ASSESSMENT FRAMEWORK FOR PRIORITISING WATERWAYS IN WESTERN AUSTRALIA – REPORT B

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1.0 STRUCTURE OF REPORT

Report B of the Framework contains supplementary appendices not included with Report A. These appendices detail:

- State-based (Appendix C) and national (Appendix D) strategies and frameworks for assessing waterways
- Scales and management units (Appendix E)
- Defining and assessing values of waterways (Appendix F)
- Defining and assessing threats to waterways (Appendix G)
- Setting priorities and management responses (Appendix H)
- Waterway classification and reference conditions (Appendix I)
- Approaches to waterway assessment (Appendix J)
- Monitoring and evaluation (Appendix K)
- Photographic imagery of waterway case studies (Appendix L)
- Stakeholder engagement in framework development (Appendix M)

APPENDIX C: STATE-BASED STRATEGIES AND FRAMEWORKS

Victoria

The Victorian River Health Strategy (VRHS) released in 2002, provides the management framework in which the Victorian government in partnership with the community makes decisions on the management and restoration of rivers in Victoria. This document includes background information on river health, current and predicted future river condition, current and future pressures (threats) on rivers and streams, a vision for Victoria's rivers and a series of targets to achieve this vision, a detailed management framework for protecting rivers of very high value and for establishing 5 and 10 year targets for river protection and restoration through community-driven regional planning processes, specific management arrangements for water allocation and the management of river flows, water quality and the river channel and its restoration, and an outline of institutional arrangements and funding for the management of river health in Victoria. This Strategy aims to provide the means for a fair and equitable allocation of water, an improvement of water quality and riparian and in-stream habitat, and an effective mix of protection and restoration activities.

The VRHS recognised that before a management framework could be developed for Victoria, it was important to have some idea of the current ecological health or the waterways of the State. This was achieved through a benchmarking exercise, where the environmental condition of 950 reaches of Victorian rivers was assessed using the Index of Stream Condition (ISC) which combines information on biota, flow regime, water quality and physical condition of the channel. This exercise resulted in a classification of Victorian rivers based on river condition.

The recognition of 'Heritage Rivers' predates this Strategy. After reviewing the value of all its rivers in 1991, the state of Victoria through the Land Conservation Council recognised 18 'Heritage River' reaches, and 26 Natural Catchment Areas, and protects these systems under legislation. In particular, the Ovens and Mitchell Rivers were recognised as 'icon' rivers because of their high conservation value, natural flows and 'intactness' of the entire river system, and their significance for larger systems such as the Gippsland Lakes and Murray-Darling system. The VRHS embraces the results of this review, and builds on the concept of recognition of 'Heritage Rivers'.

The VRHS also recognised that there were a number of other rivers in the state which had State-wide and regional environmental, social and economic values. Management of these rivers is considered through the regional planning process which identifies rivers or river reaches of high value and sets priorities for their protection and restoration. This priority setting process is risk-based and designed to protect existing high value areas and restore those areas where there are the highest gain for resources invested and long-term community commitment. The VRHS proposes that present waterway management plans evolve into River Health Strategies (RHSs). A key feature of these RHSs is the inclusion of a register of all the major environmental, economic and social assets associated with rivers falling into the region in question. The Strategy proposes the development of a consistent, statewide approach to the identification and valuation of river-related assets, and also lists an indicative set of target areas to be included in regional RHSs and related Action Plans. These RHSs are developed by Victoria's 10 regional bodies, the 'Catchment Management Authorities' using this proposed consistent framework.

An important framework for water management that also needs to be considered for Victoria is the Victorian Water Allocation Framework laid down in the *Water Act 1989.* This Framework protects river health by providing water to sustain rivers, provides users with entitlements to water and provides clarity on the entitlements of all users in times of drought, enables water users to make informed choices about their use and management of water, protects social and cultural values, facilitates the movement of water to its highest value use, and enables community input into decisions on water allocation. Mechanisms to achieve this include the establishment of Bulk Entitlements (BEs) and the issuing of licences to individuals for extracting water. Rivers with a high environmental value and a high level of risk (e.g. of major loss of habitat and poor water quality) are given the highest level of management effort, resulting in the development of a community-based Streamflow Management Plan (SFMP).

Currently in Victoria, catchment-based water quality related action plans have been developed to deal with specific issues such as nutrients and salinity. There is thus no one plan that encompasses all water quality issues and projects within a region. The VRHS also proposes a complementary process to the RHS to manage water quality in Victoria through the development of Water Quality Action Plans (CWQAPs) by the Catchment Management Authorities. These plans will build on existing salinity and nutrient management plans, with an expansion to include a range of other water quality issues such as turbidity, thermal water pollution and toxicants. The revised State-wide statutory policy framework for water quality protection in Victoria, *SEPP (Waters of Victoria)* is to be used to set environmental quality objectives as part of this process.

One of the environmental values considered in the indicative common, consistent set to be used in the development of a regional RHS is that of ‘representativeness’. Essentially, ‘representative rivers’ are those that are ecologically healthy and can be used to represent the major river classes that once occurred naturally across Victoria. A preliminary classification based on land type and systems (Land Conservation Council 1991), and later fish and aquatic invertebrates and terrestrial biodiversity (Doeg 2001) was thus undertaken, resulting in the recognition of 19 river regions across the State. The VHRS lists a number of suggested representative river reaches that fall within these 19 river regions for consideration by the Victorian Environment Assessment Council.

Victoria has clearly made progress towards its goal of an integrated approach for water management in the State. It recognises that the cornerstones of the VHRS, the regional River Health Strategies and Water Quality Action Plans need to build on past commitment and investment, with no loss of impetus and goodwill.

New South Wales

Following a review of natural resource management in New South Wales, 13 Catchment Management Authorities (CMAs) were established across the State in 2003 (*Catchment Management Authorities Act 2003 No 104*). These are locally driven organisations with boards that report directly to the NSW Minister for Natural Resources, and are primarily responsible for involving regional communities in management and the delivery of funds from the NSW and Commonwealth Governments for natural resource management in their regions. Included in their mandate are the preparation of Catchment Action Plans (CAPs) and the helping of communities to make decisions on water management.

The NSW Stressed Rivers Assessment was developed by the NSW Department of Land and Water Conservation to provide a consistent framework for classifying rivers with regard to different priorities and policies affecting each sub-catchment (Bennett et al. 2002). The Stressed Rivers Assessment determines overall stress by categorising sub-catchments based on environmental (environmental health) and hydrologic (current water usage) stress, future risk (estimated based on development of all existing water entitlements) and conservation values (Queensland EPA 2007).

The stressed rivers approach successfully combined environmental values and threats to determine river management priorities across different scales (local, regional and statewide). However, it was also found that program objectives needed to be clearly communicated to stakeholders to ensure appropriate indicators and spatial scale were used for assessments (Bennett et al. 2002). Recommended users of the Stressed Rivers Assessment include government agencies, NRM managers and catchment managers (Queensland EPA 2007).

The NSW Stressed Rivers uses the following methods to assess waterway values:

- Selection of sub-catchment and mapping boundaries;
- Estimation of hydrologic stress as the proportion of daily flow extracted within sub-catchments, based on 80^{th} or 50^{th} percentile stream flow;
- Compilation of environmental stress indicators, including extent of riparian vegetation, bank condition, terrestrial vegetation cover, the presence of structures, water quality data, and for tidal zone areas, the extent of acid sulphate soils and their risk to aquatic systems;
- Statistical (principle component) analysis to rank indicators according to thresholds into overall stress levels of high, medium or low; expert panels also assessed the environmental stress for each sub-catchment;
- Consultation with regional stakeholders to provide subjective assessment input;
- Assessment and rating of overall future risk to stream health and water usage;
- Identification of conservation value; and,
- Overall stress classification – hydrologic and environmental stress rankings combined to create a final category of stress for a sub-catchment (Bennett et al. 2002).

Queensland

The South East Queensland Healthy Waterways Strategy (SEQHWS) is an integrated set of activities aimed at delivering a range of outcomes essential for maintaining and improving the health of South East Queensland's (SEQ) waterways. This strategy is the successor to the South East Queensland Regional Water Quality management Strategy which was developed in 2001. The Strategy has been organised into a series of 12 action plans, one of which is the Protection and Conservation Plan. This Plan is aimed at the protection of not only High Ecological Value (HEV) waterways, but also other waterways that, while not recognised as HEVs, have significant ecological or conservation values, or make an important contribution to wider waterway health. As there has been little systematic work undertaken on the identification of such waterways, the Protection and Conservation Plan identifies this task as a priority.

Tasmania

Conservation of Freshwater Ecosystem Values (CFEV) assessment framework (Tasmania)

The Conservation of Freshwater Ecosystem Values (CFEV) assessment framework was developed by the Tasmanian Department of Primary Industries, Water and Environment as part of the Water Development Plan for Tasmania (Queensland EPA 2007). The CFEV framework design is based on Comprehensive, Adequate and Representative (CAR) principles, complementing terrestrial and marine management systems currently used in Tasmania as well as Naturalness, Representativeness and Distinctiveness (NRD) (Queensland EPA 2007). The assessment used existing environmental (drainage network, digital elevation model and catchment regions at a scale of 1:25 000; biophysical classification, naturalness score) and special value (flora, fauna, limnology and geomorphic) data to audit freshwater values of waterways in Tasmania (Queensland EPA 2007). All waterways were then given a management priority score of low, medium or high priority with efforts focussed on protecting or restoring high conservation value ecosystems (Queensland EPA 2007).

Northern Territory

The 39 major rivers in the Northern Territory are grouped together to form four drainage divisions – the Timor Sea and the Gulf of Carpentaria, both located in the ‘humid’ climatic zone, and the Western Plateau and Lake Eyre, located in the ‘arid’ climatic zone. The Department of Natural Resources, Environment and The Arts is responsible for the assessment, monitoring, management, planning, protection and sustainable utilisation of water resources in the Northern Territory. The Northern Territory Water Act provides for the investigation, allocation, use, control, protection, management and administration of water resources, and the Water Management branch was set up to implement this legislation. Although the Territory does not have a single documented Strategy, or Framework, management of water resources is achieved through the development of Water Allocation Plans for each region. These plans include consideration of both environmental and cultural flows. In addition, areas where there is a need for close management of water resources are proclaimed as Water Control Districts. Legislation in Water Control Districts covers all aspects of sustainable water resource management, including the investigation, use, control, protection and allocation of water resources.

Western Australia

A large variation in climate and rainfall, with much of the State receiving less than 400 mm per year, and a subsequent scarcity and uneven distribution of water resources, characterises the Western Australian landscape. There are about 208 recognised major waterways, 170 smaller creeks, and numerous small tributaries in Western Australia (Water & Rivers Commission, 2000). The Australian Water Resources Council (AWRC) recognises seven water resource regions in Western Australia, each representing a collective of surface drainage basins. The State Government has the prime responsibility for managing these water resources, and does so through many agencies working together in partnership with the community and industry.

Statewide Waterways Needs Assessment (SWNA)

The State-wide Waterways Needs Assessment (SWNA) uses the Pressure-State-Response model developed by the United Nation's Organisation for Economic Cooperation and Development (OECD) (Figure 1) to prioritise water management requirements in Western Australia (Water & River Commission 2002). It assigns values to each waterway, determines the current 'condition' or level of degradation, of a waterway that is subjected to a range of 'pressures', and identifies the level of management responses that currently exist. Using these data, criteria are established for resource investment.

