

Australian River Assessment System (AusRivAS)

Background

The Australian River Assessment System (AusRivAS) is a system for assessing the health of Australia's rivers. The system was developed as part of the Monitoring River Health Initiative (MRHI) of what was then known as the National River Processes and Management Program (and more recently as the National River Health Program) commencing in 1993. The MRHI aimed to provide a basis for a consistent and scientifically sound approach to river condition assessment nationally, that allows comparison of the condition of streams and rivers both within and between States and Territories. AusRivAS is the result of approximately 11 years of R&D, much of that funded by the Australian Government through a partnership between the Australian Government (Environment Australia, Land & Water Australia (LWA), CSIRO, and the Murray–Darling Basin Commission (MDBC)), State and Territory agencies, researchers and industry.

The system was developed because of the growing concern in the community and government about the degradation of Australian rivers, and a recognition of the need to monitor and assess their biological condition (CEPA 1992). The first extensive inventory of river conditions had been carried out in Victoria in 1990 by the Victorian Department of Water Resources. Biological features included the vegetative cover of banks and verges, abundance of aquatic plants, cover for fish and amount of organic debris. This inventory showed that larger streams and streams in cleared areas were in the worst biological condition. This conclusion was in contrast to that reached when only physical factors were considered, stressing the need for biological assessment (CEPA 1992).

There was no national consensus on how biological monitoring should be conducted, and the NRHP sought to develop monitoring techniques that were scientifically sound and had support across all Australian Government, State and Territory agencies. AusRivAS is now the only nationally endorsed approach for measuring aquatic ecosystem health at site, catchment, regional and state/national scales.

The Project

Investment costs

Table 1 presents the investment costs by year for Land & Water Australia, Environment Australia and others (nominal \$ terms). LWA contributed 10.5% of the total investment in nominal terms.

Table 1: Resources invested (nominal dollars) by year for LWA, EA and others

Year	LWA(a)	EA	Other (b)	Total
1992–93	1,627	5,448	9,433	16,508
1993–94	6,117	20,479	1,622,250	188,846
1994–95	145,857	488,305	1,500,084	2,134,246
1995–96	322,657	1,080,201	1,620,009	3,022,867
1996–97	260,625	1,207,310	1,506,552	3,074,487
1997–98	223,615	748,626	1,049,354	2,021,595
1998–99	277,757	929,881	1,149,725	2,357,363
1999–2000	28,597	95,736	23,132	147,465
Total	1,366,853	4,575,985	7,020,539	12,963,377

- (a) The EA funds were pooled with LWA funds in the National River Health Program (NRHP). EA contributed around 77% of the \$13 million budget of the program, and it can be assumed that the same percentages apply to the AusRivAS component of the NRHP (Elizabeth Ann, pers. comm. 2003). Another source (Gray, pers. comm. 2003) stated that in the order of \$4.8 million plus staff time had been expended by EA since 1996–97, including a direct payment of \$1.5 million to LWA. It is assumed that these amounts have been appropriately accounted for using the above distribution.
- (b) Includes Agriculture WA, Queensland Department of Primary Industries and Fisheries, CSIRO Land and Water, Environmental Research Institute, Australian Water Technologies, NSW Environment Protection Authority (EPA), Murray Darling Freshwater Research Centre, University of Canberra, Monash University, University of Tasmania, University of Western Australia, Edith Cowan University, Murdoch University, Water and Rivers Commission (WRC) WA, Conservation and Land Management (CALM) WA, NSW Department of Sustainable Natural Resources, Australian Water Quality Centre, Environment Protection Office, Water Eco-Science Pty Ltd, Victorian Environmental Protection Authority, Victorian Department of Natural Resources and the Environment, Tasmanian Department of Environment and Land Management, Inland Fisheries Commission Tasmania, Tasmanian Department of Primary Industries, Water and Environment, ACT Department of Urban Services, NT Department of Infrastructure, Planning and Environment.

One estimate puts the ongoing cost of maintaining the models by the Cooperative Research Centre for Freshwater Ecology (CRCFE) at about \$95,000 per annum (Donohue, pers. comm. 2003). Another estimate consistent with the previous is that the cost is between \$6,800 and \$200,000 plus staff time depending on the objectives (Gray, pers. comm. 2003). Both of these estimates exclude the cost of site assessments, which would be undertaken by the State and Territory agencies.

Investment Description

AusRivAS is designed to use the concept of ‘departure from natural’ (as measured by changes in aquatic macroinvertebrate, fish, riparian vegetation, and diatom community assemblages, as well as changes in physical structure and flow regimes) to monitoring river health. Most often, macroinvertebrates are used. The presence or absence of these macroinvertebrates can provide an overview of the prevailing conditions and health of a waterway over the period of 6–12 months and sampling requires only one or two visits per year. This contrasts with physical and chemical assessments, which provide an indication of the condition of the waterway at an instant in time, and may require intensive sampling through time.

