

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 River and Lake William Hovell (14 GL) on the King River.

The Ovens Valley covers 7,900 km^2, less than 1% of the Basin area.

River Ecosystem Health

The Ovens Valley river ecosystem was rated in **poor health**.

(Lowland, Slopes and Montane zones: Poor; Upland zone: Moderate).
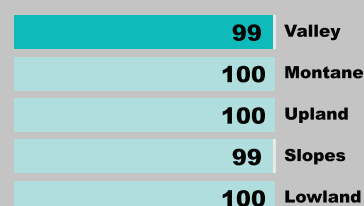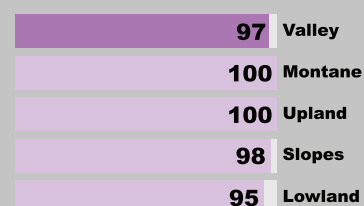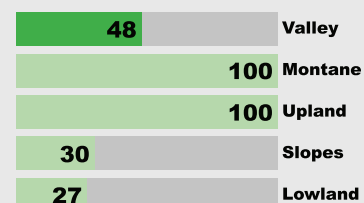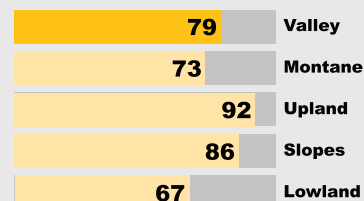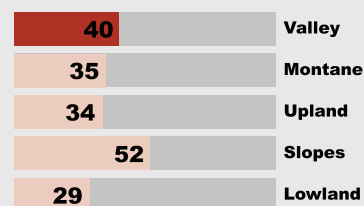
The Fish community of the Ovens Valley river system was rated in poor condition, with an aggregate Fish Index score (SR–FI) of 40. (Lowland zone: Very Poor condition; Slopes zone: Poor condition; Upland and Montane zones: Very Poor condition).

In general, the fish community had reduced numbers of expected native species—the sixth lowest number of fish caught per site (51) of all 23 Basin valleys—of which 33 were native and 18 were alien. Alien biomass averaged 4.7 kg/site; native biomass 1.8 kg/site. Recruitment varied among zones, however, evidence of recruitment was observed for 75% of native species observed in the valley. Only one native species, two-spined blackfish, was recorded as recruiting in the Montane zone. Both Murray cod and trout cod were reported as recruiting in some sites. Five of the six alien species caught showed evidence of recruitment, the exception being goldfish.
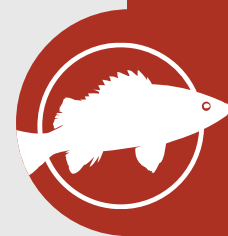
Fish

The Macroinvertebrate community of the Ovens Valley river system was rated in moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 79. Lowland zone: Moderate condition; Slopes and Upland zones: Good condition; Montane zone: Moderate condition).

Family richness generally was reduced compared to reference condition. Diversity was high (average 28 families per site), with the Upland zone being most diverse at site scale (average 34 families per site). The valley contained 82% of the families found across the Basin, with the Lowland zone having the lowest representation of Basin-wide fauna. Most (77%) of the fauna of the valley was found in the Slopes zone.

Macroinvertebrates

The riverine Vegetation of the Ovens Valley river system was rated in poor condition, with an aggregate Vegetation Index score (SR–VI) of 48. (Lowland and Slopes zones: Very Poor condition; Upland and Montane zones: Good condition).

The riverine vegetation of the Ovens Valley is notable for the marked contrast in condition between the upper and lower parts of the valley. Condition ranges from near reference for the Montane and Upland zones to very poor for the Slopes and Lowland zones. There was low abundance and nativeness in the near riparian domain in the Slopes and Lowland zones, and a contrast between the near riparian domain in the lower valley and the lowland floodplain domain. The latter has moderate scores for abundance, stability and nativeness; and is in better condition.