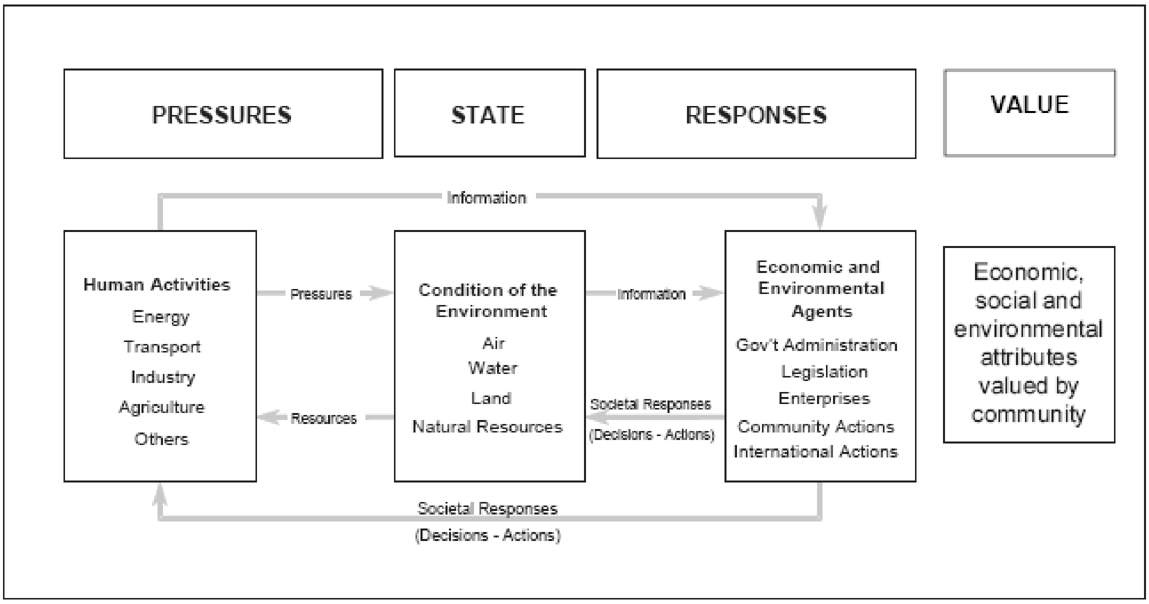
The SWNA is a consultative decision support tool based on questionnaires and stakeholder panel review, incorporating economic, social and ecological categories and issues. Each questionnaire is divided into four categories, each of which has a number of 'issues':

1. waterway values (seven 'issues')
2. waterway condition expressed as a level of degradation (six 'issues')
3. waterway pressures (nine 'issues'), and
4. management responses (seven 'issues')..

Each 'issue' is ranked into five levels (1 to 5), whereby higher ratings for the 'waterway values' category of issues indicate a higher value attributed to the waterway, higher ratings for the 'waterway condition' category of issues indicate increasing degradation, and higher ratings for the 'waterway pressure' category of issues indicate increasing land and water use pressures. Higher ratings for the 'management response' category indicate increasing management responses are in place.

Implementation of the SWNA tool is achieved through six steps: (i) establishment of a stakeholder panel, (ii) review and adaptation of the questionnaire to suit the study area, (iii) completion of the questionnaire by the panel for each waterway, (iv) collation and analysis of the results, (v) review against agreed criteria and adjustment of results, and (vi) agreement and documentation of final prioritisation.

Figure 1. The Pressure-State-Response model (adapted from OECD, 1993) (Water and Rivers Commission 2002)



Draft Waterways Management Framework for Western Australia

The Department of Water developed a working document in 2004 which outlined some of the steps which could make up a State-wide framework. This document suggests some broad value categories (industrial water, primary industries, drinking water, recreation and tourism, aesthetic, heritage and spiritual, scientific and aquatic ecosystem and ecological functioning), briefly reviews the various tools (e.g. foreshore assessments and Stream Condition Index) that have been used in Western Australia to assess the condition of waterways, and proposes the use of a value/condition/threat matrix to generate an overall rating for a waterway. The latter is seen as a modification of the Salinity Investment Framework (SIF) where values, threats and condition are classified as either ‘high’, ‘medium’, or ‘low’, resulting in 27 potential waterway characteristic combinations. Recognising that this is too many combinations for effective management, this document suggests that each potential combination be placed in one of four broad categories: (i) conservation value with excellent natural condition, (ii) acceptable value, with acceptable condition but altered from the natural state, (iii) modified value, with unacceptable altered condition which has reduced or compromised values and requires action to improve, and (iv) degraded value, with advanced changes to condition leading to significant compromises in values and reduced waterway functions. These four categories were aligned with specific management responses, such that values for waterways placed in the ‘conservation value’ category are protected, those for the ‘acceptable value’ category are managed, and those for the ‘modified value’ category are restored. The document goes on to develop three ‘stability’ categories to describe the relative stability of the waterway given current conditions. These categories are (i) stable, further to

Although this approach acknowledges that condition, or naturalness is one of many ecological values that should be considered, it places particular emphasis on condition, thus effectively ‘weighting’ this criterion of ecological value.

Agency Statement of Important Natural Resource Management Assets in Western Australia

In 2006 CONRACE identified NRM assets and threatening processes for Western Australia. This is intended to be a coordinated, broad-scale assessment of priorities for investment by the State government in NRM. Using the ‘value versus threat matrix’ developed by the Salinity Investment Framework (SIF),

State Water Quality Management Strategy (SWQMS)

The Government of Western Australia is presently developing a State Water Quality Management Strategy (SWQMS) in the form of a series of documents with the primary objective of ensuring that an administrative structure for water quality management is established in Western Australia that is consistent with the National Water Quality Management Strategy (NWQMS). Once a ‘significant’ waterway has been identified using a prioritisation framework, the SWQMS proposes a step-by-step process to implement Guidelines Nos. 4 and 7 of the NWQMS for that particular waterway. Thus, very briefly, step 1 would involve the identification of ‘environmental values’, or uses (these could be either ecological, or social), step 2, the development of specific management goals for the waterway through the setting of ‘environmental quality objectives’, step 3, the determination of ‘environmental quality guidelines and Standards or Targets, and step 4, the establishment of an ‘environmental management system’ (EMS) to ensure that the waterway is managed sustainability.

South Coast Region

The South Coast region includes over 100 major rivers or tributaries, 33 estuaries and more than 300 recognised wetlands. There have been a number of initiatives in the South Coast

Region aimed at the assessment and prioritisation of waterways, including two projects funded by South Coast NRM Inc. (Table 1).

Table 1: South Coast NRM funded projects involving the assessment of waterway and wetland values and priorities for the SW Region.

ID	Project title
	Increasing our knowledge of waterway ecological values
	Water source and allocation planning

In 2004, the Water and Rivers Commission (now Department of Water) collated all available information on the extent of catchment clearing, the availability of surveys or action plans, water quality monitoring data, and flow and channel stability data for each river and major tributary. Using this information, the values of the rivers of the South Coast Region were evaluated using the State-wide Waterways Needs Assessment approach. Initially, attempts were made to score ecological, commercial and social values, using agreed-upon criteria. The values were then combined to reach a general view on the overall value of the river. Condition, pressures faced and management responses were also evaluated. This approach immediately highlighted the inadequacy of the available information and led to projects being funded as part of the South Coast Region’s Investment Plan on the identification of cultural (indigenous and European) values as well as ecological values during 2006-2008.

This evaluation has been valuable in guiding but not necessarily, determining ‘final’ priorities for waterway management in the Region (C. Gunby, pers. comm.). In reality the specific choice of investment required the consideration of other factors such as the work of other agencies, the priorities for land and biodiversity as identified in the Strategy, connection to broader projects and the desire for the community to invest in such areas. However, it was a valuable tool in particularly highlighting areas in the east of the region and in less populated areas that had high values but little investment, and in guiding projects to better understand some of the pressures (e.g. certain types of land use). It particularly challenged the more traditional approaches, such as the “squeaky wheel approach' to investment, which often leads to a focus on the most degraded systems, rather than on systems identified through a systematic and objective process. Interestingly, a similar approach was used for wetlands and estuaries, and it is with the latter that it was found to work best – probably due to the greater amount of information available and the fewer number of systems. The approach did not work well with wetlands, as there was not sufficient information on these systems. Instead, wetlands were evaluated according to other criteria, such as designation as RAMSAR or other national status wetlands.

More recent attempts (2006-2008) at prioritising waterways include activities undertaken as part of a water resources regional planning project being undertaken by DOW and funded by South Coast NRM Inc. (Table 59). This project is aimed at long term strategic planning of water management, with an emphasis on the Lower Great Southern area stretching from the Deep River in the west to the Pallinup River in the east. As part of its scope, this project includes the identification, documentation and comparative assessment of the ecological, social and cultural values of surface and groundwater systems in the Region. The project focuses on the ecological values of the in-stream, riparian and estuarine zones, and any wetlands that are hydrologically linked to the river systems, and has as one of its aims, the identification of potential future water supplies. Recognising that an agreed and accepted methodology for assessment of WA waterways was yet to be developed, the proponents of this project used a river ecological evaluation framework developed from the State wetlands evaluation framework and the work of Dunn (2000), Phillips et al. (2001), Bennett et al. (2002) and Kingsford et al. (2005). The project has attempted to be as comprehensive as possible regarding the inclusion of attributes and criteria, although not all criteria could be scored initially in the current project. It is intended that this framework be extended and improved in future for wider use in waterways management of the region's rivers (N. Arrowsmith, pers. comm..).

South West Region

The South West Catchment Council (SWCC) is responsible for the implementation of projects funded by the National Heritage Trust (NHT) and the National Action Plan for Salinity and Water Quality (NAP) in the South West Region. Included in the suite of projects funded by SWCC are three which involve at least some aspects of the assessment of waterway or wetland values, classification and priority setting (Table 2).

Table 2: SWCC funded projects involving the assessment of waterway and wetland values and priorities for the SW Region.

ID	Project title
WH.01a	Ecological Water Requirements and Environmental Water Allocation: Assessing the ecological, social and economic value of priority water resources in the South West Region
WH.03a	Mapping, classification and evaluation of wetlands
WQ.05a	South West Waterway Strategy and IDSS

In 2005 the South West Regional Strategy for Natural Resource Management identified the need for a priority listing of waterways, wetlands and habitats based on an improved understanding of asset values, threats and actions. To this end, a Waterway Health Sub-

Strategy was recently completed by Spatial Vision in 2008 for the South West Catchment Council (SWCC). This Sub-Strategy follows an asset-based approach, identifying the values of, and the threats faced by the region's waterways, wetlands and estuaries. A risk assessment was conducted to identify the values at risks from the variety of threats identified, and a priority setting process was developed to identify assets with the greatest need for protection and action. This Sub-Strategy is intended to guide public spending on waterways, wetlands and estuaries in the Region.

The Sub-Strategy includes only those waterways mapped at a scale of 1: 250,000, as well as nine estuaries and 19 wetlands. It identifies 31 asset attributes, including 21 environmental attributes (covering biodiversity, representativeness and significance and naturalness), five social attributes (covering recreational and cultural values) and five economic (covering water supply, commercial fishing, land value, infra-structure and water-based tourism) attributes. An assessment was conducted for each of these asset attributes for each reporting unit (sub-catchment) across the study area. For each attribute, a rating system was developed that evaluated the contribution of each attribute to the value of the asset on a scale of 1 (small or no contribution) to 5 (significant contribution).

Table 3. Environmental attributes assessed to identify value of waterways in the South West Waterway Health Sub-Strategy (modified from Pelikan et al. 2008).

	Environmental attributes
Biodiversity	1. Threatened and priority aquatic fauna. Presence of significant species dependent on prolonged/permanent immersion in water at some stage of the life cycle – fish, amphibians, mammals and reptiles
	2. Threatened and priority riparian fauna. Presence of significant species dependent on contact with water at some stage of the life cycle, but not using it as habitat – mostly riparian birds and mammals. Presence of species defined as recorded in a 100 m buffer from the waterway. It is recognised that the riparian zone around individual reporting units may vary, but without detailed local mapping a value of 100 m has been selected.
	3. Threatened and priority aquatic flora. Presence of significant floating, rooted or emergent species growing in the waterway.
	4. Threatened and priority riparian flora. Presence of significant species restricted to within a 100 m buffer from the waterway.
	5. Threatened water dependent ecological community. Presence of significant community associated with waterways.
Representativeness and significance	6. Significant areas. Areas associated with waterways that have a legislative basis – e.g. national parks and conservation reserves.
	7. Representative areas. Areas that are good representative examples of a particular class of waterway, where a classification scheme has already been developed.
	8. Remnant vegetation. Presence of remnant vegetation associated with waterways but with no formal conservation status.
	9. Rarity of vegetation types in the landscape. Presence and percentage of representative vegetation associations associated with waterways at a regional scale.
	10. Significance of endemic flora or fauna types in the landscape. Presence of endemic species.
	11. Significant drought refuge areas. Presence and persistence of aquatic habitats remaining during extended dry periods.
	12. Significant water dependent fauna migratory habitat. Presence of and/or use by migratory species.
	13. Significant areas for different life stages. Areas that are important as breeding or nursery

	grounds for species that spend most of their life cycle elsewhere.
	14. Significant scientific sites. Areas that have been well studied or have unusual characteristics of scientific importance.
Naturalness	15. Natural or pristine waterways (classified as in excellent condition).
	16. Degree of naturalness of invertebrate communities (classified according to AusRivAS data).
	17. Degree of naturalness of waterbird communities.
	18. Degree of naturalness of aquatic plant communities, based on aquatic plant species present observed versus species expected.
	19. Degree of naturalness of riparian plant communities, based on riparian plant species observed versus species expected.