Land & Water Australia, in partnership with Environment Australia (now the Department of the Environment, Water, Heritage and the Arts (DEWHA), and State/Territory agencies, provided funding for the development of the AusRivAS framework, datasets, training and quality-assurance support,

related R&D, models, and the predictive software used to run them. This development was undertaken by the Cooperative Research Centre for Freshwater Ecology (CRCFE) and the various state agencies. The CRCFE drew heavily on a system from the United Kingdom called RIVPACS (River Invertebrate Prediction and Classification System) to develop AusRivAS and a *Bioassessment Manual*.

In its current form, AusRivAS is based on national protocols for the rapid sampling, identification, coding and sorting procedures used to obtain data about macroinvertebrates, and associated river habitat and water chemistry. The national protocols, software platform and support resources facilitate the sharing of data and collaboration among agencies, consultants, community groups and other parties. The standardisation of the overall framework and reporting outputs also allows direct comparative assessment across catchments, regions, jurisdictional boundaries and states.

State agencies were contracted under the MRHI to collect macroinvertebrate and environmental data at almost 2000 reference and 4000 test sites across Australia between 1995 and 2000. The reference-site data collected were then used to develop and test models. In addition, a national assessment of river health was carried out using the AusRivAS models and monitoring data collected by the States and Territories. This assessment revealed that approximately 30% of sites had lost up to 50% of the types of macroinvertebrates that should have been present, and the associated ecosystems were consequently significantly impaired. In many cases, the data can also be used to identify the sorts of impacts that cause changes to the biota, as the AusRivAS software platform also contains diagnostic tools to assist with data interpretation. This data supported the *National Land and Water Resources Audit* (the Audit) and the national *State of the Environment* (SoE) reports. AusRivAS has been applied to more than 70,702 km of Australian rivers (Gray, pers. comm. 2003).

The Australian Government through DEWHA, in partnership with State and Territory agencies and the CRCFE, has been administering the ongoing development of AusRivAS since 1996. All government agencies have access to the AusRivAS software and training and support services via the internet. It is also made available to consulting firms, schools, universities and community groups.

The software runs a series of State and Region-based season- and habitat-specific predictive models. The technique works by identifying a number of reference sites (natural, minimally impacted or best available) where invertebrates and the physical and chemical properties are sampled (approximately 1500 sites). Each State or Territory has a nominated 'lead' agency responsible for site selection and sampling and ongoing custodianship of their respective datasets and models. The models are built by using the reference sites. Data collected from the sampling of a stream or river of interest are entered into the relevant state/regional AusRivAS model for a particular season or year. The model expresses outputs (O) as a ratio of the number and type of animals found at the test site compared with the number and types of animals that were expected (E) (O:E). The ratios are then allocated into five bands that categorise the degree of disturbance at a particular site. While the ratios do not provide a definitive indication of the cause of a disturbance, they allow individual streams to be considered and prioritised in terms of degradation or ability to regenerate in a catchment-wide, regional, State-wide or even nationwide context.

Reasons for success of the innovation include:

- the appropriateness of using a biological approach to assess riverine condition.

- national coordination and cooperation in the development of the approach. This has led to the standardised sampling, analysis and modelling protocols that now exist. Although the approach is generally standard, there are subtle differences both between and within States.
- rapid adoption into national and regional reporting frameworks, e.g. ANZECC, ARMCANZ water quality guidelines, SoE reporting (Davies, pers. comm. 2003).
- rapid collection, sorting and identification, which reduces the costs and barriers associated with more-traditional biological monitoring.
- the ability for adequately trained communities to be involved in biological monitoring.
- cost effectiveness.

Principal outputs

The principal output of the innovation is standardisation through a nationally consistent system, including support documentation, hardware and software (including models), training, QA/QC procedures, auditing, models and professional support. The system is being actively used by all States and Territories for water-quality monitoring and river-health assessment. Other outputs include improved scientific knowledge on the structures of macroinvertebrate, fish and diatom communities in streams, and the physical structure and chemical composition of our rivers and streams.

Principal outcomes

AusRivAS is being actively used across Australia by all levels of government for catchment-based monitoring, water-quality monitoring, river-health assessment, environmental reporting, catchment planning and river management.

As mentioned earlier, the models were used to carry out the first National Assessment of River Health. The results of this assessment were then reported in the 2001 *State of the Environment Report*, and the *National Land and Water Resources Audit* (2002) and the *Snapshot of the Murray–Darling Basin*.