Vegetation

The Physical Form of the Ovens Valley river system was rated in good condition, with an aggregate Physical Form Index score (SR–PI) of 97. (Lowland, Slopes, Upland and Montane zones: Good condition).

The valley's river channel form, bank dynamics, bed dynamics and floodplain dynamics were all rated as good. Overall, the valley's riverine physical form was close to reference conditions, although there was some indication of elevated sediment loads and deposition in the Lowland zone.
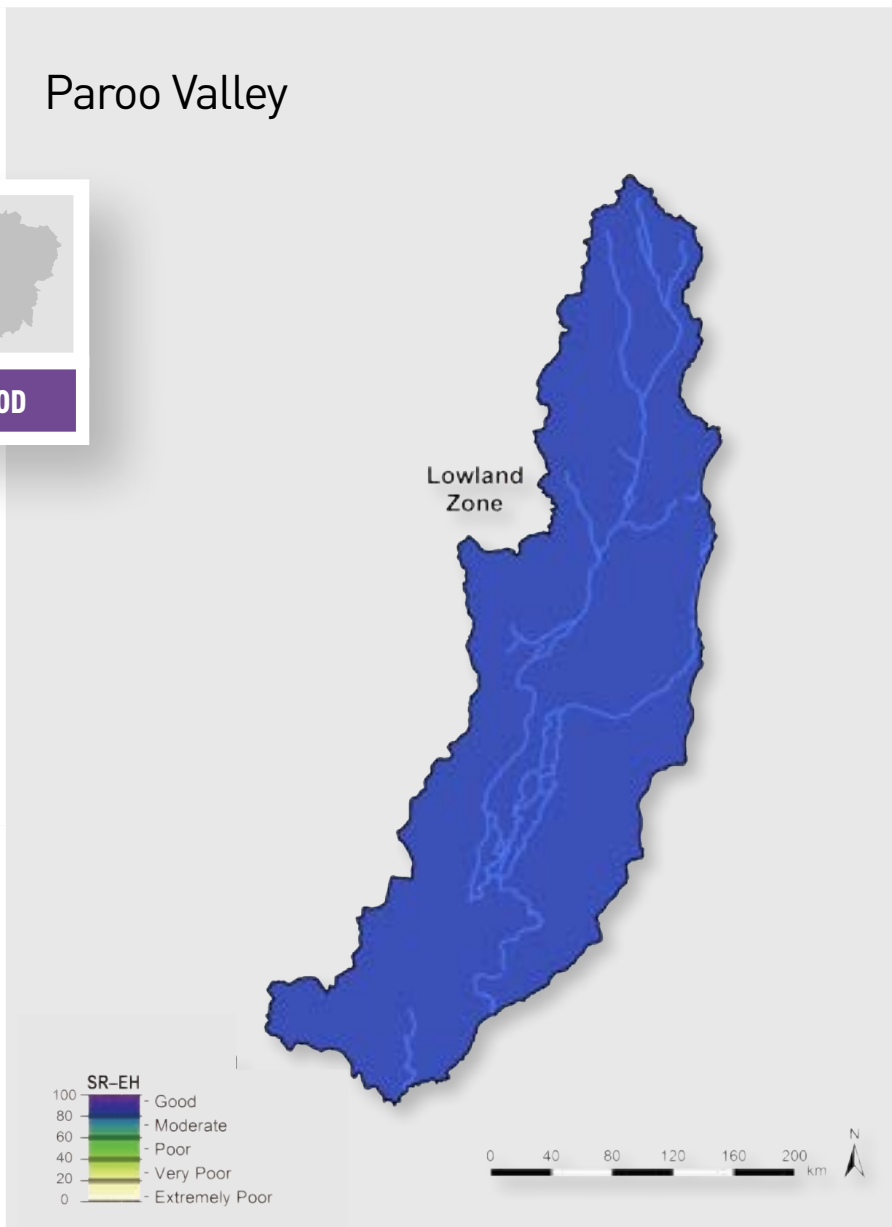
Physical Form

The Hydrology of the Ovens Valley river system was rated in good condition, with an aggregate Hydrology Index (SR–HI) score of 99. (Lowland, Slopes, Upland and Montane zones: Good condition).

