River Restoration Framework

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Introduction

Rivers are an integral part of our culture and our economy but our record in managing these essential resources over the past hundred years has been riddled with short-sightedness. Many Australian waterways and catchments are degraded due to intensive human impacts including diversions, storages, clearing vegetation and other habitat removal, introduced species and pollution.

The effects of damage to aquatic ecosystems through these changes have long been known and demonstrated.

Throughout Australia there have been calls from all levels of society, from the general public through to the highest level of government, for urgent action to redress the degradation of rivers and to manage them in an ecologically sustainable manner, providing both the benefits to society and the ecological functioning on which those benefits depend.

This *River Restoration Framework* provides a simple step-by-step process, through which the complex task of river restoration can be undertaken across Australia. Aimed at catchment managers and community groups as well as scientists and other stakeholders, it highlights the core requirements and elements of river restoration.

> "River restoration is defined as aiming to protect and rehabilitate the physical and biotic processes of a river in a way that is conducive to the progression of ecosystems toward their natural state."
>
> (Koehn *et al.* 1997)

The main aim of the framework is to change the current fractured and *ad hoc* nature of river restoration activities by providing a process that incorporates the variety of biophysical, societal, economic and political structures in Australia that affect and are affected by river restoration. This framework promotes a cohesive approach to restoring rivers and will help to produce a common bond between people undertaking restoration activities.

The limitations of prescriptive approaches to river restoration activities, which commonly focus on single issues addressed in isolation (eg. erosion control), and are framed within classification (or cookbook) procedures, are now widely recognised. It is unlikely that textbooks or off-the-shelf manuals will provide the perfect or even the optimal solution in every case. Rather, river restoration activities must be flexible and be developed to fit the individual river system and its associated problems. To achieve this, empirically derived knowledge that pertains to the particular system will generally be required.

These are three key principles in the proposed river restoration framework:

1. Management procedures must be flexible and adaptable.
2. There must be much greater integration and communication of knowledge between disciplines (within the sciences and across to the social sciences).
3. The community must have ownership of the project (where ownership constitutes control over decision-making processes, and commitment to follow through all six steps of the restoration process).

The framework is further driven by a set of guiding principles, divided into general, ecological and management principles. *General principles* are those that apply specifically to this framework. *Ecological principles* include those associated with the conservation of biodiversity, encompassing ecologically sustainable development and restoration. *Management principles* include those associated with management systems, risk management and adaptive management. Linked to these principles is a series of concepts that underpins our understanding of river systems. Section V provides further details about these guiding principles and concepts.

This framework will help overcome many of the constraints in technical knowledge transfer and exchange across Australia. It will improve access to tools for conducting restoration while it promotes increasing knowledge about the way in which different elements of the system respond to those tools.

This document

Section I of this document briefly outlines the framework. Section II summarises the elements of each step of the process or framework, and the tools that accompany them. Section III describes the restoration process in more detail.

The tools that can be applied at the various steps in the restoration framework are outlined in Section IV. Some of these tools are applicable across a range of steps while others are relevant to a particular step. While this manual does not *determine* which tool is appropriate for each step, it provides guidance on the type of tools available, their purpose, input requirements and outputs. The choice of tool will be influenced by many factors, including budget, the time available, scale, the amount of risk inherent in using the tool, previous information and data collected, personal experience and expertise and access to equipment.

Section V provides further details about guiding principles and concepts.

Section VI contains a glossary, acknowledgments and references.

Users of this document are strongly encouraged to undertake all the steps in the framework. Completing only part of the river restoration process may undermine the integrity of the expected outcomes.

PRINCIPLES FOR THIS FRAMEWORK

General principles

- Link science, communities, stakeholders and management in the process of river restoration
- Be generic and useable—applicable across Australia
- Fit into broad spatial and temporal scales, while acknowledging all scales
- Be result oriented, providing environmental and social outcomes
- Be strategic and pro-active—have a long-term visionary approach with short, medium and long-term objectives
- Have ongoing feedback loops
- Continually increase the knowledge base through education, training and field experience and research
- Address causes before symptoms
- Emphasise consultation and consensus over compromise

Ecological principles

- Be conservation oriented, striving to support ecologically sustainable development
- Work with nature by using baseline data and monitoring
- Enhance biological diversity and ecological integrity toward an objectively defined 'natural' or pre-European condition
- Have scientific rigour and sound methods

Management principles

- Follow adaptive management principles—learn by doing; be robust and flexible; not prescriptive
- Incorporate community involvement—enhance community empowerment, be honest and manage expectations
- Implement through existing agencies and structures wherever possible
- Follow principles of best practice such as auditing—use stepping stones/building blocks to improve practice

SECTION I: THE FRAMEWORK IN BRIEF

The Basic Steps

The framework establishes a stepwise restoration process which incorporates the development of a restoration plan. The process can be used as a resource to assist with restoration planning and activities. It can be used in conjunction with technical manuals such as *A Rehabilitation Manual for Australian Streams* (Rutherfurd *et al.* 1999, 2000) which give a more detailed account of the technical aspects of restoration planning and activities.

> The order in which the steps are completed may be flexible, although each step of the process should be completed to ensure a systematic approach to the restoration process.
>
> Completion will entail progression through the feedback loops within the framework (see p. 10).

The essence of each of the steps (Figure 1) is:

Restoration team — leadership group.

Scoping — defining the boundaries.

Vision — securing ownership and direction.

Restoration plan — systematic method for developing restoration activities in response to a restoration problem.

Implementing the plan — carrying out the activities.

Monitoring and maintenance — reviewing the activity and maintaining it over time.

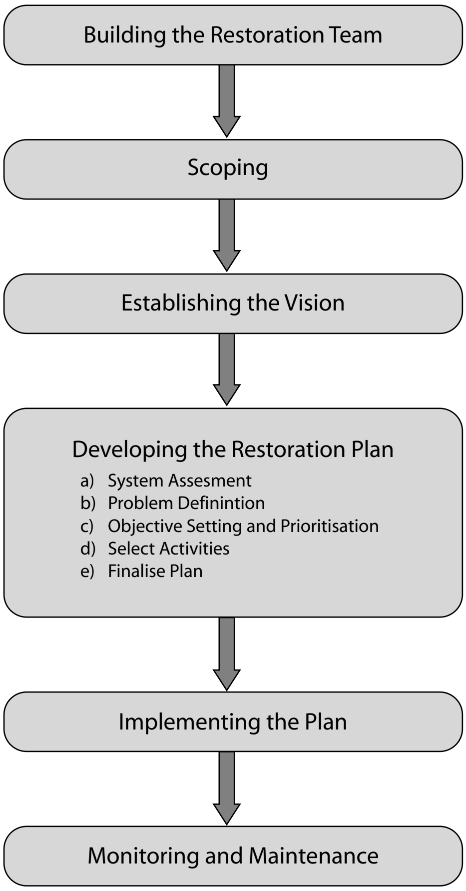

Figure 1. The river restoration framework

The Six Elements of Each Step

There are six steps of the framework and six elements to consider during each step. Figure 2 gives an example of a single step of the framework and its six elements.

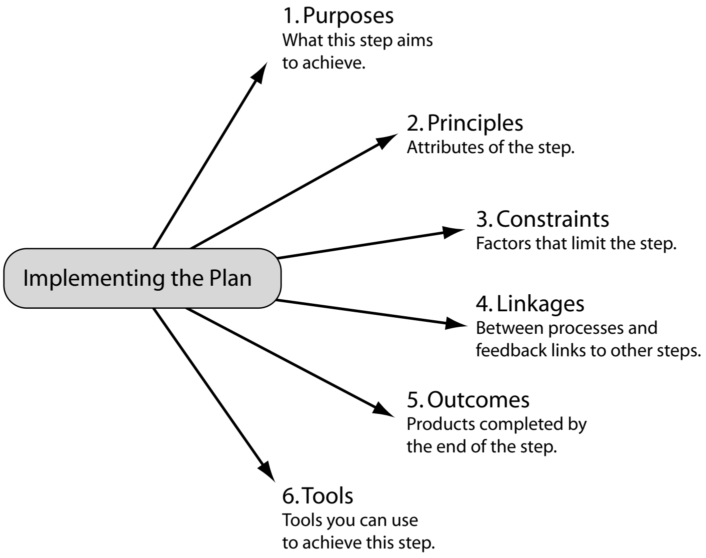

Figure 2. An example of one step of the river restoration framework

Links and Community Involvement in the Framework

Various links are mentioned throughout the framework and these are brought together below.

Links between steps of the framework

While each of the six steps of the framework has discrete tasks, the steps are interrelated and influence other steps as the process is followed. This is demonstrated by the series of feedback loops in Figure 3. Outputs of monitoring will often be integrated into the restoration team, vision and, particularly, the planning process. In this way the knowledge gained about the effectiveness of the project's approach to river restoration will inform future planning. It may be beneficial for some changes to be made to the restoration team throughout this process.

Objectives are linked to the vision to ensure that the outputs of the project reflect the views of the stakeholders.

Links between people

One of the most important aspects of river restoration is the links that the activities forge between people, primarily: individuals, scientific disciplines, community groups, government agencies, non-government organisations, government and international organisations at local, regional, national and international levels, respectively.

These links will provide for:

- sharing information;
- coordination and practical support;
- assessment of needs; and
- allocation of auditing resources.

These links will also ensure that the project adheres to the policies and protocols of governments and international agreements.

Links to other projects

Outputs of monitoring will increase the knowledge gained about the effectiveness of the project's approach to river restoration. In this way, the knowledge gained about the effectiveness of the project's approach to river restoration will inform future planning in other areas.

Links between disciplines

The framework provides an opportunity for interdisciplinary research. Through application of this framework, the spatial scales over which geographical, geomorphic, hydrological, and ecological processes occur can be integrated.

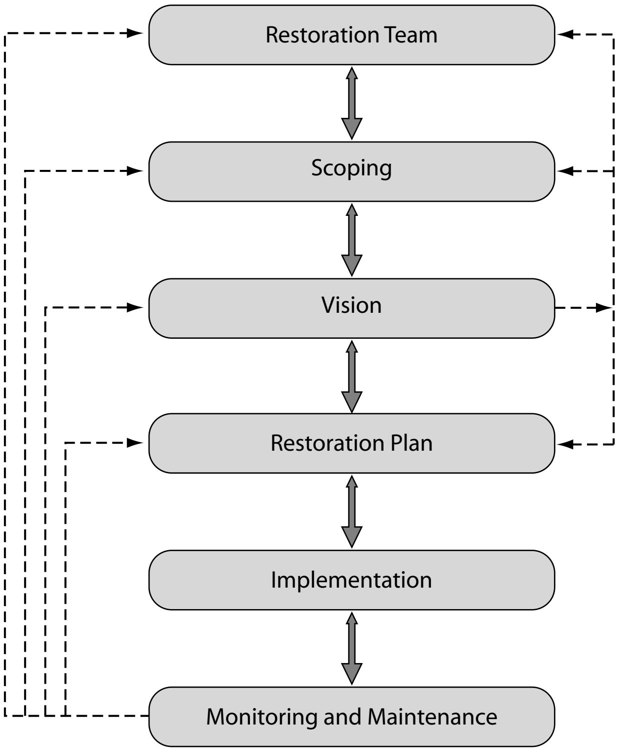

Figure 3. Links in the river restoration framework

Evaluation, Documentation, Communication and Community Empowerment

Evaluation, documentation, communication and community empowerment occur at the heart of each step of the framework. These activities can:

- lead to the sharing of knowledge and constructive development of activities through effective communication between stakeholders, but also with the wider community;
- empower community judgments and actions by increased knowledge and understanding of restoration activities;
- provide continuity and transparency by documenting decisions, actions and results; and
- allow the success or failure of the activity to be evaluated to improve restoration activities in the future.

Evaluation and documentation

Purposes/outputs and outcomes of each step must be evaluated at each step of the framework.

Although the restoration plan will ultimately document the works to be undertaken, it is also important to document the process and the activities that are undertaken as part of it. This will greatly assist in organisation, avoid confusion and misunderstandings, provide a complete record of the restoration process from which improvements can be made, and record justifications for decisions that have been made. Appointment of a 'record keeper' and use of checklists may be useful. A standardised format for report writing may also be useful.

Written documentation:

- demonstrates that the plan is happening;
- demonstrates design criteria;
- documents the process by which decisions were made;
- assists in discussions with others;
- documents details that may otherwise be forgotten;
- provides information to new participants;
- informs decision-makers and funding agencies;
- provides transferability to other projects; and
- assists future decision-making.

Communication

Communication is essential for the success of any river restoration project. The process of providing information and updates to the restoration team members, stakeholders and the general community helps to ensure understanding and support. Receiving information, advice and feedback from these people is also important, and processes should be put in place to facilitate this.

Community empowerment

Empowerment may be described as a sense of personal control, influence and concern with actual rights to social and political power. Community empowerment can be engendered through proper communication, real involvement and influence, and participation. Community empowerment involves ownership. This is the key to effective long-term river restoration.

Evaluation, documentation, communication and community empowerment are core components of each stage in the framework.

SECTION II: RESTORATION STEPS IN SUMMARY

Step 1 Building the Restoration Team

A restoration team is very important to complete the restoration project. Funding needs to be provided to bring the team together. It may include members who can contribute key skills and interests, and be able to work together both in the field and the office. Additional skills may be added to the team as they are required throughout the project, although a core group of members is needed to provide continuity and see the project through to its conclusion. The core group will consist of the local project manager, a scientist/expert in a relevant field, a community representative and a government representative. At times throughout the restoration process other team members will join and leave the team according to the skills that are needed for each step.

Recommended team members

- **Local project manager** (catchment management authority or equivalent)
- **Scientists/expert representatives**
  - geomorphologist & hydrologist
  - freshwater ecologist
  - plant (aquatic and riparian) ecologist
  - sociologist/ community development worker
- **Community representatives**
  - member of a cultural group
  - farmer/landholder & industry representative
  - angler
- **Government representatives**
  - relevant State agency representative
  - local shire representative
  - catchment authority representative
  - river operator

1. PURPOSES

- To provide ownership of the project
- To ensure adequate knowledge is available for the restoration activity
- To provide a forum for cross-fertilisation of ideas and for educating and incorporating the concerns of the wider community
- To provide continual knowledge updates and continuity by following the project from start to finish
- To provide flexible co-ordination
- To enhance communication between the project and other project teams, in terms of national, regional, and bioregional plans
- To develop a restoration plan supported by stakeholders
- To provide documentation of decisions and actions within the team taken throughout the restoration project

2. PRINCIPLES

- Dynamic — incorporate skills according to needs
- Manageable
- Subject to review
- Provides leadership, information, and honesty
- Open-minded, seeking the broader view
- Even balance of users/conservers
- Inclusive

3. CONSTRAINTS

- Skills available
- Knowledge gaps
- Logistics — distance & communication (ie. availability/ ability to attend meetings)
- Different values/personalities
- Private scientific consultants reluctant to reveal commercially sensitive information

4. LINKAGES

- To other levels of government
- To wider community
- Within the team
- Across disciplines and to other experts within disciplines
- To other steps
- To other planning processes
- To stakeholders
- To future projects

5. OUTCOMES

- Project leadership and ownership
- Better communication between stakeholders
- Development and management of the restoration plan
- Improved coordination of river restoration activities
- Honest and transparent process to restore a waterway ecosystem
- Improved ecological integrity of the river system

6. TOOLS FOR RESTORATION TEAM

- Communication and group processes
  - round-table workshop
  - six thinking hats (see page 41)
  - press release/regular column
  - participatory rural appraisal
- Management
  - AEAM (adaptive environmental assessment and management)
  - PERT (flow chart)/GANTT (bar chart) scheduling techniques
  - conflict resolution

Detailed descriptions of the tools are given in Sections III & IV

CHECKLIST

☐ Has the restoration team been brought together?
☐ Is a range of disciplines represented?
☐ Will key members see the project through to completion?
☐ Have all the participants been informed of the restoration initiative?
☐ Have linkages been recognised and formalised?
☐ Has the decision structure been developed and point of contact identified?
☐ Does the restoration team have the skills and information to succeed in the tasks?
☐ Are the political/commercial/value conflicts manageable to the point that worthwhile outcomes can be reasonably expected?

Tips

➢ Establish a core team that can see the project through.

➢ Ensure communication both within the team and between the team and the stakeholders.

➢ Add to the team or enlist other expertise as required.

➢ Attendance at meetings and interactions with others will help raise awareness of issues that may affect restoration outcomes.

Step 2 Scoping

Scoping ensures that the restoration activity is the best solution to the restoration problem. It sets the boundaries (geographic and otherwise) of the project. An overview is developed by collating existing scientific, technical, social and economic information. Knowledge gaps and constraints, the main degrading influences, present strengths and potential pressures on future strengths of the system are all identified. Possible problems are defined and further analysis recommended to determine whether problems are actual or only perceived. This information is shared amongst the team thereby promoting realistic development of plan parameters (ie. clear sense of what can be achieved in the vision).

1. PURPOSES

- To determine the breadth and depth of, and constraints to, the restoration activity using current knowledge
- To determine which areas of the catchment can be restored and may need a restoration plan
- To produce a list of resources, constraints and baseline data
- To help identify the boundaries of the vision
- To ensure that restoration strategies and the detail of activities are established within a catchment context

2. PRINCIPLES

- A broader assessment — scientific, social, political, economic, constraints, evaluation
- Make decisions using all current knowledge
- Broad focus but integrated
- Stakeholder analysis
- Decisions supported by information
- Takes into account all degrading influences
- Awareness of spatial and temporal scales
- Built on platforms already in place

3. CONSTRAINTS

- Data and information not accessible and/or incompatible
- Resources — skills, funding, number and type of people, materials, time
- Amount of time it takes for all participants to understand the context of the project

4. LINKAGES

- To the vision
- To the plan
- Across disciplines
- To a wider context
- To the make-up of the restoration team
- To other planning and environmental strategies

5. OUTCOMES

- A good understanding of the context of the project by all those participating in it
- Knowledge of the main degrading influences and strengths of the system
- Informed decision-making enabled by collation of current information relevant to the restoration activities
- A restoration team that is abreast of current knowledge of the potential restoration problems and general health of the system
- A realistic assessment of the boundaries of the project

6. TOOLS FOR SCOPING

- **Communication**
  - workshop
  - round-table discussion
  - AEAM
  - multi-criteria decision-support systems
  - reports
- **Biophysical/socio-political and economic data collection and analysis**
  - expert panel
  - river styles and other field surveys
  - historical analysis
  - interviews/surveys
  - SWOT analysis (strengths, weaknesses, opportunities, and threats)
- Community mapping

Detailed descriptions of the tools are given in Sections III & IV.

CHECKLIST

☐ Has a list of priorities been completed?
☐ Has a list/map of strengths and constraints been completed?
☐ Have baseline data — biophysical, social, economic — been collected and analysed?
☐ Is there a good understanding of the context of the project by all those participating in it?
☐ Does everyone involved recognise the main strengths and degrading influences of the system?
☐ Has an assessment of the adequacy of the current research base been completed?
☐ Has a list of skills and resources been completed?
☐ Have funding sources been identified?
☐ Has a digital or hardcopy database been established?

Tips

- ➢ Think laterally.
- ➢ Think creatively.
- ➢ Consider all factors.
- ➢ Consider other people's views.
- ➢ Take a broad view.
- ➢ Concentrate on systems and non-technical issues.
- ➢ Identify the primary causers or drivers of problems (termed 'pressures' in this framework).
- ➢ Identify appropriate benchmark sites.

Step 3 Establishing the Vision

Establishing a vision for the restoration project provides two things:

1. a concept of what is to be achieved by the project in an overall sense; and
2. a process for including all aspects and ideas in arriving at this concept.

Both of these actions are important for the initiation of a project that will be owned by its stakeholders.

A vision should identify the ideal outcome beyond initial projects. The visions must also be practical, relevant and achievable.

1. PURPOSES

- To identify a common purpose and provide a clear overriding direction
- To provide a product-orientated vision statement(s) arrived at by consensus
- To produce a clearly defined catchment-wide, long-term biophysical vision to provide an underlying template for restoration activities
- To engender commitment and focus of communities involved in the restoration project

2. PRINCIPLES

- Must be visionary
- Takes short, medium and long-term goals into account
- Is subject to review — may need to be reviewed and/or revised after system assessment
- Gives a common direction or concept
- Fits within a definition of river restoration
- Shared — community orientated
- Simple — must be easily communicated and as visual as possible
- Can change over time
- Must not be made in isolation — has technical input
- Considers spatial and temporal scales — may need to be set for different scales if the project is part of a larger restoration effort, eg. catchment-wide
- Must emphasise an objectively defined 'natural' or pre-European state of the river or stream
- Builds on protection of high quality sites and conservation planning

3. CONSTRAINTS

- Lack of baseline knowledge
- Conflicting interests
- Unfamiliarity with this process
- Definition of 'naturalness'
- Consensus may be difficult to achieve
- May not be possible, because of lack of knowledge or understanding by participants, to define a biophysical basis for the vision in terms of what is achievable

4. LINKAGES

- To scoping and system assessment
- Across disciplines
- To wider community
- To other environmental and planning strategies

5. OUTCOMES

- A sense of ownership, which builds commitment and focus for those involved in the restoration project
- A cohesive team with strong leadership and sense of direction
- Recognition of the benefits of the process of establishing the vision

6. TOOLS FOR SETTING A VISION

- Data collected during scoping
- Communication
  - workshops
  - vision sessions
  - questions
  - field day/vision day

CHECKLIST

☐ Has a broad range of interest groups been included to establish the vision?
☐ Has a vision statement(s) been written?
☐ Has the vision been arrived at by consensus?
☐ Is the vision clear?
☐ Is the statement expressed in a way that is inspirational?
☐ Has consensus been reached on the mission of the restoration initiative?
☐ Has a biophysical basis been defined in terms of what is achievable? (At the very least we must know that the restoration team's vision is attainable.)

Tips

- ➢ Start with a personal vision.
- ➢ Treat everyone as equals.
- ➢ Seek alignment not agreement.
- ➢ Encourage interdependence and diversity.
- ➢ Consider using an interim vision.
- ➢ Focus on dialogue not just the vision statement. The test of the vision is not in the statement but in the directional force it gives. The process is more important than the product for this particular step (Senge *et al.* 1994).
- ➢ Do not let the vision be too limited by scoping.

Step 4(a) Developing the Restoration Plan — System Assessment

The development of the restoration plan is a major component of this framework. This step has been divided into five components:

(a) system assessment;
(b) problem definition;
(c) objective setting and prioritisation;
(d) assessing options and selecting activities; and
(e) finalising the plan.

Informed decisions on what needs to be done can be made only after an assessment has been made of the state of the system and the pressures on it. This should include all biophysical components and be undertaken through a thorough, objective and scientific process.

1. PURPOSES

- To obtain a better knowledge of problems that require restoration
- To better target solutions to problems
- To assess the state of the system
- To help set objectives and indicators for evaluation
- To collate information and determine knowledge gaps
- To provide a report on the health of the river including the main degrading processes
- To identify what can realistically be achieved in terms of 'biophysical naturalness' by defining target conditions at reference sites to use as a benchmark
- To understand the interconnectivity between parts of the system
- To identify future pressures
- To understand how human impact or disturbance differs from disturbance that occur as part of natural variability and natural processes

2. PRINCIPLES

- Scientific — systematic and objective
- Incorporates scientific, social, economic and cultural elements
- Multi-disciplinary and broad
- Balances rigour versus rapidity
- Spatially and temporally integrated
- Recognises limitations of data
- Gives a sense of direction of change — ie. degrading versus recovering
- Information is derived primarily from the target river or catchment
- Knowledge of other systems used with critical assessment of application and relevance to target system

3. CONSTRAINTS

- Multitude of attitudes and approaches but not well integrated
- Many approaches are not generic
- Lack of skills/expertise
- Lack of tools in many areas
- Lack of baseline data
- Lack of understanding of system behaviour by participants

4. LINKAGES

- To scoping
- Across disciplines
- To wider community

5. OUTCOMES

- A comprehensive understanding of the nature and state of the problem
- Increased understanding of the structure and function of different elements of the river system and the interactions between them
- Increased understanding of the biology and ecology of aquatic species
- Increased understanding of ecological and physical limits
- A forecast of likely future river conditions if current trends are maintained

6. TOOLS FOR SYSTEM ASSESSMENT

- Biophysical/socio-political and economic data collection
  - expert panel
  - index of stream condition
  - AusRivAS
  - fish and other aquatic fauna surveys
  - river styles and other geomorphological surveys
  - habitat survey
  - riparian
  - extra interviews and community mapping (if there are still knowledge gaps after scoping)

Detailed descriptions of these tools are given in Sections III and IV.