As with many national assessments, the different States/Territories have benefited in different ways from initiatives at standardising approaches across Australia. Examples of use in each state/territory are provided below.

Victoria

- DSE (Victoria) uses AusRivAS as part of its index of stream condition (ISC) Aquatic Life component (RipRap 1999). The index of stream condition is an integrated measure of river health that aims to provide information to assess trends in the long-term conditions of rivers. It assesses five components of streams, including hydrology, water quality, physical form, streamside vegetation and aquatic life. All invertebrate data collected between 1998-2004 and assessed using AusRivAS was incorporated into the 2nd ISC assessment which was released in 2006 (Metzeling, pers. comm., 2008).
- AusRivAS has been incorporated into the Instream Monitoring Protocol that is used to guide the Victorian EPA's licence requirements (Metzeling, pers. comm. 2003). It is also used in risk-based

assessments as advocated by the new Australian Water Quality Guidelines (2000) (Metzeling, pers. comm. 2003).

- The Victorian River Health Strategy (2003) incorporates targets using SEPP compliance as a measure. One SEPP indicator is AusRivAS. Similar targets are built into some Regional River Health Strategies (Metzeling, pers. comm., 2008).

New South Wales

- AUSRIVAS sampling protocols are currently being used to collect data for the following monitoring programs
 - Monitoring Evaluation and Reporting program in all river systems in Eastern NSW as part of the Framework.
 - Sustainable Rivers Audit (SRA). A monitoring program in the Murray-Darling Basin to assess the ecological condition of rivers in the basin.
 - Monitoring programs to assess the ecological condition of rivers within Sydney Water Catchment areas (over 50 sites each year)
 - Monitoring programs to assess the condition of urban streams
 - Monitoring programs and one-off sampling events to detect the impacts of mine discharges, and other point source impacts
 - A monitoring program to assess the condition of Alpine and sub-alpine streams in areas where cloud seeding is occurring in NSW.
- The use of O/E values for reporting the results of the Sustainable River Audit is currently under review. For the current reporting period (2008) an alternative measure is used pending the development of new AUSRIVAS models for the basin and evaluation of the performance of O/E values and alternative measures based on macroinvertebrates.
- AUSRIVAS O/E values and the data collected using the NSW AUSRIVAS sampling protocols are used for conservation planning activities as part of a decision support tool to help Catchment Management Authorities determine regional priorities for conservation actions for rivers and streams, and as part of biodiversity assessments for regional biodiversity management plans

South Australia

- In South Australia (SA), AusRivAS is a component of the EPA's ambient monitoring program for streams, covering 43 sites around the State, providing a biological measure of condition to complement water chemistry and physical measurements taken at each site. This work, as well as all monitoring programs carried out by the EPA, is currently under review and it is anticipated that future work will involve a field assessment to determine if sites have changed significantly and formal samples will only be taken if some threshold of change has occurred (Goonan, pers. comm., 2008).
- Previous AusRivAS data has been used by the EPA in SA in numerous investigations of the impacts from discharges to streams which occasionally involves the collection of new data from impacted and unimpacted sites to determine the spatial extent of environmental harm. Results have been used in prosecutions relating to serious and material environmental harm, breach of license, and clean-up orders. Note that there have been no discharges to inland waters in the past 15 years for which there is not a nearby AusRivAS site to allow some historical perspective on stream condition (Goonan, pers. comm., 2008).
- AusRivAS data has been used in SA as part of a range of studies that include clarifying the linkages between biota and landuse at catchment, riparian and reach scales; taxonomic studies;

habitat preference studies, effects of fire on stream condition; environmental flows projects; recent bioregionalisation discussions and modelling, university and consultant projects (e.g. NLWRA Assessment of River Condition, salt sensitivity project by CSIRO, Clare Valley ephemeral streams project) (Goonan, pers. comm., 2008).

- The AusRivAS approach is currently included in the MDBC's Sustainable Rivers Audit but alternative biotic indices are being tested along with the AUSRIVAS O/E index (Goonan, pers. comm., 2008).
- Some NRM regions in SA have also included AusRivAS sampling as part of their monitoring programs designed to report on the state and condition of waters in their regions, with most work carried out in the Mt Lofty Ranges (Goonan, pers. comm., 2008).
- Selected results from using AusRivAS in SA have been written up in regional brochures, biodiversity reports in some regions, scientific publications (e.g. locust spraying impacts in Flinders Ranges, new records of invertebrates in SA, salinity is not necessarily bad for biodiversity) (Goonan, pers. comm., 2008).
- In SA, the intention at this stage is to continue to use the general sampling protocols developed under the AUSRIVAS program in SA and to test alternative bioassessment approaches against disturbance gradients, with the aim of improving the ability to assess site condition and predict degrading processes before they occur if possible (Goonan, pers. comm., 2008).