Similarly, 18 threats were identified as being relevant to South West waterways, estuaries and wetlands, and each of these were evaluated for each reporting unit on a scale of 1 (none or low level) to 5 (extreme level). For many of these threats, subjective assessments had to be made, as quantitative data were not available. Thus, initially, two data matrices were produced; a matrix of data with values for each attribute in each reach or estuary, and a matrix of data with values for each threat in each reach or estuary. Due to significant data gaps in the two data matrices (70% of value attributes data and 80% of threat data were recorded as ‘no data available’), data were scaled to the subcatchment level using a length-weighted average, resulting in final subcatchment scores in favour of longer reaches with data. reaches. The final data matrices for risk assessment consisted of 94 subcatchments scored for 29 value attributes and 17 threats.

These data then contributed to a risk assessment, an evaluation of the risk to each attribute from each threat in each reporting unit. This risk-based analysis was based on two components; consequence and likelihood. The ratings assigned for value were used to measure ‘consequence’, based on the premise that the higher the value of an attribute at a particular site, the higher would be the consequences if such a value were to be impacted by a threat. Likelihood was assessed using two components – the ‘threat level’ (measured using the ratings assigned for each threat for each reporting unit), and the ‘association’, a measure of how much influence a particular threat can have on an attribute. Association ratings were assigned for each possible combination of threat and attribute, whereby a value of 1 indicated that it was “practically impossible that the threat will impact on an attribute”, to 5, which indicated “strong evidence that the threat would impact on the attribute”.

The risk-based approach to prioritisation of management actions adopted in the Sub-Strategy facilitated the identification of threats that needed a management response. Different combinations of ‘consequence’, ‘threat level’ and ‘association’ were assigned different ‘risk ratings’ (Risk = consequence + threat level + association), where the highest risk ratings were assigned to combinations where the level of threat is likely to affect a highly valued attribute in the short term. High risk ratings were also assigned to situations where the actual level of threat is low to medium, but there would be a high risk to a valued attribute if the level of threat was to increase. Based on scores for consequence, threat and association, the Sub-Strategy recognises five ‘active threat management’ priority groups (‘very high’, ‘high 1’, ‘high 2’, ‘medium 1’ and ‘medium 2’), and two ‘preventative threat management’ priority categories (‘High 1’ and ‘medium 1’). Any combination not included in this scheme was deemed to be of low risk, and was assigned a zero value as its risk assessment score.

The South West Catchment Council also funds a project on the ecological water requirements and environmental water allocation for waterways in the Region. This project is aimed at assessing the ecological, social and economic values of priority water resources in the SW region.

APPENDIX D: NATIONAL STRATEGIES AND FRAMEWORKS

Before comparing the various national- and state-based waterway management frameworks and assessments it is worth briefly discussing their general aims and purpose, who developed them and why. Of these frameworks/assessments, management outcomes are a key purpose/outcome of only a handful, including:

- Ecological risk assessment (National)
- Irrigation Ecological Risk Assessment Framework (National);
- Conservation of Freshwater Ecosystem Values (CFEV) (Tas);
- Stressed Rivers Assessment (NSW);
- Statewide Waterways Needs Assessment (WA); and,
- Sustainable Rivers Audit (Murray-Darling Basin)(Queensland EPA 2007).

Although waterway assessments are not management frameworks it is worth including these to gain insights into value identification and assessment. Table 4 summarises some of the national and state-based frameworks/assessments relevant to waterways in Australia. Those marked with an asterisk, including frameworks with management purposes/outcomes, are discussed in detail below.

National Framework for the assessment of River and Wetland Health (FARWH)

The National Framework for the Assessment of River and Wetland Health (FARWH) is being developed as part of the Australian Water Resources 2005 project being conducted by the National Water Commission. The FARWH aims to provide a framework for assessing river and wetland ‘health’, and is based on a hierarchical model of river and wetland function, whereby broad-scale catchment characteristics affect the physical and chemical ‘template’ of rivers, which in turn influence the biota.. Use of the Framework by States and Territories for the assessment of river health will ensure that these assessments are comparably nationally. The FARWH uses six key components which represent ecological integrity to assess river and wetland health:

1. Physical form
2. Water quality and soils
3. Aquatic biota
4. Hydrological disturbance

5. Fringing zone
6. Catchment disturbance (Government of Australia 2007).

FARWH assessments are a flexible process, as although these six key components should be represented in all assessments, the FARWH does not outline which indices should be chosen to represent them. Instead describes how to create indices so that comparisons can be made without the same measurements in each place (Government of Australia 2007). This enables States and Territories to include data sets which are currently being collected through programs such as AusRivAS, the Victorian Index of Stream Condition, the Victorian Index of Wetland Condition, the Tasmanian Conservation of Freshwater Ecosystem Values Project, the Queensland Wetland Program, and the Lake Eyre Basin Rivers Assessment.

Assessments for each component of the Framework are based on departures from reference conditions, where reference conditions have been set by using minimally disturbed sites, historical data, modelling of past conditions and professional judgement.

National River Health Program and AusRivAS

The National River Health Program involved collection of water quality and macroinvertebrate samples using a standard protocol from a large number of rivers across Australia. Sites where water quality and biota were in relatively good condition were selected as reference sites for comparison with sites with modified water quality and biota (Dunn 2000). This data was then analysed to identify site types and groupings and to characterise the reference condition for development of a predictive model (AusRivAs) (Dunn 2000). AusRivAS assessed river health for impact assessment of catchment management by predicting expected aquatic macroinvertebrate fauna in the absence of environmental stress (Dunn 2000). Although data collection for AusRivAs requires trained users, the results of these assessments are intended for use by catchment managers, natural resource managers, community groups and government agencies (Queensland EPA 2007).

Wild Rivers Project

Wild Rivers are recognised as important representatives of largely unchanged systems. They are defined as *'those rivers which are undisturbed by the impacts of modern technological society. They remain undammed, and exist in catchments where biological and hydrological processes continue without significant disturbance. They occur in a variety of landscapes, and may be permanent, seasonal or dry watercourses that flow or only flow occasionally'* (Water and Rivers Commission, 1999).

In 1993, the Australian Heritage Commission commenced the Wild Rivers Project. The Project included three concurrent programs covering:

- systematic identification of Australia's Wild Rivers
- development of guidelines for the sustainable management of Wild Rivers (including *Conservation Guidelines for the Management of Wild Rivers* (Australian Heritage Commission, 1998))
- communication and consultation.

As part of the Australian Heritage Commission's Wild Rivers Project, the Water and Rivers Commission (now the Department of Water) was involved in the data verification process and identification of undisturbed or Wild Rivers in Western Australia. The report (*Water and Rivers Commission*, 1999) to the Australian Heritage Commission concluded that forty-nine possible Wild Rivers existed within Western Australia.

The Australian Heritage Commission (Water and Rivers Commission, 1999), the Department of Water originally recognised 49 Wild Rivers in Western Australia. The Upper Yule River was recently downgraded due to development in the catchment, bringing the State's total to 48. Thirty-seven of these Wild Rivers are located in the Kimberley and Pilbara Regions. These waterways and their catchments remain generally undisturbed due to their isolation, rugged topography or land tenure.

Ecological Risk Assessment

Ecological Risk Assessment has been used by the Water Studies Centre at Monash University to assess the level of risk to the health of river systems by a number of stressors, including physical, chemical and biological stressors as well as management actions (Queensland EPA 2007). This process should involve stakeholders in identifying ecological values and likely hazards as well as characterising and ranking risks (Queensland EPA 2007). The assessment combines a number of methodologies and techniques, including:

- Planning the assessment by setting management goals, objectives and resources available;
- Formulating the problem to determine assessment scope;
- Identifying ecological values and likely hazards to these values;
- Analysing risks to ecological values using qualitative, semi-qualitative or quantitative risk assessment methods;
- Characterising and ranking risks, including uncertainties and assumptions, to make them available to decision makers and stakeholders;

- Developing a risk management plan to minimise the risks;
- Implementing the risk management plan;
- Monitoring the system to provide information on the effectiveness of the plan (Queensland EPA 2007).

This approach involves the expertise of a multidisciplinary team and the results are useful for catchment managers, approving authorities, water supply authorities, industry and natural resource managers (Queensland EPA 2007).

Irrigation Ecological Risk Assessment Framework

The Irrigation Ecological Risk Assessment Framework is also based on the Ecological Risk Assessment Framework developed by the Water Studies Centre at Monash University. The framework aims to assist the irrigation industry to incorporate a transparent, scientific, precautionary and ecologically sustainable approach to management of environmental risks (Queensland EPA 2007). To ensure uptake of management plans, stakeholder involvement is critical for identifying ecological values, hazards and to rank risks (Queensland EPA 2007).

Sustainable Rivers Audit (Murray-Darling Basin)

The Sustainable Rivers Audit was developed by the Murray-Darling Basin Commission in order to measure river health across the four states which make up the Murray-Darling Basin network. Information gained from fish, macroinvertebrates and hydrology of regulated rivers indices provide river managers and users with unbiased data to give insights into river health variability and facilitate management through decision support and impact assessment (Queensland EPA 2007).

Table 4. Summary of Australian management frameworks (data from Queensland EPA 2007).

Management framework	National/ State/ Regional	Method type	Scale	Purpose type	Water types	Purpose summary
National River Health Program and AusRivAS*	National	Index	Aggregation, regional, sub-regional	Function	Freshwater	Standardised method to monitor/assess ecological condition of Australian rivers.
Wild Rivers*	National	Model	Regional, sub-regional	Priority Value	Freshwater Estuarine	Identify Australia's wild rivers.
Ecological Risk Assessment*	National	Framework	Aggregation, regional, sub-regional	Function Management Priority	Freshwater marine estuarine	Assess the level of risk to river ecosystem health from management actions.
Guidelines for protecting Australian waterways (ecological values)	National	Framework	Aggregation, regional, sub-regional	Value	Freshwater marine estuarine	Systematic, comprehensive and flexible method to assess ecological value of waterways.
Irrigation Ecological Risk Assessment Framework*	National	Framework	Regional, sub-regional	Function Management Priority Value	Freshwater	Quantify and prioritise ecological risks arising from irrigation activities.
Rapid Appraisal of Riparian Condition (RARC)	South-east Australia	Rapid Assessment	Aggregation, sub-regional	Function Priority	Freshwater	Provide an understanding of current condition of riparian zones and determining factors.
Sustainable Rivers Audit	Murray-Darling Basin	Index	Regional	Function Management	Freshwater	Determine ecological condition and health of river valleys in the Murray-Darling Basin.
Tropical Rapid Appraisal of Riparian Condition (TRARC)	Northern Australia	Rapid Assessment	Aggregation, habitat, regional, sub-regional	Function	Freshwater	Assess riparian health using a standardised approach which can be used widely.
Conservation of Freshwater Ecosystem values (CFEV)*	Tas	Index	Regional, Sub-regional	Function Management Priority Value	Freshwater	Identify important freshwater values on Crown and private land
Index of Stream condition (ISC)	Vic	Index	Regional	Priority	Freshwater	Assess stream condition and detect long-term changes in overall condition over whole catchments.

Management framework	National/ State/ Regional	Method type	Scale	Purpose type	Water types	Purpose summary
River Styles	NSW	Classification	Regional, sub-regional	Function Priority	Freshwater estuarine	Describe and analyse river reach geomorphic character and behaviour.
Assessing the conservation value and health of NSW rivers (Pressure-Biota-Habitat)	NSW	Rapid assessment	Aggregation, sub-regional	Function Value	Freshwater	Assess the environmental conservation value and health of NSW rivers.
Stressed Rivers Assessment*	NSW	Rapid assessment	Regional, sub-regional	Function Management	Freshwater	Prioritise catchments for resource planning and management.
Statewide Waterways Needs Assessment*	WA	Rapid assessment	Regional, sub-regional	Function Management Priority	Freshwater	Prioritise waterway management requirements through stakeholder involvement, including economic, social and ecological considerations.
Ecosystem Health Monitoring Program (EHMP)*	Regional Qld	Index	Aggregation, habitat, regional, sub-regional	Function Value	Freshwater marine estuarine	Regional assessment of the ambient ecosystems of South East Queensland's catchments, estuaries and Moreton Bay.
State of the Rivers	Qld	Rapid assessment	Regional, sub-regional	Function Priority	Freshwater	Gather information on the ecological and physical condition of water courses in Qld using a consistent and objective methodology.
Geomorphic Assessment of Rivers (GAR)	Queensland	Rapid assessment	Regional, sub-regional	Function Priority	Freshwater	Understand and classify river character and behaviour.
Fish Habitat Area Selection and Assessment	Queensland	Index	Aggregation, habitat	Function Value Priority	Freshwater estuarine	Investigate the most valuable, pristine and productive habitats for FHAs through a strategic planning process.
AquaBAMM	Queensland	Index	Aggregation, regional, sub-regional	Value	Freshwater estuarine	Assess conservation values of stream ecosystems within a catchment.