CHECKLIST

☐ Has a report on the health of the river, including degrading processes and limitations to restoration, been produced?
☐ Have the spatial and temporal linkages that influence system condition been identified?
☐ Do participants have an appropriate understanding of their river system and the physical limitations of restoration?
☐ Has a natural state of the river been established objectively?

Tips

- ➢ Create a team atmosphere for the expert panel.
- ➢ Ensure appropriate social and scientific expertise.
- ➢ Think broadly.
- ➢ Think laterally.
- ➢ Keep an open mind.
- ➢ Underpin with science.
- ➢ Use to build knowledge base.
- ➢ Compare with a 'natural' condition.
- ➢ Think about assessment using holistic methods.

Step 4(b) Developing the Restoration Plan — Problem Definition

Defining the problem is essential to ensure that restoration can tackle the causes of the problem rather than just its symptoms. This process, undertaken using the information collected during system assessment, can help avoid the influence of conscious and subconscious value judgments that may inhibit the correct diagnosis of problems. Substantiation against the ‘do nothing’ option is required. A clear understanding of the problems leads to clearly defined objectives. The problem must be viewed in the context of natural variability in river character and behaviour.

1. PURPOSES

- To ensure the problem(s) and its causes are properly identified so that actions can address the problem
- To assess the feasibility of the plan
- To identify limiting factors and research/information needs
- To target resources in a way that maximises environmental benefits

2. PRINCIPLES

- Is based on scoping and system assessment
- Uses outcomes of system assessment
- Is a precursor to prioritisation and objective setting
- Has clear statements of the problem
- Focuses on causes, but identifies both causes and symptoms
- Uses a wide range of appropriate experts and community supporters to mitigate bias
- Assesses limiting factors
- Is an honest attempt to address the problem
- Is clear and concise
- Is framed within a restoration context
- Is framed in terms of direction of changes (ie. trajectories) recognising past, present and future trends
- Recognises that system responses to disturbance may be non-linear and complex (assume evolutionary and/or successional responses)
- Assesses the implication of a ‘do nothing’ or protection approach
- Re-assesses perceptions in the light of available evidence

3. CONSTRAINTS

- Multiple agendas
- Space and time context
- Restoration time frame
- Pre-existing value judgments
- Some problems appear too big or expensive to fix

4. LINKAGES

- Across disciplines
- To wider community
- To scoping, system assessment objective setting and prioritisation
- To indicators

5. OUTCOMES

- Greater assurance that the restoration problem is being addressed
- Chemical, biological and physical aspects of the problem are identified and causal linkages are investigated

6. TOOLS FOR PROBLEM DEFINITION

- **Biophysical/socio-political and economic knowledge**
  - Reports from studies done in system assessment and scoping
- **Communication**
  - mind mapping
  - flow diagrams
  - cause/effect mapping
  - interrelationship diagrams
  - log frame matrices
- **Management**
  - multi-criteria group decision support systems
  - AEAM

Detailed descriptions of these tools are given in Sections II and III.

CHECKLIST

❏ Have the problems been clearly defined and communicated to all stakeholders?
❏ Have limiting factors been identified?
❏ Has problem definition led to a need to change the restoration team structure?
❏ Do the problems reflect the historical analysis of changes to the river system?
❏ Have the problems been defined with reference to the unique elements of the catchment?
❏ Have the problems been framed in terms of the catchment as well as individual sites?

Tips

➢ Use to build knowledge base.

➢ Adopt a precautionary approach.

➢ Recognise that small problems today may be big problems tomorrow.

➢ Look upstream *and* downstream.

➢ See the big picture.

➢ Be flexible: problems may change rapidly and unpredictably.

Step 4(c) Developing the Restoration Plan — Objective Setting and Prioritisation

All objectives should be SMART (**s**imple, **m**easurable, **a**chievable, **r**ealistic and **t**ime-bound). Objectives should be devised to clearly identify the aim of the task, which helps progress toward the vision. Objectives must be measurable in terms of biophysical, social and economic benefits and form the key component for evaluation of success.

Consideration should be given to both spatial and temporal scales. Site or reach specific objectives must fit within the catchment plan. Priority setting must be undertaken to ensure that the most important objectives can be achieved. These can be decided on scientific, economic and social grounds.

1. PURPOSES

- To provide a method for judging whether the vision is being realised
- To set evaluation measures
- To provide a list of objectives and sub-objectives based on limiting factors
- To list priorities for restoration sites and activities
- To ensure a balance between conservation and rehabilitation activities

2. PRINCIPLES

- Has measurable objectives
- Is strategic
- Clearly defines time scales — short-, medium- and long-term objectives
- Clearly defines spatial scales eg. reach, order, ecosystem, catchment and biogeographic region
- Objectives are simple, measurable, achievable, realistic and time-bound
- Reiterative process
- Must be objective
- Has a clear capacity/procedure for priorities to be made from different disciplines
- Uses best available knowledge
- Recognises uncertainty

3. CONSTRAINTS

- Knowledge of limiting factors
- Lack of community support
- Lack of political/managerial will/interest
- Preconceived values and vested interests
- Scales of the problems extend beyond the scales of the objectives

4. LINKAGES

- Cross-checked with vision; select options and restoration activities; monitoring
- Across disciplines and to wider community
- To spatial and temporal scales
- To other tributaries, ecosystems and system processes
- Upstream/downstream
- Local scales must fit within the overall plan

5. OUTCOMES

- A directed, measurable understanding of what we want the river to look like
- Clear understanding of what is important and why we want to do it
- Understanding of the context of river restoration in relation to other resource and environment plans and activities
- A documented procedure to follow to achieve the vision

6. TOOLS FOR OBJECTIVE SETTING AND PRIORITISATION

- Management
  - strategic priorities
  - log frame matrices
  - multi-criteria, group decision support systems

Detailed descriptions of these tools are given in Sections III & IV.

CHECKLIST

☐ Are the objectives measurable and clearly stated?
☐ Do the objectives assist in realising the broader based vision?
☐ Is there consensus on stated objectives?
☐ Are the causes rather than the symptoms being addressed?
☐ Have the objectives been prioritised?
☐ Have the stream reaches been prioritised?

Tips

➢ Let all team members develop objectives and then use consensus techniques to decide on the final objective(s).

➢ Use appropriate experts.

➢ Think broadly.

➢ Think laterally.

➢ Keep an open mind.

➢ Use primary and secondary objectives.

➢ Check objectives against vision.

Step 4(d) Developing the Restoration Plan — Assessing Options and Selecting Activities

The option(s) selected should satisfy the vision statement and resulting objectives. The restoration activity could be considered as part of an experiment from which lessons can be learnt to guide and improve future activities.

It is important to examine the potential consequences of each option. From the range of proposed options, the selected one should be practicable and produce the greatest benefits. More detailed planning of the selected restoration activity may be required.

1. PURPOSES

- To identify and select options and activities based on meeting objectives
- To select the alternative(s) that produce the greatest benefits
- To check that the restoration activity(ies) satisfy the vision statement and objectives
- To check that the options fit within the bigger picture of restoration activities
- To choose between options on the basis of feasibility, cost, availability etc.
- To design a schedule for activities and implementation
- To predict the outcomes and effectiveness of the selected options

2. PRINCIPLES

- Meets objectives
- Socially and environmentally acceptable
- Economically, socially and technically viable
- Assesses feasibility
- Not single-issue focused
- Must fit into local and reach management
- Includes non-technical options
- Identifies risks
- Incorporates cost–benefit analysis
- Links design to evaluation requirements
- Identifies benefits compared to 'do nothing'
- Is adaptive

3. CONSTRAINTS

- Approaches must not be too prescriptive
- Approaches must be based on an understanding of the problem
- Most procedures are focused on a single issue
- Some knowledge gaps on techniques (may need something new)
- Nature and viability of options — if not feasible then loop back to problem/objective and reassess

4. LINKAGES

- To objectives, scoping and implementation
- Across disciplines
- To wider community
- Upstream/downstream and tributaries
- To system processes
- To other ecosystems

5. OUTCOMES

- Ongoing 'learning'
- Knowledge increases about the different activities that can be used

6. TOOLS FOR SELECTING OPTIONS AND RESTORATION ACTIVITIES

- **Biophysical/socio-political and economic knowledge**
  - *A Rehabilitation Manual for Australian Streams Volume 2* (Rutherfurd *et al.* 2000)
  - *Stream Corridor Restoration Principles, Processes and Practices* (Federal Interagency Stream Restoration Working Group 1998)
- **Management/communication**
  - see tools for scoping (some scoping type work will be needed to assess what options are available and which activities will be most suitable)
  - costing and cost–benefit analysis
  - risk assessment
  - AEAM

Detailed descriptions of these tools are given in Sections III and IV.

CHECKLIST

❑ Have you explored all options?
❑ Have you undertaken feasibility analysis?
❑ Have you considered monitoring, evaluation and maintenance options?
❑ Has the 'do nothing' option been explored?

Tips

- ➢ Use reality checks.
- ➢ Also look for lateral solutions eg. water savings.
- ➢ Treat as an experiment we can build from and learn.
- ➢ Underpinned by science.
- ➢ Test restoration procedures on a small scale first.

Step 4(e) Developing the Restoration Plan — Finalising the Plan

The last step of the planning process is to finish the plan. This step must ensure that there is support for the plan, a period to address disagreements and that all areas are covered. Integration with other local and regional plans should be clearly defined. The plan should then be formally 'signed off' and consideration given to the implementation team.

1. PURPOSES

- To provide a robust plan for on-ground works, monitoring, evaluation, and maintenance, which is 'signed off' by an appropriate authority
- To consolidate a clear understanding of the capabilities of the project
- To provide a prelude to the works schedule
- To provide a final consultative network
- To provide a communication strategy
- To increase understanding by stakeholders about why restoration is undertaken
- To increase knowledge of restoration and of biophysical processes in rivers
- To improve the health of waterway ecosystems
- To complete a final risk assessment of proposed objectives and activities

2. PRINCIPLES

- Must integrate well with other plans
- Clear, concise, illustrative and with no jargon
- Must fit vision
- Defensible/transparent
- Must include evaluation and be subject to independent review
- Revision by restoration team
- Accepted by stakeholders so ownership is maintained
- Commitment to long-term planning
- Commitment to adaptive management

3. CONSTRAINTS

- Must deal with final disagreements
- Lack of resources or political will to implement
- Multiple issues/agendas
- Tendency to reflect prevailing dogma
- Ownership difficulties

4. LINKAGES

- To implementation team
- To contractors
- To works schedule
- To evaluation

5. OUTCOMES

- Ownership (community empowerment) and support for desired restoration activities
- Restoration activities determined using a systematic method

6. TOOLS FOR FINALISING THE PLAN

- Management
  - AEAM
  - PERT
  - GANTT
- Communication
  - round-table discussion
  - workshop

Detailed descriptions of these tools are given in Sections III and IV.

CHECKLIST

☐ Does reach-based plan fit into the bigger picture?
☐ Does the plan reflect the vision and objectives?
☐ Have measures of performance and time-lines been set?
☐ Have roles and responsibilities been identified?
☐ Has the plan been 'signed off'?

Tips

➢ Use easy to read layout.

➢ Have consultative period before final release.

➢ Continue to source funding throughout the process so that money is available to carry out the activity.

➢ Communicate the plan effectively to others (use visual tools).

➢ Refer to benchmarks (ie. undisturbed sites).

Step 5 Implementing the Plan

During the implementation of the plan you need to consider who carries out the works, what exactly the works entail, the implications, the whereabouts of the works and the time frame within which the works will be carried out. The tasks that need to be undertaken throughout the implementation step will vary with the type of restoration activities that have been decided on. Outside services may need to be contracted for some activities. The works schedule will need to have clear and concise activities listed that can be contracted out if required. Schedules are likely to vary each time a new restoration activity is decided upon. A schedule from a similar activity undertaken at a different site or time is unlikely to be directly applicable to a new activity.

1. PURPOSES

- To design an implementation/works schedule, clearly specifying roles and responsibilities
- To appoint contractors and consultants as the activities require
- To undertake and complete restoration activities and works according to the schedule

2. PRINCIPLES

- Reflects vision, objectives, and plan
- Can be prescriptive
- Explicit and detailed budget, time line and allocation of tasks
- Low impact environmental engineering
- Educational — training for works teams (implementors)
- Is subject to documented evaluation and independent review
- Must consider local environmental and safety guidelines and legislation
- Is realistic and practical
- Is adaptive — builds knowledge

3. CONSTRAINTS

- Access logistical and practical issues
- Lack of resources
- Lack of support
- Timing

4. LINKAGES

- To objectives and vision
- To final product

5. OUTCOMES

- Better targeted contracts
- Better trained staff, contractors
- Building the capabilities and capacity of the community to be involved in restoration activities

6. TOOLS FOR IMPLEMENTATION

- **Management**
  - scheduling – PERT, GANTT
  - contract negotiation (if necessary)
  - stream stabilisation techniques
  - habitat reinstatement techniques
- **Communication**
  - newspaper columns
  - field days

CHECKLIST

☐ Has a reality check been done — are the works and works schedule feasible?
☐ Have the risks been assessed?
☐ Have the roles and responsibilities for contractors (if contractors are needed) been defined?
☐ Have site clean-ups been scheduled?
☐ Has a celebration for the completion of the works been scheduled?
☐ Are qualified and experienced supervisors present to oversee restoration activities and works?

Tips

➢ Be opportunistic for funding.

➢ Realise 'learning by doing' (ie. follow adaptive environmental management procedures).

➢ Define contractors' roles and responsibilities.

➢ Be practical.

➢ Obtain permissions and permits.

Step 6 Monitoring and Maintenance

Monitoring is essential to measure the success or failure of the project. Without measures of success, continued support is hard to justify. Learning from failures and identifying where improvements can be made is also important. Monitoring should be conducted using objectives, indicators and benchmarks.

The completion of a restoration activity does not mean you can walk away from it. To ensure success most activities will need ongoing maintenance.

1. PURPOSES

- To ascertain the impact of the restoration works and activities on biological, physical, social and economic elements of the system
- To provide progressive assessments/data/reports/reviews of the project
- To provide a mechanism for judging how a restoration activity is proceeding indicating the success or failure of the activity
- To re-appraise and possibly change the vision, objectives or schedule for implementation of works
- To determine changes in understanding
- To determine improvements in conservation ethic
- To provide ideas and opportunities for improved designs and adaptive management

2. PRINCIPLES

- On-going — implemented according to procedures documented in the restoration plan
- Must be adaptive if circumstances require
- Provides understanding of direction of change (ie. links to process-based understanding)
- Carefully documented and reported.
- Educational — building on knowledge
- Focused on health and ecological integrity
- Pivotal role in assessment
- Leads to reappraisal and may change scope of vision
- A key to adaptive management (learning by doing)
- Leads to reappraisal and may change scope of vision, objectives, plan and on-ground actions
- Acknowledges the need to manage expectations

3. CONSTRAINTS

- What to measure, how often, by whom, how to integrate
- Social and economic values
- How to link to progressive learning
- Ensuring methods efficiently provide accurate data
- Quality assurance and quality control
- Changes to indicators over time
- Traditional reluctance to monitor and maintain works
- Takes seasonal conditions into account
- Current short-term funding arrangements and budgetary uncertainty

4. LINKAGES

- To evaluation
- To vision
- To reshaping objectives
- To restoration activity
- To assessment

5. OUTCOMES

- Ongoing system assessment
- Measures of success of the project
- Important steps for adaptive management
- Adaptation of management including modification of works

6. TOOLS FOR MONITORING AND MAINTENANCE

- **Data collection for monitoring**
  - as in system assessment
- **Management for Maintenance**
  - scheduling (PERT, GANTT AEAM)
- **Communication for monitoring and maintenance**
  - reports
  - press releases
  - field day/workshop

Detailed descriptions of these tools are given in Sections III and IV.

CHECKLIST

☐ Do you have a maintenance schedule?
☐ Have monitoring, maintenance, and modification of works or management activities been budgeted well into the future?
☐ Are the appropriate experts involved?
☐ Are monitoring results being fed back into the community?
☐ Are the right scientific questions being asked — do they relate directly the way in which the system has responded to restoration activities?
☐ Are the correct components of the system being measured?

Tips

➢ Hold a midpoint review.

➢ Evaluate indicators.

➢ Check progress against objectives, indicators and benchmarks.

➢ Use the outcomes of other projects as benchmarks.

➢ Indicators and criteria to be measured carefully.

➢ Use reference sites.

➢ Be aware of seasonal and natural variation.

➢ Categorise types of data.

➢ Ensure that data are of good quality.

SECTION III: RESTORATION STEPS IN DETAIL

Step 1 Building the Restoration Team

Purposes/outputs

- To provide ownership of the project
- To ensure adequate knowledge is available for the restoration activity
- To provide a forum for cross-fertilisation of ideas and for educating and incorporating the concerns of the wider community.
- To provide continual knowledge updates and continuity by following the project from start to finish
- To provide flexible co-ordination
- To enhance communication between the project and other project teams, in terms of national, regional, and bioregional plans.
- To develop a restoration plan supported by stakeholders
- To provide documentation of decisions and actions within the team taken throughout the restoration project

Principles

The restoration team is ultimately responsible for guiding the restoration plan throughout the process from scoping through to implementation and maintenance. The team can provide a forum for the cross-fertilisation of ideas necessary to address the complex issues faced river restoration. Multiple problems may present themselves—all demanding a solution.

The complexity of issues that need to be addressed in river restoration make it unlikely that one person alone has all the skills required to ensure a comprehensive solution.

Questions such as:

"What is the problem?";
"What needs fixing?";
"What is possible to achieve?";
"In what order should it be fixed?",
can be better dealt with if different viewpoints, different knowledge bases and different experiences are brought together to examine the problem.

Approaching restoration as a team will enable different views, along with different technical and cultural needs, to be taken into account. A team approach should aid the transfer of knowledge and increase adoption of best practice measures.

Benefits of a team

A team can share information and knowledge, alerting others to the requirements of different stream activities, the consequences of actions on biophysical components and the capacity/procedures to resolve these issues. Improved transfer of knowledge and innovation can best occur through combined planning and field activities (ie. strategies and activities can be directly linked). Different viewpoints, knowledge bases and experience can be explored to come up with optimal solutions.

A holistic team approach will increase cost-effectiveness by preventing *ad hoc* decision making, which may not consider the effects of decisions on other components and activities.

Responsibilities of the team

The restoration team is responsible for developing the restoration plan, documenting the process and ensuring there is effective communication throughout the process.

The team provides advice and support to the lead agency and is responsible for:

- solving conflicts that may arise during the restoration process;
- communication with the wider community, including education and awareness raising;
- developing and managing the restoration plan;
- overseeing implementation, monitoring and evaluation;
- establishing points of contact and a decision structure;
- identifying funding sources; and
- documenting the process.

All team members should have responsibility for these functions. Nevertheless, different individuals may have greater input at various stages due to their knowledge and past experience. The way tasks are undertaken will vary with: the type of problem or activity that is being addressed; the individuals and the group formed as a combination of those individuals; and the resources available.

It is important that the restoration team recognises how other activities with corresponding plans, such as Salinity Management Plans, may impact on the river restoration activity. These groups should consult to ensure coordination and cooperation throughout the river restoration process (see Chapter 7: The Big Picture).

The team is responsible for ensuring that restoration activities are not agenda driven, recognising at the outset the inherent constraints and underlying goals of river restoration:

- to be conservation orientated, striving to support ecologically sustainable development;
- to work with nature by using baseline data and monitoring to understand and enhance natural recovery; and
- to enhance biological diversity to a ‘natural’ condition by protecting and reinstating natural habitat and biophysical processes.

Solving conflict

At times, different needs and views of the stakeholders will produce conflict. Environmental management problems that result in conflict are solved when diverse stakeholder interests, both complementary and oppositional, are accommodated by the process that yields decisions about management objectives and actions to be taken (Decker and Chase 1997).

The restoration team needs to consider the likely sources of conflict. Factors that may produce conflict are:

- different perceptions of the same situation;
- selection of information considered relevant to an issue (avoid narrow selection and interpretation of scientific data);
- failure to give due recognition to the uncertainties associated with data;
- failure to appreciate social, political and cultural values regarding environmental issues;
- failure to consider the concerns of the community;
- failure to consider broader environmental issues (over local, site-specific ones); and
- failure to manage both social and cultural needs (expectations) and environmental (scientific) needs.

The team should discuss the pros and cons of problems while listening to other members and taking their views into account. An increased understanding of the issues confronting other members of the team will help to lead to an increased co-ordination of river restoration activities.

Given that many streams are valued for their use as a resource for water supply, transport, waste disposal, fishing etc., a major conflict may arise in finding the balance between these values and ‘conservation’ values (with ‘conservation’ values used in this sense as the protection of natural ecological functioning). In parts of Australia, current plans try to integrate the competing uses of streams relating to their cultural and social significance, recreation value, economic value and ecological values. Unfortunately, many of these uses are contradictory (Rutherfurd *et al.* 1999).

There are several ways to address this problem. Rutherfurd *et al.* (1999) recommend completing the restoration plan before addressing the conflict: “By developing your restoration plan in isolation [from catchment management plans] you can be sure you have identified the most important ecological problems in your stream and … you will know the environmental cost of any compromise.”

This framework advocates a more inclusive approach, obtaining consensus between the various local user groups, conservationists and scientists (who will be working towards conservation outcomes). If technical (scientific) advice does conflict with local values, the issue may become one of ownership of ideas—an imposed plan with no local support will not achieve substantial on-the-ground benefits, while reactive local planning and implementation without appropriate advice generally produces unsustainable outcomes. Unless these dualities are addressed and a consensus-based strategy is determined, there is no coherent basis for proceeding with river restoration activities. Mutual empowerment needs to be established and maintained by the restoration team throughout the process.

Communication

Community ownership is enhanced via two-way communication and involvement in the decision-making process. The wider community should be able to understand the nature and importance of the problem, the decision-making process and solutions to the problem. Effective communication will allow a broad input of ideas, issues and possible solutions that will enable the plan to be robust. The choice of tools such as adaptive environmental assessment and management (AEAM), will also affect communication and the level of understanding, by taking communication into account.

Developing and managing the restoration plan

The team approach should aid the development of a robust plan in which the multiple issues of a problem may be addressed. This entails technical aspects of the restoration problem and issues of ownership, education, awareness raising and documentation of the restoration works. It is only when the components are considered together, that the potential for successful outcomes is maximised.

The outcome of the restoration team should be a robust plan of action that is accepted by those involved and those who will be affected by restoration activities.

Implementation, monitoring and evaluation

By overseeing implementation, monitoring and evaluation, the team improves ownership of the plan, on-ground works and the results of works. The team builds knowledge about the biophysical elements of the stream system during the scoping and system assessment stages of the framework. During implementation and monitoring and maintenance the team will gain experience about which river restoration activities are most successful in meeting restoration objectives. This knowledge and experience is continually incorporated into the framework and may influence the make-up of the restoration team, the content of the vision and thus the objectives, implementation and monitoring steps will lead to informed decisions and better long-term outcomes

Documentation

One of the key functions of the team is to provide a platform for appropriate documentation throughout the planning process and including monitoring and auditing. Documentation of the restoration team discussions and reasons for courses of action will provide:

1. a basis for the continued increase in knowledge of restoration;
2. accountability to the public and funding sources;
3. evidence to produce when conflict arises, thus helping to avoid misunderstandings; and
4. the capacity to learn from mistakes.