ACT

- The ACT is continuing a level of AusRivAS monitoring that forms part of the annual water reporting process (ACT Government, 2007).
- AusRivAS has been used in the assessment of the effects of the widespread Canberra 2003 bushfires (Nichols, pers. comm. 2003).
- AusRivAS is used for specifying ecological objectives in the ACT Environmental Flow Guidelines 2006 (ACT Government, 2006). AusRivAS is also used as a performance criterion in certain ACT water abstraction licences (Chester, pers. comm., 2008).

NT

- The NT Department of Natural Resources, Environment and the Arts is using AusRivAS to assess developments (e.g. land clearing) in the Darwin region, and in the Daly River Catchment. Darin-Daly genus and family level models, including one season (early dry season) and a single habitat (Stream edge) have been developed, in addition to the Top End models (Townsend, pers. comm., 2008).
- AusRivAS assessment using macroinvertebrates is now being incorporated into the requirements of wastewater discharge licenses issued by the NT Department of Natural Resources, Environment and the Arts (Townsend, pers. comm., 2008).

Tasmania

- AusRivAS was used in the Tasmanian State of Rivers program to report on river health and to identify stressed rivers in Tasmania, and has contributed to Tasmanian Water Management Plans and the identification of freshwater ecosystem values (Read, pers. comm. 2003). It has also been used to develop core datasets for the Conservation Framework for Freshwater Dependent Ecosystems for the State.
- AusRivAS is used to report on Tasmania Together priority benchmarks (TT 12.2.2) (Graham, pers. comm., 2008).

- AusRivAS is used in Tasmania in the development of investment strategies and resource condition targets by regional NRM committees (Graham, pers. comm., 2008).
- Other uses of AusRivAS in Tasmania include in training and accreditation programs, Conservation of Freshwater Ecosystems Values (CFEV) validation, and incorporation into the Tasmanian River Condition Index (TRCI) and testing of the TRCI methodology. Users of AusRivAS in Tasmania include DPIW, NRM groups, Hydro Tasmania and consultants (Graham, pers. comm., 2008).

Queensland

- AusRivAS has been used in ecological condition assessment, environmental flow assessment and licence-compliance monitoring (including several legal cases) in Queensland (e.g. by the Department of Natural Resources and Water in the water allocation and management (WAMP) process) and NSW (by EPA and the Department of Planning, Infrastructure and Natural Resources) (Choy, pers. comm. 2008).

Western Australia

- AusRivAS has been used for local assessment of south-western rivers in WA by the Department of Water in two estuarine catchments (van Looij, pers, comm., 2008).
- The Water Corporation in WA uses AusRivAS to assess streams in drinking water catchments (van Looij, pers, comm., 2008).
- A number of consultants in Western Australia offer AusRivAS as part of their services (van Looij, pers, comm., 2008).

Additional uses of AusRivAS include:

- A number of States have embarked on formal training programs to extend the AusRivAS methodology to community groups, local government and industry. For example, EPA Victoria provides training and competency testing courses to any interested party, principally consultants engaged in biological monitoring work.
- AusRivAS-related tools such as SIGNAL and taxonomic key guides are being used by schools and community groups for educational and investigative purposes; for example, Waterwatch. In addition, DEWHA has developed support systems for Natural Resource Management regional coordinators, for example, 'community' versions of AusRivAS.
- AusRivAS is being used for research by various academic institutions, particularly the CRCFE which has developed the predictive models.
- The AusRivAS model and software are available for commercial purposes (e.g. consultants and industry) and can be accessed on the internet with appropriate passwords and used with appropriate training and accreditation.
- The system has been trialled in New Zealand and Indonesia, but it was not adopted in New Zealand. It was also being actively developed, with Australian support, within the USA to replace and/or supplement the US EPA's IBI system, nationally (Davies, pers. comm. 2003).
- Some projects under the National Action Plan for Salinity and Water Quality (NAP) and NHT may have drawn on AusRivAS data for performance measurement and funding allocation decisions. AusRivAS may also have been taken into account in State and Australian government policy development.
- Macroinvertebrates are one of the core indicator under the Natural Resource Management (NRM) Monitoring and Evaluation. AusRivAS, by way of macroinvertebrate data, has also been

recognised as a potential input in the National Framework for the Assessment of River and Wetland Health (Choy, pers. comm., 2008).

- AusRivAS has also been used in the Sustainable Rivers Audit of the Murray-Darling Basin.