The Ovens Valley river system was characterised by both mainstem river and headwater streams in good condition. The mainstem river reaches were in good condition and characterised by near reference condition in flow variability and low- and zero-flow events and little or no alteration in any other indices. The headwater streams were also generally characterised by little or no alteration in any indices.

Hydrology

Paroo Valley

Lowland Zone

SR–EH

100	
80	- Good
60	- Moderate
40	- Poor
20	- Very Poor
0	- Extremely Poor

0 40 80 120 160 200
km

N

83	**Valley**
83	**Lowland**

86	**Valley**
86	**Lowland**

100	**Valley**
100	**Lowland**

99	**Valley**
99	**Lowland**

|	
100	**Valley**
100	**Lowland**

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 River 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^2 or nearly 7% of the Basin area.

River Ecosystem Health

The Paroo Valley river ecosystem was rated in **good health**.

(Lowland zone: Good).
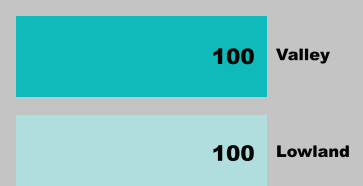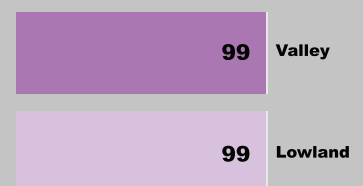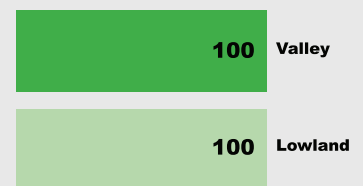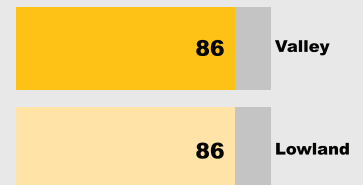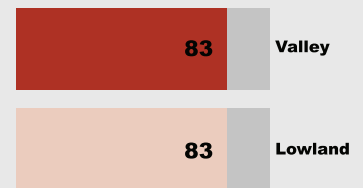
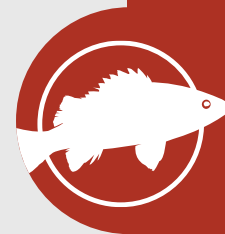**The Fish community of the Paroo Valley river system was rated in good condition, with an aggregate Fish Index score (SR–FI) of 83. (Lowland zone: Good condition).**

In general, the fish community of the Paroo Valley had reduced numbers and distribution of expected native species. The Paroo Valley ranked first amongst all 23 Basin valleys for recruitment, with all native fish species caught showing recruitment at some sites. Of the three alien species caught, only goldfish showed no evidence of recruitment. The balance between native and alien species, as reflected by the nativeness indicator, was good.

Fish

The Macroinvertebrate community of the Paroo Valley river system was rated in good condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 86. (Lowland zone: Good condition).

The proportion of sites in good condition was very high (82%); the remaining sites (18%) were in moderate condition. Family richness generally was low, but was high relative to reference condition. Diversity was low (average 18 families per site) but this is natural in this river system and most sites had the expected diversities of macroinvertebrate families.

Macroinvertebrates

The riverine Vegetation of the Paroo Valley river system was rated in good condition, with an aggregate Vegetation Index score (SR–VI) of 100. (Lowland zone: Good condition).

The riverine vegetation of the Paroo Valley is notable for its good condition and lack of change and loss. The Paroo had near reference scores for nativeness, main vegetation group abundance and richness, and stability and fragmentation. There was a lower score (moderate) only for structure in the near riparian domain.

Vegetation

The Physical Form of the Paroo Valley river system was rated in good condition, with an aggregate Physical Form Index score (SR–PI) of 99. (Lowland zone: Good condition).