Who should be on the team?

The core group of the restoration team should comprise a local project manager, scientists or experts in a relevant field, community representatives and government representatives. The project manager should be responsible for coordinating who is on the team at any given time. The team itself will also assess the need for changes in its composition over time.

However, the structure of the team should be seen as organic—evolving and adapting in response to the restoration problem objectives and/or activities. The team will reflect a combination of technical skills and local interests. The composition of the team must be flexible, with the capacity for members to be enlisted or to leave on a needs basis. The team should be inclusive, attempting to bring together those who affect and are affected by the problem and possible solutions.

The exact make-up of the team at any given time will be determined by the particular restoration activity/problem of concern. This is a reason why it is important to clearly document the decision-making process. Rogers and Bestbier (1999) call this a goal maintenance system (GMS), which provides ‘institutional memory’. Documentation will ensure that new members will be able to understand what has gone on before them.

Recommended team members include:

- Local project manager (catchment management authority or equivalent)
- Scientists/expert representatives such as
  - a geomorphologist/hydrologist
  - freshwater ecologist
  - plant (aquatic and riparian) ecologist
  - sociologist/community development worker
- Community representatives such as
  - a member of a cultural group
  - farmer/landholder
  - angler
- Government representatives such as
  - a relevant State agency representative
  - local shire representative
  - catchment authority representative
  - river operator

Team members may also be chosen according to their ability to provide as broad a network of contacts as possible. In selecting the team it should also be realised that team members provide the ability to create a network. At the beginning of the planning phase, emphasis may be placed on social science, community participation/education skills to raise awareness of issues, and develop effective consultation and communication processes. A greater reliance on technical and scientific knowledge, particularly aquatic ecology and geomorphology, will be necessary during system assessment and in the monitoring phases of the project. Community knowledge and scientific skills should be seen as being mutually beneficial.

The size of the team will depend on the scale of the activity or problem. Problems occur when teams get too large. An overly large group can become impractical to manage. Sub-groups may be a solution to this. At a minimum it is suggested that a core group for the team would consist of the following people and skills base.

Team members

A local project manager, such as a representative from a regional natural resource management body (eg. a catchment management authority, in Victoria) can bring to the project co-ordination, communication, conflict resolution, organisational and financial management skills. A local project manager may have a good understanding of the local networks, ensuring speedy information exchange and an ability to relate to the local communities thereby aiding the capacity to translate knowledge from the team to local people. They may also have an understanding of local waterway ecosystems and aquatic environments.

Aquatic ecologists bring expertise on fish, macroinvertebrates, plants, water quality and aquatic processes. They will bring knowledge of interactions between organisms and their environment.

A geomorphologist brings knowledge about the physical workings of a river system. Teamed with ecologists they can advise management regarding scale, the interactions between processes and the range of likely outcomes of various in-stream restoration activities.

N.B. scientists with good communication skills and understanding of local community needs, will also be able to provide knowledge directly to the community.

A sociologist and community development worker will be able to complete the social and economic research needed and ensure that members of the community participate effectively. They may also be able to take on a community liaison role, helping with publicity, education and information transfer.

An angler may have knowledge of the best spots for fishing and familiarity with stream environments. They may represent a major user group. The role of the angler is quite different from the aquatic ecologist.

Community group representatives may include local action or environmental groups and ‘user groups’ of the river such as anglers and other recreational users. They can provide a method for fast exchange of information, a tremendous support network to individuals and a way of pooling resources.

A farmer/landholder may have good understanding of local conditions, how the local waterway has changed over time and the nature of their local community. They may know who would be prepared to have a demonstration site on their property, hence enabling more people to understand problems and possible solutions of river restoration.

A river operator/manager can give advice on planning and resource assessment, techniques for flood control and water availability in highly impacted or regulated rivers, or in areas where irrigation is a significant pressure. They can explain operating procedures and constraints and allow the team to consider alternatives and better methods that reduce costs.

A government agency officer has knowledge about the river restoration issues and possible solutions, particularly in relation to legislation and policy development.

It may be also be important to have engineers, vegetation specialists etc. as part of the core group; depending upon the nature of the problem.

If the team is missing one or two representatives then members of the team may have to become multi-skilled in an attempt to represent the missing areas. This is particularly relevant to missing scientific disciplines. Ecologists may need to be partly skilled in geomorphology and vice versa. Many States are short of experienced consulting aquatic ecologists, geomorphologists and sociologists. Some people may be accessed through educational institutions as graduates or postgraduate students, but if less experienced scientists are used, then those who are more experienced need to review the outputs, verifying recommendations and conclusions. Obtaining a second opinion may be useful, regardless of the experience of the scientists on the team, as a precautionary measure to prevent bias.

Conclusion

A cohesive, inclusive team that is able to resolve conflicts and communicate effectively is an essential element of river restoration. Some tools that will help to achieve this are listed on the next page. Further discussion on group dynamics can be found in Section V.

Tools for the restoration team

For a detailed description of the tools, including references, see the alphabetical listing in Section IV: Tools for river restoration.

Tool	Purpose/When to use the tool
Brainstorming A group of people think of as many ideas as they can about the topic in question	To quickly gather many ideas without getting caught up in discussion
Cause and effect mapping Fish bone diagram with effect at the end of the spine and main causes as ribs. Contributors to the main cause can be sub-branches of the ribs	To explore the contributing causes or reasons for a particular problem or issue and to help identify root causes rather than symptoms
Communication strategies Advertising campaign; community service announcements; street stalls, displays. Generic messages Sound bites and slogans that the public can remember easily.	To raise awareness of the importance of rivers and river restoration
Celebrations of achievements	To maintain motivation.
Creative analysis A range of exercises such as mini brain storming, lists of pros and cons etc.	To escape from being 'mentally blocked'
Group and project records Documenting financial, activities, meetings, media coverage, membership (Woodhill and Robins 1994)	To learn from past experiences and remain accountable to funding bodies and to the public
Invitations to events Target people by geographical, environmental, cultural, industry, activity, community characteristics	Target key community 'individuals' and get them on side; personalised invitation increases the likelihood of attendance and participation
Ladder of inference A conceptual model that describes the thought process leading to assumptions and adversarial approaches.	To build an awareness of individuals thinking and reasoning: making that thinking and reasoning known to others; inquiring into others thinking and reasoning
Manuals	To aid system assessment and planning
Microsoft Project® Software package	Project management aid – budget, schedules, personnel etc.
Reporting/conversation Individuals to report vision back to the team/group	To create transparency and an understanding of different stakeholders /members perspectives
Round-table workshop	Bring groups of people together to exchange ideas Bring a range of views to the fore
Six thinking hats White – information Red – feelings Black – risk assessment Yellow – creative, logical, positive Green – new ideas, possibilities Blue – overview, problem definition, outcomes, organiser of the thinking process	To align the thinking of members of a group for a defined time to tackle a particular problem or generate certain information

Step 2 Scoping

Purpose/outputs

- To determine the breadth, depth and constraints of the restoration activity using current knowledge
- To determine which areas of the catchment can be restored and may need a restoration plan
- To produce a list of resources, constraints and baseline data
- To help to identify the boundaries of the vision
- To ensure that restoration strategies and detail of activities are established within a catchment context

Principles

Restoration plans may fail for a number of reasons. Often failure results from insufficient resources to complete the project, or when the problems to be solved increase during the project, beyond the resources available. A plan that is abandoned during the process places great stress on the people involved, leading to burn-out and disillusionment with any future restoration activities. It is therefore essential that limits to the project boundaries be established early in the process. Scoping is the initial process of identifying activity boundaries, focusing on the potential limitations that are placed on restoration activities.

Resource assessment

Usually, the major constraint to completing the restoration process will be access to resources—money, and consequently skills and professional help. The first part of the scoping stage will involve assessing the funding in relation to the basic requirements of the river restoration framework. The checklists will be a guide to these basic requirements (see Section I throughout; Evaluation p. 81). If there is not enough funding to engage professionals as part of the restoration team in the assessments or monitoring, or if resources are too limited to complete predicted activities that are required to begin to restore the river, the restoration process must stop at this point to avoid wasted effort.

An initial lack of funding may not be terminal and lateral solutions should be sought to mitigate the funding crisis. Scientific assessment may be able to be completed through established research programs and there may be a possibility of becoming associated with one of these and sharing the data. Corporate partnerships, other government departments and non-government organisations that deal with conservation may all be good sources of additional funding.

Scope your project by:

- identifying the project's boundaries;
- identifying constraints and actions to overcome them; and
- building on existing platforms, strengths and capabilities.

Initial assessment

Scoping may involve a rapid technical assessment of what is achievable, to help constrain the vision to something that has practical meaning.

Taking an expert panel approach, a geomorphologist, hydrologist and biologist may examine maps and aerial photos of the region, carry out site visits and delineate the restoration problems in their broadest sense. The procedure to follow may be adapted from the British Columbian model – Level 1 Analysis of the *Interior Watershed Assessment Procedure* (Anonymous 1995). By mapping the catchment, including underlying geology, roads and stream crossings, areas of potential erosion, riparian buffers, land uses and recording peak flows, this model provides guidance on where management efforts can be based to address underlying causes of problems.

Several of the manuals (see Section IV: Tools for river restoration) provide information on how to carry out an initial assessment or scoping exercise.

Part of the initial assessment will involve using research reports and papers from universities and government agencies to obtain baseline data.

The initial assessment will identify knowledge gaps that need to be filled as part of a more detailed study. This can be carried out during system assessment.

A socio-political and economic study should be carried out at the same scale, giving a broad view of the prevailing interests and needs of the community. A social scientist with a background in sociology, economics and political science may examine Australian Bureau of Statistics data and complete interviews or surveys to focus on particular issues.

The restoration team will then collate available information to help determine the boundaries that constrain the restoration plan—limitations and potential for restoration activities and river recovery—with a focus that is broader than the local level. It should be noted that the value systems and previous experience of the team may limit this information.

A new and better understanding of the restoration problem emerges as the team discusses the plan boundaries by sharing information, assumptions and available scientific and technical information. Evaluation of the available information and knowledge can further refine understanding. Reconciling management boundaries in terms of the different components of the restoration activity may have to be repeated following this new understanding.

Engaging the community in the scoping exercise, once the initial analysis is complete, will serve to reveal the extent and nature of public concerns (Harding 1998). This will help the restoration team to decide which issues need to be addressed when developing restoration activities.

Boundaries and scale

Setting the context of the restoration project includes describing the biophysical, socio-economic and legal systems at the local, regional, national and international levels over numerous time scales (Rogers and Bestbier 1999).

Geographical boundaries provide a sense of place for organising community-based involvement and the appropriate context for technical assessment (Federal Interagency Stream Restoration Working Group 1998). Objectives should be set at a number of geographical scales, and indeed each activity is likely to require actions that are carried out at different scales.

Identifying the boundaries between different scales for socio-economic and legal systems is relatively straightforward, as jurisdiction is prescribed largely by the three tiers of government which are in turn constrained by international political organisations, economics and legislation. Some cultural boundaries may be less straightforward and further investigation may be needed.

A restoration activity is likely to fail if processes are operating at a larger scale than the geographical, social and political boundaries of the restoration activity. Scales at which assessments and restoration take place must therefore be relevant to the biophysical processes they are attempting to observe or manage.

Biophysical processes occur on multiple scales from the micro-scale, for example, predation by macroinvertebrates to world scale processes such as global warming.

Recent attempts to reconcile the scales of nature and science/management in riverine systems have focused on creating a hierarchy of physical (rather than biological) scales and attributes over coinciding time scales (Frissel *et al.* 1986, Rosgen 1994, Brierley 1999, Rutherfurd *et al.* 1999, c.f. Noss 1986). Hierarchical structure offers three major benefits:

1. classification at higher levels narrows the set of variables needed at lower levels;
2. it provides for integration of data from diverse sources and at different levels of resolution; and
3. it allows the scientist or manager to select the level of resolution most appropriate for their objectives (Frissel *et al.* 1986).

Baseline surveys of river character and behaviour at a catchment scale provide a useful starting point for scoping the condition and potential causes of degradation in the system in both physical and biological terms. Working down through a hierarchy of scales captures the significant physical processes governing habitat structure and associated biological processes. Determining condition at a number of scales will identify areas in a ‘natural’ state, which may be protected and used as reference sites to copy when restoring more disturbed sites. Attributes of other patches, such as loss of complex habitat structure, may reflect the effects of human disturbance and degradation, thus pointing to areas to be restored. Identifying processes and linkages that occur between and within the space–time scales can point to the type and scale of restoration activities that need to be undertaken.

Restoration problems are generally framed in terms of the loss of biodiversity. This must be assessed not only in terms of structure or composition but also in relation to functional aspects, as these provide the mechanisms by which the biological system will either recover or undergo further degradation. Scoping the relationships will identify where the major threats lie and, alternatively, where the system is robust.

Stream types will be the next level of classification. Brierley (1999) has developed a comprehensive river classification system (River Styles™) that aims to refine the space–time classification looking at linkages of river reaches within a catchment and the recovery potential of different types of streams. The *Rehabilitation Manual for Australian Streams* (Rutherfurd *et al.* 1999, 2000) also has a useful classification system based on the level of degradation of a river and thus its potential to recover. These more refined classification systems are likely to be used in the system assessment stage of this framework.

Initial scoping of degradation problems at a number of scales before deciding on the scale at which the restoration activities will take place helps to ensure that the range of physical, ecological and social processes that may affect the restoration activity are captured (Harding 1998).

Having scoped the restoration problems at a number of space–time scales, a useful boundary or scale at which restoration activities should be targeted is one that reflects:

1. the scale of relevant ecological and physical processes;
2. the scale of human-induced pressures and their effect on the stream corridor; and
3. social organisation of people and where they are distributed across the landscape.

Scoping tasks

More specifically, scoping may focus on:

- identification of the appropriate scientific, participatory, and managerial tools available to complete each of the steps of the project;
- identification of potential impacts/outcomes to be assessed;
- identification of limits to the restoration project (biogeographical, financial, available information, time frame);
- identification of the current and previous structure and function of the waterway ecosystem;
- identification of community concerns regarding the restoration project;
- descriptions of restoration problems in terms of managerial requirements;
- identification of methods for each of the steps of the project;
- identification of roles and responsibilities of the various people/groups involved; and
- description of the depth and breadth of the restoration project (adapted from Harding 1998).

During the scoping stage, elements of the system that are potentially good indicators of recovery must be identified.

Conclusion

Scoping will help to define the key issues and areas of concern to be referred to throughout the visioning and planning stages of the project. There follows a list of tools and their associated purposes that may help with the scoping step

Tools for scoping

For a detailed description of the tools, including references, see the alphabetical listing in Section IV: Tools for river restoration

Tool	Purpose/When to use the tool
Benefit /cost analysis (BCA) Costs and benefits of an activity, or objective are listed and may be quantified for use in prioritising	To understand positive and negative aspects and resources needed for an activity
Cause and effect mapping Fish bone diagram with effect at the end of the spine and main causes as ribs.	To explore the contributing causes
Community research/mapping Networks wants and needs	To gain information about the dynamics of the community—key members community groups etc.
Empirical catchment model approach Uses hydraulic geometry or regime relationships such as width discharge relationships, planform/width relationships to predict equilibrium channel form as a basis for stable channel design.	To define restoration trajectory and design of restoration works based on the equilibrium form of the river
Fish barriers database	To supply data for river management recommendations.
Geophysical/ecological/biological data and reports Climate, soils, environmental problems, land capability maps etc.	To obtain baseline data and information during to use during scoping
GIS mapping and modelling Geographic information system Satellite imaging of vegetation, land-use types, precipitation, geographical features	To present information such as hydrological, catchment boundaries, streams etc. for planning
Historical records/reconstruction approach Includes photographs, explorers diaries etc.	To define river restoration trajectory by outlining pre-disturbance state
Interrelationship diagrams Between 5 and 20 factors contributing to the problem are listed in a circle	To identify which, of a series of causes, are the most important
Level 1 Analysis of the *Interior Watershed Assessment Procedure* A guide to mapping a catchment, including underlying geology, roads and stream crossings, areas of potential erosion, riparian buffers, land uses and recording peak flows	To aid initial assessment during scoping
Locality mapping An outline of the local area is drawn – roads, towns, property boundaries etc.	To help identify local issues and knowledge gaps
Mind mapping A dendrogram is formed with ideas expanding outwards from the central issue	To cluster ideas to see links between them and to pick out the most important issues
Questionnaire and surveys A preparatory tool for the vision exercise	To gain information from a large number of people in a structured way

Tool	Purpose/When to use the tool
Research reports from universities or government agencies	To obtain baseline data as part of scoping
River Styles™ Catchment-based system assessment with prioritisation based on biophysical processes and river condition; baseline assessment to assess connections throughout a catchment and control on river character and behaviour.	Geomorphic assessment; will aid in understanding river character and behaviour; can be used in system assessment, prioritisation, problem definition, and establishing the vision
Semi-structured interviewing Broad question, conversational interviewing	To gain information on an issue from an individual or small group, such as a family
Socio-economic data and reports Population, types of enterprises, finances.	To assess the socio-economic system
SWOT Strengths, weaknesses, opportunities, and threats analysis	Assessment, scoping, evaluation
Venn diagrams Overlapping circles represent interacting groups	To describe interaction or overlap between groups of people, issues, geographical areas

Step 3 Establishing the Vision

Purpose/outputs

- To identify a common purpose and provide a clear overriding direction
- To provide a product orientated vision statement(s) arrived at by consensus
- To produce a clearly defined catchment-wide, long-term biophysical vision to provide an underlying template for restoration activities
- To engender commitment and focus of communities involved in the restoration project

Principles

The success of each restoration project depends on the commitment and focus of the communities and participants involved. Establishing a vision will help to create this.

Further, unless a vision is clearly defined, the restoration team will not know what they are working towards or whether their efforts are successful.

A vision statement is broad and is about an improved state that the project should achieve well into the future.

For example:
"We will create a sustainable riverine ecosystem, relying on natural processes to invigorate and sustain structure and function."

Developing a shared vision

Bring participants together

The restoration project will involve several overlapping participants including:

- those within the geographic area of the project;
- farming, indigenous, conservation and local government communities; and
- those outside the geographic area such as the State and Federal Government and scientific agencies and institutions.

Bringing these groups together early in the restoration process to develop a shared vision will generate the commitment and focus needed for a successful project. Through the establishment of a vision, each participant may be encouraged to forge their own sense of meaning and their own unique sense of contribution to the project (Senge *et al.* 1994). The restoration team should see itself as serving the communities and their larger vision.

Understand people's values

In order to gain consensus on the vision, all stakeholders' views and values must be seen as valid. However, the vision frames the restoration plan and must reflect the ecological and conservation principles inherent in the framework (see Introduction). The vision created by the participants will be largely determined by value systems that form their attitudes towards restoring the riverine ecosystem.

Therefore, establishing the vision is also part of the educational process. As participants gain knowledge about ecological sustainability and the long-term economic and environmental benefits of restoration, views and values may change and the hope is that individuals will be inclined to place a higher priority on ecological rather than short-term economic values. Thus, for some participants, the first step of this process is to establish an awareness of the problem. It may also be important to educate participants about the necessity of making changes to current practices and behaviours in order to reverse river degradation.

Develop a shared vision by:

- bringing the different participants together;
- understanding other people's values;
- making the benefits obvious;
- using an interim vision if needed; and
- updating the vision as needed to keep it relevant.

Making the benefits obvious

It is important to note that many people within the community may have a limited amount of time to devote to river restoration projects. People may allocate time to the project according to the potential benefits for them.

The benefits of the project to each participant must be made obvious. Some communities will need the project to enhance the intrinsic ecological values, commercial viability, aesthetics and/or recreational aspects of the river.

An interim vision

Due to the diversity of needs, an early consensus of ideas necessary to create a vision may be elusive.

Rather than getting bogged down in the task of seeking alignment and consensus, an interim vision may be used and refined during the plan.

Updating the vision

Community attitudes and needs will change over time. Changing attitudes and the changing nature of the political and ecological context of each project will lead to the vision being revised and updated at least every few years. The vision must always be relevant if it is to be a motivating and cohesive force behind the restoration project.

The process

Vision sessions

Informal communications, educational activities and formal brainstorming sessions in which all members of the stakeholder groups participate can be used to generate a vision for the project.

In these educational sessions, the vision can be clarified as differing from specific goals and objectives (see Figure 4) by explaining that visions are broad statements about an improved state that the project should achieve well into the future.

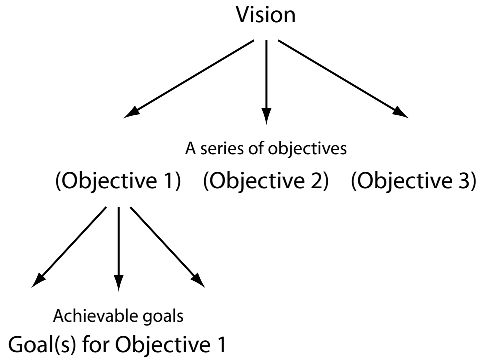

Figure 4. The objectives hierarchy

It should also be noted that creating the vision does not mean the allocation of tasks to certain groups of people. It is not a time for discussing the details of planning or implementation. These aspects will be covered in later steps.

Brainstorming sessions in small groups can be used to develop individual visions. During these sessions, questions, prompts and other vision statements (Section V) may be used to develop the vision for the particular project. Issues and vision statements that arise from these vision sessions may be documented and circulated to participants after the sessions.

Conclusion

A shared vision may consist of one sentence with supporting statements that reflect key issues identified during the vision sessions. Below are some tools that may help establish the vision.

Tools for establishing the vision

For a detailed description of the tools, including references, see the alphabetical listing in Section IV: Tools for river restoration.

Tool	Purpose/When to use the tool
Brainstorming A group of people thinks of as many ideas as it can about the topic in question	To quickly gather many ideas without getting caught up in discussion
Freshwater ecology and geomorphology courses Education, community consultation, On-site examples of riverine ecology, geomorphology and degradation	To increase understanding of riverine ecology, scope views and inspire action Trainers and community group leaders should be targeted
Questions Open ended What do we see five years from now?	To warm up to and define the vision To ensure that the group is focused during the visioning process
Reflection Individual reflection on deeper purpose of the project	To create understanding of how the project fits in to each individual's life and the broader regional or even global conservation background
Round-table workshop	Bring groups of people together to exchange ideas Bring a range of views to the fore
Small group vision sessions Feed into the overall vision	To gather key ideas/statements to guide the overall vision To develop the vision in a manageable, non-intimidating environment
Vision day/field day	Vision setting, education, assessment

Step 4(a) Developing the Restoration Plan — System Assessment

Purpose/outputs

- To obtain a better knowledge of problems that require restoration
- To better target solutions to problems
- To assess and understand the state of the system
- To help set objectives and indicators for evaluation
- To collate information and determine knowledge gaps
- To provide a report on the current health of the river including main degrading processes
- To identify possible trends in system processes and composition
- To identify what can realistically be achieved in terms of 'biophysical naturalness' by defining target conditions at reference sites to use as a benchmark
- To understand the interconnectivity between parts of the system
- To identify future pressures
- To understand human impact in the context of natural variability

Principles

System assessment is necessary to clearly determine the current state of the riverine environment, including the surrounding social and economic conditions.

The condition of a stream is determined by many factors. Rutherfurd *et al.* (1999) identify five key components of stream health:

1. riparian zone;
2. physical structure;
3. in-stream fauna and flora (organisms);
4. water quality; and
5. water quantity.

A river system is generally complex and the linkages between the five components require analysis from a wide range of disciplines. An aquatic ecosystem is the sum of each of its components plus the interactions between components. Interactions occur when the physical or biological elements of one part of the stream or catchment affect the behaviour of other elements, where elements may be structural or functional. Gaining knowledge about how components interact and how these interactions affect health is important because it enables us to determine causes of environmental problems in waterways and ultimately how those problems can be managed or improved.