AusRivAS enables management agencies that have adopted it to assess riverine status more directly, and can assist with diagnosis of problems. It has also led to a wider recognition of the importance of biological monitoring of river health.

Table 2 shows the aquatic biota index (macro-invertebrates) results for each State and Territory using AusRivAS as reported in the State of the Environment Report 2006. It should be noted that this assessment includes reaches of river in urban and intensive agriculture catchments.

Table 2: Aquatic biota index (macro-invertebrates) results using AusRivAS

	Total length of reach (km) in each category and percentage of total in parentheses				Percentage of total length with data
	Reference	Significantly impaired	Severely impaired	Extremely impaired	
Qld	9,334 (80)	1,997 (17)	250 (2)	16 (1)	16
NSW	11,366 (50)	7,551 (34)	2,801 (13)	690 (3)	38
ACT	169 (64)	76 (29)	17 (7)	0 (0)	97
Vic	9,347 (76)	2,447 (20)	344 (3)	49 (1)	77
Tas	4,248 (75)	1,097 (20)	142 (3)	100 (2)	100
SA	7,866 (83)	1,098 (12)	124 (1)	389 (4)	98
WA	4,401 (64)	1,977 (29)	419 (6)	31 (3)	27
NT	2,063 (88)	247 (10)	47 (2)	0 (0)	11
Total	48,793 (69)	16,490 (23)	4,144 (6)	1,275 (2)	34

Source: State of Environment 2006

Benefits associated with the innovation

While the above shows that AusRivAS is being used widely at present, the associated benefits from its use and hence from the investment will be principally captured in the future. A large part of the output from this investment is in the form of knowledge and a system of bioassessment that did not exist before. This bioassessment system will undergo improvement and modification in the future but AusRivAS can be credited with adding a new biological monitoring tool to the agenda for assessing the health of waterways. The result is that Australia has an additional tool for gauging the health of its waterways now and in the future. However, it should be recognised that bioassessment is still in its infancy in Australia and is largely limited at present to impact and condition assessment.

The ultimate impact of an improved monitoring system needs to be viewed in the context of management actions and responses to monitoring information. At present, relationships between river health and long-term actions such as improving land-management practices, riverbank stabilisation, removing restrictions to flows, improving stream habitats, increasing environmental flows, restoring riparian vegetation etc. are not well established, although some management changes of these types

have been made already. As these identified causal factors commence being manipulated to a greater extent, the value of monitoring, of which bioassessment can form a part, will increase significantly.

Economic benefits

- The standardised assessments allow more-effective plans and priorities to be developed by governments for river management, including protection and rehabilitation.
- Progress can be made more rapidly in overall river health due to the standardised assessment methods.
- There will be less wastage of public resources due to the improved and more nationally consistent and coordinated assessment processes.
- NAP will be more effective as regional bodies will use AusRivAS as part of a national river-condition indicator in developing investment strategies and targets.
- There may be reduced wastage of non-comparable data because of standardisation (Nichols, pers. comm. 2003)
- Improved taxonomic materials (Nichols, pers. comm. 2003)
- Improved assessment and quality of data, and improved confidence in data collected due to QA/QC procedures (Nichols, pers. comm. 2003)

Environmental benefits

- Potentially improved ecological health of rivers, and associated benefits (e.g. improved water quality) due to standardised interpretations of ecological condition and subsequent management actions.
- Much greater understanding and knowledge of riverine ecosystems, particularly the invertebrate component and its associated environmental needs (Metzeling, pers. comm. 2003).
- An additional measurement tool for environmental regulation (such as EPA licences) and policy purposes (Metzeling, pers. comm. 2003)

Social benefits

- Educational benefits to school children and others in the community participating in Waterwatch and similar programs that utilise the AusRivAS method.
- Increased capacity of individuals who have been trained in the use of AusRivAS (in both data collection and use of the model). There is now a greater number of trained individuals, including those in community groups, and the increased capacity empowers communities to help and monitor the environment (Nichols, pers. comm. 2003).
- Community benefits due to the greater ease and clarity of communicating bioassessment results, and the ability to put local/regional results in a large scale (e.g. regional, State and national) context.

Public versus Private Benefits

The vast majority of benefits from AusRivAS are public benefits. These are generally in the form of an improvement in water quality, or understanding of water quality issues in a particular waterway. Public benefits also accrue in the form of improved effectiveness of government spending. Benefits from addressing water quality issues in Australia will accrue to all sectors of society who value improved water quality, including consumers of water (town and irrigation supply) and those who have an interest in the sustainability of natural resources.

Match with National Priorities

The Australian Government's national and rural R&D priorities are reproduced in Table 3.