The valley's river channel form, bank dynamics, bed dynamics and floodplain dynamics were all rated as good. Overall, the valley's riverine physical form was characterised by close to reference conditions for all indicators, although there was some channel enlargement and elevated sediment loads. There was little change from reference in floodplain sedimentation in the Lowland zone.

Physical Form

The Hydrology of the Paroo Valley river system was rated in good condition, with an aggregate Hydrology Index (SR–HI) score of 100. (Lowland zone: Good condition).

The Paroo Valley river system was characterised by a mainstem river and headwater streams in good condition. The mainstem river and headwater streams were generally characterised by being near to reference condition in high over bank floods, low over bank floods, flow variability, flow seasonality, low- and zero-flow events, high-flow and flow gross volume.

Hydrology

Warrego Valley

Slopes Zone

Lowland Zone

SR–EH
100 — Good
80 —
60 — Moderate
40 — Poor
20 — Very Poor
0 — Extremely Poor

50	Valley
53	Slopes
38	Lowland

86	Valley
87	Slopes
83	Lowland

100	Valley
100	Slopes
100	Lowland

89	Valley
91	Slopes
84	Lowland

100	Valley
100	Slopes
100	Lowland
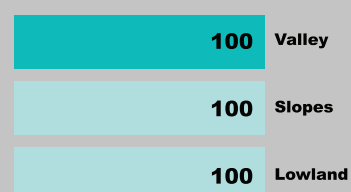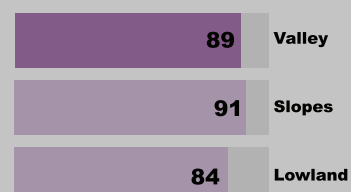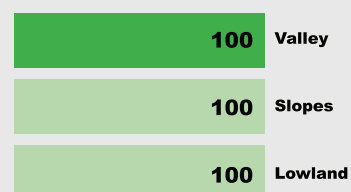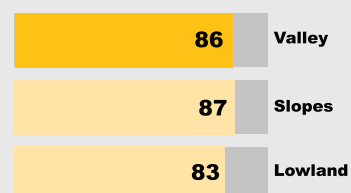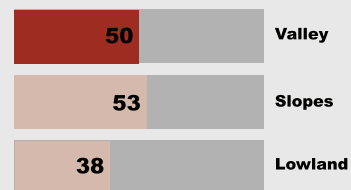
The headwaters of the Warrego River rise near the Warrego and Chesterton ranges in the northernmost part of the Basin, converge near Augathella and Charleville and flow southward as the Warrego, meeting the Darling River downstream of Bourke. Below Cunnamulla the river breaks into distributaries, some 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^2, or 6% of the Basin area.

River Ecosystem Health

The Warrego Valley river ecosystem was rated in **moderate health.**

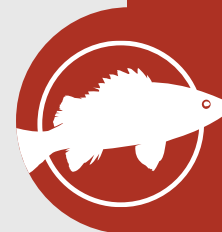(Lowland and Slopes zones: Moderate).

The Fish community of the Warrego Valley river system was rated in poor condition, with an aggregate Fish Index score (SR–FI) of 50. (Lowland zone: Very Poor condition; Slopes zone: Poor condition).

The fish community had a moderate score for expected native fish species, a good score for nativeness and a very poor score for native fish recruitment. The valley had lost native species richness, but native species still contributed over 58% of the biomass in samples and outnumbered alien species by 14:1. Native fish recruitment was generally very poor in both zones: freshwater catfish, Hyrtl's tandan and Murray cod showed no evidence of recruitment. However, bony herring was numerous, widespread, and recruiting strongly.

Fish

The Macroinvertebrate community of the Warrego Valley river system was rated in good condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 76. (Lowland and Slopes zone: Good).

The communities of both zones showed minor or no differences from reference condition, with the Slopes zone being in better condition. The proportion of sites in good condition was high (71%); 10 sites (29%) were in moderate condition. Family richness generally was low, but was high relative to reference condition.