It is important that system assessment is informed by scientific knowledge. Cross-disciplinary scientific or expert panels are one way of ensuring this. A scientific/expert panel may consist of aquatic ecologists, riparian specialists, geomorphologists, hydrologists, engineers and river operators. These can be brought together on the restoration team to communicate and discern linkages within and between their different areas of knowledge.

Knowledge gaps, identified at the scoping stage, can be used to highlight information that needs to be gathered during system assessment. Knowledge gaps and uncertainties that cannot be addressed during system assessment or those identified by the scientific/expert panel should be taken into account when defining the problem and, where practical, incorporated into the objectives.

Data collected on elements of the system during system assessment may provide the 'before' data that will be used to evaluate the success of the restoration project. The elements of the system chosen for measurement during system assessment must therefore contain good indicators (see Section V, p.121) and methods of data collection must be suitable for ongoing monitoring.

One of the tasks of system assessment will be to compare the current health of the stream to identified benchmarks or 'reference conditions'. Reference conditions represent as closely as possible the desired outcome of restoration (Federal Interagency Working Party 1999) and are usually sites as close to the natural state as possible. If such sites do not exist, reference conditions may be identified through a review of historical records and anecdotal information (Rutherfurd *et al.* 2000).

What needs to be assessed

Currently, system assessment of waterways falls into a number of categories. These fit the five key components of stream health mentioned above:

1. riparian (vegetation);
2. geomorphological;
3. biological;
4. water quality; and
5. flows.

Each category represents an essential aspect of stream health, yet it is rare for all of these categories to be assessed at the same time. A successful restoration project depends on adequate assessment of each of these five categories.

1. Riparian assessment

The ecological functions of riparian vegetation include:

- regulation of the physical structure of the stream channel and adjacent terrestrial ecosystem by providing habitat and food for fish, macroinvertebrates and terrestrial fauna, by determining input and characteristics of large woody debris (LWD) which partly controls sediment storage and transport, and local flow characteristics;
- maintenance of bank and channel stability by provision of solid root mass and ground cover;
- regulation of stream temperature by providing shade;
- regulation of in-stream biological production by determining inputs of small organic debris (leaves, detritus, terrestrial insects, large woody debris, dissolved organic carbon) to the channel;
- regulation of in-stream algal production by controlling the amount sunlight (for photosynthesis) reaching the stream; and
- sediment and nutrient and filtration and capture (Koning 1999).

Riparian vegetation condition may be assessed using the 'traffic light' classification outlined in the *Rivercare* manual (Raine and Gardiner 1995). This provides a simple method of assessing riparian vegetation (and some geomorphic characteristics) that can be carried out by community groups. The method is based on comparing the site or reach with photos of totally denuded, partially denuded and non-denuded sites as designated red, yellow and green, respectively. Management advice is then given on the basis of the designation. The A–D classification (Pen and Scott 1995) may also be adopted.

Given the variety of functions of riparian vegetation, a system assessment should at the very least provide information on the capacity of the riparian zone to function in each of the ways described above.

- Percentage overhang of the stream will give an indication of the ability of the riparian zone to function as a temperature and light regulator.
- The presence of large, old trees is a good indication of the ability of the riparian zone to provide habitat and food in the form of large woody debris.
- Density and composition of near-bank (5 m from waters edge; Abernethy and Rutherfurd 1999) vegetation will determine bank stability and input of small organic debris and nutrient capture ability.

2. Geomorphic assessment

River Styles™ provides a geomorphic summary of river character and behaviour. Each River Style is characterised by a distinctive set of attributes, analysed in terms of channel geometry, channel planform, and the geomorphic units that make a river reach (eg. landforms such as pools, riffle, levees, floodplains etc.). Assessment of the assemblage of geomorphic units within a river reach, and interpretation of their form–process relationships, provide a basis for analysis of river behaviour.

The distribution, connection and controls on river processes are explained in terms of **catchment scale** boundary conditions (eg. geology, slope, valley width, discharge, etc.) that determine topography, material character and supply, and water availability. The River Styles™ procedure is applied within a *nested hierarchical approach*, allowing direct linkage upwards and downwards in the gradational scale shown in Figure 5 (Brierley *et al.*, in press).

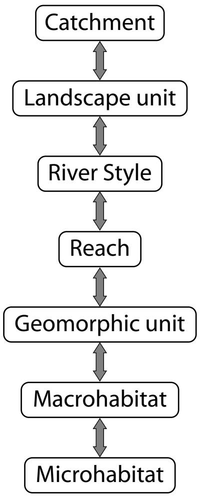

Figure 5. Gradational scale applied within a nested hierarchical approach to geomorphic assessment

Newbury and Gaboury (1993) also provide a method for assessing the physical elements of a stream that can be used without training.

3. Biological assessment

Ecological assessments use in-stream fauna as indicators of stream health. Fish may be good indicators of trends in in-stream health because they occur over a wide range of habitats. They have a major impact on the distribution and abundance of other aquatic organisms because of their important role as both predators and prey (Watts 1999). A fish survey needs to be undertaken by experienced fish biologists with due consideration to:

- adequate survey intensity;
- appropriate survey equipment (gear types); and
- natural variation in numbers of fish through space and time.

Macroinvertebrates are also good indicators of stream health. AUSRIVAS is a rapid and rigorous method of assessing stream health using macroinvertebrate communities. It includes a set of computer models relevant to particular States and Territories, seasons and habitats for macroinvertebrates. The composition of macroinvertebrate families is predicted for a sub-sample (or site) based on physical, chemical and vegetative features of the site. The predicted composition is then compared with the observed composition of families. Differences between observed families and predicted families may indicate disturbance or lack of stream health.

4. Water quality

Taking advantage of the existing 'Waterwatch' program may be the best way to assess water quality for restoration projects. Water quality monitoring means examining the physical, chemical and biological characteristics of water—observing how these factors change over time, and at different positions along a water body.

Physical characteristics include, for example, temperature, pH and turbidity. Important chemical characteristics are the levels of nitrates, phosphates and salts in the water. An important biological characteristic of water is the number and type of macroinvertebrates (water bugs such as dragonflies, beetles, and even yabbies).

Different animals have different tolerances to pollution in water, so by identifying which ones are present, and which ones are absent, it is possible to determine the condition of the water. Collected data may be exchanged through electronic networks with neighbouring groups to build up a picture of water quality through an entire catchment.

An important process which community-based water quality monitoring programs hope to achieve is to translate the knowledge of any water quality problems into constructive actions (Waterwatch Australia 1997).

5. Flows

An assessment of flows is important if there are any diversions (for irrigation or winter storage etc.) from the river system or if the river system is regulated by dams or weirs. The best practice framework for environmental flows is an eleven-step process that gives a very detailed analysis of the effects of a full range of flows on significant ecological and geomorphological and socio-economic attributes of the stream and associated stakeholders (Arthington *et al.* 1998). If used in conjunction with the 'cascading seasonal flow methodology' (Doeg, in press), for steps four through eight, it provides a scientific as well as inclusive and transparent approach to the assessment of flows.

Many of the manuals listed in Section IV: Tools for river restoration, provide information about how to carry out system assessments looking at a range of biophysical components, although few incorporate all five components listed above

Specific examples of system assessment activities include:

- determining the possibilities for improving quantity and timing of flow relative to biological requirements of in-stream communities;
- identifying appropriate river structure given prevailing boundary conditions;
- identifying vegetation and habitat required for river structure;

- surveying and assessing all weirs, dams, and levees, to determine their impedance to migration and dispersal for in-stream organisms;
- establishing stream flow necessary for adequate function of in-channel restoration structures; and
- surveying and assessing risks of impingement and entrainment of fish at water abstraction points (Cowx and Welcomme 1998).

Involving the community

Community groups and stakeholders may also be able to complete many of the system assessment activities. To enable communities to obtain an accurate understanding of condition and linkages between components of their streams, community level assessment should utilise current scientific knowledge including expert advice. Involving the community in this way may reduce the resource/conservation conflict.

Adaptive management

Research to establish causal linkages will take some time and will be undertaken outside the restoration process. Even so, knowledge of river systems will never be complete, but lack of scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation—the ‘precautionary principle’ (Anonymous 1996). Management will continue regardless of the limitations to knowledge, so the management process needs to be adaptive to take into account the results of new studies when they become available. It may be necessary to update the plan (or attach amendments) if such results have implications for a large number of objectives. Updated plans and amendments should go through a wide consultation process.

The results of the system assessment may bring to light new methods for restoration or a different understanding of the stream problems. Working through the problem definition step (Step 4b) to clearly document the known problems and the limitations that may hinder the restoration process, may necessitate changes in members of the restoration team and the scope of the plan.

The resources (time, effort and money) spent on assessment must be balanced to ensure scientific rigour without prohibitive expense. Poor assessment, however, will only waste money and will not provide the information necessary to establish the health of the system or indicate the success of the project. The fact that our knowledge is limited by the lack of data must be recognised.

Experimental design can be important in both assessment and monitoring, particularly for successful adaptive management.

Conclusion

System assessment is a vital step in the production of a restoration plan. Without knowledge of the current conditions, desired reference conditions and the potential for improvements, none of the following steps can be undertaken with confidence.

Tools for system assessment

For a detailed description of the tools, including references, see the alphabetical listing in Section IV: Tools for river restoration.

Major tools

Tool	Purpose/When to use the tool
AusRivAS (and other RIVPACS based models) Gives a broad-scale assessment of river health for different regions within a State or Territory using macroinvertebrates as indicators	For the rapid assessment of river conditions or ‘health’ using macroinvertebrate communities System assessment; monitoring; and evaluation
Fish surveys Sampling streams and comparing expected versus observed data, species richness and abundance indices etc. (eg. NSW Rivers Survey and Standardised Surveys)	To aid in system assessment as well as the evaluation and monitoring steps of the framework
Flows assessment 1. The best practice framework for environmental flows 2. Cascading seasonal flows methodology	To assess the amount of flow required to minimise negative ecological impacts System assessment

Major tools — cont'd

Tool	Purpose/When to use the tool
Manual – *Rivercare* River condition assessment with a focus on community planning, riparian vegetation, stream alignment and stability	To provide a rapid, coarse assessment of reach condition with the view to aid community planning for riparian revegetation, and stream alignment and stabilisation System assessment; implementation
Water watch Community program that monitors water quality and collects data on central data base	To obtain data on water quality System assessment
River Styles™ Catchment-based system assessment with prioritisation based on biophysical processes and river condition; baseline assessment to assess connections throughout a catchment and control on river character and behaviour	Geomorphic assessment; to aid in understanding river character and behaviour; can be used in system assessment, prioritisation, problem definition, and establishing the vision

Other tools

Tool	Purpose/When to use the tool
Bio Map System of mapping flora and fauna data in Victoria	To map flora and fauna data from a range of data sources onto one map
Expert/scientific panel Multidisciplinary group of scientists/experts who conduct a largely subjective assessment; based on visual assessment and baseline data	To assess the system using a multi-disciplinary approach To use for assessment and priority setting
Fish Barriers Database Inventory of fish barriers in Victoria and New South Wales	To supply data for river management recommendations; can be used experimentally to trial different methods and monitor their suitability
Fish surveys Sampling streams and comparing expected versus observed data, species richness and abundance indices etc. (eg. NSW Rivers Survey and standardised surveys)	To aid in the system assessment as well as evaluation and monitoring steps of the framework
Geophysical/ecological/biological data and reports Climate, soils, environmental problems, land capability maps, etc.	To obtain baseline data and information during to use during scoping
GIS mapping and modelling Geographic information systems (GIS) Satellite imaging of vegetation, land-use types, precipitation, geographical features	To present information such as hydrological, catchment boundaries, streams, development, on a spatial basis Output can be in a format suitable for assisting managers and communities to plan
Habitat surveys Aerial photographs, snag counts, aquatic vegetation, riparian vegetation.	To assess the habitat as it relates to the health of the system
Historical records/reconstruction approach Includes photographs, explorers' diaries	To define river restoration trajectory by outlining pre-disturbance state using cross-checked data

Other tools — cont'd

Tool	Purpose/When to use the tool
Hydraulic models Faraday and Charlton method Manning's Equation (simple mathematical) Backwater analysis (complex mathematical) etc.	To predict the effects of in-stream structures (eg. the size of scour holes) and to aid in understanding of flow/flood depth, velocity etc.; also, type of flow flood assessments, low flow assessments and risk assessments
Hydrologic models/analysis Rainfall run-off models RORB, RAFTS TOPOG (mathematical/computer models) River gauging data Flow duration analysis etc.	To aid in assessment and understanding flow regimes in stream systems during assessment and design The listed tools move from the rapid, 'black box' type of approach (eg. rational method) through to the complicated distributed parameter, process type models (TOPOG)
Index of biotic integrity (IBI) Method of assessing the relative environmental quality of a diverse set of rivers on a consistent standardised basis in an approximate ecological area	To assess environmental quality of the river
Index of stream condition A measure of a stream's change from natural or ideal conditions by assessing hydrology, physical form, streamside zone, water quality and aquatic life	To benchmark the condition of streams, assess the long-term effectiveness of management intervention in managing and rehabilitating streams and aid objective setting by waterway managers
Manuals Several documents developed both in Australia and overseas that provide procedures, protocols and tools for carrying out various aspects of the river restoration process	To provide a process or set of tasks and required information for an initial assessment or scoping exercise
MBACI Multiple before and after control impact experimental design	Assessment and evaluation To provide an experimental design that maximises statistical power or the ability to detect effects of experimentation actions
Reference reach approach Using an undisturbed stream or site within the catchment as a benchmark to copy	To base the restoration trajectory on the characteristics of an undisturbed stream or reach
'State of Rivers' An assessment procedure that gives a detailed static description of the condition of the river in a GIS format	To aid planning and prioritisation

Step 4(b) Developing the Restoration Plan — Problem Definition

Purpose/Outputs

- To ensure the problem(s) and its causes are properly identified so that actions can address the cause as well as the problem
- To assess the feasibility of the plan
- To identify limiting factors and research needs
- To target resources in a way that maximises environmental benefits

Principles

Clearly understanding and describing the problem will allow the causes (rather than symptoms) to be determined and appropriate solutions to be derived. Problems in this sense refer to not only the biophysical problems, but also include a number of other categories associated with the successful completion of the plan eg. financial, technical, information transfer, lack of interest or knowledge, and these must all be described. The restoration team is responsible for ensuring that stakeholders and the wider community have a clear idea of what the problem is at the end of this step.

During the problem definition stage, the data and analysis documented during scoping and system assessment steps should be critically and carefully examined. As stated by Hutchinson (1999) "…assumptions about the nature of the problem can have a profound effect on the solutions offered for it".

There is a need to analyse the results of scoping and system assessment in such a way that assumptions and perceptions about the system are highlighted and addressed. The problem definition step provides a summation of the main restoration issues.

The inter-linkages between problems and pressures span different disciplines and operate over multiple scales. The interdisciplinary approach to system assessment needs to be continued through to problem definition as analyses and conclusions are refined to make concise statements of the problems.

A workshop approach may be the best way to present and interpret the data and analyses from across disciplines. Interactions among components of the system that fall within the scope of each discipline can be discussed. The scales within or between which these interactions occur must also be discussed. The biophysical management problem can then be defined in terms of the scale at which it is occurring and the interactions that affect it.

The amount of time and effort that will need to go into pinpointing which pressures are causing problems should not be underestimated. In many ways this is the most important part, and potential turning point, in the river restoration process. If problems are well defined and well understood the restoration process is much more likely to succeed.

Anthropogenic (human) pressures or natural environmental pressures may cause stream problems. Table 2.4.1 gives some examples. Many problems can arise from a number of pressures. For example, vegetation clearing may lead to several forms of geomorphological and hydrological problems and to loss of species.

Problems may also compound, one causing another. For example, the creation of gullies may lead to sediment slugs; habitat degradation may lead to species loss. Identifying the fundamental problem or pressure that sits atop this hierarchy of causal linkages is very difficult. Nevertheless, it is essential that we attempt to determine the key problems in the catchment.

Table 2.4.1 Some human-induced pressures that cause stream problems. (Adapted from Kapitzke et. al 1998, Rutherfurd *et al.* 2000, Working Group on Waterway Management 1991, and the Federal Interagency Stream Restoration Working Group 1999.)

	Problem	Pressures
Ecological	In-stream and riparian habitat degradation	Stock watering/access, vegetation clearing, desnagging, channelisation; flood control measures and other river and engineering works, deliberate and accidental introductions of exotic species, sedimentation.
	Presence of exotic species	Deliberate and accidental introductions of exotic species
	Loss of native species	Most of the pressures listed
	Barriers to fish migration	Building dams, weirs, fords, barrages
	Decline in water quality	Agricultural and industrial waste disposal and run-off
Hydrological	Altered flow and flood regimes	Diversion (irrigation, and other agricultural and urban water uses), building dams, flood control measures
	Altered flood height and inundation characteristics	As above
	Altered precipitation patterns	Catchment vegetation clearing
	Changes to groundwater levels	Irrigation, soil compaction
Geomorphological	Bank failure/slumping	Riparian vegetation clearing, channelisation, extraction (removal of sand and gravel from within the channel)
	Gully formation	Vegetation clearing, road building, plough lines
	Channel incision and widening	Construction of drains, vegetation clearing
	Sedimentation and slugs	Dam desilting, extraction, stock access, bank erosion, riparian vegetation clearing
	Chain of pond degradation	Stock access and grazing, vegetation clearing
Social/institutional	Degraded water quality	Agricultural and industrial waste disposal and run-off, and those pressures associated with sedimentation
	Lack of knowledge/communication	Lack of will, time and resources of politicians/community and scientists, language barriers
	Diversion caps	Ecological requirements
	Flood damage	Ecological requirements and engineering
	Lack of resources/finances	Individual, micro and macro-economic pressures
	Inadequate legislation	Lack of political will, time and resources.
	Lack of incentives to follow best management practice	Lack of will, knowledge, time and resources of politicians/ community

The causal relationships between pressures and social or institutional problems are harder to isolate due to a high degree of interconnectivity. Many pressures such as lack of resources/finances are also problems in the local context. It essential when looking at social problems as well as biophysical problems to look at the broader (larger scale) political and economic context in order to elucidate the fundamental problems and associated causal linkages.

Fundamental problems

There may be a causal chain of events responsible for every degraded structural attribute and function of the riverine system (Federal Interagency Working Party 1999). By tracing causal linkages, the fundamental problems may be identified.

The problem definition step needs to address problems and pressures in terms of data collected, scientific knowledge, and changes to management as a result of this knowledge. In order to do this, a matrix may be completed using information that has been gathered during system assessment. In this way management problems can be concisely stated. Significant problems can be listed in the matrix along with pressures and other limiting factors that may hinder the success of restoration activities. Details of the analyses that point to methods of overcoming these limiting factors can be placed in the boxes where problems and limiting factors intersect in the matrix.

Suggestions of how anthropogenic pressures and other limiting factors may be overcome can be initially addressed at this point. One of the major limiting factors is that systems, whether the riverine or the surrounding social and economic systems, are likely respond to restoration activities in a complex and often unpredictable manner.

Conclusion

Degradation may be the result of human induced and/or natural environmental pressures. It is often difficult to make causal links between these pressures and changes in the riverine system. However, time spent determining the ultimate causes of problems means that less effort will be directed addressing symptoms and more effort spent on activities likely to show the greatest benefits.

Tools that may be used for defining the problem are listed below.

Tools for Problem Definition

Tool	Purpose/When to use the tool
Cause-and-effect mapping Fish-bone diagram with effect at the end of the spine and main causes as ribs. Contributors to the main cause can be sub-branches of the ribs	To explore the contributing causes or reasons for a particular problem or issue and to help identify root causes rather than symptoms
Flow diagrams Write down the action to be taken at the bottom of a page, map out steps that need to be taken and factors affecting that action	To illustrate and analyse consequences (positive and negative) of particular issues/actions
Interrelationship diagrams Between 5 and 20 factors contributing to the problem are listed in a circle. Each is identified as cause or effect of another. Arrows point from 'causer' to 'causee'. Factors that are most often the 'causer' will be the driving factors and should be focused on	To identify which of a series of causes are the most important and how they relate to each other To stimulate discussion, analyse information and determine priorities
Round-table workshop Group meeting and discussion formally facilitated with a set agenda and/or series of tasks	Bring groups of people together to exchange ideas Bring a range of views to the fore
SWOT Strengths, weaknesses, opportunities, and threats analysis. Can be done as a brainstorming exercise or as a synthesis of other information	To identify strengths, weaknesses, opportunities and threats in relation to a project in assessment, scoping, evaluation

Step 4(c) Developing the Restoration Plan — Objective Setting and Prioritisation

Purpose/Outputs

- To provide a method for judging whether the vision is being realised
- To set evaluation measures
- To provide a list of objectives and sub-objectives based on limiting factors
- To list priorities for restoration sites and activities
- To ensure a balance between conservation and rehabilitation activities is undertaken

Principles

Objectives can be defined as outputs of the project (Rutherfurd *et al.* 1999) and may be seen as statements about how and when the problems identified during the scoping and the problem definition step will be solved. Objectives form a connection between problem definition, vision, scoping and system assessment, and the next step in designing and measuring the progress of the activity. The vision sets the bearing that should be followed in choosing an activity. For instance, if the Vision is: "To have a sustainable riverine ecosystem, relying on natural processes to invigorate and sustain structure and function." and one of the problems has been defined as: "Flood regimes are being retarded by diversions and lateral discontinuities due to the presence of flood levee banks," then objectives would be devised that clearly reflect the vision and allow measurement of progress towards solution of the problem, such as: "To re-establish natural flooding processes within five years".

Objectives for this framework must conform to the idea of being **SMART**:

Specific—they are detailed enough to be immediately applicable.

Measurable—the outputs of the objectives can be measured in order to evaluate the restoration process.

Achievable—they can be completed with the available resources (finances, skills, labour and time).

Realistic—level of uncertainty, non-linear responses to stress and restoration activities, and risks must be taken into account.

Time bound—a time frame must be explicitly written into each objective.

Making the objectives measurable

Meeting objectives means producing outputs. It is the *outputs* that are measured rather than the objectives themselves (Sloan and King 1997). Outputs are measured to ensure the proposed solutions are actually helping to rectify the degradation problem.

How well outputs can be measured depends largely on the choice of indicator. Indicators must be sensitive enough to detect the amount of change that has been specified as the range of success in setting the objective.

The choice of indicator will vary according to the type, activity, scale and underlying processes of the biophysical system. Some activities may have an immediate impact, whereas for others it may take many years before an impact is observed. For example, macroinvertebrate populations may recolonise in months whereas fish populations may take years.

Making the objectives achievable

The scoping step allows the identification of the boundaries of the restoration project. The objectives must therefore be framed such that they fit into the scope of the project.

Keeping the objectives realistic

Objectives need to be realistic. Unrealistic objectives may end with dissatisfaction, as over-ambitious aims are met with failure. Aims that are not ambitious enough will mean that we proceed more slowly than is necessary to restore waterways, which will also create stresses and problems. Some groups may prefer to be cautious—under-promise and over-achieve —in this way success beyond expectations is likely and lack of success will not be met with too much disappointment.

Using current knowledge effectively can help to ensure that objectives are realistic. Identifying the biophysical and financial and other social boundaries during scoping will help to ensure objectives are matched to the limits of what can be achieved under current conditions. By identifying limitations, actions that need to be undertaken to successfully carry out the restoration activity are delineated. Incorporating the probable cause or causes of degradation determined during system assessment and problem definition will ensure objectives solve the problems directly.

Realistic objectives can be more easily achieved by considering:

- the temporal and spatial scales at which the objectives are measured;
- the biophysical system that is being restored;
- the types of disturbances and stressors on the system;
- the limiting factors noted when defining the problem (previous step);
- how objectives produce outputs that can be measured;
- the range of measurements within which success is defined;
- the values of the community; and
- the priorities of other natural resource and environmental initiatives.

What should the objectives cover?

The objectives must describe all things that need to be done to solve the identified problems and thereby attain the vision.

Objectives must also cover monitoring the progress that is made towards solving the degradation problems, and the restoration process must also be evaluated and maintained. The restoration works are not limited to physical in-stream activities. They may include communication and education activities such as writing reports and newspaper columns, and other actions that lead to improving their understanding of restoration issues and potentially changing practices that are detrimental to the stream environment.