APPENDIX E: SCALES AND MANAGEMENT UNITS

The South West Catchment Council Waterway Health Sub-Strategy has developed a system of spatially-based management, or 'reporting' units for their region. Each of their recognised 12 estuaries and 19 wetlands formed a single reporting unit, while a hierarchical system of reporting units was developed for waterways. The region is divided into nine river basins, and some of these are further subdivided, resulting in a total of 15 'Surface Water Management Areas'. The latter are further subdivided into a total of 94 subcatchments, the basic reporting unit for waterways in the region. At the 'finest' scale, 1195 waterway reaches are recognised, defined as stretches of waterway, generally less than 20 km long and spatially located between tributary inflows. These reaches have been termed 'river links' by some authors. Although the NLWRA has defined a branching network of river links joined by nodes for Australia, based on the AUSLIG 9-second digital elevation model (DEM), this network has
yet to be fully verified.

The FARWH proposes that assessments should be conducted at the scale of river reaches, rather than at the river basin level, due to the considerable diversity of river condition likely to be encountered at the latter level. These assessments can then be aggregated to broader spatial scales, such as surface water management areas, or entire States.

APPENDIX F: DEFINING AND ASSESSING WATERWAY VALUES

Waterway values

Waterways are significant state assets for environmental, social and economic reasons (EPA 2005). Ecological values are assessed by waterway management frameworks such as FARWH and NSW Stressed Rivers assessment, however there is also the need to include social and economic values including public benefit, welfare, safety and health (Department of Water 2004). The Western Australian State-wide Waterways Needs Assessment, the DoW draft management framework and the South-West Waterway Health Sub-Strategy all address economic, social and ecological values. The South-West Waterway Health Sub-Strategy uses 31 attributes to assess waterway, wetland and estuary values, including environmental, social and economic attributes (Pelikan et al. 2008).

Values are what makes waterways important and methods for determining relative value will vary, with quantitative measures for economic value and more qualitative measures for social values (State NRM Office 2007).

Recognition of waterway values is an important strategic approach for goal and priority setting (Department of Water 2004). Failure to recognise, discuss and incorporate values when goal setting for waterways may greatly reduce the effectiveness of management efforts (Department of Water 2004). Where insufficient information exists for identification of values, core or default values may be applied (Table 5).

Values can be identified by processes such as:

- Panel assessment (expert and/or community);
- Numerical assessment (questionnaire, survey etc.);
- Weightings; and,
- Cut-off points/decision rules/principles (Department of Water 2004, in preparation).

Conflicts may arise where there are multiple and competing values of waterways. The potential values of waterways may also change over time due to:

- Public awareness;
- Education;
- Economic and political influences; and,

- Environmental factors such as floods, climate change and catchment clearing (Department of Water 2004).

Table 5. Broad value categories for waterways and examples of activities (Department of Water 2004).

Broad value category	Example activities
Industrial water	Power generation Mining and mineral processing
Primary industries	Crop irrigation Stock drinking water Commercial fishing Aquaculture
Drinking water	Drinking water for humans/wildlife/stock
Recreation and tourism	Boating, sailing, rowing, waterskiing etc. Swimming Fishing Scenery Walking and camping Bird-watching Tourism
Aesthetic, heritage and spiritual	Aboriginal cultural heritage Historical Landscape Sense of place Spiritual values Walking and camping
Scientific	Scientific research
Aquatic ecosystem and ecological functioning	Ecological corridors Filtering Fish populations and migration Food Habitats, including migratory birds Food webs Natural drainage of land Flood conveyance and storage (floodplains) Drought and dry season refuge (e.g. river pools) Maintenance of diversity and abundance of indigenous flora/fauna Ecological processes, structure and integrity Rarity or uniqueness Representativeness Riparian vegetation

Ecological values

Bennett et al. (2002) defined ecological value as ‘the natural significance of ecosystem structures and functions, expressed in terms of their quality, rarity and diversity. Significance can arise from individual biological, physical or chemical features or a combination of features.’ Dunn (2000) defined ecological value as ‘not only the aquatic biota (fish, invertebrates, macrophytes) but also the biota of the riparian or foreshore zone, the river habitats and geomorphology.' This author also included physical and biological river processes, and the roles a river plays in sustaining other systems such as karst, estuary, floodplains and wetlands.

Australian initiatives which have assessed ecological value include State of the Rivers assessments in Western Australia and Queensland, the Index of Stream Condition assessment in Victoria, the Stressed Rivers project in New South Wales, the National River Health Program's AusRivAS project, and the Wild Rivers project undertaken across Australia (Table 6). These assessments have generally adopted one of two approaches: (i) the assessment of condition, or change against a nominated benchmark, using one or two key indicators, or (ii) the assessment of ecological or conservation value using a broader range of criteria and indicators.

Table 6: Summary of Australian methods of waterway assessment for determining ecological value (Dunn 2002; Phillips et al. 2001; Bennett et al. 2002).

Name of method	Category of method	Technique	Focus/criteria
National River Health Program – AusRivAS (Australia)	Condition assessment	Collects macroinvertebrate data from river systems throughout Australia. Individual site data is grouped to characterise reference condition, then formalised via AusRivAS model software. Models are calibrated to allow comparison of macroinvertebrate assemblages between reference and impacted sites.	Macroinvertebrates used to: • assess river health • infer environmental impact
Wild Rivers (Australia)	Condition assessment and naturalness value	Uses a 'river wildness' index comprising State data of various disturbance indicators. Data is combined using specific decision rules to give all river sections across the country a score, giving a level of river system disturbance. Indices of catchment and in-stream disturbance form the basis of the overall score.	Assess naturalness using: • catchment disturbance • waterway disturbance
Index of Stream Condition (Victoria)	Condition assessment and naturalness value	An assessment of individual indicators. Data for each indicator are scored, indexed and given arbitrary numerical values. The indicator scores are then combined to give an overall value. More applicable to disturbed systems, but useful for naturalness value.	Hydrology Physical form Streamside zone Aquatic life Water quality
Stressed Rivers (NSW)	Condition assessment and conservation value	A subcatchment-level approach in which categories are derived through measurement of environmental and hydrological stresses, resulting in a matrix of stress classifications and management categories. Also identifies rivers of high conservation value, using a criteria-based analysis.	Water usage Species of significance Remnant habitats Geomorphology
State of the Rivers (WA)	Condition assessment and naturalness value	A method for mapping major forms of degradation within the State. Rivers are assigned one of five categories defining river condition to determine the feasibility for rehabilitation (if required), and to assist the Water and Rivers Commission management objectives.	Pressures on rivers Waterway disturbance
Water Resource Environmental Planning (Qld) – conservation value guideline	Conservation value	Conservation value derived using a numerical approach for ecological criteria. A weighting system is used for combining indicators. Values include ecology, geomorphology, hydrology, recreation, landscape and cultural heritage. This work led to the development of this guideline. (Although developed independently of SERCON, the system has a number of similar features.)	Naturalness Condition Bio- and geodiversity Rare and threatened Uniqueness/rarity Cultural heritage

Based on these and other assessment initiatives, Bennett et al. (2002) have developed an 'Ecological Value Guideline', the aim of which is to 'provide a systematic, comprehensive and flexible method to describe the ecological values of waterways and floodplains', and also to 'support both environmental planning and development assessment.' These guidelines adopt a hierarchy of criteria, indicators and measures to describe ecological value.

Examination of the approaches used by the various assessments (see Table 6) reveals reasonable consistency in the criteria used. Following a survey of waterway managers across Australia, Dunn (2000) proposed (and Bennett et al. (2002) supported) the following criteria for identifying ecological values:

- Naturalness – waterways in pre-European or undisturbed condition
- Representativeness – the degree to which the waterway is typical
- Diversity and richness – waterway biodiversity and geodiversity
- Rarity – waterways with uncommon/threatened biota, form or processes
- Other special features – includes: features which are generally uncommon or which sustain other important/interesting ecosystems; important waterway functions; important keystone or indicator species etc. (Dunn 2000).

Each of the criteria is assessed using either 'attributes', 'indicators', and/or 'measures'. Indicators that integrate information over time (such as macroinvertebrates) are recommended (Bennett et al., 2002). Dunn (2000) developed a set of 'attributes' for each of the five criteria; Bennett el. (2002) modified this hierarchy by rephrasing Dunn's (2000) attributes of high ecological value as indicators of a range of ecological values, reducing overlap and redundancies between indicators, and arranging them into generic categories.

Bennett et al. (2002) also highlighted the importance of classifying waterways according to type for defining reference condition against which 'naturalness' can be compared, and for assessing the 'rarity' and 'representativeness' of particular river types. A biogeographical river classification is lacking for Western Australia.

Economic values

If an asset can be assigned economic values then the values should be assessed in financial terms, these assets include infrastructure and agricultural productivity (State NRM Office 2007). Table 7 presents a summary of economic attributes used to identify waterway values in the South West Waterway Health Sub-Strategy (Pelikan et al. 2008).

Table 7. Economic attributes assessed to identify value of waterways in the South West Waterway Health Sub-Strategy (modified from Pelikan et al. 2008).

	Economic attributes
Economic	1. Water supply. Use for potable water supply, irrigation delivery or direct extraction.
	2. Commercial fishing and aquaculture. Use for commercial fishing and aquaculture.
	3. Land value. Productive value of surrounding land use, such as agriculture, forestry etc.
	4. Water-based tourism. Use for tourism activity dependent on water.
	5. Infrastructure. Presence of significant public or private infrastructure.

Social values

Table 8 presents a summary of social attributes used to identify waterway values in the South West Waterway Health Sub-Strategy (Pelikan et al. 2008).

Table 8. Social attributes assessed to identify value of waterways in the South West Waterway Health Sub-Strategy (modified from Pelikan et al. 2008).

	Social attributes
Social	1. Active primary contact recreational use. Use for primary contact activities such as swimming.
	2. Active secondary contact recreational use. Use for secondary contact activities such as boating and canoeing.
	3. Passive recreational use. Use for passive use such as walking and sight-seeing.
	4. Recreational fishing. Use for recreational fishing.
	5. Spiritual and cultural use. Presence of areas or sites with high cultural heritage including indigenous and European.

Assessing condition

Waterways in good condition usually have increased environmental, economic and social values compared with poor condition waterways. Condition is however, only one of several ecological values which should be assessed, as poor condition waterways can have important environmental values such as uniqueness, representativeness, biodiversity and habitat (Department of Water 2004).

Waterway condition can be assessed in a number of ways. The various tools currently used to assess waterway condition in Western Australia are summarised in Table 9 (Department of Water 2004).

Table 9. Tools for assessment of waterway condition in Western Australia.

Assessment type	**Method**	**Scale and useability**	**Threat asses.** [1]	**Skill level** [2]
Foreshore assessment (farming areas)	Based on rank stability, riparian vegetation, vegetation cover and habitat diversity. [1]	Paddock. Repeatable, requires detailed info. [2]	Y	Low-moderate
Foreshore assessment (urban/semi-rural)	Based on rank stability, riparian vegetation, vegetation cover and habitat diversity. [1]	Local reach. Repeatable, requires detailed info. [2]	Y	Low-moderate
Foreshore assessment (north-west WA)	Based on rank stability, riparian vegetation, vegetation cover and habitat diversity. [1]	Paddock. [1] Repeatable, requires detailed info. [2]	Y	Low-moderate
Stream condition index	Remote assessment (e.g. satellite imagery and aerial photographs). [1]	Sub-catchment [1]	N	
State of the Rivers (Land and Water audit)	Mapping of river degradation statewide (Incorp. Wild rivers data). [2]	Catchment [2]. Repeatable, requires detailed info. [2]	Y	Moderate
Wild rivers	Theoretical disturbance model and expert field verification. [1]	Catchment or Reach, Repeatable, requires detailed info. [21]	Y	Low
SWNA questionnaire	Expert panel assessment. [1]	Catchment [1]	Y	

(Department of Water 2004)[1] and (Bennett et al. 2002)[2]

APPENDIX G: DEFINING AND ASSESSING THREATS TO WATERWAYS

Threats to waterways are those processes known to negatively impact waterway functioning, and reduce their values. Although there have been different approaches adopted for assessing the level of threats or degradation processes, there appears to be reasonable consistency in the identification of these processes for Western Australia. Penn (1999) identified the following degradation processes for streams of south-west Western Australia:

- Salinisation and waterlogging,
- Erosion and sedimentation,
- Riparian zone degradation,
- Eutrophication and deoxygenation,
- Introduced fish,
- River diversion, drowning and blockage: dams, weirs and culverts,
- Weed invasions,
- Toxic chemical,
- Stream ecosystem degradation, and,
- Organic pollution.