Table 3: National and Rural R&D Research Priorities 2007-08

Australian Government	
National Research Priorities	Rural Research Priorities
1. An environmentally sustainable Australia	1. Productivity and adding value
2. Promoting and maintaining good health	2. Supply chain and markets
3. Frontier technologies for building and transforming Australian industries	3. Natural resource management
4. Safeguarding Australia	4. Climate variability and climate change
	5. Biosecurity
	<i>Supporting the priorities:</i>
	1. Innovation skills
	2. Technology

The AusRivAS research is aimed at improving sustainability and natural resource management (National Research Priority 1 and Rural Research Priority 3).

Quantification of benefits

While the benefits from AusRivAS described above are difficult to quantify, we have made an attempt to value them. Some broad assumptions have been made.

Previous methods used in quantification

ACIL (1996) quantified the benefits through assuming that the use of the AusRivAS model would replace other methods of testing water quality, and that AusRivAS would have lower costs than those existing methods. However, in 1999 ACIL found that this had not eventuated, and that those who had adopted AusRivAS were still using the existing methods as well. ACIL (1999) calculated the benefits by assuming that there was a 50% likelihood that AusRivAS brought forward 'improved stream restoration' across Australia by 1 year to 2005. The value of this stream improvement assumed was \$50 per Australian household, estimated via benefit-transfer techniques.

In 2001, BDA found that government officers agreed AusRivAS would contribute to better river health policy, planning and action and would bring forward the benefits of improved river health, but none of those officers would comment on the likely level and timing (BDA 2002). BDA did not calculate the benefits of the innovation, as they reported that AusRivAS was a knowledge product that would generate benefits only through the subsequent use of that knowledge by river management groups and policy makers, and was therefore not suitable for quantitative analysis. They added that NAP is a key policy response that will draw on AusRivAS in the development of catchment river

health targets, the determination of funding allocations and ongoing monitoring. They acknowledge that the outputs of the AusRivAS model were used by NLWRA, SoE and the MDBC Sustainable Rivers Audit and that these will influence State and Australian government policy making. However they state that detailed studies would be required to determine the contribution of AusRivAS to these policy approaches, and that determination of the outcomes and benefits from these policies may not be observable for decades.

Method of quantification

As described in the benefits section above, the principal benefits of AusRivAS will not be evident for many years, and it will be just one of many factors contributing to improved river health across Australia. As BDA (2002) pointed out in its assessment, AusRivAS is a knowledge product that will contribute to benefits through the subsequent use of that knowledge. This makes it very difficult to quantify in a benefit–cost framework, but the following approach has been taken for quantifying the benefits from AusRivAS. Table 4 summarises the assumptions made in this analysis and some of them are explained below.

- From a choice-modelling study, healthy rivers (as opposed to unhealthy rivers) can be valued at \$25,200 per km across all Australians. This is based on a study that found that Australian households are each willing to pay \$0.08 per 10 km of waterway for them to be restored to ‘fishable and swimmable’ (Van Bueren and Bennett, 2000). There are 7 million households in Australia, however only 45% are assumed willing to make the payment (Van Bueren and Bennett, 2000). This results in a total willingness to pay of \$25,200 per km of river restored. Households are willing to pay this amount annually for 20 years.
- It is assumed that the use of AusRivAS will benefit only a proportion of the rivers in Australia. For the purposes of this assessment, it is assumed that it will potentially benefit those rivers assessed by the NLWRA’s environment index as moderately modified, substantially modified and extensively modified. This is equivalent to 161,764 km (NLWRA 2002). It is further assumed that only 50% of those kilometres of river have the potential to be restored completely to a healthy state. This proportion is assumed to be constant both ‘with’ and ‘without’ the research
- AusRivAS is assumed to be used only on 50% of those with the potential to be restored. This may seem like a high proportion, however it should be recognised that AusRivAS will also be used on rivers not assessed by the NLWRA.
- Many policies and management activities contribute to restoring river health. Monitoring and evaluation (M&E) is a key ingredient in this restoration, and bioassessment is an important component of the M&E of river health. AusRivAS as the only nationally endorsed bioassessment method will contribute significantly to M&E.
- For the purposes of this study it is assumed that M&E increases the probability of successful rehabilitation. Without M&E, the probability of successful rehabilitation is assumed to be 10%, with M&E, this probability increases to 20%.
- It is further assumed that with the addition of a bioassessment tool such as AusRivAS, this probability increases further, to 22%. Therefore, the benefit attributable to AusRivAS is an overall 2% improvement in the probability of river restoration being successful.
- It is assumed that the first year the restoration of the rivers takes place is 2004–05 (5% of the assumed river length) and restoration continues to accrue in a linear fashion over the next 20 years.