Objectives need to cover four areas:

- the restoration activities themselves;
- monitoring the restoration activities;
- evaluating the restoration activities and the restoration process; and
- maintaining the restoration activities.

The objectives hierarchy

The next step down from objectives in the objectives hierarchy are goals (see p. 48). Goals are the statements of what will actually be done on the ground. Goals will be defined during the next step in the framework—assessing options and selecting activities. As each objective reflects the vision, each goal reflects the objective from which it is derived. By creating this hierarchy we ensure that we set up the restoration process within a meaningful time frame in order to meet bigger picture catchment-framed vision. It also means that the restoration objectives and consequential activities will reflect the view of the community.

Measurables for objectives can be defined by three performance criteria:

1. *Empowerment indicators* – all measurement of the information, resources and opportunities available to communities.
2. *Implementation indicators* – allow measurement of the extent to which information has been understood, resources used and opportunities taken up for on-ground works.
3. *Resource condition indicators* – show improvement in the condition of the river system.

Prioritisation

Setting priorities means placing objectives in order of importance. After the objectives have been selected, the goals, activities and tasks that stem from these will also be prioritised. The order in which the activities are placed will reflect the order of the objectives from which they are derived. Priorities can be decided on social, economic and scientific grounds. Management priorities are generally influenced by social and economic considerations. If these are not more closely linked to environmental considerations, however, there is less chance of a waterway ecosystem being restored.

It is important to recognise that priorities should be derived for each site. One overarching rule may serve to provide guidance but differences from site to site in the biophysical, social and economic components mean that priorities should be decided on the basis of those factors relevant to a particular site (ie. on a case-by-case basis). Nevertheless, all priorities will be governed by social, management and biophysical processes that are occurring at larger scales and so they must be put into a broader context. Catchment management plans, precipitation, and habitat degradation at the catchment scale, and climatic and economic processes at even greater scales, will determine priorities at the site.

Not only must objectives be prioritised, but also the sites within the catchment, in order to decide which sites should be restored first. Deciding where to start will depend in part on which problems are defined as 'fundamental' during the problem definition step. Primarily, this geographical prioritisation will depend on the degree to which different areas are degraded and thus the likelihood of successful restoration. Sites that are less degraded (ie. with high recovery potential) should generally be tackled before those with low recovery potential (Rutherfurd *et al.* 1999, Brierley 1999.)

Protection is always the first priority

Protection and conservation of relatively undisturbed and/or rare fragments of the catchment is the first priority. These sites may also be used as reference reaches if they have the same geomorphic character as those chosen for restoration activities. Following these sites, reaches are prioritised according the recovery potential and trajectory.

Recovery potential

To define the recovery potential of reaches, a biophysical approach can be used whereby catchment or landscape-scale planning forms the basis of prioritisation (Hobbs and Norton 1996, Federal Interagency Working Party 1998, Brierley 1999, Rutherfurd *et al.* 1999). Within this geographically defined area, the river geomorphology has been characterised during system assessment according to the assumption that "ecological recovery is contingent upon…appropriate geomorphological processes and stream morphology" (Erskine 1999). Next, each reach is categorised according to (Rutherfurd *et al.* 1999, Brierley 1999):

- recovery potential or condition, including ease with which the reach may be restored;
- rarity; and
- the trajectory of recovery or degradation.

Changing priorities

The possible benefits of meeting lower priority objectives should always be documented during prioritisation. This may become important if, during implementation, some of the higher priority objectives prove too difficult to achieve and need to be set aside in favour of meeting lower priority objectives. Another way of tackling this problem involves an adaptive management approach, changing and updating objectives as the restoration process progresses.

Conclusion

The objectives refine the vision to a set of measurable statements. Objectives may be statements about how the problems identified during scoping and the problem definition step will be solved. These statements must reflect current knowledge about appropriate indicators and limitations to the restoration process.

Prioritising objectives and sites for restoration is determined by the perceived importance of the degradation issues and likelihood of success (ie. the degree of recovery potential of the site). Identifying where protective measures are needed and following adaptive management protocols are important aspects of prioritisation.

The tools listed on the next page will aid the objective setting and prioritisation process.

Tools for objective setting and prioritisation

For a detailed description of the tools, including references, see the alphabetical listing in Section IV: Tools for river restoration.

Tool	Purpose/When to use the tool
AEAM (adaptive environmental assessment and management) Decision-support system that operates on a computer modelling/workshop platform incorporating economic, social and environmental components of the system	To set priorities and can be used for evaluation also
Double paired weighting A process by which alternatives are assigned a rank and the highest ranking alternative becomes the highest priority.	To set priorities
Matrices One axis with processes that degrade and the other with social, economic, ecological, geomorphic, hydrological elements that are affected; each is then ranked against the other Also, to prioritise solutions, degrading process on one axis and possible solution	To gain a clear idea of priorities with respect to degrading processes, important elements to repair or problems to solve — problem solving, objective setting and prioritisation
Multiple criteria analysis/multiple criteria group decision support systems Options ranked according to dominance or relative importance within the aggregate benefit	To support group decision-making processes by quantitatively assessing multiple options against goals or values
State of Rivers An assessment procedure that gives a detailed, static description of the condition of the river in a GIS format	To aid planning and prioritisation
Strategic priorities A series of observable or quantifiable statements that grounds the vision in concrete results for which action plans can be created.	To galvanise commitment from the people of the restoration team
SWOT Strengths, weaknesses, opportunities, and threats analysis; can be done as a brainstorming exercise or as a synthesis of other information	To identify strengths, weaknesses, opportunities and threats in relation to a project in assessment, scoping, evaluation

Step 4(d) Developing the Restoration Plan — Assessing the Options and Selecting Activities

Purpose/Outputs

- To identify and select activities based on meeting objectives
- To select the activities that produce the greatest benefits
- To check that the restoration activities satisfy the vision statement and objectives
- To check that the activities fit within the bigger picture of resource management and conservation
- To choose between options on the basis of feasibility, cost, availability etc.
- To design a schedule for activities and implementation
- To predict the outcomes and effectiveness of the selected options

Principles

Whereas prioritisation (step 4c) focused on site selection and prioritising objectives, assessing options and selecting activities focuses on choosing the specific goals and associated tasks that must be carried out to meet the objectives. Many of the constraints that are considered during objective setting and prioritisation such as:

- resources;
- ecological benefits;
- consultation with the wider community;
- social and environmental acceptability; and
- likelihood of success

will be considered again but in reference to specific activities rather than broader objectives.

Feasibility analysis

In addition to these constraints, a feasibility analysis will need to be completed, looking at factors such as:

- viability—how long will the restoration works last, will they survive a 10-year, 50-year, 100-year flood; or other catastrophic events?
- maintenance requirements—will the restoration works need to be constantly evaluated and maintained, or evaluated every year to every five or ten years?
- the likely consequences of the activity—what are the potential side-effects or off-site impacts of the specific activities?

Specific planning

In particular, the following must be assessed:

- how the methods will be combined into an overall restoration program;
- expected construction methods;
- access and site requirements;
- estimates of the size, quantities, and costs of the materials used;
- final layouts of activities;
- the benefits of conducting the activities compared with the costs of not conducting the activity;
- complementarity between activities; and
- ability to obtain consensus based on appropriate technical advice.

A series of activities should be chosen that will enable objectives to be met in each of the areas discussed previously:

1. the restoration works;
2. monitoring the restoration works;
3. evaluating the restoration works and the restoration process; and
4. maintaining the restoration works.

Assessing the options:

- Weigh alternatives
- Which is likely to produce the greatest benefit?
- Satisfy vision statement and objectives
- What is feasible?
- Ensure achieving short-term goals creates long-term benefits

More detailed planning of the selected restoration activity may need to be undertaken. The factors to be examined will depend on the type and scale of the activity that has been selected. The restoration team may chose to cease practices that are degrading the stream, for example, stopping the practice of the taking snags out of rivers or 'desnagging'. If it is best to do something, activities may include reconstructing meanders, awareness raising campaigns, providing alternative watering sources for stock, or revegetating areas. The scale of the activities may range from a particular site through to an entire catchment.

Conclusion

Restoration activities will focus on addressing restoration issues from the biophysical level to the social/ institutional level. The selection of the range of activities can be based on a number of factors including the viability, maintenance requirement and potential consequences of each activity.

If some of the activities are potentially difficult to carry out, contingency activities should be described at this stage and notes about these should be incorporated into the plan.

Some tools are listed below that may aid the process of assessing options and selecting activities.

Tools for selecting options and activities

For a detailed description of the tools, including references, see the alphabetical listing in Section IV: Tools for river restoration.

Tool	Purpose/When to use the tool
Benefit/cost analysis (BCA) Somewhat like SWOT analysis (see 'S' in A– Z of tools in Section IV)—potential costs and benefits of an activity, or objective are listed and may be quantified for use in prioritising	To understand positive and negative aspects and resources needed for an activity or objective.
Costing	To find out and document an approximate cost for activities during scoping, objective setting and selecting options
Multiple criteria analysis/multiple criteria group decision support systems Options ranked according to dominance or relative importance within the aggregate benefit	To support group decision-making processes by quantitatively assessing multiple options against goals or values
Strategic priorities A series of observable or quantifiable statements that grounds the vision in concrete results for which action plans can be created	To galvanise commitment from the people of the restoration team
SWOT Strengths, weaknesses, opportunities, and threats analysis; can be done as a brainstorming exercise or as a synthesis of other information	To identify strengths, weaknesses, opportunities and threats in relation to a project in assessment, scoping, evaluation
Risk assessment/analysis Evaluating the risk of management practice failing and restoration activities or natural events causing further degradation or species extinctions	To identify and when possible quantify risks for each restoration activity under consideration

Step 4(e) Developing the Restoration Plan — Finalising the Plan

Purpose/Outputs

- To provide a robust plan for on-ground works, monitoring, evaluation, and maintenance, which is signed off by an appropriate official
- To consolidate a clear understanding of the capabilities of the project
- To provide a prelude to the works schedule
- To provide a final consultative network
- To provide a communication strategy
- To increase understanding by stakeholders about why restoration is undertaken
- To increase knowledge of restoration, and of biophysical processes in rivers
- To improve the health of waterway ecosystems
- To complete a final risk assessment of proposed objectives and activities

Principles

The options and activities have been selected on the basis that they are the best ways to meet the objectives of the river restoration plan. Now, it is time to finalise the plan. This involves completing a detailed statement about exactly how the objectives will be met. The options and activities that have been selected in the previous step will be placed in order of priority and the plan will describe how each directly relates to the objectives. Contingency activities will be noted for the more difficult tasks at this stage.

It is important to ensure that there is community support for the plan and opportunity is provided to address disagreements thereby attaining consensus.

Integration with other plans should be clearly defined. The plan should then be formally ‘signed off’ or approved by the funding body(ies) and consideration given to establishing the implementation team. This is likely to overlap with the restoration team but should include contractors or those doing the works.

The restoration plan is a description of what actions will be taken and what structural (if any) alterations will be made to the target site(s), rather than description of exactly who will carry the actions out and over what period of time etc. A more detailed works schedule assigning responsibilities to individuals and contractors will be developed in the initial stage of implementation (step 5).

Contingency plans need to be considered for activities that are potentially difficult. Rutherfurd *et al.* (1999) pose a number of questions that need to be answered during finalising the plan, such as the following:

- Will the project be making a difference in 20 years time? How long will any alterations to the stream last?
- Is the project big enough? Is a reach being treated rather than a single point of the stream?
- Are processes operating in the stream being addressed? Are these processes being addressed with consideration of the entire catchment?
- Is vegetation being encouraged to grow to stabilise the channel?
- Is the river at the stage that it can recover? If it is quite degraded and degrading further it may take decades or centuries to recover.

- If the river has a reasonably good recovery potential, does the plan work with the stream (ie. is the project following the a natural recovery trajectory?
- Are the right tools being used?
- Should you experiment to check that you *are* using the right tools?
- Has the project been designed to minimise any undesirable consequences or possible negative impacts?

Risk assessment

A risk assessment should also be done at this stage also, to answer the following questions:

- What are the major threats to the restoration project?
- What extreme events is the project designed to survive (for example floods, fire and drought)?
- What is the cost of failure of the project?
- What are the costs if the project is not carried out?
- What other factors are present in the catchment that may jeopardise the success of the works?

The completion of a restoration project should be celebrated by the restoration team, stakeholders community and participants. This should also be included in the schedule!

Conclusion

Finalising the plan involves documenting the objectives, goals and activities concisely and completing a final reality check and risk assessment. Some tools to aid in this process are listed below.

Tools for finalising the plan

For a detailed description of the tools, including references, see the alphabetical listing in Section IV: Tools for river restoration.

Tool	Purpose/When to use the tool
Manual – ***A Rehabilitation Manual for Australian Streams* Vol 1.** Topics include rehabilitation concepts, and a 12-step rehabilitation procedure with emphasis placed on physical rehabilitation, especially stream stabilisation and stream habitat.	To aid with assessment and planning
Project management software Microsoft Project® with attachments such as PERT (critical path analysis) and GANTT	To aid with planning an evaluation
Risk assessment/analysis Evaluating the risk of management practice failing and restoration activities or natural events causing further degradation or species extinctions	To identify and when possible quantify risks for each restoration activity under consideration

Step 5 Implementing the Plan

Purpose/Outputs

- To design an implementation/activities schedule, clearly specifying roles and responsibilities
- To appoint contractors and consultants as the activities require
- To undertake and complete restoration activities and activities according the schedule

Principles

Implementing the plan is the ultimate aim of all the steps that have come before, so consideration of how the plan is to be realised is crucial.

Implementation of the plan is likely to generate the most interest throughout the local community, so the beginning of on-ground works may represent the best opportunity for improving community education through signage, media coverage and field days.

In implementing the plan consideration must be given to:

- who carries out the works;
- what exactly the works entail;
- in what order they will be completed;
- the whereabouts of the works; and
- the time frame within which the works will be carried out.

The restoration activities are not limited to physical in-stream and riparian works. They may include communication and education activities such as writing reports and newspaper columns, holding field days and other actions that lead to improving the understanding of restoration issues and potentially changing practices that are detrimental to the stream environment

The schedule

Some scoping and prioritisation tools will be needed to assess the tasks and the order in which they need to be completed, how much each will cost and who is available to carry them out. The works schedule includes a detailed budget and estimate of the resources that are needed and available.

Tasks that need to be undertaken throughout the implementation step will vary with the type of restoration activities that have been chosen. Services may need to be contracted out for some activities. It is important that the contractor understands the objectives of the project and agrees with them (Rutherfurd *et al.* 1999). Contract preparation and project management skills may need to be added to the restoration team at this stage to ensure smooth implementation.

Schedules are likely to vary from site to site. A schedule for a similar activity undertaken at a different site or at a different time may not be directly applicable to a new activity and vice versa.

Adaptive management

Implementation is simply doing what you said you were gong to do in the plan (Rutherfurd *et al.* 1999). In practice, however, it may not be quite so simple. Implementation may not adhere strictly to the schedule due to unforeseen circumstances. Feedback loops from implementation to the planning process must be established. The schedule and the plan may need to be revisited on a number of occasions and alterations made to reflect what is happening ‘on the ground’. Contingency plans may need to be put in place or if some activities are proving difficult to carry out, activities that are lower priorities may need to be undertaken instead.

Conclusion

Effective implementation requires an integrated approach. Although much of the responsibility will rest with a range of government agencies, co-operation with other stakeholders and community groups will be necessary. Remember, ownership of restoration must ultimately reside with many different agencies and local groups, not just river managers.

Tools for implementing the plan

For a detailed description of the tools, including references, see the alphabetical listing in Section IV: Tools for river restoration.

Tool	Purpose/When to use the tool
Bed replenishment Artificial addition of bed materials or capturing bed materials being moved down the stream in sediment traps	To reinstate natural or optimal bed materials into section of stream in order to provide habitat for aquatic organisms and stabilise incised stream
Communication strategies—informing participants and the community Generic messages (sound bites and slogans that the public can remember easily), advertising campaign, community service announcements, street stalls displays, field days	To raise awareness of the importance of rivers and river restoration Restoration team, implementation
Fish/platypus cover Protecting undercut banks and installing large woody debris (LWD) – anchored, unanchored, pendants, clumped, log jams	To provide habitat, spawning sites and cover for fish and platypus in a way that mimics natural conditions and orientation
Fishways Rock ramp, riffles, flooding culverts with down stream weirs, vertical slot	To allow fish to move up and down stream of barriers
Freshwater ecology courses/field days Education, community consultation, on-site examples of riverine ecology and degradation	To increase understanding of riverine ecology, scope views and inspire action Trainers and community group leaders should be targeted Vision setting
Full-width structures Low structures that span the width of the channel	To stabilise the stream bed by forming a backwater pool upstream and a scour pool and bar formation downstream
Longitudinal bank protection (revetment) Directly armouring the bank to protect it from abrasion—should be used in conjunction with revegetation	To control erosion and consequent sediment yields, enhance pool depth and stabilise banks for future riparian regeneration
Manual – *Stream Analysis and Fish Habitat Design. A field manual* Planning, field surveys, stream behaviour, and design and construction of stream habitat works	To use in conjunction with the national framework for a detailed understanding of the physical components of the river system
Meander reinstatement Putting meanders back into the stream	To reverse deepening and widening and consequent ecological degradation caused by stream artificial straightening

Tool	Purpose/When to use the tool
Other design tools Rock size analysis eg. CHUTE, RIP RAP Meander analysis methodologies, scour depth analysis, alignment approaches	To design restoration structures
Partial width bank erosion control structures Including groynes (non-permeable and limited in their usefulness), retards (permeable) and relatively untested structures	To stabilise the bank by moving the attack point to a hard structure, or moving the thalweg of the stream away from the eroding banks, to narrow or stabilise over-wide streams
Press releases Or regular newspaper columns, reports etc.	To raise public awareness of river restoration issues and to share information
Project management software Microsoft Project® with attachments such as PERT (critical path analysis) and GANTT	To aid with planning an evaluation
Revegetation of steam banks and riparian zone Planting terrestrial plants and macrophytes	To control sub-aerial erosion, fluvial scour and mass failure

Step 6 Monitoring and Maintenance

Purposes/Outputs

- To ascertain the impact of the restoration works and activities on biological, physical, social and economic elements of the system
- To provide progressive assessments/data/reports/reviews of the project
- To provide a mechanism for judging how a restoration activity is proceeding indicating the success or failure of the activity
- To re-appraise and possibly change the vision, objectives or schedule for implementation of activities
- To determine changes in understanding
- To determine improvements in conservation ethic
- To provide ideas and opportunities for improved designs and adaptive management

Principles

Monitoring is the way of measuring whether a restoration project is performing according to plan. It involves measuring components of the waterway ecosystem to determine the impact of restoration activities; that is, how well the activities are meeting the objectives and producing the desired outputs and outcomes.

There are three elements required to determine the progress and success (or failure) of a restoration activity and ultimately the health of the biophysical system. They are:

1. well framed objectives – to show what the aim of the activity is;
2. sensitive indicators – the elements that are measured to indicate whether the objectives are being met need to show detectable changes within the monitoring time frame; and
3. appropriate benchmarks and criteria – reference sites and criteria must represent the natural, historical state of the target site(s) or provide a meaningful basis for comparison given prevailing boundary conditions.

What can be measured?

The suite of variables or indicators suitable for monitoring is large, but the selection of indicators for a specific restoration plan is dependent on the purpose of the monitoring program (Schneider 1992). The purpose may be:

- to find out whether the waterway is returning to a state of health and ecological integrity (or is it still being degraded?);
- to increase understanding of specific problems;
- to measure a suite of variables in order to pinpoint specific problems; and/or
- to measure the performance of the restoration activity.

A discussion on the limitations to the selection of ecological indicators and factors to take into account when interpreting them is given in Section V.

Effective monitoring of restoration works through the use of realistic objectives, sensitive indicators and appropriate benchmarks should be carried out with due consideration to achieving outputs and outcomes.

Monitoring provides information for the evaluation of the restoration process (see Evaluation, p. 80).

Maintenance

Why is it important?

Maintenance is important because it ensures that the benefits of some activities continue to meet restoration objectives. In some cases maintenance works are a continuation of the works plan (eg. tree watering, weed and rabbit control).

Maintenance includes the continuation of restoration activities and repairs to in-stream or riparian works as part of:

1. scheduled maintenance—regularly scheduled upkeep;
2. remedial maintenance—to remediate problems noted in annual inspections; and
3. emergency maintenance—in response to emergencies such as flash floods (Federal Interagency Stream Restoration Working Group 1999).

Maintenance is important to continue support and ownership for the restoration activity. If maintenance of some physical works does not occur, the works may fail or, even worse, cause greater problems than had they not been undertaken in the first place.

Tasks for monitoring and maintenance

There are many tasks that will need to be undertaken during the monitoring and maintenance step. These are listed below.

- assigning responsibility for maintaining the restoration works;
- maintaining restoration works may require continued physical actions to upkeep a structure;
- sharing knowledge of experience with other groups to help to ensure an overall increase in restoration knowledge;
- maintaining restoration data sets collected during system assessment and monitoring;
- adjusting restoration activity in response to evaluation and further knowledge as it becomes available (ie. adaptive management);
- reporting monitoring results to stakeholders and wider community so that they can see that something is happening; and
- contributing knowledge to new projects.

Below are some tools that may be used to aid the monitoring and maintenance step.

Tools for monitoring and maintenance

For a detailed description of the tools, including references, see the alphabetical listing in Section IV: Tools for river restoration.

Tool	Purpose/When to use the tool
AEAM (adaptive environmental assessment and management) Decision-support system that operates on a computer modelling/workshop platform incorporating economic social and environmental components of the system	To set priorities; can be used for evaluation also
Ausrivas (and other RIVPACS-based models) Gives a broad-scale assessment of river health for different regions within a State or Territory using macroinvertebrates as indicators	Monitoring; environmental assessment; and evaluation
MBACI Multiple before and after control impact Experimental design	Assessment and evaluation To provide an experimental design that maximises statistical power or the ability to detect effects of experimentation actions
Empirical catchment model approach Uses hydraulic geometry or regime relationships such as width discharge relationships, planform/width relationships to predict equilibrium channel form as a basis for stable channel design	To define restoration trajectory and design of restoration works based on the equilibrium form of the river

Tool	Purpose/When to use the tool
Expert/scientific panel Multidisciplinary group of scientist/expert who conduct an assessment based on visual assessment and baseline	To use for assessment and priority setting
Fish surveys Sampling streams and comparing expected versus observed data, species richness and abundance indices etc. (eg. NSW Rivers Survey and Standardised Surveys)	To aid in the system assessment as well as evaluation and monitoring steps of the framework
Habitat surveys Aerial photos, snag counts, aquatic vegetation, riparian vegetation	To assess the habitat as it relates to the health of the system
Index of stream condition The index is a measure of a stream's change from natural or ideal conditions by assessing hydrology, physical form, streamside zone, water quality and aquatic life.	To benchmark the condition of streams, assess the long-term effectiveness of management intervention in managing and rehabilitating streams and aid objective setting by waterway managers
Reference reach approach Using an undisturbed stream or site within the catchment as a benchmark to copy	To base the restoration trajectory on the characteristics of an undisturbed stream or reach
Maintenance—remedial, scheduled and emergency Including redesign or rebuilding of in-stream structures and pest and weed control	Regular inspection of on-ground works and careful analysis of performance will point to which of remedial, scheduled or emergency maintenance is required

The Big Picture

Restoration is part of the bigger picture of environment and natural resource management. This chapter places a restoration plan in the context of State, regional and Federal planning. Federal programs that can influence restoration are outlined.

A restoration plan is shown at the centre of a cluster of management plans which fall under the umbrella of catchment-based planning (Figure 6), For example, *Rivercare* plans and plans for fish management, streamflow management, soil conservation and water quality management, have been (or are being) developed in response to environmental issues. Catchment plans will often fall within regional plans, which will in turn fall within State strategies for natural and regional development such as the Murray–Darling Basin Commission Native Fish Management Strategy, Algal Strategy and National Biodiversity Strategy.