Using the Pressure-State-Response Model developed by the Organisation for Economic Cooperation and Development (a United Nations body), the Statewide Waterways Needs Assessment (Water & Rivers Commission, 2002) identified the following issues for ‘waterway condition expressed as a level of degradation’:

- Erosion and sedimentation,
- Eutrophication,
- Salinity,
- Feral animals,
- Weed infestations,
- Pollution from point sources, and
- Ecosystem fragmentation.

This Assessment also identified ‘pressures’ exerted on Western Australian waterways:

- Land development: residential and rural,
- Land development: intensive agriculture,

- Land development: broadacre farming,
- Land development: pastoral,
- Water development,
- Recreation,
- Commercial fishing,
- Industrial discharge,
- Water abstraction, and agricultural discharge.

Threats vary in both severity and time (Department of Environment 2003). Threats to waterways should be considered in terms of short and long time frames and may include:

- Vegetation clearing;
- Cattle access;
- Point- or diffuse-source pollution;
- In-stream barriers;
- Weeds (riparian and aquatic);
- Exotic fauna species ;
- Overfishing;
- Sand and gravel extraction;
- Sedimentation; and,
- Changes in land use (Phillips et al. 2001).

The Environmental Protection Agency (2005) identified the following activities and works which either individually or cumulatively, impact on waterways and their associated values:

- Native vegetation clearing along waterways or in catchments;
- Nutrient and chemical application associated with agricultural/urban and other activities;
- Construction and ground disturbing activities which contribute to erosion;
- Inappropriate stormwater and wastewater management;
- Draining saline water into waterways;
- Altering waterway course;
- Controlling water flows (e.g. dams, weirs etc.);
- Filling;
- Excavation and mining;
- Effluent discharge;

- Changed fire regimes;
- Introduction of pest and weed species; and,
- Increased human activity along waterways and in catchments (EPA 2005).

Although the South-West Waterway Health Sub-Strategy did not group threats to waterways in the Region in the categories listed above, many of the threats recognised and scored in this Strategy do align with the processes listed above (Table 10) (Pelikan et al. 2008).

Table 10. List of threats to waterways assessed in the South-West Waterway Health Sub-Strategy (modified from Pelikan et al. 2008).

Threats to waterway attributes	
Water quality	1. Level and trend in surface water salinity. Level of salinity in waterways compared to pre-European levels where known. Otherwise assumed threat from known level of salinity to fresh waters, which may be modified by trend in salinity levels.
	2. Level and trend in surface water nutrients. Level of nitrogen or phosphorus in waterways compared to pre-European levels where known.
	3. Level and trend in surface water turbidity. Level of turbidity in waterways compared to pre-European levels where known.
	4. Level and trend in surface water pH. Level of pH in waterways compared to pre-European levels where known.
	5. Reductions in water temperature. Reductions in water temperature in waterways specifically from low-release reservoirs.
	6. Level of toxic chemicals. Levels of toxic chemicals compared to ANZECC guidelines for defined uses of waterway
Water quantity	7. Alterations to flow regime. Changes to the flow regime in waterways due to the extraction of water for consumptive purposes.
Food and energy resources	8. Reduction in riparian vegetation width. Changes to the maximum width of riparian vegetation along waterways,
	9. Reduction in riparian vegetation continuity. Changes to the length of intact riparian vegetation.
Physical habitat	10. Extent/severity of alterations to bank structure. Erosion of streambanks.
	11. Extent/severity of alterations to waterway streambed. Aggradation or degradation of the bed of waterways.
	12. Presence and influence of waterway barriers. Barriers in waterways that prevent the movement of migratory fish species.
	13. Physical disturbance of habitat and biota from human activities. Presence of activities that can result in physical disturbance of habitats (e.g. trampling) or biota (e.g. noise) due to human activities near the waterway.
Biological interactions	14. Presence and severity of introduced aquatic plants. Presence of aquatic weeds.
	18. Presence and severity of pest animals. Presence of aquatic and riparian pest animals.
	19. Presence and severity of introduced riparian plants. Presence of riparian weeds.

The DoW draft management framework (2004) uses the Salinity Investment Framework (SIF) and the State NRM Assets process to assess threats to waterways. This approach has also been utilised by the NRM Senior Officers Group to identify priorities in NRM for threats such as eutrophication, acidification, over-clearing, introduced plants and animals and water erosion (State NRM Office 2007).

The key question in the SIF for addressing threat is ‘how much of the asset’s value will be affected and when will this happen if it has not already?’ (Department of Environment 2003). ‘Asset’ in SIF indicates an item of value, including:

- A discrete physical, biological or human-made entity (e.g. single species, sites with indigenous heritage values or historic buildings);
- Location or sites with single or multiple values (e.g. water resource, bushland and rural towns); and
- Non-tangible qualities with values (e.g. skills that a community can apply to managing waterways) (Department of Environment 2003).

The SIF uses three broadly defined groups to describe threat, these are:

- High: Imminent (< 2020);
- Medium: 2020 – 2050;
- Low: > 2075 or asset significantly impacted now but not expected to deteriorate further (Department of Environment 2003).

Although these groups refer to the risk of salinisation, these rankings have been used for other NRM threats (State NRM Office 2007).

APPENDIX H: SETTING PRIORITIES AND MANAGEMENT RESPONSES

Priorities should be set to maximise outcomes of the planned management outcomes (Phillips et al. 2001). Priority setting in the DoW draft framework (2004) is guided by the following principles:

1. **Value -** The first priority should be to invest in waterways of high value or those with multiple values (i.e. social, economic, environmental and scientific values).
2. **Condition -** The second priority is to invest in waterways that are in the best condition.
3. **Pressure -** The third priority is to invest in waterways that are subject to the highest pressure.
4. Fourthly, as appropriate to management goals:
    a. Invest in waterways where community interest is highest.
    b. Invest in waterways whose condition is deteriorating rather than stable or recovering.
    c. Invest in waterways where there is a high likelihood of success and/or a technically feasible solution.
    d. Invest in waterways where the cost/benefit ration is lowest.
    e. Invest in waterways where existing management effort or response is lowest.

Although value is subjective, it is used as the first discriminator as it reflects to environmental, economic, social or scientific importance of a waterway. Condition reflects both the principle that waterway health and value are linked and that it is more efficient to protect healthy waterways before restoring degraded waterways. Pressure indicates the urgency of management intervention, i.e. the higher the pressure or threat to a waterway, the higher the investment priority (Department of Water 2004).

The value-condition-pressure framework for waterway prioritisation is also used in the Statewide Waterways Needs Assessment (SWNA), where waterways are then ranked using a matrix (Figure 2) (Water and Rivers Commission 2002). As the SWNA is a consultative process, matrix rankings are not fixed, and are instead used as a guide for panel debate based on local knowledge and other factors (Water and Rivers Commission 2002). This is useful for synthesising large volumes of information to provide a preliminary list of priorities, however, full prioritisation requires application of a set of criteria determined to suit local circumstances or funding environments (Water and Rivers Commission 2002). These criteria should include waterway:

- Value;

- Security in terms of reservation;
- Ease of management;
- Existing condition (level of degradation);
- Likely changes if nothing is done;
- Risks (e.g. flooding); and,
- Community interest in management (Water and Rivers Commission 2002).

The NSW Stressed Rivers assessment used levels of environmental and hydrologic stress and conservation value to prioritise river management, with high priority sub-catchments including:

- Those where demand for water already equal or exceeds supply (hydrologic stress);
- Those where the water environment is significantly degraded (environmental stress);
- Areas of particular natural environmental value (high conservation value) (Bennett et al. 2002).

In the absence of data, priority setting can be based on the results of an expert panel assessment of the issues (Phillips et al. 2001).

High Value		PRESSURE		
		High	Medium	Low
CONDITION	High Degradation	3/4	3	3
	Medium Degradation	2	2	2
	Low Degradation	1	1	1
Medium Value		PRESSURE		
		High	Medium	Low
CONDITION	High Degradation	6	6	6
	Medium Degradation	5	5	5
	Low Degradation	3/4	4	4
Low Value		PRESSURE		
		High	Medium	Low
CONDITION	High Degradation	9	9	9
	Medium Degradation	8	8	8
	Low Degradation	7	7	7

Figure 2. Split-ranking matrix for prioritising waterways (Water and Rivers Commission 2002).

Threat and value information are then used to create a value-threat matrix (Figure 3), to identify groups for feasibility investigations and to assist priority setting (Department of Environment 2003). This approach can be reprocessed with new information when an assets allocation within the tiers is contested (Department of Environment 2003). According to the Department of Environment (2003) the value-threat matrix:

- Provides a simple and transparent approach for identifying highly-important assets for further feasibility assessment.
- Reduces the workload by ensuring detailed feasibility studies are only carried out for assets of high value or priority.
- Identifies assets and priority groups of assets requiring community participation.
- Can be applied at state, regional and local scales
- Incorporates multi-agency information in identifying priority groups of assets.

State Assets/Region Assets		Value		
		High	Medium	Low
Threat	**High** Existing and/or near (< 2020) and substantial	1st Tier		
	Medium Intermediate time (2020–2075) and/or not significant threat		2nd Tier	
	Low Long term (> 2075) or already impacted significantly			3rd Tier

Figure 3. Value versus threat matrix and the three asset tiers (Department of Environment 2003)

Notes: 1st tier: includes asset items or groups of items of high value and at high threat from salinity.
2nd tier: includes asset items or groups of items of high value at medium threat, and items of medium value at high threat from salinity, and asset items of medium value at medium threat.
3rd tier: remaining asset items or groups of items that include low value and/or low threat.

The draft DoW framework (Department of Water 2004) also suggests that the SWNA provides a useful alternative framework for relating threat or pressure to waterway values. This framework also integrates waterway condition, which is critical as waterway values are dependant on condition (Table 11) (Department of Water 2004). In this framework a higher rating for:

- Waterway values indicates a higher value attributed to the waterway.
- Waterway condition indicates increasing degradation.
- Waterway pressure indicates increasing land and water use pressures.
- Management response indicates increasing management responses (Department of Water 2004, in preparation).

The DoW draft framework added an extra step to the SIF value-threat matrix to incorporate waterway condition assessment (Table 12) (Department of Water 2004).

Table 11. Statewide Waterways Needs Assessment (SWNA) ranking of waterway condition, pressures and values (adapted from Department of Water 2004)

Rating (1 to 5)	Waterway condition	Waterway pressures	Waterway values
1	**None:** the problem does not exist.	**None:** there is no pressure on the waterway or suite of waterways.	**None:** the attribute does not contribute in any way to the value of the waterway or suite of waterways at any level.
2	**Minor:** localised degradation only.	**Minor:** the pressure affects less than 20% of the waterway or suite of waterways.	**Minor:** the attribute contributes to the value of the waterway or suite of waterways at a local level.
3	**Moderate:** problem is extensive but at a low level or locally-intensive.	**Moderate:** the pressure affects 20-50% of the waterway or suite of waterways	**Moderate:** the attribute contributes to the value of the waterway or suite of waterways at local and regional levels.
4	**Severe:** the problem is widespread and intense but is manageable with the right land use practices and resources.	**Severe:** the pressure affects 50-80% of the waterway or suite of waterways.	**Important:** the attribute contributes to the value of the waterways or suite of waterways at local, regional and State levels.
5	**Extreme:** the problem or form of degradation is at the extreme level of the spectrum where it is difficult to see how it could get any worse.	**Extreme:** the pressure is widespread and affects more than 80% of the waterways or suite of waterways.	**Significant:** the attribute contributes to the value of the waterway or suite of waterways at local, regional, State and national levels.
Unknown: unable to answer question with any certainty			

Table 12. SIF value-threat matrix (adapted from (Department of Environment 2003) integrated with waterway condition (Department of Water 2004).