Macroinvertebrates

The riverine Vegetation of the Warrego Valley river system was rated in good condition, with an aggregate Vegetation Index score (SR–VI) of 100. (Lowland and Slopes zones: Good condition).

The Warrego Valley is notable for the consistently good condition of its riverine vegetation. In both the Slopes and Lowland zones, abundance, richness and nativeness metrics were all near reference. Structure is in moderate condition in the Lowland zone and quite variable, indicating patchy clearing in the near riparian domain.

Vegetation

The Physical Form of the Warrego Valley river system was rated in good condition, with an aggregate Physical Form Index score (SR–PI) of 89. (Lowland and Slopes zones: Good condition).

Overall, the valley's riverine physical form was characterised by elevated sediment loads since European settlement associated with limited sedimentation in the Lowland zone river channel and floodplain. There was also evidence of channel contraction. The valley's river channel form, bank dynamics and floodplain dynamics were rated as good. Bed dynamics was rated as moderate.

Physical Form

The Hydrology of the Warrego Valley river system was rated in good condition, with an aggregate Hydrology Index (SR–HI) score of 100. (Lowland and Slopes zones: Good condition).

The Warrego Valley river system was characterised by a mainstem river and headwater streams in good condition. Both the mainstem river reaches and the headwater streams were characterised by having near to reference condition in high over bank floods, low over bank floods, flow variability, flow seasonality, low- and zero-flow events, high-flow and flow gross volume.

Hydrology

Wimmera Valley

Lowland Zone

Slopes Zone

SR–EH
100 — Good
80 —
60 — Moderate
40 — Poor
20 — Very Poor
0 — Extremely Poor

0   20   40   60   80   100 km

44	Valley
68	Slopes
33	Lowland

69	Valley
70	Slopes
69	Lowland

40	Valley
21	Slopes
49	Lowland

84	Valley
66	Slopes
91	Lowland

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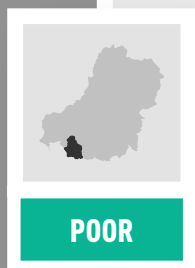
The Wimmera River rises in the hills in the south of the catchment and terminates in wetlands that include Ramsar-listed sites at lakes Hindmarsh and Albacutya, two of the largest natural freshwater lakes in Victoria. There are seven storages (>15 GL) on tributaries but only one small storage, Mount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

The Wimmera Valley covers about 30,000 km^2, or nearly 3% of the Basin area.

River Ecosystem Health

The Wimmera Valley river ecosystem was rated in **poor health.**
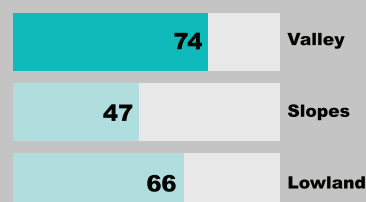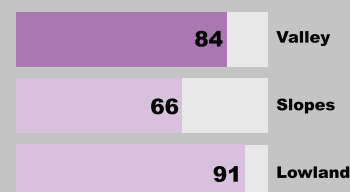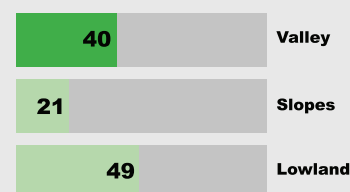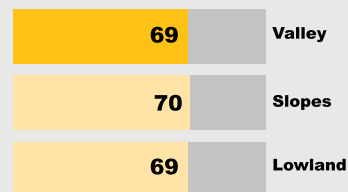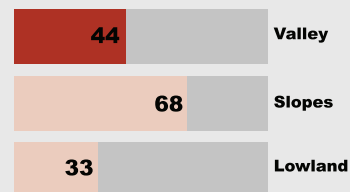
(Lowland and Slopes zones: Poor).