Due to river system linkages, actions undertaken as a result of the restoration plan are likely to influence and be influenced by actions formulated under other plans. A review of actions suggested by other plans during the scoping, objective setting and implementation steps of this manual is essential to identify conflicting and complementary actions.

Catchment-based plans are being developed in most States and Territories as part of the response to the National Strategy for Ecologically Sustainable Development (NSESD) (Commonwealth of Australia 1992). Catchment-based plans effectively place community-based priority resource issues, such as water quality and biodiversity, on a scale consistent with State and Federal planning units, thus reducing overlaps, ad hoc planning and misunderstanding. A catchment plan is framed within a regional plan that is, itself, framed within State and Territory strategies for natural resource management and regional development. These strategies should be consistent with Commonwealth strategies such as ecologically sustainable development (described below) and the National Strategy for the Conservation of Biological Diversity (Section V).

The National Strategy for Ecologically Sustainable Development

In 1992, the heads of government endorsed the National Strategy for Ecologically Sustainable Development (NSESD), which aims to ensure that the importance of the environment is considered in the economic choices of governments, industry and consumers.

NSESD is implemented using a cooperative approach with strong leadership at the national level. An aim of NSESD is to ensure decision-making processes effectively integrate both long and short-term economic, environmental, social and equity considerations. Most development decisions occur at the local level while major decision-making powers in land-use management reside with State and local government authorities. The National Environmental Protection Council was established in 1997 to develop national measures for environment protection.

The Inter-governmental Committee for Ecologically Sustainable Development provides the administrative forum for progressing key national issues through reports to the Council of Australian Governments (COAG) on the implementation of the NSESD. Various mechanisms exist for advice and input such as Ministerial Councils; for example, the Australian and New Zealand Environment and Conservation Council (ANZECC), the National Environmental Protection Council and the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ).

Of particular relevance to river restoration is the impact of the NSESD framework on the agricultural, fisheries and water resource management sectors.

One of the criteria of NSESD is:

> To create a framework of integrated government policies and programs which promote community based self reliant approaches to agricultural resource management.

Criteria such as this have led to the development of catchment and regional management plans based on 'whole-of-catchment' approaches to sustainable development.

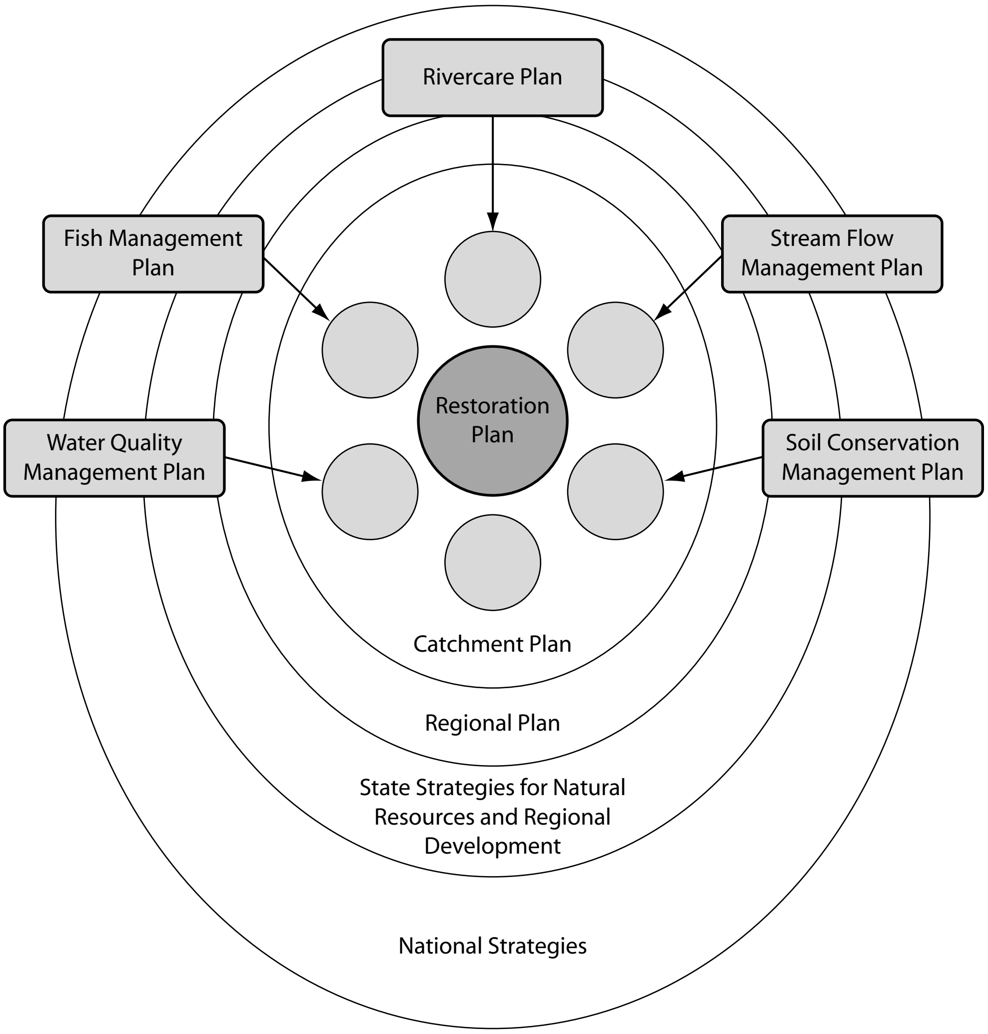

Figure 6. Restoration planning within the bigger picture

As part of these plans, catchment management committees and catchment management authorities have been established in one guise or another. They are at different levels of development, however, depending on the pre-existing structures and requirements of resource management within each State or Territory. Essentially these groups are concerned with increasing community knowledge and empowerment with respect to resource management issues.

The following Commonwealth programs and the Natural Heritage Trust contain components that can influence restoration activities through providing funding, information and support. There appears to be no overall program that addresses restoration.

The Natural Heritage Trust

The Natural Heritage Trust (NHT) was set up in response to increased recognition of the importance of the health of the environment to economic, social and conservation objectives. The NHT focuses on the protection, conservation and sustainable use of Australia's natural resource base through constructive and cooperative partnerships between governments, communities and the private sector. A key aim of the Trust is the better integration of conservation and natural resource management programs to rehabilitate and ensure the protection of the natural environment. The NHT was to be the foundation for the conservation of biodiversity and the ecologically sustainable management of Australia's land and water resources. NHT funding is due to finish in June 2001. Seven of the major programs of the NHT are relevant to river restoration, and may provide funding for river restoration projects.

1. Murray–Darling 2001 Fish Rehabilitation Program

The Murray–Darling 2001 (MD2001 Fish Rehab. Program) was designed to contribute to the rehabilitation of the Murray–Darling Basin. It aims to accelerate activities through the Natural Resource Management Strategy to promote and coordinate effective planning and management for the equitable, efficient and sustainable use of the water, land and other environmental resources of the Murray–Darling Basin.

Funds are available for projects, which implement on-ground activities where the project is part of an agreed integrated catchment management framework. All projects funded under Murray–Darling 2001 require State funding to match Commonwealth NHT funding. Groups, government agencies and others seeking support for activities consistent with the objectives and priorities of the Murray–Darling 2001 Program should apply through the Natural Heritage Trust's annual 'One Stop Shop' process.

2. National Land and Water Resources Audit

The Audit is a four-year, $30m NHT program in partnership with States, industry and community groups to provide an assessment of the extent of natural resource degradation and include an economic analysis of each problem. Primarily, the focus of the Audit will be on the needs of the Commonwealth and State agencies. Local government, rural industries, community groups, and a range of other government and non-government organisations will also benefit from the Audit.

The Audit will provide an appraisal of Australia's natural resource base, in the following areas:

- policy assessment and development;
- investment decisions;
- evaluating program and policy;
- performance; and
- direct resource management, particularly by government.

3. Riverworks Tasmania

Riverworks Tasmania is the public name of the Tasmanian Regional Environmental Remediation Program, an initiative designed to improve and protect the unique environment of Tasmania by reducing and removing sources of pollution.

Riverworks Tasmania is a three-year, $8.75m program which started in 1996. The program brings together community consultation and environmental science to develop individual projects to enhance the water quality and social amenity of Tasmania's key waterways. Funding is from the Natural Heritage Trust, and the program is managed jointly by the Supervising Scientist Group of Environment Australia and the Tasmanian Department of Environment and Land Management.

4. Waterwatch Australia

Separate Waterwatch programs are run in each State and Territory of this Commonwealth program. The programs are educational and aim to monitor the health of local stream, creeks, and rivers using volunteers. Data sets collected by Waterwatch groups are provided to each State or Territory's water quality database. There is a Waterwatch coordinator in each State/Territory.

5. Fisheries Action Program

The Fisheries Action Program aims to rebuild Australia's fisheries to more productive and sustainable levels.

It gives priority to funding practical projects in freshwater, estuarine and marine environments that address the causes of the degradation of fisheries resources rather than the symptoms.

The Fisheries Action Program is run by Agriculture, Fisheries and Forestry – Australia, in close co-operation with State and Territory governments and community groups. The Program meshes with existing State and Territory fishcare activities.

6. Landcare

Landcare is a locally based approach to fixing environmental problems and protecting the future of our natural resources. There are now more than 4,250 Landcare groups across Australia. About one in every three farmers is a member of a Landcare group.

The NLP (National Landcare Program) encourages on-ground action, which will result in integrated and sustainable natural resource management at the farm, catchment and regional level. Support will be provided for the development of locally initiated and managed projects addressing critical issues on public and private land for the public benefit. The NLP will also support an expansion of property management planning to give farmers improved natural resource and business management skills.

7. The National Rivercare Program

The National Rivercare Program (NRP) is a major investment that is aimed at ensuring progress towards the sustainable management, rehabilitation and conservation of rivers outside the Murray–Darling Basin and to improve the health of these rivers.

The NRP seeks to encourage the development of strategic and integrated responses to address identified river issues. Its focus is on freshwater streams. Projects in coastal or tidal areas will not be funded under NRP. The expected outcome of projects is improvement in the water quality and ecological values of river systems. NRP projects should focus on activities that:

- maintain or improve water quality by preventing pollution (such as trapping sediments or nutrients);
- improve the management of discharges or control stock access to rivers;
- manage accelerated erosion or build-up of river banks or beds (where it is ecologically and hydrologically sound to do so); and
- contribute to healthy streams and ecosystems.

Other federally funded programs include:

Living Cities program

The Urban Waterways and Reducing Coastal Pollution element of the Living Cities program addresses urban stormwater, Waterwatch and Urban River Health. The Urban River Health program will establish a national monitoring regime for urban rivers including bioassessment monitoring activities and ongoing development of nationally consistent protocols for assessing urban river health.

The National Water Quality Management Strategy

This strategy aims to achieve sustainable water use by protecting and enhancing water quality while maintaining economic and social development. Guidelines for water quality monitoring and reporting are included in the 20 documents of the strategy. The national water quality guidelines for fresh and marine waters are currently under review. These guidelines are not mandatory. State and Territory governments determine water quality standards.

State of the Environment Reporting

The Australian State of the Environment Report was called for in the NSESD. The report is a key element in providing information on the condition of and the pressures on the natural environment; and societal responses to these pressures and conditions.

Water issues

The Commonwealth and all State and Territory governments undertake state of the environment reporting although there is no national framework. Some States and Territories have a legislated commitment to reporting, others do not. The Commonwealth Government has no legislative obligation to produce state of the environment reports, but has undertaken to produce one every five years. The next is due in 2001.

Conclusion

Restoration activities need to be understood in terms of the relationships with other plans and the system of planning from the local to Federal levels of government.

Restoration plans must also consider State, regional and catchment plans. These, together with linkages to other projects and local regulations, are an important task for the recovery team.

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Links

Understanding relationships between aspects of river restoration is essential for the success of a river restoration project. This understanding provides a context for the project, ensures that all possible resources are identified and utilised, and that the people who need to be informed about the project are informed. Some relationships will need to be actively created and maintained, including the integration of different scientific disciplines, and those between institutions, government and non-government agencies and organisations. Communication processes will create these links. Links between various steps within this river restoration framework also need to be actively maintained via protocols and performance indicators. Other relationships already exist and must simply be identified and used to aid the restoration project. These are the links within and between geographical, geomorphological, hydrological and ecological systems.

Links between people

Links between local and State government and non-government agencies, scientific disciplines and community groups will be useful for:

- sharing information;
- gaining practical support and assessing needs; and
- ensuring accountability with respect to the allocation and auditing of resources.

At the broader level, links between the restoration team and government and international organisations such as International Union for the Conservation of Nature (IUCN) will ensure that the project adheres to the policies and protocols of governments and international agreements.

These links may be created by communication and information gathering via:

- workshops and meetings;
- documentation and correspondence protocols (eg. between funding bodies and project team);
- media – radio shows, regular columns in newspapers and press releases etc.;
- email, obtaining memberships to organisation and inclusion on relevant mailing lists; and
- researching and collecting copies of national and international policies and agreements pertaining to conservation.

Links between elements of the framework

Other important links to make are those between different aspects of this framework. Hansen (1996) describes "The links between professional know-how, democratic processes and the practical world" as essential to river restoration.

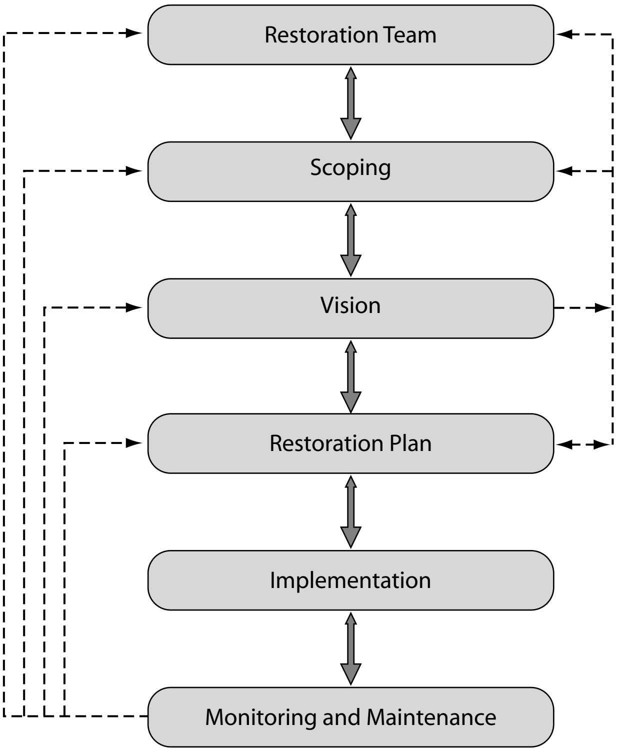

Figure 7. Links between steps of the frame

This framework ensures these linkages by connecting the vision to the plan and the plan to implementation via an objectives cascade from the vision to the prioritised goals used to guide implementation. By following the stepwise process from the beginning, the project will be guided by this cascade, and restoration works will reflect the input of the stakeholders as well as the knowledge of the professionals involved.

It is also important to have a strong connection between the tools that are used and the outputs and outcomes that are required. Linking tools to objectives and outcomes ensures that the choice of tool will lead to the desired endpoint. The restoration team ensures that the most appropriate and efficient tools are used.

As the project proceeds, feedback loops become apparent (Figure 7). The scoping stage will inform decisions about the make-up of the team and the constraints imposed on the vision, while it feeds information into the system assessment stage. The results of monitoring will be integrated into almost all steps of the framework.

Links between the spatial and temporal scales

It also very important that the team recognises links between the spatial and temporal scales over which natural processes occur.

Knowledge of these links will provide:

- a focal point for managers and planners;
- the ability to target predictions and make them useful;
- the ability to identify biophysical responses;
- an indication of the importance of patch mosaics and patch dynamics for management; and
- a framework for interdisciplinary research (Rogers and Bestbier 1999).

Evaluation

The benefits of undertaking evaluation

Woodhill and Robins (1998) suggest that evaluation (in conjunction with monitoring) enables a group to:

- improve the focus and procedures of a project as it proceeds;
- develop the skills and understanding of people involved in a project;
- provide information for planning a new project;
- demonstrate the worth of your group or organisation;
- justify and promote the project to the wider community;
- be accountable to agencies funding a project; and
- contribute information to broader scale monitoring and evaluation.

Determining how effective our actions are in relation to objectives and resources is at the core of undertaking evaluation.

Knowledge

Evaluation is an important component of adaptive management and can help us learn about success and failure. Coupled with monitoring, it can help us determine cause and effect and influence future selection of restoration options. Limitations to our current restoration activities can be recognised so that we can make improvements. Learning about new ways of doing things can increase our feelings of self-worth and empowerment.

We can evaluate our restoration activities in a way that will increase knowledge by asking ourselves:

- Did we do what we set out to do?
- Did it work? Why or why not?
- What will we repeat or do differently next time? (from Woodhill and Robins 1998).

Deciding between different options

When it comes to making the decisions on which technique to use for a restoration activity, evaluation is a useful method with which to make comparisons and determine feasibility. The costs and benefits of the individual techniques can be compared. Such considerations might include the cost of labour and materials against the benefits of improved environment, or the benefits of doing the restoration activity against the costs of not doing the restoration activity at all.

When should evaluation be conducted and what should be evaluated?

Evaluation needs to be an informative, recurring exercise and not something that is “done at the end” (Butterworth and Syme 1997). Records need to be kept and indicators to judge success or failure need to be developed during the initial stages of the restoration process. By leaving evaluation to the end of the process, data may not be available to carry out the evaluation.

The following aspects of the process should be considered:

- The different steps of the restoration process and the process itself to ensure that the process is doing what is supposed to do. Consideration can be given to how the outcomes and outputs of individual steps within the process are being achieved. Adjustments can be made to the way each step is carried out—in terms of adding or removing any part of it that is not helpful to obtaining the outputs and outcomes. Alternatively, the outputs and outcomes may not be reflecting the purposes of the step and hence adjustments may need to be made to them.
- As our knowledge increases, evaluation can be used to adjust the vision and redefine indicators.
- Restoration is not just a technical activity. The reasons why a restoration activity does not do what it is supposed to, or does not occur, may be due to social and economic factors. Social and economic factors likely to effect the success or failure of the restoration activity need to be explored as well.

How is evaluation useful?

Evaluation is of little use on its own. Recommendations stemming from evaluation must be made and implemented. If this occurs, evaluation can assist restoration in five main ways:

- ensuring the health of the stream is improved by the restoration activities;
- ensuring public funds are spent appropriately and are accounted for;
- increasing knowledge;
- deciding between different options; and
- ensuring that the process runs as smoothly and efficiently as possible.

Evaluation should place equal importance on the environmental, social and economic costs and benefits of a restoration activity.

1. Ensuring that the health of the stream is improved by the restoration activities can achieved through:

- a comprehensive monitoring regime that is rigorously carried out;
- a considered choice of indicators to measure within that monitoring regime;
- effective documentation of the monitoring;
- feeding the results and analysis of the monitoring of all restoration projects back into the planning; and
- communicating the results and analysis to other restoration projects.

2. Public accountability can be ensured by:

- evaluating whether or not restoration activities have resulted in maximum on-the-ground (or in-stream) benefits;
- comparing alternative expenditures;
- identifying the uncertainties surrounding the benefits of restoration activities;
- increasing rational decision-making on the basis of the benefits and costs of a plan;
- increasing understanding of the uncertainties surrounding the benefits of restoration activities;
- prioritising between competing investments;
- producing equitable cost-sharing arrangements by identifying who benefits and by how much; and
- targeting scarce resources to specific priority restoration activities.

3. Knowledge is accumulated through:

- sampling before and after the restoration activity so that there is a record of how things have changed;
- assessing causal links by coupling evaluation with monitoring;
- recognising limitations to our current restoration;
- innovation, which may stem from negative evaluation;
- evaluating the progress of the selected restoration activity; and
- exploring social and economic factors that are likely to effect the success or failure of the restoration activity.

4. Different options can be compared by evaluating costs and benefits of the individual techniques and outcomes

The restoration *process* can be assessed in terms of:

- the overall process (ie. question whether the process is improving restoration activities on the ground);
- the different steps of the restoration process, by matching the outputs and outcomes to what actually happened—can these steps be improved? What procedures could you put in place to improve them?
- evaluation is an integral part of maintaining ownership and encouraging empowerment. Positive feedback will increase feelings of self-worth in participants and constructive negative feedback will define a new direction and encourage innovation;
- evaluation can be used to adjust the vision and redefine indicators;
- are the outputs and outcomes satisfactory or should they be adjusted? ie:
  outputs—is the restoration activity producing the desired output? For example, an increase in tourism or a reinstatement of the natural process;
  outcomes—is the restoration activity having the desired consequence? For example, future developments are increasingly ecologically sustainable.

What factors will influence evaluation?

There are many methods available for conducting an evaluation. Important considerations include the following:

- Some factors of a river environment are easy to measure and quantify as numerical data, for example costs, abundance of species and river heights. Other factors can be considered only by their characteristics of having or not having a certain quality or property, for example, aesthetic and recreational values. Evaluation methods need to be able to compare both types of data.
- Value judgments—the world views that we have can influence the values we place on different factors. This can mean that evaluation can be subjective depending on the individual's world views.
- Imperfect knowledge and uncertainties—we don't know all the answers to technical questions let alone social and economic questions.

Internal or external evaluation

Evaluation can be participatory, if it is conducted internally, and can lead to increased knowledge and refinement of the restoration activity. Independent evaluations are conducted by external groups or individuals.

- External evaluation may be less subjective than an internal evaluation but it may also be more threatening.

Evaluation checklist

The following checklist is an example to provide direction. A summary of each of these lists can be found in Section II. Some of the items will be relevant to all projects. For most projects, however, the list will need to be changed. Additions and subtractions may be made to the checklist according to the type of restoration activities being undertaken and the nature of the project as a whole.

1. Building the restoration team

- ☐ Has the restoration team been brought together?
- ☐ Is the team made up of a range of scientists and community representatives?
- ☐ Is a range of disciplines represented?
- ☐ Will key members see the project through to completion?
- ☐ Are the political/commercial/value conflicts manageable to the point that worthwhile outcomes can be reasonably expected?
- ☐ Have all the participants been informed of the restoration initiative?
- ☐ Have linkages been recognised and formalised?
- ☐ Has there been communication with the wider community, including education and awareness raising
- ☐ Has the decision structure been developed and point of contact identified?
- ☐ Does the restoration team have the skills and information to succeed in the tasks?
- ☐ Have funding sources been identified?
- ☐ Is the team developing and managing the restoration plan?
- ☐ Is the team overseeing implementation, monitoring and evaluation?
- ☐ Is the team documenting the process?

2. Scoping

- ☐ Have funding sources been identified?
- ☐ Has a list of skills and resources been completed including identification of the appropriate scientific, participatory, and managerial tools available to complete each of the steps of the project?
- ☐ Has a list/map of strengths and constraints been completed?
- ☐ Has and assessment of the adequacy of the current research base been completed?
- ☐ Have baseline data—biophysical, social, economic—been collected at a number of scales and analysed?
- ☐ Have the current and previous structure and function of the waterway ecosystem been identified?
- ☐ Does everyone involved recognise the main strengths and degrading influences of the system?
- ☐ Is there a good understanding of the context of the project by all those participating in it?
- ☐ Have community concerns regarding the restoration project been identified?
- ☐ Has a description of the depth and breadth of the restoration project been completed, including the boundaries described by biogeography, financial, available information, time frame been identified?
- ☐ Has an initial list of priorities been completed?
- ☐ Has a digital or hardcopy database been established?
- ☐ Have the potential impacts/outcomes to be assessed been identified?

3. Establishing the vision

- ☐ Has a broad range of interest groups been included to establish the vision?
- ☐ Has a vision statement(s) been written?
- ☐ Has the vision been arrived at by consensus?
- ☐ Is the vision clear?
- ☐ Is the statement expressed in a way that is inspirational?
- ☐ Has consensus been reached on the mission of the restoration initiative?
- ☐ Has a biophysical basis been defined in terms of what is achievable? (At the very least we must know that the restoration team’s vision is attainable.)