<table>
<tr><th rowspan="14">Threat</th><th rowspan="2">Threat/ value</th><th colspan="3">Value</th></tr>
<tr><th>High</th><th>Medium</th><th>Low</th></tr>
<tr><td rowspan="4">High</td><td>SIF tier 1</td><td>SIF tier 2</td><td>SIF tier 3</td></tr>
<tr><td>High condition</td><td>High condition</td><td>High condition</td></tr>
<tr><td>Medium condition</td><td>Medium condition</td><td>Medium condition</td></tr>
<tr><td>Low condition</td><td>Low condition</td><td>Low condition</td></tr>
<tr><td rowspan="4">Medium</td><td>SIF tier 2</td><td>SIF tier 2</td><td>SIF tier 3</td></tr>
<tr><td>High condition</td><td>High condition</td><td>High condition</td></tr>
<tr><td>Medium condition</td><td>Medium condition</td><td>Medium condition</td></tr>
<tr><td>Low condition</td><td>Low condition</td><td>Low condition</td></tr>
<tr><td rowspan="4">Low</td><td>SIF tier 3</td><td>SIF tier 3</td><td>SIF tier 3</td></tr>
<tr><td>High condition</td><td>High condition</td><td>High condition</td></tr>
<tr><td>Medium condition</td><td>Medium condition</td><td>Medium condition</td></tr>
<tr><td>Low condition</td><td>Low condition</td><td>Low condition</td></tr>
</table>

Notes: High condition = limited degradation; Medium condition = some degradation; and low condition = highly degraded.

Management response

Following assessment and understanding of waterway values, conditions and threats it is then possible to assign a management response. This process is further enhanced by an understanding of the condition trend i.e. whether the waterway is improving, stable or deteriorating, within a catchment context (Department of Water 2004).

The DoW draft framework (2004) groups six management categories (secure, maintain, restore, stabilise, contain and adapt) into four broad aims for waterway management:

1. To fully protect waterways values:
   Secure: of such importance that action is needed to fully protect environmental and social values.
   Maintain: prevent negative alteration to existing waterway condition, practices and standards.
2. To improve waterway health:
   Restore: reinstate specific values, conditions, standards or practices.
3. To manage degradation:
   Stabilise: halt degradation processes.
   Contain: limit degradation processes.
4. To manage function:
   Adapt: accept that environment is highly degraded, identify the functions still operational and manage those functions.

APPENDIX I: WATERWAY CLASSIFICATION AND REFERENCE CONDITIONS

Waterways vary in longitudinal, lateral and vertical dimensions and this variation can be used to determine waterway types (Bennett et al. 2002). Waterway classification is required for comparison of values across waterway types and also to establish reference conditions for value assessment (naturalness, representativeness and rarity) (Bennett et al. 2002). Classification can also be used to set priorities within class types (Kingsford et al. 2005).

Classifications can apply to either single scale, or local/continental scales through hierarchal frameworks, to link rivers to the surrounding catchments and landscape (Kingsford et al. 2005). At a single scale, stream order measures relative position in the drainage network and can indicate biotic and physical characteristics of a river segment (Kingsford et al. 2005). Single scale classifications seldom apply beyond where they were developed, unlike hierarchical classifications (Kingsford et al. 2005).

Hierarchical classifications can be divisive or agglomerative (Kingsford et al. 2005). An example of hierarchical classification is the national FARWH assessment, which uses a hierarchal model of river and wetland function to provide locally relevant assessments which are comparable across jurisdictions (Government of Australia 2007). Divisive classifications start from large, ecologically heterogeneous areas and successively divide them into lower more homogenous levels. This method uses mapping of ecological units, with progressively increased resolution, data and analysis (Kingsford et al. 2005). Agglomerative approaches integrate objects according to shared similarities, beginning from the lowest levels of the hierarchy and progressing to higher levels (Kingsford et al. 2005). This method is inductive and generally independent of spatial constraints, although it is dependant on data availability at finer scales (Kingsford et al. 2005).

Attributes used for classification may be direct measures of ecological characteristics or the factors responsible for the waterway's characteristics (Kingsford et al. 2005). Classification of waterways is not clear-cut and rivers, for example have been classified using:

- Macroinvertebrates;
- Ecoregions;
- Microhabitat features;
- Stream order;
- Fish;
- Geomorphology;

- Riparian vegetation; and,
- Aquatic plants (Bennett et al. 2002).

These attributes generally fall into two main types of classification; 1) biological classification using biota to define bioregional types or 2) biophysical classification using surrogate measures to define different types of aquatic systems (Kingsford et al. 2005). Ultimately, the choice of attributes will depend on the use of the classification e.g. for an ecologically and geomorphologically relevant classification attributes such as; flora/fauna community structure; biological processes; measures of habitat, water quality/quantity, geomorphology; and catchment/regional features (Bennett et al. 2002). Generally no single classification will suit all applications, especially given the variability of available data and expertise (Kingsford et al. 2005). Where possible spatial and temporal variation should also be incorporated into classifications by:

- Using indicators which reflect temporal variation.
- Accept that values may change with time and therefore that the values represent a ‘snap-shot’ of the catchments waterways.
- Represent temporally varying data as ranges rather than mean values.
- Use coefficients of variation to represent temporal variation.

Kingsford et al. (2005) identified three essential elements for river classification:

- **Scale** – requires hierarchical scales which recognize spatial and temporal scales for stream ecosystem processes, biotic processes and protection and management mechanisms.
- **Attributes** – should be temporally stable or integrate temporal variation and reflect ecosystem processes and distribution patterns of aquatic biota. The choice of attributes will be influenced by data availability and measurement practicality. Data requirements and specialist knowledge must be commensurate with classification scale and objectives.
- **Consistent methodology** – methods need to be repeatable and clear. Group boundaries need to be consistently and transparently derived.

Within the DoW draft framework (2004) waterway classification does not refer to the biological or biophysical classification of waterways, rather it relates to waterway categorisation as discussed in 1. Approaches to waterway assessment, earlier in this document. In the DoW draft framework (2004) classification is done within the context of management, with four management classifications:

1. **Conservation value -** excellent natural condition.
2. **Acceptable value -** acceptable condition but altered from natural state. This changes but does not reduce the range of values.
3. **Modified value** – unacceptable altered condition, which has reduced or compromised values and requires action to improve.
4. **Degraded** – advanced changes to condition leading to significant compromises in values, only some waterway functions are still in place.

Reference condition

Reference sites describe the range of naturally occurring conditions within a given waterway type (Bennett et al. 2002). Reference condition should be based on pre-established criteria that exist across a wide range of reference sites (Bennett et al. 2002).

Table 13 gives an example of criteria used to define reference condition (Bennett et al. 2002). In the absence of pristine sites the reference condition 'best obtainable quality' is used (Bennett et al. 2002).

Reference conditions can be based on:

- Regional reference sites – applicable to whole aquatic communities; acceptable levels of disturbance must be established; habitat classification still required.
- Historic data – useful if sites have been sampled; inconsistencies possible in databases;
- Paleoecological data – essentially limited to lakes, diatoms and chironomids; poorly suited to streams;
- Biotic indices – compare to a predetermined hierarchy of values; conditions represented by indices may not be attainable because of habitat differences;
- Experimental laboratory data – establishes relationships between test species and stressors; not applicable to wider community and not tested on many stressors;
- Quantitative methods – establish reference conditions through curve fitting; data reliability can affect models;
- Best professional judgement – usually undertaken by panel of experts and/or peer review; value of judgement is a function of the scientists' expertise and the quality of the data supplied to them; and,
- Disturbance methods – reference sites are those with no or minimal disturbance (Bennett et al. 2002).

Table 13. Example of criteria used to define reference condition (Bennett et al. 2002)

No.	Reference condition selection criteria
1	No intensive agriculture upstream
2	No major extractive industry (current or historic) within 20 km
3	No major urban area (>5000 population) within 20 km
4	No significant point-source waste water discharge within 20 km upstream
5	No dam or major weir within 20 km upstream
6	Seasonal flow regime not greatly altered
7	Riparian zone of natural appearance
8	Riparian zone and banks not excessively eroded beyond natural levels or significantly damaged by stock
9	Stream channel not affected by major geomorphological change

APPENDIX J: APPOACHES TO WATERWAY ASSESSMENT

According to Kingsford et al. (2005) there are four approaches to waterway assessment, some of which can be used together, including:

1. **Comprehensive, adequate and representative (CAR) principles**
    - These principles have been used widely for selecting conservation areas in terrestrial systems and marine reserves.
    - Waterways with values not already captured within protective management frameworks are rated at a higher priority for identification and protection.
    - Classification is a prerequisite for representativeness assessment.
    - E.g. Tasmania's Conservation of Freshwater Ecosystem Values.
2. **Categorisation**
    - Identifies waterways of particular conservation value.
    - Based on establishment of descriptive classifications and thresholds for criteria.
    - Transparent process which identifies waterways by level of disturbance.
    - E.g. Stressed Rivers program in NSW (management categories based on hydrological stress and conservation value).
3. **Criterion-based approaches**
    - Identifies criteria and thresholds which much be met for listing
    - Allows for common criteria to be promoted while allowing flexibility in the range of evidence provided.
    - Values of a place are tested against the criteria, not against another place of the same type.
    - E.g. Ramsar convention for wetlands and FARWH.
4. **Scoring and ranking**
    - Scoring can be used for comparisons for relative assessment in criterion-based approaches.
    - Numerical indices of ecological value are a simple way of conveying importance or significance.
    - This can be an objective method for comparing variables (or measures) that describe each criterion's attribute (or indicator) of waterways.
    - This method assigns a rating (1-5) to measures that describe attributes.
    - Requires definition of benchmarks by either comparing measured values to a reference condition, expected classification or similar classes of waterways.

- E.g. FARWH assesses indices relative to reference (pre-European conditions) with a range standardized between 0 and 1 (Government of Australia 2007) and Wild Rivers (Dunn 2000).

The DoW draft framework uses the approach of categorization, referred to as classification, with waterways categorized according to environmental values, conditions and threats (Table 14) (Department of Water 2004).

Table 14. Matrix of waterway assessment frameworks (DoW 2004)

	Criteria												
	Values												
Waterway Assessment	Ecological	Economic	Social	Waterway health/ condition	Conservation value	Hierarchal system	Geomorphic structure	Function (physical/community/landscape)	Naturalness/representativeness/ distinctiveness	Comprehensive/Adequate/ Representative (CAR)	Acceptable risk	Ecological problems/ waterway pressure	Management response/implications
National River Health Program and AusRivAS*	✓			✓									
Wild Rivers*	✓												
Ecological Risk Assessment	✓			✓							✓		
Guidelines for protecting Australian waterways (ecological values)	✓								✓				
Conservation of Freshwater Ecosystem values (CFEV)	✓				✓		✓		✓	✓			
Index of Stream condition (ISC)	✓			✓									
Assessing the conservation value and health of NSW rivers (Pressure-Biota-Habitat)	✓			✓	✓								
Stressed Rivers Assessment*	✓			✓	✓						✓		
State of the Rivers	✓			✓									
Ecosystem Health Monitoring Program (EHMP)*	✓			✓									
Statewide Waterways Needs Assessment*	✓	✓	✓	✓	✓							✓	✓
Tropical Rapid Appraisal of Riparian Condition (TRARC)	✓			✓				✓					
Rapid Appraisal of Riparian Condition (RARC)	✓			✓				✓					
Sustainable Rivers Audit	✓			✓				✓					
River Styles	✓			✓		✓	✓	✓					
Irrigation Ecological Risk Assessment Framework	✓			✓							✓		
Geomorphic Assessment of Rivers (GAR)	✓			✓		✓	✓	✓					
Fish Habitat Area Selection and Assessment	✓	✓		✓	✓					✓			✓
AquaBAMM	✓			✓	✓								