The Fish community of the Wimmera Valley river system was rated in poor condition, with an aggregate Fish Index score (SR–FI) of 44. (Lowland zone: Very Poor condition; Slopes zone: Moderate condition).

The fish community was characterised by a poor score for expected native fish species, a very poor score for nativeness and a moderate score for native fish recruitment. The Lowland zone in particular had few native fish and lacked 43% of the predicted native species. Alien species contributed over 89% of the biomass in samples. Native fish recruitment was poor in the Slopes zone and moderate in the Lowland zone.
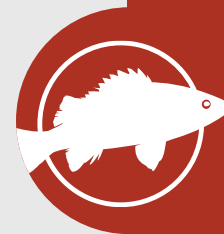
Fish

The Macroinvertebrate community of the Wimmera Valley river system was rated in moderate condition, with an aggregate Macroinvertebrate Index score (SR–MI) of 69. (Lowland and Slopes zones: Moderate condition).

The proportion of sites in moderate or good condition was high (77%). Family richness generally was reduced compared to reference condition. Diversity was low (average 17 families per site). The valley contained 55% of the families found across the Basin.

Macroinvertebrates

The riverine Vegetation of the Wimmera Valley river system was rated in poor condition, with an aggregate Vegetation Index score (SR–VI) of 40. (Lowland zone: Poor condition; Slopes zone: Very Poor condition).

In this valley, the Lowland zone has a greater influence on the valley condition index than the Slopes zone, due to its greater stream length. Abundance and diversity for the valley vegetation was low, as were the scores for quality and integrity. There was low nativeness in the near riparian domain of the Slopes zone. The lowland floodplain domain was in somewhat better condition.

Vegetation

The Physical Form of the Wimmera Valley river system was rated in good condition, with an aggregate Physical Form Index score (SR–PI) of 84. (Lowland zone: Good condition; Slopes zone: Moderate condition).

Overall, the valley's riverine physical form was characterised by elevated sediment loads since European settlement and associated sedimentation in the river channel and floodplain. There was also evidence of channel enlargement and simplification. The valley's river channel form and bank dynamics was rated as good. Bed dynamics was rated as poor and floodplain dynamics was rated as moderate.

Physical Form

The Hydrology of the Wimmera Valley river system was rated in moderate condition, with an aggregate Hydrology Index (SR–HI) score of 74. (Lowland zone: Moderate condition; Slopes zone: Poor condition).

The Wimmera Valley river system was characterised by a mainstem river in moderate condition and headwater streams in good condition. The mainstem river reaches were generally characterised by moderate differences from reference condition in flow variability, flow seasonality, low- and zero-flow events and high-flow and near reference in flow gross volume. The headwater streams generally showed little or no alteration in any indices.

Hydrology

8. RECOMMENDATIONS

ISRAG recommends that the following be considered for future SRA-like, large-scale condition surveillance reports:

- Within themes, there is scope for improvements to some metrics, additions to metrics, and improvements to methods for defining reference condition.

- Addition of themes and spatial components in line with related Basin monitoring programs. The SRA's spatial context should be increased to explicitly assess other parts of the riverine landscape (floodplains, wetlands, terminal lakes). The SRA should also include other ecological components such as birds.

- Alignment of surveillance monitoring with management and policy initiatives and requirements, including the Basin Plan.

- Focussing analyses and assessments on targets as well as differences from reference, with the latter serving as the assessment benchmark. Targets should be set and integrated across a range of scales, from individual assets to valley scale.

- Improve the diagnostic capacity of monitoring results and interpretation.

There is a growing need for information that links human drivers such as water and land management to ecosystem responses. Design and analysis should evolve to facilitate such diagnostic interpretation, while not losing a primary surveillance role.

ISRAG recommends the inclusion of assessments of wetland and floodplain woodland systems as identified under the Basin Plan, including the Lower Lakes and Coorong and other key assets.