4a. Restoration plan — system assessment

- ☐ Has the expert panel approach been used for system assessment?
- ☐ Have each one of the following elements of the system been assessed: riparian, geomorphological, biological/ecological, water quality and flows?
- ☐ Have the possibilities for improving quantity and timing of flow relative to biological requirements of in-stream communities been determined?
- ☐ Have spatial and temporal linkages, which influence system condition, been identified?
- ☐ Has a natural state or reference condition of the river been established as objectively as possible?
- ☐ Has a reference reach been identified?
- ☐ Has a report on the health of the river, including degrading processes and limitations to restoration, been produced?
- ☐ Does the report:
  - – identify appropriate river structure given prevailing boundary conditions;
  - – identify vegetation and habitat required for river structure;
  - – include a survey and assessment of all weirs, dams, and levees, to determine their impedance to migration and dispersal for in-stream organisms;
  - – include information on the stream flow necessary for adequate function of in-channel restoration structures; and

  - include a survey and assessment of risks of impingement and entrainment of fish at water abstraction points?
- ☐ Will the information provide good ‘before data’ to compare with data collected after the restoration project is completed?
- ☐ Do participants have an appropriate understanding of their river system and the physical limitations of restoration?
- ☐ Have adaptive management principles including the precautionary principle been considered?

4b. Restoration plan — problem definition

- ☐ Have the problems been clearly defined and communicated to all stakeholders?
- ☐ Have limiting factors been identified?
- ☐ Has problem definition led to a need to change the restoration team structure?
- ☐ Do the problems reflect the historical analysis of changes to the river system?
- ☐ Have the problems been framed in terms of the catchment as well as individual sites?
- ☐ Has the problem been defined with reference to the unique elements of the catchment?
- ☐ Have restoration problems been described in terms of managerial requirements?
- ☐ Has problem definition been balanced by identification of the strengths of the system?

4c. Restoration plan — objective setting and prioritisation

- ☐ Are the objectives measurable and clearly stated?
- ☐ Do the objectives assist in realising the broader based vision?
- ☐ Is there consensus on stated objectives?
- ☐ Are the causes rather than the symptoms being addressed?
- ☐ Do the objectives cover monitoring, evaluation and maintenance, as well as restoration activities/on-ground work?
- ☐ Have the objectives been prioritised?
- ☐ Have stream reaches been prioritised on a catchment by catchment basis beginning with the most rare or pristine habitats to set aside for protection?

4d. Restoration plan — assessing options and selecting activities

- ☐ Have you explored all alternatives?
- ☐ Have you undertaken a feasibility analysis?
- ☐ Have you considered monitoring options?
- ☐ Has the ‘do nothing’ option been explored?
- ☐ Have the methods for each of the steps of the project been identified?

4e. Restoration plan — finalising the plan

- ☐ Does reach based plan integrate with other plans?
- ☐ Does the plan reflect the vision and objectives?
- ☐ Have measures of performance and time-lines been set?
- ☐ Have roles and responsibilities of the various people/ groups involved been identified?
- ☐ Have contingency activities been noted?
- ☐ Have the risks been assessed?
- ☐ Does the plan comply with relevant legislation and guidelines?
- ☐ Has the plan been ‘signed off’?

5. Implementing the plan

- ☐ Have roles and responsibilities of the various people/ groups/ contractors involved been assigned?
- ☐ Have quotes, budget allocations, and contracts (where necessary) been finalised?
- ☐ Has a site-map of the works been completed?
- ☐ Has the detailed time-line for the works been completed?
- ☐ Has a reality check been done—are the works and works schedule feasible?
- ☐ Have site clean-ups been scheduled?
- ☐ Has a celebration for the completion of the works been scheduled?
- ☐ Are qualified and experienced supervisors present to oversee restoration activities and works?

6. Monitoring and maintenance

- ☐ Are right scientific questions being asked?
  - do they relate directly the way in which the system has responded to restoration activities?
- ☐ Are the appropriate experts involved?
- ☐ Look back. Has the process been set up in such a way as to facilitate good monitoring and evaluation; ie. are there:
  - well framed objectives, to show what the aim of the activity is;
  - sensitive indicators, the elements that are measured to indicate whether the objectives are being met need to show detectable changes within the monitoring time frame;
  - appropriate benchmarks and criteria—reference sites and criteria must represent the natural, historical state of the target site(s) or provide a meaningful basis for comparison given prevailing boundary conditions?
- ☐ Are the correct components of the system being measures?
- ☐ Has monitoring, maintenance, and modification of works or management activities been budgeted well into the future?
- ☐ Are monitoring results being fed back into the community and the plan?

☐ Do you have a maintenance schedule and a maintenance budget?

General questions

☐ What organisational issues have you had to address?
☐ What lessons have you learnt?
☐ How have you made this information available for other groups to use?
☐ What tools have you used?
☐ Would you use them again? Why? Why not?
☐ Who were the funding bodies for the restoration activities?
☐ Were their any other potential financial backers that could have been approached?
☐ How can the plan be adjusted as new results become available?

Tools for evaluation

Tool	Purpose/When to Use the tool
Contingent valuation method (CVM) An evaluation method that accounts for environmental and socio-economic impacts of on-ground works; evaluation method that takes into account people's values	To evaluate the socio-economic and ecological impact of on ground works
SWOT Strengths, weaknesses, opportunities, and threats analysis; can be done as a brainstorming exercise or as a synthesis of other information	For assessment, scoping, evaluation
Vision day/field day	To discuss the main themes arising from questionnaires and smaller vision sessions. Relevance, priority as well as the connection to the purpose of the project can be discussed for vision setting, education, assessment, priority setting, evaluation
***Rapid Appraisal of the Economic Benefits of River Management* Volumes 1 and 2**	Assist catchment management authorities throughout Victoria with the evaluation of waterway management strategies and programs
Multicriteria analysis	Provides a means to assess value that considers more than monetary estimates of value
Benefit–cost analysis	To compare benefits of actions with the monetary costs
A Rehabilitation Manual for Australian Streams	Provides technical evaluation methods
Performance evaluation	To assess how effective implementation was with respect to specific chosen biophysical parameters or indicators
Trend assessment	Longer term sampling to evaluate changing biophysical conditions at various spatial and temporal scales
Risk analysis/assessment	To identify and when possible quantify risks for each restoration activity under consideration

Adaptive Management and Community Participation

Adaptive management

A flexible approach is required when managing complex and variable natural systems, such as Australian rivers. One such approach is known as adaptive environmental assessment and management (Walters and Holling 1990), which recognises that management action is often required within a framework of incomplete knowledge. The principle of adaptive management or ‘learning by doing’ proceeds on the basis of using the best available scientific knowledge whilst recognising uncertainty in scientific understanding. This means that plans can be initiated without further extensive studies, and with appropriate monitoring and evaluation, new information can be adapted to progressively improve management. This allows actions to be undertaken using the best available knowledge, with the results of those actions adding to the knowledge base. Properly designed management actions can mean that learning from mistakes can add to our knowledge base.

Uncertainty occurs largely through our lack of understanding of our biological systems and the way that they function. By consciously recognising uncertainty, however, we are able to better understand and forecast the likely consequences of our actions. Uncertainty means that our approach to management should be an iterative, open-ended, adaptive process. It is not always feasible, cost effective or possible to use clever experimental design to answer key questions. Scale and cost also mean that often key factors cannot be separated from all other possible environmental influences.

Adaptive environmental assessment and management (AEAM) is a philosophical and methodological framework designed to deal with the uncertainties inherent in environmental change (Doolan and Grayson 1995). Recognising that precise predictions of ecosystem responses to management actions are not always possible, it takes an exploratory and adaptive approach based on an assessment of the ‘whole system’. This takes into account natural variability and system dynamics without attempting to represent every process in detail. It uses a computer simulation model to predict responses to a range of options. Monitoring programs can then be designed and data collected to refine the model and increase understanding.

AEAM is a process that links people with a common problem, using existing knowledge as efficiently as possible in order to develop and evaluate management options. It is often said that the formulation of the model teaches more than the model itself. The model and process also present technical information in a readily digestible form. The use of the process and the principles of adaptive management do not necessarily have to incorporate a computer model to gain better results.

Given that current knowledge of ecosystem processes in Australian river systems is incomplete, and that substantial gaps exist in the knowledge of river ecology and functioning in Australia, a flexible and adaptive approach to river restoration is both appropriate and necessary.

Community participation

Community involvement in river restoration is essential because the community usually owns the land adjacent to the stream (Smith 1999). Community involvement or participation needs to be true ownership of the local project, where ownership constitutes real input to decision-making processes and commitment to follow through all steps outlined in the National River Restoration Framework.

The National Strategy for Ecologically Sustainable Development (Intergovernmental Committee for Ecologically Sustainable Development 1996) couches participation in terms of education, communication and “informed contributions” but not control over decision making. Although education and communication aid effective participation they are not, in themselves participation. Authentic participation must involve empowerment.

Support for participation (Intergovernmental Committee for Ecologically Sustainable Development 1996) can also be described as devolving responsibility to the community, in programs that lead to ecologically sustainable development (Intergovernmental Committee for Ecologically Sustainable Development 1996).

Ownership, along with commitment to the river restoration process, ultimately resides with the body that has control over it. Approaches may vary on a regional or project-by-project basis, depending on the existing structures within the local area. Some areas may have government agencies that are responsible for waterway and or catchment management. These agencies may take undertake river restoration with some community input. In other areas, land and resource management responsibilities may reside primarily with Landcare groups and restoration will be more likely to be implemented and owned by the community. In cases such as these, it is recommended that existing structures are used to implement restoration.

Government agencies responsible for natural resource management such as Catchment Management Authorities in Victoria, will often facilitate community participation in land and, increasingly, in river management activities. Where these types of bodies are less community orientated, existing Landcare structures may be used to implement river restoration. The National Landcare Program (NLP) has created a platform of participation upon which more sustainable resource management can be built (Morrisey 1999). NLP is a very good participatory model and has an established membership that is likely to be interested in undertaking river restoration activities.

Community participation and ownership in river restoration is engendered by this National Framework via the restoration team, encouraging involvement in restoration activities and communication and education strategies.

The National River Restoration Framework is in its early stages. Thus, to obtain effective participation, the most important task is to make the community aware of the importance of river restoration and the existence of the National Framework. Education about the most important elements of river restoration must be available for groups which show interest in undertaking river restoration activities. Maintaining participation over time depends on adequate policy, legislative and financial responses to the needs and issues raised by participants. On a local level, groups will often need ongoing support and direction from government agency staff. Successful participation in these groups also depends on high levels of citizen involvement, equity, and cost efficiency (Sewell and Phillips 1979).

SECTION IV: TOOLS FOR RIVER RESTORATION

Introduction

The term ‘tool’ refers to equipment, sources of information, processes, techniques, and methods that may assist in undertaking river restoration.

A range of tools is presented within this framework. Some of these are applicable across a range of steps while some are relevant only to a particular step. While this manual does not determine which tool is appropriate for each step, it provides guidance on the type of tools available, their purpose, resources required and scope.

The choice of tool will be influenced by many factors including:

- budget;
- time availability;
- scale;
- data collected and knowledge base;
- personal experience;
- access to equipment and sites; and
- what expertise is available.

Use caution when choosing a tool. Consider the assumptions of the tools, such as the data needed before you can use them. When assumptions are not explicit, try to determine them. In this way, the best tool can be selected for the purpose.

The following table provides a number of tools that are currently being used for river restoration activities. Some tools are well developed and have been tested under a range of conditions while others are less developed and more experimental. It is important to communicate with people who have experience in using the tools so that the limitations (listed as ‘Scope’ in the table) are considered.

Tools are listed in alphabetical order by name.

Key

Tool – name of the tool and brief description

Purpose /when to use – what the tool is used for; the situations for which it is most applicable; and at which step to use it.

Resources – cost and skills required or training needed to use the tool.

Scope – spatial and temporal scale for which the tool is designed; level of development and complexity; linkages; data required before the tool is used; and limitations/ weaknesses.

Reference – scientific papers; government publications; website addresses; and organisations that have information on the tools.

Tools from A–Z

Tool	Purpose/When to use the tool	Resources required – skills, cost	Scope	References
Action planning A list of actions, who, when, resources etc.	To help timetabling and allocation of tasks Implementation	Low level facilitative skills; low cost	Within the bounds of the projects	Woodhill and Robins 1994
A–D grading of rivers A method of stream foreshore assessment based on riparian vegetation, erosion, siltation, riparian soil cohesion, human induced disturbance	To aid system assessment especially for riparian assessment	Some training needed to do the assessment; low cost	Aimed at volunteers, landholders and community groups	Pen and Scott 1995
Aerial Video Spectroscopy	For riparian assessments of large and/or remote areas. Scoping/System Assessment	Expensive but will cover large areas cheaply relative to conventional on-site reconnaissance or river walks if areas are vast and/or remote.	Large geographical scales. Relatively low resolution and needs some ground truthing.	Steve Janicke, WRC Western Australia.
AEAM (Adaptive environmental assessment and management) Decision support system that operates on a computer modelling/ workshop platform incorporating economic social and environmental components of the system	To set priorities; can also be used for Evaluation Monitoring and Maintenance	Can be modified to suit available skills; low cost	No set complexity – can be modified according to need	Doolan and Grayson 1995
A Rehabilitation Manual for Australian Streams Vol 1 See under 'M' – Manual				
AusRivAS (and other RIVPACS based models) Gives a broad-scale assessment of river health for different regions within a state or territory using macroinvertebrates as indicators	For the rapid assessment of river conditions or 'health' using macroinvertebrate communities System assessment Monitoring and Evaluation	Scientific skills; medium cost	Complex	Barmuta *et al.* 1999

Tool	Purpose/When to use the tool	Resources required – skills, cost	Scope	References
Bed replenishment Artificial addition of bed materials or capturing bed materials being moved down the stream in sediment traps	To reinstate natural or optimal bed materials into section of stream in order to provide habitat for aquatic organisms and stabilise incised stream Implementation	Scientific and engineering skills needed; medium to high cost	For site rehabilitation	Rutherfurd *et al.* 2000
Benefit /Cost Analysis (BCA) Somewhat like SWOT analysis (see 'S') potential costs and benefits of an activity, or objective are listed and may be quantified for use in prioritising	To understand positive and negative aspects and resources needed for an activity or objective Scoping, Evaluation, Select Options and Activities	No skills needed or costs involved	Any scale relevant to the project	Coffey 1994 Rutherfurd *et al.* 2000
Bio Map System of mapping flora and fauna data in Victoria	To map flora and fauna data from a range of data sources onto the one map System Assessment	No need for additional software or training and NRE staff can complete maps on-site from any networked computer	1:100 000 map sheet; 30 m resolution; 24 data sets overlayed	http://resourceweb/corpmgt/itt/netreg.html
Brainstorming a group of people think of as many ideas as they can about the topic in question	To quickly gather many ideas without getting unduly caught up in discussion Restoration Team, Vision Setting	Low level facilitative skills; low cost	Any scale relevant to the project	Woodhill and Robins 1994
Cause and effect mapping Fish bone diagram with effect at the end of the spine and main causes as ribs. Contributors to the main cause can be sub-branches of the ribs	To explore the contributing causes or reasons for a particular problem or issue and to help identify root causes rather than symptoms Scoping; Problem Definition	Low level facilitative skills; low cost	Any scale relevant to the project	Woodhill and Robins 1994
Celebrations of achievements	To maintain motivation Restoration Team	Low level organisational/event coordination skill; low cost	Local/site scale but may be larger depending on scale of activities	n/a

Tool	Purpose/When to use the tool	Resources required – skills, cost	Scope	References
Communication strategies **Receiving Input** Public hearings, task forces training seminars, surveys/interviews, focus groups, workshops, phone in radio programs, internet websites **Informing participants and the community** Generic messages (sound bites and slogans that the public can remember easily), advertising campaign; community service announcements; street stalls displays	To raise awareness of the importance of rivers and river restoration Restoration Team	Media liaison skills and written communication skills; variable costs	Media liaison skills; broad coverage of the population; links between community and scientists	n/a
Community research/mapping Networks, wants and needs	To gain information about the dynamics of the community – key members of community groups, etc. Scoping	Sociological/community development skills required; medium cost	Catchment – local scales	Hawtin 1994
Contingent Valuation Method (CVM) An evaluation method that accounts for environmental and socio-economic impacts of on ground works	To evaluate the socio-economic and ecological impact of on-ground works	Sufficiently large budget and knowledge of the complexity of CVM is needed to address its inherent problems; high cost	Intensive preliminary research needed Cannot be generalised – the results of CVM used for one issue cannot be applied to another	Bennet *et al.* 1997 Cameron 1997
Costing	To find out and document an approximate cost for activities during scoping, objective setting and selecting options	Low cost	Up-to-date information on prices needed	Rutherfurd *et al.* 2000
Creative analysis A range of exercises such as mini brain storming, lists of pros and cons etc	To escape from being 'mentally blocked' Restoration team	Low level facilitation/education skills; low cost	Any scale relevant to the project	Rickards 1990

Tool	Purpose/When to use the tool	Resources required – skills, cost	Scope	References
Critical systems heuristics	To determine the boundary of the system with due consideration to subjective interested, values and knowledge of those who judge	Scientific skills needed	Links participation with knowledge accumulation and problem definition	Ulrich 1993 Hutchinson 1999
Double paired weighting A process by which alternatives are assigned a rank and the highest ranking alternative becomes the highest priority	To set priorities	Minimal skills; low Cost	Simple	Koehn *et al.* 1997 pp. 56–59
Environmental Impact Assessment NSW Determination of ecological, social and economic impacts of a development and proposed measures to protect the environment	To ensure that any development of a visually or ecologically sensitive site is subject to the most rigorous assessment of environmental impact	Scientific skills needed; high cost	Complex	
Expert/scientific panel Multidisciplinary group of scientist/expert who conduct an assessment based on visual assessment and baseline	To use for Scoping, System Assessment and Priority Setting; Monitoring and Maintenance	Scientific skill; low Cost	Complex; site specific; can be limited by group dynamics	Arthington 1998
Fish surveys Sampling streams and comparing expected versus observed data, species richness and abundance indices etc. (eg. NSW Rivers Survey and Standardised Surveys)	To aid in the system assessment as well as evaluation and monitoring steps of the framework	Some biological/fish knowledge required. Experience in netting and electro-fishing required.	Passive (net) methods do not capture variability in abundance due to dependence on species, and activity etc.	Harris and Gehrke 1997
Fish/platypus cover Protecting undercut banks and installing large woody debris (LWD) – anchored, unanchored, pendants, clumped, log jams	To provide habitat, spawning sites and cover for fish and platypus in a way that mimics natural conditions and orientation For Implementation	Low cost; some scientific and engineering knowledge to decide on placement	Large woody debris should be seen as stopgap until a regenerated riparian zone can supply timber to the stream. Not all streams have LWD naturally eg. tropical streams Important design constraints in relation to erosion	Rutherfurd *et al.* 2000 Koehn and O'Connor 1990

Tool	Purpose/When to use the tool	Resources required – skills, cost	Scope	References
Fishways Rock ramp, riffles, flooding culverts with down stream weirs, vertical slot fishways Inventory and prioritisation of fishways	To allow fish to move up and down stream of barriers which is may be essential to maintain life cycle characteristics for some species For Implementation	Scientific and engineering knowledge needed; medium to high cost	Needs to take natural flow and structural conditions into account Other important design constraints	McGuckin and Bennett 1999
Flow diagrams Write down the action to be taken at the bottom of a page, map out steps that need to be taken and factors affecting that action	To illustrate and analyse consequences (positive and negative) of particular issues/actions For Problem Definition;	Low level facilitative skill; low cost	Any scale relevant to the project	Woodhill and Robins 1994
Flows assessment The best practice framework for environmental flows Cascading seasonal flows methodology	To assess the amount of flow required to minimise negative ecological impacts System Assessment	Scientific skills required; high cost	Catchment scales	Arthington, 1998 Doeg, in press
Freshwater ecology courses/field days Education, community consultation, On-site examples, of riverine ecology and degradation	To increase understanding of riverine ecology, scope views and inspire action Trainers and community group leaders should be targeted Vision setting	Scientific and educational skills required	Links between community and scientists Scale: on site	Parks Flora and Flora NRE Vic
Full width structures Low structures that span the width of the channel and are overtopped by water at most flows including gabion, rock boulder structures and artificial riffles and experimental (not yet tested) structures	To stabilise the stream bed by forming a backwater pool upstream and a scour pool and bar formation downstream Implementation,	Engineering and scientific skills essential; medium to high cost	Several important constraints on design especially year-floods that they are designed to withstand	Rutherfurd et al. 2000

Tool	Purpose/When to use the tool	Resources required – skills, cost	Scope	References
Geophysical/ ecological/ biological data and reports Climate, soils, environmental problems, land capability maps, presence/absence data, species richness data, threatened/ endangered species list, farm and catchment plans, reports commissioned by water and land management authorities	To obtain baseline data and information during to use during scoping Scoping; System Assessment;	Minimal skills; low cost	Catchment scale maximum time scale should be sought	n/a
GIS Mapping and Modelling Geographic information system Satellite imaging of vegetation land use types, precipitation, geographical features, Arcview.	To present information such as hydrological, catchment boundaries, streams, development, on a spatial basis. Output can be in a format suitable for assisting managers and communities to plan Scoping; Monitoring and Maintenance	Needs high level skills and is time consuming therefore can be quite expensive It is worth looking into GIS information that has been gathered already	Should only be used if data is distributed widely and applicable to a number of other parties Dependent on the quality of available data and field checks Lack of biological information Links physical attributes to spatial scales Can be linked to modelling programs	Natural Resource Systems, DNRE Vic Rutherfurd et al. 2000
Group and project records documenting financial, activities, meetings, media coverage, membership	To learn from past experiences and remain accountable to funding bodies and to the public Restoration Team	Administrative skills; project management software	To be used at each step of the project	Woodhill and Robins 1994
Habitat surveys Aerial photos, snag counts, aquatic vegetation, riparian vegetation	To assess the habitat as it relates to the health of the system; System Assessment; Monitoring and Maintenance	Scientific skills; medium cost	Some methods limited by subjective quantification of the amount of habitat	n/a
Historical records/reconstruction approach Including photographs, explorers diaries, surveyors notes, archival records, railway and road bridge cross sections, local interviews, historical societies	To define river restoration trajectory by outlining pre disturbance state using crosschecked data Creates sound basis for restoration activities and thus increases cost effectiveness Scoping; System Assessment	Some research skills needed; low cost	The information may not be available in all areas; in-stream and flood plain conditions may have been irreversible altered so attempt to recreate the 'original' state will fail	Davis and Finalyson 1999 Erskine and Webb 1999 Rutherfurd *et al.* 2000

Tool	Purpose/When to use the tool	Resources required – skills, cost	Scope	References
Hydraulic models Faraday and Charlton Method Manning's Equation (simple mathematical) Backwater analysis (Complex mathematical) Steady state Models eg. HEC, RAS Hydrodynamic Quasi 2 models eg. EXTRAMS and Mike 21 Full 2D models eg. cells models and Mike 21	To predict the effects of in-stream structures (eg. the size of scour holes) and to aid in understanding of flow/flood depth, velocity etc Also type of flow flood assessments, low flow assessments and risk assessments System Assessment; Monitoring and Maintenance	Technical knowledge required to use it – engineers, hydrologists, geomorphologists	Catchment scale	Rutherfurd *et al.* 2000 Open Channel Hydraulics
Hydrologic Models/Analysis Rainfall–run-off models River gauging data Flow duration analysis Annual flood frequency curves	To aid in assessment and understanding flow regimes in stream systems during assessment and design The listed tools move from the rapid, 'black box' type of approach (eg. rational method) through to the complicated distributed parameter, process type models (TOPOG); System Assessment; Monitoring and Maintenance	Scientific skills; Low cost Some knowledge required to use it – ecologists, hydrologists, engineers, geomorphologists	Complex, relevant to a variety of scales	Arthington 1998 CRC Catchment Hydrology Centre for Environmental Applied Hydrology
Index of Biotic Integrity (IBI) method of assessing the relative environmental quality of a diverse set of rivers on a consistent standardised basis in an approximate ecological area	To assess environmental quality of the river System assessment; Monitoring and Maintenance	Fish biology/ecology skills needed High cost	Medium complexity, need baseline data on 'metrics'; all results are relative; still in need of validation and comparison with other river health assessment schemes	Harris and Silveira, 1997
Index of Stream Condition The Index is a measure of a stream's change from natural or ideal conditions by assessing hydrology, physical form, streamside zone, water quality and aquatic life	To benchmark the condition of streams, assess the long-term effectiveness of management intervention in managing and rehabilitating streams and aid objective setting by waterway managers, Monitoring and Maintenance	Scientific skills; primarily for water mangers not scientists	Medium level of complexity, scale stream reach (tens of kilometres), long term	Anonymous 1997