	Indices													
	Stressors			Environmental values										
Waterway Assessment	Biological	Chemical	Physical/hydrological	Naturalness	Representativeness	Diversity	Rarity	Special /unique features	Priority spp./ ecosystems	Threatened species/ ecosystems	Waterway disturbance	Future waterway behaviour	Connectivity	Classification/river styles
National River Health Program and AusRivAS*														
Wild Rivers*				✓										
Ecological Risk Assessment	✓	✓	✓											
Guidelines for protecting Australian waterways (ecological values)				✓	✓	✓	✓	✓						
Conservation of Freshwater Ecosystem values (CFEV)				✓	✓		✓	✓						✓
Index of Stream condition (ISC)														
Assessing the conservation value and health of NSW rivers (Pressure-Biota-Habitat)						✓	✓							
Stressed Rivers Assessment*	✓	✓	✓							✓				
State of the Rivers											✓			
Ecosystem Health Monitoring Program (EHMP)*														
Statewide Waterways Needs Assessment*								✓						
Tropical Rapid Appraisal of Riparian Condition (TRARC)											✓			
Rapid Appraisal of Riparian Condition (RARC)														
Sustainable Rivers Audit							✓							
River Styles											✓	✓		✓
Irrigation Ecological Risk Assessment Framework	✓	✓	✓											
Geomorphic Assessment of Rivers (GAR)														
Fish Habitat Area Selection and Assessment								✓						
AquaBAMM				✓		✓		✓	✓	✓	✓		✓	

	Indices: Ecological importance																	
	Diversity					Structural habitat				Disturbance								
Waterway Assessment	Physical diversity	Biological diversity	Fish communities	Macroinvertebrates	Vegetation	Habitat	Vegetation cover	Debris	Aquatic/channel habitat	Disturbance	Native veg/weeds	Regeneration	Reach environs	Bed/bar/bank conditon	Resilience/vigour	Hydrology	Physical form/cross section	Water quality
National River Health Program and AusRivAS*		✓		✓														
Wild Rivers*					✓					✓								
Ecological Risk Assessment																		
Guidelines for protecting Australian waterways (ecological values)	✓	✓	✓	✓	✓	✓	✓				✓					✓	✓	✓
Conservation of Freshwater Ecosystem values (CFEV)		✓			✓													
Index of Stream condition (ISC)		✓		✓	✓	✓		✓	✓		✓	✓				✓	✓	✓
Assessing the conservation value and health of NSW rivers (Pressure-Biota-Habitat)	✓	✓	✓	✓	✓						✓				✓		✓	✓
Stressed Rivers Assessment*		✓	✓	✓	✓									✓		✓		✓
State of the Rivers		✓	✓	✓	✓	✓	✓	✓	✓	✓	✓		✓	✓		✓	✓	✓
Ecosystem Health Monitoring Program (EHMP)*		✓																✓
Statewide Waterways Needs Assessment*		✓			✓						✓							✓
Tropical Rapid Appraisal of Riparian Condition (TRARC)		✓			✓		✓	✓		✓	✓	✓						
Rapid Appraisal of Riparian Condition (RARC)		✓			✓	✓	✓	✓		✓	✓	✓						
Sustainable Rivers Audit		✓	✓	✓												✓		
River Styles																		
Irrigation Ecological Risk Assessment Framework		✓	✓	✓	✓													✓
Geomorphic Assessment of Rivers (GAR)													✓					
Fish Habitat Area Selection and Assessment		✓	✓		✓	✓												✓
AquaBAMM	✓	✓	✓	✓	✓	✓		✓		✓	✓					✓		✓

	Indices					
	Management/ planning			Social importance		
Waterway Assessment	Risk factors/ assessment	Decision support	Management response	Scenic/recreational/ conservation values	Waterway pressure	Sub-catchment disturbance
National River Health Program and AusRivAS*						
Wild Rivers*						✓
Ecological Risk Assessment	✓	✓				
Guidelines for protecting Australian waterways (ecological values)						
Conservation of Freshwater Ecosystem values (CFEV)						
Index of Stream condition (ISC)						
Assessing the conservation value and health of NSW rivers (Pressure-Biota-Habitat)	✓					
Stressed Rivers Assessment*						✓
State of the Rivers				✓		✓
Ecosystem Health Monitoring Program (EHMP)*						
Statewide Waterways Needs Assessment*			✓	✓	✓	✓
Tropical Rapid Appraisal of Riparian Condition (TRARC)						
Rapid Appraisal of Riparian Condition (RARC)						
Sustainable Rivers Audit						
River Styles						
Irrigation Ecological Risk Assessment Framework						
Geomorphic Assessment of Rivers (GAR)						
Fish Habitat Area Selection and Assessment						
AquaBAMM						

	Method					Purpose				Priority			Management response		
Waterway Assessment	Index	Framework	Classification	Model	Rapid assessment	Function	Value	Management	Priority	Protection	Restoration	Health	Decision support	Impact assessment	Risk assessment
National River Health Program and AusRivAS*	✓					✓									
Wild Rivers*				✓			✓		✓	✓					
Ecological Risk Assessment		✓				✓		✓	✓			✓	✓		✓
Guidelines for protecting Australian waterways (ecological values)		✓					✓								
Conservation of Freshwater Ecosystem values (CFEV)	✓					✓	✓	✓	✓	✓	✓			✓	
Index of Stream condition (ISC)	✓								✓	✓	✓	✓			
Assessing the conservation value and health of NSW rivers (Pressure-Biota-Habitat)					✓	✓	✓								
Stressed Rivers Assessment*					✓	✓		✓					✓		
State of the Rivers					✓	✓			✓		✓				
Ecosystem Health Monitoring Program (EHMP)*	✓					✓	✓								
Statewide Waterways Needs Assessment*					✓	✓		✓	✓		✓		✓		
Tropical Rapid Appraisal of Riparian Condition (TRARC)					✓	✓									
Rapid Appraisal of Riparian Condition (RARC)					✓	✓			✓		✓				
Sustainable Rivers Audit	✓					✓		✓					✓	✓	
River Styles			✓			✓			✓	✓	✓				
Irrigation Ecological Risk Assessment Framework		✓				✓	✓	✓	✓		✓				✓
Geomorphic Assessment of Rivers (GAR)					✓	✓			✓	✓	✓				
Fish Habitat Area Selection and Assessment	✓					✓	✓		✓	✓					
AquaBAMM	✓						✓								

APPENDIX K: MONITORING AND EVALUATION

Monitoring and evaluation is critical for determining whether management of a waterway has achieved/or is achieving set goal(s), and should be funded and resourced accordingly (Price 2007). Results from this process should be communicated and used to review management actions (Department of Water 2004) for continued improvement and priority setting (Price 2007).

Monitoring and evaluation (M&E) programs need to meet the following criteria to ensure success and justify resource use:

- M&E programs need to have clear objectives and a defined purpose to decide what data and how often it should be collected;
- There should be an effective link between M&E and the management decisions it will influence;
- Measured attributes must have the potential to detect changes and differences at the spatial/temporal scales anticipated;
- Measured attributes must reflect project outputs and outcomes;
- Use of protocols to ensure consistent and reliable measurement; and,
- Adequate funding to ensure effective M&E (Price 2007).

The purpose of evaluation should generally guide monitoring programs (Price 2007) and is therefore discussed first.

Evaluation

Waterway management programs can be evaluated at two levels:

1. **Output** evaluation – completion of milestones within agreed timeframe and delivered outputs.
2. **Outcome** evaluation – measures over time whether required changes in condition (e.g. less bank erosion, lowered water temperature, increased in-stream habitat) have been achieved, and whether they are the result of the project (Price 2007).

Output evaluation is straightforward and should be considered as a minimum requirement for good management. However, outcome evaluation is more complex and difficult due to short timeframes, large spatial scales of many outcomes (e.g. improved water quality), signal to noise ratio due to large climate variability, frequency of measurement, lack of baseline data and the need to measure multiple variables (Price 2007). Some of these issues can be addressed by identifying indicators which can be assessed easily and cheaply (Price 2007).

Monitoring

The type of monitoring system should be based on the data required to detect change from baseline conditions and to separate project or treatment effects from those due to natural spatial and temporal variability (Price 2007). The emphasis on many waterway projects will be to measure change from degraded or unsatisfactory conditions to less degraded or closer to natural conditions (Price 2007). In this instance, either a matching but untreated control site or an adjacent reference site is required to distinguish treatment effects from natural variability (Price 2007). Where comparison with other sites is not possible the collection of baseline data becomes important and before-after-control-impact (BACI) sampling designs may be useful (Price 2007).

Indicator selection

Attributes of waterways which can be monitored to indicate whether progress is being made to achieve a goal are termed ‘indicators’. Successful evaluation of management requires appropriate indicator or target selection, which may depend on:

- The available management plan;
- Financial and human resources;
- Consistency with local, regional and State indicators;
- The amount of available data to establish the current level or temporal variation of an indicator (Department of Water 2004).

The DoW draft framework (2004) recommended consideration of the following factors when selecting indicators:

- Monitoring complexity (choice between simple, for e.g. photos taken at regular intervals from the same position, or complex weekly water quality monitoring programs).

- Risk assessment i.e. how critical is monitoring and whether chosen indicator will provide sufficient information about system change.
- Use of suites of indicators to give a more complete picture
- Use of compromise indicators where ideal indicators are prohibitively expensive.
- Consistency of indicators across all states and territories, and where appropriate, those used overseas.

Furthermore, useful indicators have the following characteristics:

- Linked directly to a key aspect of condition, function or pressures (stressors);
- Detect change at the required spatial and temporal scales;
- Can be interpreted without ambiguity;
- Are sensitive to the anticipated changes following treatments;
- Can be measured easily and cheaply with a high degree of accuracy and repeatability;
- Can be measured using existing methods; and,
- Useable data already exists or is being collected (Price 2007).

In order to maintain flexibility and ensure that the same measurements do not need to occur in all waterways, the FARWH assessment defines six key components (as discussed earlier) which need to be represented in all assessments and provides guidelines for consideration when determining indices (Government of Australia 2007). In FARWH assessments consideration should be given to:

- The weighting of indices when aggregating from finer measurement scales (reach or individual wetland) to represent the surface water management area (stream length or wetted area of individual wetlands).
- Methods of integration, which may follow expert rules
- Sensitivity analysis to determine which indices contribute most to assessments
- Where data is missing, at least three of the six components should be present for assessment
- At the scale of an entire surface water management area, at least five percent of the recognised river reaches or wetlands should be represented (Government of Australia 2007).

There are two general approaches useful for deciding which indicators should be monitored:

- **Condition-pressure-response framework** – indicators chosen to provide information about waterway condition, pressures on that condition, and the responses to those pressures.
- **Ecosystem framework** – indicators selected to reflect critical waterway characteristics and functions, considered in the context of catchment landscape position, geology, topography, climate and land use (Price 2007).

Indicators most often used for assessing ecological value include:

- Level of disturbance, compared to natural or reference condition, of hydrology, water quality, flora, fauna, geomorphology and ecological processes;
- Rarity of flora/fauna or geomorphological features;
- Habitat diversity and flora/fauna diversity; and,
- Service to surrounding geomorphic or ecological systems (flooding, refuge, key habitat, migration or karst landscapes) (Bennett et al. 2002).

Table 15 presents a summary of the various criteria and indicator(s) used to assess waterway condition in Australia (Queensland EPA 2007).

Table 15. Summary of Australian management frameworks criteria and indicator(s) (Queensland EPA 2007).