Table 4: Assumptions for the valuation of benefits from AusRivAS

Variable	Value	Source
Value of healthy rivers to Australian households	\$0.08 per 10 km	Van Bueren and Bennett (2000)
Number of households in Australia	7 million	Australian Bureau of Statistics, BDA(2002)
Proportion of households willing to pay for healthy rivers	45%	Van Bueren and Bennett (2000)
Value of healthy rivers to Australia	\$25,200 per km per annum for 20 years	Derived from above
Length of rivers used in analysis	161,764 km	Total length of reaches assessed by the NLWRA's environment index as moderately modified, substantially modified and extensively modified.
Proportion of kilometres that could be restored by 2025	50%	Agtrans assumption
Proportion of kilometres that could be restored that AusRivAS is used on	50%	Agtrans assumption
Probability of those 50% of rivers being restored by 2025 without AusRivAS	20%	Agtrans assumption
Probability of those 50% of rivers being restored by 2025 with AusRivAS	22%	Agtrans assumption
First year of improvement	2004–05	Agtrans assumption
River restoration rate	Equal proportions over 20 years from 2004–05 to 2023–24	Agtrans assumption

Results

All past cost and benefits were expressed in 2006-07 dollar terms using the CPI. All benefits after 2006-07 were expressed in 2006-07 dollar terms. All costs and benefits were discounted to 2006-07 using a discount rate of 5%. The base run used the best estimates of each variable, notwithstanding a high level of uncertainty for many of the estimates. The base analyses ran for the length of the investment period plus 25 years from the last year of investment (1999-2000) to the final year of benefits assumed (2024/25).

Investment criteria were estimated for both total investment and for the LWA investment alone. As well as for the 25 year benefit period, each set of investment criteria were estimated for different

periods of benefits. Benefits for LWA investment criteria were estimated as 10.5% of the total benefits, 10.5% representing the proportion of total costs contributed by LWA. The investment criteria are reported in Tables 5 and 6.

Table 5: Investment criteria for total costs and benefits (discount rate 5%)

Criterion	0 years	5 years	10 years	15 years	20 years	25 years
Present value of benefits (\$m)	0.0	1.12	20.11	54.04	95.56	138.94
Present value of costs (\$m)	28.10	28.10	28.10	28.10	28.10	28.10
Net present value (\$m)	-28.10	-26.98	-7.99	25.94	67.46	110.84
Benefit:cost ratio	0	0.04	0.72	1.92	3.40	4.94
Internal rate of return (%)	negative	negative	1.97	9.89	12.89	14.21

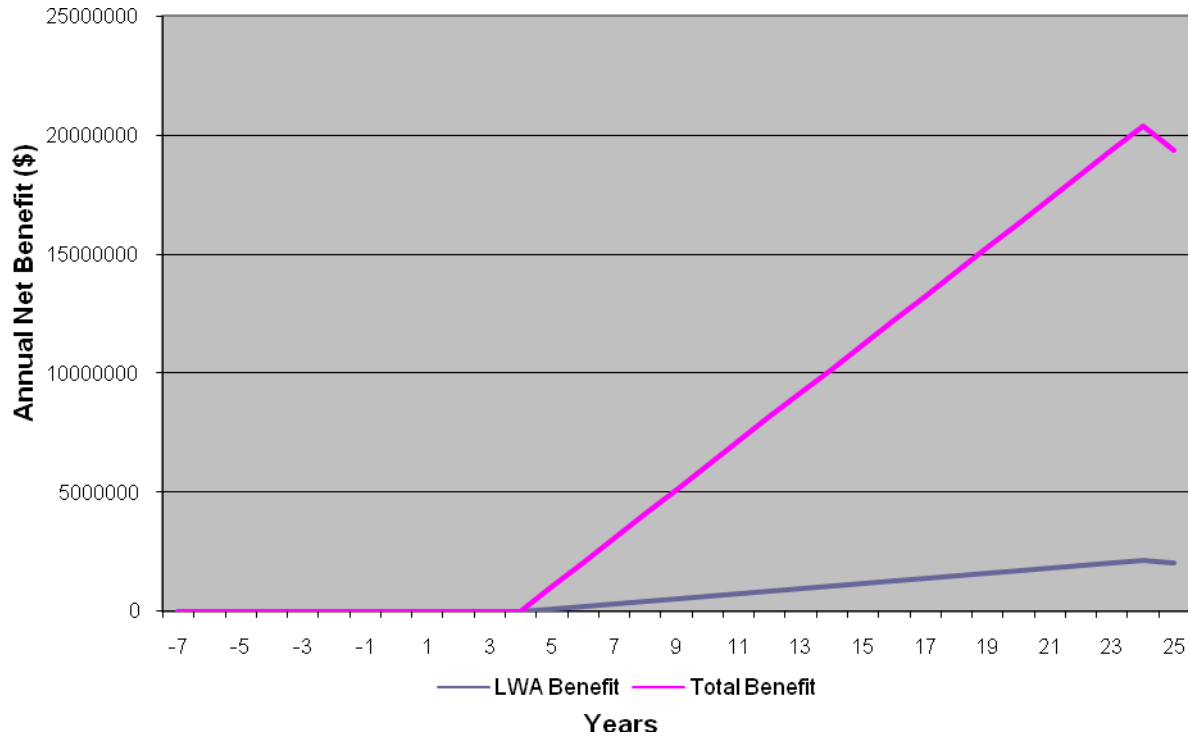
Table 6: Investment criteria for LWA costs and benefits (discount rate 5%)