ISRAG strongly recommends that links be established between asset-focussed monitoring and evaluation proposed around specific watering interventions under the Basin Plan and 'whole of river system' surveillance monitoring and assessment as soon as possible, under a fully integrated monitoring program. This could be achieved by:

- developing an integrated Monitoring and Evaluation framework which explicitly describes the policy and conceptual basis, design, analysis and interpretation for monitoring across scales from valley to asset, short to long term, and 'intervention' to 'surveillance'

- inclusion of common ecosystem components (indicators) across several monitoring programs under a unified design framework

- developing common sets of ecosystem targets that each monitoring activity should address, under a common conceptual and design framework.

Without this, ecosystem condition monitoring activities are at risk of lacking focus, being limited in applicability and lacking in flexibility to respond to a changing management and policy environment.

Fish

ISRAG identifies a need to refine the definition of reference condition, in particular around levels of recruitment required to sustain populations at zone and valley scales over the medium to longer term, and to better accommodate the variety of recruitment strategies employed by native fish species. In addition, improvement in the definition of reference condition across all Fish theme metrics should be pursued using a variety of techniques, especially modelling. The introduction of relative abundance measures into the assessment would greatly improve its utility and sensitivity.

Macroinvertebrates

ISRAG re-states the need for future assessments to include the recommendations made in SRA report 1 for incorporation of 'mega–invertebrates' (crayfish and mussels) and relative macroinvertebrate abundance. Quantification of reference values for a measure of relative abundance (e.g. in relative abundance classes) is likely to be feasible and would add considerable value—in terms of sensitivity and ecological significance—to the macroinvertebrate assessment for the Basin.

Vegetation

ISRAG advises that a substantive ongoing effort in vegetation mapping is required to address many of the systematic errors and issues with the current quality of vegetation data, and particularly to address the need for dedicated mapping of riverine (riparian and floodplain) vegetation.

The degree to which the condition of the Near Riparian domain reflects that of the true riparian zone (e.g. as a correlate/surrogate) is, however, unclear. We strongly recommend that investment be made in the characterisation and mapping of riparian vegetation to overcome this problem.

There remains a considerable need to derive a well-designed collection of ground-truth data in synchrony with LiDAR data collection, and investment in a small program to better define reference cover estimates. The combination of optical imagery and LiDAR should also be further explored.

Physical Form

ISRAG recommends that further quality assurance against ground-truthed field measurements occurs in future LiDAR data conversion.

The development of a remote-sensing approach (whether LiDAR or by satellite) to the assessment of floodplains—for vegetation, wetland and floodplain form— accompanied by a field-verification QA/QC program is recommended. As is incorporating a geomorphological 'typology' within the modelling approach to refining the quantification of reference condition for LiDAR-derived Physical Form theme metrics.

Hydrology

ISRAG identifies a need to integrate farm dam and land-cover modelling within the water resource modelling framework. A further improvement will be to extend water resource modelling to represent all diversions within the catchment, including in the smaller unregulated streams. It is particularly important to build an improved understanding of hydrological change on the Basin's lowland floodplains.

Investment in a standardised high resolution DEM (Data Elevation Model) for Murray–Darling Basin catchments, as well as floodplain extent mapping, is a high priority.

Another important need identified by ISRAG is to link data used in the Physical Form and Hydrology themes to assess hydraulic conditions and connectivity—including wetting/drying of the streambed, inundation of bank and bench habitat, mobilisation of bed sediments and floodplain/wetland inundation. This functional assessment could be extended to consider landscape-scale metrics related to artificial barriers and inundation of habitats by man-made impoundments, and create a framework within which the use of infrastructure to reinstate desirable aspects of the reference flow regime might be assessed.

ISRAG suggest that if LiDAR and imagery data collection were repeated for both Physical Form and Vegetation in the next two to six years this should—once the 2010 data are fully analysed—allow assessment of responses of these components to the floods.

ISRAG recommend routine ongoing sampling and assessment continue for the SRA to document trends in Fish, Macroinvertebrates and Hydrology across the Basin. We also recommend initiation of repeat assessments for Physical Form and aspects of Vegetation within the next five years.