Management framework	National/ State/ Regional	Criteria	Indicator(s)
National River Health Program and AusRivAS	National	Ecological importance	Occurrence of macroinvertebrates
Wild Rivers	National	Ecological importance Social importance	Stream disturbance Sub-catchment disturbance
Ecological Risk Assessment	National	Ecological importance	Biological stressors Chemical stressors Physical stressors
Guidelines for protecting Australian waterways (ecological values)	National	Ecological importance	Diversity Naturalness Rarity Representativeness Special features
Irrigation Ecological Risk	National	Ecological importance	Algal blooms

Assessment Framework			Biodiversity Primary production Water quality
Rapid Appraisal of Riparian Condition (RARC)	South-east Australia	Ecological importance	Vegetation cover, debris, features (regeneration), habitat and natives
Sustainable Rivers Audit	Murray-Darling Basin	Ecological importance	Fish communities Hydrological patterns Macroinvertebrate diversity
Tropical Rapid Appraisal of Riparian Condition (TRARC)	Northern Australia	Ecological importance	Vegetation cover, debris, disturbance, natives and regeneration
Conservation of Freshwater Ecosystem values (CFEV)	Tas	Naturalness Rarity Representativeness	Ecosystem naturalness Geomorphological condition Biological naturalness Rarity of classification units Physical components Biological components
Index of Stream condition (ISC)	Vic	Ecological importance	Aquatic life Hydrology Physical form Streamside zone Water quality
River Styles	NSW	Ecological importance	Comparison with pre-disturbed conditions Prediction of likely future behaviour River styles
Assessing the conservation value and health of NSW rivers (Pressure-Biota-Habitat)	NSW	Ecological importance Management and planning	Biological diversity Physical diversity Rarity Resilience Vigour Risk factors
Management framework	**National/ State/ Regional**	**Criteria**	**Indicator(s)**
Stressed Rivers Assessment	NSW	Ecological importance	Conservation value Environmental stress Hydrological stress
Statewide Waterways Needs Assessment	WA	Ecological importance Management and planning Social importance	Waterway condition Waterway values Management response Waterway pressure
Ecosystem Health Monitoring Program (EHMP)	Regional Qld	Ecological importance	Biological Stream health Water quality
State of the Rivers	Qld	Ecological importance	Aquatic habitat Bank condition Bed and bar condition

			Channel habitat Cross section Hydrology Reach environs Vegetation
		Social importance	Scenic, recreational and conservation values
Geomorphic Assessment of Rivers (GAR)	Qld	Ecological importance	Geomorphic reaches
Fish Habitat Area Selection and Assessment	Qld	Ecological importance	Fisheries Habitat Unique features
AquaBAMM	Qld	Ecological importance	Connectivity Diversity and richness Naturalness aquatic Naturalness catchment Priority species and ecosystems Special features Threatened species and ecosystems

In order to quickly compare different sites it may be useful to combine a range of riparian indicators to give a single score or index (Price 2007). Various components may be weighted, according to their relative importance, to determine the index and it

is essential to measure indicators on the same scale (Price 2007), for example 1 to 5 (Bennett et al. 2002). This approach is used in national and state waterways management frameworks such as; guidelines for protecting Australian waterways and FARWH.

Target setting

Targets for indicators may also be appropriate to assess goal achievement and should be set for the best possible result expected from a successful management action (Department of Water 2004). Targets can be set in a number of ways, including characterisation into three types:

- Aspirational targets – to be achieved in greater than 50 years;
- Resource condition targets – to be achieved between 10 to 50 years; and,
- Management action targets – to be achieved in one to five years (Department of Water 2004, in preparation).

Where waterway quality or the range of values is unacceptable to the community, management aims should focus firstly on stabilising the system and then on improving the waterway values and condition (Department of Water 2004).

Integration of regional and local data

The DoW draft framework aims to flexibly incorporate both quantitative and qualitative data collected by the DoW and regional NRM groups across different spatial scales.

In the EHMP based in south-east Queensland, the feasibility of integration of locally collected council data and government department data was assessed (South East Queensland Healthy Waterways Partnership 2008). In this assessment it was suggested that local data would 'value add' to the EHMP by allowing data interpretation at a finer catchment scale (South East Queensland Healthy Waterways Partnership 2008). The approach to integrate local council monitoring programs is flexible and does not aim to enforce any one particular methodology. However, in order to ensure development of a coherent and successful program between the local and regional programs, the South East Queensland Healthy Waterways Partnership (2008) made the following recommendations:

- Councils should consider collection of suggested indicators.
- Standard operating procedures from each authority accompany data to determine validity.
- Local monitoring data should be reported separately.
- A single data base and analysis package should be made available to both local authorities and the regional EHMP.

A generic approach used to develop 'local' monitoring programs. Table 16 provides an example of how different measures can be monitored by local councils and government departments and still provide information for indicator assessment. In this approach the values of each index for each site are transformed into a score 0 - 1 (unhealthy – healthy) which is standardized both for natural spatial variation across streams and measurement scale.

Table 16. Summary of EHMP regionally measured indices and recommended indices for local monitoring (South East Queensland Healthy Waterways Partnership 2008).

Indicator	**Regionally measured EHMP indices**	**Recommended indices for local monitoring**
Physical and chemical	• pH • Electrical Conductivity • Ambient water temperature (Diel maximum and range) • Ambient dissolved oxygen concentration (Diel minimum and range)	• pH • Electrical Conductivity • Ambient water temperature (Diel maximum and range) • Ambient dissolved oxygen concentration (Diel minimum and range)
Nutrient Cycling	• Nitrogen Stable Isotopes • Algal bioassay of nutrients (N:P:C)	• Nitrogen Stable Isotopes
Ecosystem Processes	• Algal growth (Chl a) • Carbon stable isotopes • Benthic metabolism (R24 and GPP)	• Algal growth (Chl a) • Carbon stable isotopes
Macroinvertebrates	• Number of taxa • PET Richness • SIGNAL Score	• Number of taxa • PET Richness • SIGNAL Score
Fish	• PONSE • O/E50 • Proportion Alien	
Habitat		• Index of Stream Condition • Shade • % Intact Buffer
Toxicants		
Pressure Data		• Flow data • Rainfall data

APPENDIX L: PHOTOGRAPHIC IMAGERY OF WATERWAY CASE STUDIES

Marbellup Brook

Figure 4: Marbellup Brook – annual weeds (Photograph: Geraldine Janicke)

Figure 5: Marbellup Brook – healthy foreshore (Photograph: Geraldine Janicke)

Berkeley River

Figure 6: Berkeley River gorge from the air (Photograph: Luke Pen)

Figure 7: Berkeley River – typical foreshore vegetation (Photograph: Luke Pen)

Figure 8: Berkeley River gorge (Photograph: Lisa Mazzella)

Figure 9: Berkeley River gorge (Photograph: Lisa Mazzella)

Fortescue River

Figure 10: Fortescue River (IMG 1279) (Photograph: website)

Figure 11: Fortescue River (IMG 0729) (Photograph: website)

Figure 12: Fortescue River (Photograph: unknown)

Figure 13: Fortescue River (Photograph: unknown)

South Coast Region

Figure 14: Fitzgerald River (Photograph: Geraldine Janicke)

Figure 15: Kalgan River (Photograph: Geraldine Janicke)

Figure 16: Frankland River (Photograph: Geraldine Janicke)

Figure 17: Bremer River (Photograph: Geraldine Janicke)

Figure 18: Oldfield River (Photograph: Geraldine Janicke)

Figure 19: Dalyup River (Photograph: Geraldine Janicke)

APPENDIX M: STAKEHOLDER ENGAGMENT IN FRAMEWORK DEVELOPMENT

Engagement principles and stakeholders

For management of waterways, like all public goods, stakeholder engagement is essential. Since there is no standard approach to engagement so engagement processes must adhere to principles that ensure standards are met and the most appropriate level of engagement is achieved. There are many principles that have been developed for community engagement but since the end users of this Framework will primarily be State government agencies and regional NRM groups, it is these organisations that constitute the 'key' stakeholders. Naturally, there are other stakeholders that will have interests in the Framework (e.g. land managers) but since the Framework will essentially be a strategic tool, engagement with these stakeholders is not anticipated until application of the Framework.

When considering stakeholder engagement the work undertaken by Aslin and Brown (2004) is notable. They emphasise the context of stakeholders' knowledge and they identified four distinctive knowledge bases or cultures:

- Local knowledge (local lived experience, place based knowledge). This emphasises the importance of 'inclusiveness' (as stated above) so the engagement undertaken for this project must obtain input from even the most remote corners of the State.
- Specialised knowledge (expert knowledge and interpretations, scientific disciplines). Waterways management requires a high level of expert input. The development of the Framework has been guided by a Technical Reference Group (TRG) and Steering Committee both of which have memberships made up of appropriate State government agency representatives (e.g. DoW, DEC, DAFWA and Department of Fisheries), regional NRM groups and other experts from academic institutions with long-standing expertise in waterways and wetland management.
- Strategic knowledge (functioning of governance systems, planning, administration and management). The Framework must take account of Government institutional and bureaucratic processes so representation from government funding bodies (e.g. Caring for our Country) is also important.
- Holistic knowledge (shared purposes and ways of synthesising, working across cultures and other knowledge systems).

Aslin and Brown (2004) emphasise that successful engagement in NRM decision-making must seek collaboration between people from all these four knowledge cultures. The stakeholders identified for consultation in the development of this Framework are all capable of contributing to one or more of these four areas. The following key organisations were consulted during the development of the Framework:

WA State Government Agencies:

- Department of Water (DoW)
- Department of Environment and Conservation (DEC)
- Department of Agriculture and Food WA (DAFWA)
- Department of Fisheries (DoF)
- Swan River Trust

Regional NRM Groups (WA):

- Perth NRM Inc.
- Avon Catchment Council (ACC)
- Northern Agricultural Catchments Council (NACC)
- South West Catchments Council (SWCC)
- South Coast NRM Inc.
- Rangelands NRM Coordinating Group (RCG)

Commonwealth Government Agencies:

- Department of the Environment, Water, Heritage and the Arts, the Department of Agriculture, Fisheries and Forestry

Academic Institutions:

- University of Western Australia (UWA)
- Murdoch University
- Curtin University

Engagement principles adopted by the Queensland Department of Communities (2004) seek to ensure the effectiveness of the engagement process. They identified six principles:

- *Inclusiveness* – connecting with those who are hardest to reach. Since the waterways Framework should be applicable across the entire State, this principle seems particularly important.
- *Reaching out* – changing the ways government and community work together for the better. In many respects this principle is concerned with institutional process. The development of this Framework will inevitably encourage some institutional change – change that hopefully encourages improved co-operation between State agencies and regional NRM groups and others who directly and indirectly have waterways management responsibilities.
- *Mutual respect* – listening, understanding and acting on a variety of experiences. Apart from being a fundamental principle in human relations, this is critical because no one organisation can claim to know all there is about waterways management.
- *Integrity* – engagement as a means of promoting integrity in the democratic processes of government. Integrity is critical if the Framework is to be widely adopted and used by stakeholders.
- *Affirming diversity* – changing the processes of government to incorporate diverse values and interests.
- *Adding value* – government and citizens working productively together to add value to management initiatives.

Frewer et al. (2001) were also concerned with effectiveness – they emphasised two criteria or areas that should be considered – ‘acceptance’ and ‘process’ (Table 17).

Table 17: Evaluation criteria for assessing the effectiveness of community engagement (Frewer et al. 2001).

Criteria	Definition
Acceptance criteria:	
Representativeness	The stakeholders should comprise a broadly representative sample of the affected population.
Independence	The engagement should be conducted in an independent (unbiased) way.
Early Involvement	The stakeholders should be involved as early as possible in the process, as soon as value judgments become salient/relevant.
Influence	The output of the procedure should have a genuine impact on policy.
Transparency	The engagement should be transparent so that stakeholders can see what is going on and how decisions are being made.
Process criteria:	
Resource Accessibility	Stakeholders should have access to appropriate resources to enable them to successfully contribute.

Task Definition	The nature and scope of the engagement task should be clearly defined.
Structured Decision-making Process	The engagement should use/provide appropriate mechanisms for structuring and displaying the decision-making.
Cost Effectiveness	The engagement should in some sense be cost effective from the point of view of the sponsors.

The engagement process

Stakeholder engagement was initiated following commencement of the project through meetings with all six NRM regional bodies to obtain first-hand knowledge of waterways management activities in the regions, and to discuss the possible alignment of the Framework with these activities. In addition, a workshop was held on 27 August 2008 with a range of stakeholders to discuss the components of the proposed Framework, and suggestions and amendments which received strong support were incorporated into the draft Framework.

There are a number of 'stages' involved in the development of this Framework: an exploratory stage, a scoping stage, a trialing stage, a review stage and a dissemination stage. Stakeholder engagement takes place during all stages (Table 18).

Table 18: Stakeholder Engagement Activities according to Framework Development Stages

Stakeholders / *Project stage*	**Type/style of engagement**
Exploratory stage:	
State Government agencies	Meetings, phone calls and email exchanges with relevant agencies.
Regional NRM groups	Focus group meetings, conference phone calls
Scoping stage	
State Government agencies; regional NRM groups; experts	Workshop in Perth: draft framework presented; various components assessed using the strengths, weaknesses, opportunities and limitations (SWOL) technique
Trialling stage:	
South Coast NRM Inc.; Rangelands NRM Inc.; DoW; Wilson Inlet Catchment Committee Inc.	Meetings, data exchanges
Review stage:	
State Government agencies; regional NRM groups; experts	Meetings, phone calls and email exchanges; final stakeholder/expert reviews of draft framework and supporting documentation
Dissemination stage:	The engagement should use/provide appropriate mechanisms for structuring and displaying the decision-making.