Criterion	0 years	5 years	10 years	15 years	20 years	25 years
Present value of benefits (\$m)	0.0	0.12	2.11	5.67	10.03	14.58
Present value of costs (\$m)	2.91	2.91	2.91	2.91	2.91	2.91
Net present value (\$m)	-2.91	-2.80	-0.81	2.75	7.11	11.66
Benefit:cost ratio	0	0.04	0.72	1.95	3.44	5.00
Internal rate of return (%)	negative	negative	2.01	10.07	13.09	14.41

The benefits calculated are public environmental benefits.

Figure 1 demonstrates the rate at which net benefits accrue.

Figure 1: Annual Net Benefit Flow



It should be noted that there is a low degree of confidence in the assumptions used in the analysis. While the quantitative results of this analysis should be treated as illustrative only, the real value of the analysis is the logic that has been developed in terms of the framework within which to consider the benefits of AusRivAS.

Another way of quantifying the benefits with more tangible assumptions would be to base an analysis on cost savings to Australia from fewer pollution events. This would be based on the finding that AusRivAS is being used as a tool in obtaining successful prosecutions in cases of water pollution. The increased prosecutions may be a deterrent to other potential polluters, with a consequent cost saving to Australia through reduced clean-up costs, reduced environmental and social costs, and reduced court and other regulatory costs. A method for pursuing this was beyond the scope of the present study.

Sensitivity Analysis

Tables 7 and 8 present the sensitivity to two of the key assumptions in the analysis. Table 6 shows that if the assumed probability of successful rehabilitation with AusRivAS is reduced from 22% to 21%, the investment criteria are still positive, with a B/C ratio of 2.5 to 1. If the probability is increased to 25%, the B/C ratio increases to 12.5 to 1.

Table 7: Sensitivity of investment criteria to the probability of successful rehabilitation with AusRivAS (LWA benefits and costs only; 25 years)

Criterion	Discount rate 5%		
	21%	Base value (22%)	25%
Present value of benefits (\$m)	7.29	14.58	36.44
Present value of costs (\$m)	2.91	2.91	2.91
Net present value (\$m)	4.37	11.66	33.53
Benefit:cost ratio	2.50	5.00	12.50
Internal rate of return (%)	10.1	14.4	20.8

Table 8 shows the sensitivity of the investment criteria to the proportion of rivers on which AusRivAS is used that can be restored. It shows that even if this proportion is reduced to 20%, the investment criteria are still positive, with a B/C Ratio of 2 to 1.

Table 8: Sensitivity of investment criteria to the proportion of rivers on which AusRivAS is used

Criterion	Discount rate 5%		
	20%	Base value (50%)	75%
Present value of benefits (\$m)	5.83	14.58	21.87
Present value of costs (\$m)	2.91	2.91	2.91
Net present value (\$m)	2.92	11.66	18.95
Benefit:cost ratio	2.0	5.00	7.5
Internal rate of return (%)	8.8	14.4	17.1

Conclusion

The main product of the AusRivAS investment is knowledge. The investment has been significant in developing knowledge and skills for bioassessment, which is a technique that was not widely used in Australia beforehand. Along with other monitoring methods, it is being used to prioritise management actions to improve river health. One of its key features is that it is a standardised method that allows comparison between and within States and Territories.

AusRivAS has already produced large benefits in the form of more effective monitoring and evaluation due to the use of bioassessment in the monitoring and evaluation of the large expenditure

expected to be made in catchments and water ways to improve water quality, biodiversity and river health (e.g. NAP).

The AusRivAS investment by LWA was undertaken in a complementary manner and was a strategic investment to deliver value at the national level. It is further evidence that the strategy of co-investment by LWA has been successful.

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