Tool	Purpose/When to use the tool	Resources required – skills, cost	Scope	References
Interrelationship diagrams Between 5 and 20 factors contributing to the problem are listed in a circle Each is identified as cause or effect of another Arrows point from 'causer' to 'causee'. Factors that are most often the 'causer' will be the driving factors and should be focused on	To identify which, out of a series of causes, are the most important and how they relate to each other To stimulate discussion, analyse information and determine priorities Problem Definition	Low level facilitative skills; low cost	Any scale	Woodhill and Robins 1994
Invitations to events Target people by geographical, environmental, cultural, industry, activity, community characteristics	Target key community 'individuals' and get them on side Personalised invitation increases the likelihood of attendance and participation Restoration team, Vision setting	Low cost and skills	n/a	n/a
Knowledge brokers/extension officers Department personnel responsible for scientific education and information transfer	To increase understanding of broader scientific problems and methods Vision setting	Education/facilitation skills Technical knowledge	Links between community and scientists	Government department responsible for land and water management in your state
Ladder of inference	To build an awareness of individuals thinking and reasoning Restoration Team	Facilitation may be needed to guide people though the ideas	May be too esoteric. Needs some background knowledge to be used effectively	Senge *et al.* 1994
Level 1 Analysis of The Interior Watershed Assessment Procedure A guide to mapping a catchment, including underlying geology, roads and stream crossings, areas of potential erosion, riparian buffers, land uses and recording peak flows	To aid initial assessment during Scoping	A level of training and scientific skills needed	Will need adjustment to incorporate different geology, land uses, conservation values and variable flow regimes associated with Australian rivers and streams	Anonymous 1995

Tool	Purpose/When to use the tool	Resources required – skills, cost	Scope	References
Locality mapping An outline of the local area is drawn – roads, towns, property boundaries etc. A map projected on to a wall and the group can add information to the map by using sticky notes	To help identify who is undertaking certain activities, where degradation problems exist and where improvements have been made by drawing on local knowledge. Also, to identify geographical regions about which little is known Scoping	Reduces the risk of obstructive conflict; low cost	Links Scoping to Vision and geographical prioritisation in the restoration plan	Woodhill and Robins 1994
Longitudinal bank protection (revetment) Directly armouring the bank to protect it from abrasion should be used in conjunction with revegetation	To control erosion and consequent sediment yields, enhance pool depth and stabilise banks for future riparian regeneration Implementation	Engineering and scientific skills essential; high cost	Some methods may restrict vegetation from establishing, prevent access to the bank by platypus and/or reduce in-stream cover by preventing undercutting and macrophyte growth at the stream edge	Rutherfurd *et al.* 2000
Manual – A Rehabilitation Manual for Australian Streams Vol 1 Topics include rehabilitation concepts, and a 12-step rehabilitation procedure with emphasis placed on physical rehabilitation especially stream stabilisation and stream habitat	To aid with assessment and planning Restoration team; Finalising the plan, Implementation	Minimal skills; Low Cost	Written to be used by community groups and catchment managers with some level of knowledge of river processes and rehabilitation techniques	Rutherfurd *et al.* 1999
Manual – A Rehabilitation Manual for Australian Streams Vol 2 Includes a comprehensive list of planning, intervention (ie. in-stream habitat structures), and evaluation tools as well as discussion on common stream problems	To aid with assessment and planning Restoration Team, Finalising the plan; Implementation	Minimal scientific and engineering skills; low cost	Emphasises temperate streams and some aspects may no be applicable to tropical streams	Rutherfurd *et al.* 2000

Tool	Purpose/When to use the tool	Resources required – skills, cost	Scope	References
Manual – Riparian Land Management Technical Guidelines Volumes 1 & 2	To inform about the physical and ecological processes of riparian lands and management guidelines including the management of nuisance plants, riparian terrestrial wildlife and stream erosion	Some lower level scientific/ engineering knowledge; low cost	Produced for use in the field	AFFA Tel 1800 020 158 Email shopfront@affa.gov.au
Manual – Rivercare River condition assessment with a focus on community planning, riparian vegetation, stream alignment and stability	To provide a rapid coarse assessment of reach condition with the view to aid community planning for riparian revegetation, and stream alignment and stabilisation System Assessment; Implementation	Scientific skills and training needed	May be limited to northern NSW coastal areas	Raine and Gardiner 1995
Manual – Stream analysis and fish habitat design: A field manual Topics include: planning; field surveys; stream behaviour; and design and construction of stream habitat works	To use in conjunction with the National Framework for a detailed understanding of the physical components of the river system, 'soft engineering' approaches to the design of in stream habitat structures Restoration Team; Finalising the plan; Implementation	Some lower level scientific/ engineering knowledge; low cost	Limited as it is not based on Australian conditions and narrow emphasis on fish habitat	Newbury and Gaboury 1993
Manual – Stream stabilisation for rehabilitation in North-East Queensland A guide to rehabilitation with a focus on tropical environments	To use in conjunction with the National Framework Restoration team; Finalising the plan; Implementation	Some lower level scientific/ engineering knowledge; low cost	Emphasises stream engineering techniques	Kapitzke *et al.* 1998

Tool	Purpose/When to use the tool	Resources required – skills, cost	Scope	References
Matrices One axis with processes that degrade and the other with social, economic, ecological, geomorphic, hydrological elements that are affected. Each is then ranked against the other Also, to prioritise solutions, degrading process on one axis and possible solutions on the other	To gain a clear idea of the priorities with respect to degrading processes, important elements to repair or problems to solve Problem Solving; Objective Setting and Prioritisation	Low level of skill and cost	Within the scale of the project may also look at processes over the catchment	Coffey 1994 Kennedy and Ross 1992
MBACI Multiple Before and After Control Impact	To design an experimental approach to river restoration activities Assessment and Evaluation, Monitoring and Maintenance	Scientific skills; high cost	Complex	Stewart-Oaten *et al.* 1986, 1992
Meander reinstatement Putting meanders back into the stream	To reverse deepening and widening and consequent ecological degradation caused by stream artificial straightening Implementation	Engineering and scientific knowledge needed; high cost in some cases	Channel deepening and other large-scale degradation precludes re-meandering	Rutherfurd *et al.* 2000 Newbury and Gaboury 1993
Microsoft Project Software package	To aid project management – budget, schedules personnel etc. Restoration Team	Some training needed; low cost	Does compensate for bad organisational skills	n/a
Mind mapping The central idea is written down and then a dendrogram (like a tree) is formed with ideas expanding outwards from the central issue	To cluster ideas to see links between them and to pick out the most important issues when discussing or brainstorming Scoping	Low level facilitative skills; low cost	Any scale	Woodhill and Robins 1994
Multiple criteria analysis/ multiple criteria group decision support systems Options ranked according to dominance or relative importance within the aggregate benefit	To support group decision-making processes by quantitatively assessing multiple options against goals or values Restoration Team; Objective Setting and Prioritisation; Select Options and Activities	Some knowledge required to use it – project team, project officer, manager High degree of technological knowledge needed to run the programs	Has not been used in river restoration before Often underdeveloped and not user friendly	International Society for Multiple Criteria Analysis http://www terry uga edu/mcdm// Davey and Olson 1998 Sanchez and Tummala 1990

Tool	Purpose/When to use the tool	Resources required – skills, cost	Scope	References
Oral history see under 'H' – historical analysis				
Other Design Tools Rock size analysis eg. CHUTE, RIP RAP Meander analysis methodologies Scour depth analysis Alignment approaches	To design restoration structures Implementation	Some knowledge required to use it – engineers; varied costs	Good data collection prior to use is required	ID&A
Partial width bank erosion control structures Including groynes (non-permeable and limited in their usefulness), retards (permeable) and relatively untested structures	To stabilise the bank by moving the attack point to a hard structure, or moving the thalweg of the stream away from the eroding banks to narrow or stabilise over-wide streams Implementation	Engineering and scientific skills essential	Several important constraints on design especially year-floods that they are designed to withstand	Rutherfurd *et al.* 2000
Press releases or regular newspaper columns, reports etc.	To raise public awareness of river restoration issues and to share information	Media liaison, writing skills	Links between community and scientists and other projects in the region and/or catchment	n/a
Project Management Software Microsoft Project with attachments such as PERT – (Critical Path Analysis) and GANTT	To aid with planning an evaluation, Finalising the plan; Implementation	Some training needed to use the software; low cost	Knowledge of priorities and deadlines needed	Randall and Poisoner 1988 http://www microsoft com/office/project/
Questionnaire and surveys A preparatory tool for the vision exercise	To gain information from a large number of people in a structured way Scoping	Some sociological/community development skills; low cost	Limited by the exact questions that need to be asked – do they depend on each community or should there be a single set for the framework? Links community values to the project	Arndt 1996 Woodhill and Robins 1994
Questions See Section V Open ended What do we see five years form now?	To warm up to and define the vision To ensure that the group is focused during the visioning process Vision Setting	Provides kick off for the Vision Day	May take too much time to go through all them	Senge *et al.* 1994

Tool	Purpose/When to use the tool	Resources required – skills, cost	Scope	References
Reference reach approach Using a undisturbed stream or site within the catchment as a benchmark to copy	To base the restoration trajectory on the characteristics of a undisturbed stream or reach System Assessment; Monitoring and Maintenance	Scientific skills required	Other streams or reaches within the same catchment or different catchments may not be comparable	Rutherfurd *et al.* 2000 Newbury and Gaboury 1993
Reflection Individual reflection on deeper purpose of the project	To create understanding of how the project fits in to each individual's life and the broader regional or even global conservation background Vision Setting	Facilitative skills required	Used within group work/ workshop situations	Senge *et al.* 1994
Reporting/ conversation Individuals to report vision back to the team/group	To create transparency and an understanding of different stakeholders /members perspectives	Facilitative skills required	Used within group work/ workshop situations	Senge *et al.* 1994
Research reports from universities or government agencies	To obtain baseline data as part of Scoping	Research/scientific skills required; low cost	Always check temporal and geographical scale of the studies – how relevant is the information to your project and to the catchment as a whole?	n/a
Revegetation of steam banks and riparian zone Planting terrestrial plants and macrophytes – using tube stock, direct seeding	To control sub-aerial erosion, fluvial scour and mass failure Implementation	Scientific skills needed in the beginning; medium cost, regular labour needed to maintain plantings	Limited by natural erosion patterns, increased power of the streams and stability of base (other stabilising techniques need to be used in conjunction with revegetation)	Rutherfurd *et al.* 2000
Rich pictures A pictorial representation of all physical entities (people, organisations, aspects of the landscape) and then describing the relationships between these with arrows	To explore the situation A good way for a group to come to a broad, shared understanding of a particular situation	Low level facilitative skills; low cost	Any scale relevant to the project	Woodhill and Robins 1994

Tool	Purpose/When to use the tool	Resources required – skills, cost	Scope	References
Risk assessment/analysis Evaluating the risk of management practice failing and restoration activities or natural events causing further degradation or species extinctions	To identify and when possible quantify risks for each restoration activity under consideration	Technical and scientific skills needed in some instances; low cost, once the data is collected	Completed for all activities at the scales at which they are to be completed	Harding 1998 pp 164–185 Lein 1997, p27 Burgman *et al.* 1993
River Styles™ – catchment based system assessment with prioritisation based on biophysical processes and river condition. Baseline assessment to assess connections throughout a catchment and control on river character and behaviour	Geomorphic assessment will aid in understanding river character and behaviour Can be used in System Assessment, Prioritisation, Problem Definition, and Establishing the Vision	Scientific skills; medium costs	Complex	Brierley 1999 Brierley and Fryirs, in press
Round table workshop	Bring groups of people together to exchange ideas Bring a range of views to the fore Restoration Team; Vision setting	Facilitative skills; medium cost	Must be kept to a scale that makes group work possible	n/a
Semi structured interviewing Broad question, conversational interviewing	To gain information on an issue from an individual or small group, such as a family	Some social research skills needed		Woodhill and Robins 1994
Six thinking hats White – information Red – feelings Black – risk assessment Yellow – creative, logical, positive Green – new ideas, possibilities Blue – overview, problem definition, outcomes, organiser of the thinking process	To align the thinking of members of a group for a defined time to tackle a particular problem or generate certain information Restoration Team	Facilitative skills; low cost	To be used in small group-work contexts	De Bono 1995

Tool	Purpose/When to use the tool	Resources required – skills, cost	Scope	References
Small group vision sessions Feed in to the overall vision	To gather key ideas/statements to guide the overall vision To develop the vision in a manageable, non-intimidating environment Vision Setting	Facilitative		Senge *et al.* 1994 Arndt 1996
Socioeconomic data and reports Population, types of enterprises, financial returns	To assess the socioeconomic system	Social research skills needed	Scale: global to local	Australian Bureau of Statistics
State of Rivers An assessment procedure that gives a detailed, static description of the condition of the river in a GIS format	To aid planning and prioritisation Objective Setting and Prioritisation	Scientific skills needed	Site specific	Rutherfurd *et al.* 2000
Statistical Techniques – multivariate community analysis ANOVA for species richness/ abundance Trend analysis for water quality	To analyse data	Some knowledge required to use it – scientists and engineers	Too many to mention Problems arise with regard to controlling Type I (rejecting a true null hypothesis) and statistical power (Type II error – accepting a false null hypothesis	Underwood 1991, 1992, 1997
Stock access – limiting stock access to streams Including fencing the riparian corridor, alternative watering	To prevent further erosion of stream banks and encourage revegetation of the riparian zone Implementation	Fencing/plumbing skills needed Can be costly especially when alternative watering methods are needed	Site specific	Rutherfurd *et al.* 2000
Strategic priorities A series of observable or quantifiable statements that grounds the vision in concrete results for which action plans can be created	To galvanise commitment from the people of the restoration team Objective Setting and Prioritisation; Select Options and Activities	Some facilitative skills; low cost	They must be small enough for people to 'put their arms around' what must be done (Senge *et al.* 1994)	Senge *et al.* 1994
Stream analysis and fish habitat design: A field manual see under 'M' Manual				

Tool	Purpose/When to use the tool	Resources required – skills, cost	Scope	References
SWOT – Strengths, Weaknesses, Opportunities and Threats analysis Can be done as a brainstorming exercise or as a synthesis of other information	To identify strengths, weaknesses, opportunities and threats in relation to a project in Assessment, Scoping, Evaluation; Problem Definition; Objective Setting and Prioritisation; Select Options and Activities	Minimal skills; low cost	Low complexity	Woodhill and Robins 1994
The ABC of riparian vegetation	To assist landholders and managers to gain a basic understanding of the role of native aquatic vegetation – grasses, rushes, sedges in rehabilitation	Developed in conjunction with landholders in workshops. Simplified learning process as an introduction to riparian and in-stream vegetation. Can be adjusted to suit audience	Links waterways, landholders to rehabilitation requirements Macrophytes with other components such as soils, habitat for bird species	Myers 1999
Venn diagrams Each entity/group is represented by a circle – large circles represent important groups, overlapping circles represent interacting groups and a small circle within a larger one represents a component of the group	To describe interaction or overlap between groups of people, issues, geographical areas Scoping	Some facilitative skills; low cost	Any scale relevant to the project	Woodhill and Robins 1994
Vision day/field day	To discuss the main themes arising from questionnaires and smaller vision sessions Relevance, priority as well as the connection to the purpose of the project can be discussed for Vision Setting, Education, Assessment, Priority Setting, Evaluation	Scientific, facilitative skills; low cost	Low complexity	Arndt 1996
Water quality Biological Physico-chemical Toxicants	Quantify a range of factors that may be affecting people using the water and in-stream biota System Assessment	Some training required		ANZECC 1992

Tool	Purpose/When to use the tool	Resources required – skills, cost	Scope	References
Waterwatch Community program that monitors water quality and collects data on central data base	To obtain data on water quality System Assessment	Low cost and skills needed	Waterwatch program may not have sampled in the catchment	Waterwatch 1997
Willow and other exotic vegetation control Including excavation, poison, poison and cut techniques	To remove willows to solve problems associated with stream choking and monocultures Implementation	Scientific knowledge needed Cost depends on method	Kill and cut the best method for safety, ascetics and cost	Rutherfurd *et al.* 2000
Workshop Group discussion, study circle	To share ideas create networks get support tackle problems for the purposes of Education, Assessment, Priority Setting, Evaluation, Problem Definition	Readily available benchmarks and methods available Facilitative skills; low cost	For practical reasons it should be kept at 30 people or below and working groups of five to ten split off for particular tasks low level of complexity	Gibson 1998

SECTION V: BACKGROUND INFORMATION ON RIVER RESTORATION

Principles

Guiding principles can be divided into ecological principles and management principles.

Ecological principles

Biodiversity

In 1992, industry, environmental groups and all three levels of Government in Australia committed themselves to a National Strategy for Ecologically Sustainable Development. One of the three core components of this National Strategy is the protection of biological diversity. The National Strategy for the Conservation of Biological Diversity was signed in 1996 to accomplish this protection. Biodiversity was defined as "the variety of all life forms—the different plants, animals and micro-organisms, the genes they contain and the ecosystems of which they form a part". Clearly, riverine ecosystems are an important and integral part of Australia's biodiversity.

Restoration principles

A general protocol for the restoration of regulated rivers was published by Stanford *et al*. (1996), which provides some useful guidance for this river restoration framework, through attention to the ecological functions of rivers on which fish populations rely for their survival. This protocol should be viewed as a hypothesis derived from the principles of river ecology, which aims to recover some of the lost capacity of rivers to sustain native biodiversity and production through the management of processes that can maintain normal habitat conditions and allow the river to do most of the work. A summary of their key points includes: restoring peak flows, stabilising base flows, reconstituting seasonal temperature regimes, maximising fish passage, instituting a management belief that relies upon natural habitat restoration rather than artificial propagation, installation of artificial in-stream structures instituting predator control and practising adaptive ecosystem management.

- Biodiversity conservation is a central pillar to ecologically sustainable development.
- Conservation is best undertaken within the natural habitats of species.
- There is the need for a comprehensive and adequate system of ecologically viable protected areas.
- Conservation is enhanced by knowledge and understanding of species, populations and ecosystems. We need to continue to develop our knowledge and understanding of species and ecosystems.

Management principles

Ecosystem management

The ten principles of ecosystem management proposed by Edward Maltby, Chair of the Commission on Ecosystem Management (Maltby 1997) are as follows:

1. Management objectives are a matter of social choice.
2. Ecosystems must be management in human context.
3. Ecosystems must be management within natural limits.
4. Management must recognise that change is inevitable.
5. Ecosystems management must be undertaken at the appropriate scale.
6. Ecosystems management needs to think globally but act locally.
7. Ecosystems management must seek to maintain and enhance ecosystem character and functioning at an appropriate level for social choice.
8. Decision-makers should be guided by appropriate tools derived from science.
9. Ecosystem management must act with caution.
10. A multi-disciplinary approach is needed.

Risk management principles

Resource management involves both risk and uncertainty. The 'precautionary principle' agreed to by Australia under Principle 15 of the Rio Declaration on Environment and Development (Intergovernmental Agreement on the Environment 1992) provides two main ways to generally guide dealing with uncertainty and risk involved with managing biological systems to maintain biodiversity:

1. When contemplating decisions that will affect the environment, the precautionary principle involves careful evaluation of management options "to avoid wherever practicable, serious or irreversible damage to the environment, and an assessment of the risk weighted consequences of various options".

2. When dealing with “threats of serious or irreversible environmental damage, lack of full scientific certainty should not be used as a reason for postponing measures to prevent environmental degradation”.

A risk management strategy involves assessing risks to biological values, regularly recording the state of those values, and developing and implementing proactive and risk minimising options. In addition to the precautionary principle, the National Biodiversity Strategy applies, and the following two risk management principles:

1. Prevention is better than cure. Protecting ecosystems is far more cost effective than attempting rehabilitation once the damage is done. Some such changes can never be rectified.
2. The causes of a significant reduction or loss of biodiversity must be anticipated, attacked at source, or prevented.

Adaptive management

Uncertainty occurs largely through our lack of understanding of our biological systems and their functioning. By consciously recognising uncertainty, however, we are able to better understand and forecast the likely consequences of our actions. Uncertainty means that our approach to management should be an iterative, open-ended, adaptive process.

The principle of adaptive management or ‘learning by doing’ proceeds on the basis of using the best available scientific knowledge whilst recognising uncertainty in scientific understanding. This means that implementation of this strategy can proceed immediately without further extensive studies, and the evaluation procedures built into them enable its progressive refinement in the light of information produced by its implementation. This allows actions to be undertaken using the best available knowledge with the results of those actions adding to the knowledge base.

The multitude of causal factors responsible for the decline of indigenous species requires that remedial action be undertaken simultaneously on a number of fronts. Nine of these issues are outlined below:

River restoration should focus on:

- restoration of ecosystem function;
- being pro-active and positive;
- ensuring sustainability of the resource;
- committing to the community ownership of problems and participation in management;
- ensuring performance-based accountable management and practices;
- being holistic, encompassing the entire ecosystem;
- using an integrated coordinated approach to maximise efficiency;
- sharing responsibilities between the community, local, State and Federal governments; and
- a dynamic and adaptable approach.

Working in a Team

Understanding effective communication

Patterns of communication can influence the morale and satisfaction of a group and affect decision-making (McKnight and Sutton 1994). Effective communication occurs when all team members have equal access to information and are able to discuss and debate information with any other team member. One member of the team should normally have responsibility for ensuring information flow within the team for the sake of efficiency and co-ordination. It should not be the role of this person to decide what information is applicable to whom, but rather to ensure everyone has equal access to information. Some typical communication problems that may arise may are described under the headings to follow:

Group polarisation

Group polarisation occurs when initial views and opinions shift and become opposed. This can be a very negative force leading to time costs, disruption and reducing the chances of a decision that is shared and supported by all members of the team.

The tyranny of distance

Methods exist to ease communication problems associated with distance – telephone, CB radio, video conferencing and email are perhaps the major ones. Costs and practicality have to be taken into account. Not all people will have ready access to email, and video conferencing may be too expensive with the technology still relatively new and undeveloped.

Another constraint is the time taken and lack of remuneration for community members of the restoration team. Costs associated with travel and time should be considered. This should not be seen as a wage but fair recompense to cover the costs of attending meetings.

Consultation processes

Some stakeholders may require different approaches. Alternative methods of public consultation for Aboriginal communities have had to be examined in the Lake Eyre Basin. Traditional forms of public consultation were not attracting wide Aboriginal interest due to the difficulties of individual Aboriginals to speak for another's country and the preference for one-on-one oral communication rather than talk at public forums. The latter is shared by others in the outback community of the Basin. Solutions were found. They included:

- involving local people in any on-ground projects; establishing partnerships with local communities to initiate projects;
- taking the time to talk to people informally; and
- collecting local knowledge as appropriate and using it in decision-making processes (Andrews 1999).

Language barriers in consultation

Language barriers can hamper the successful exchange of information. Many scientific or technical terms may not be understood by other participants or may pose an intellectual barrier. Similarly, the use of local names, directions and colloquialisms may intimidate participants form outside the local area. Graphic art may be used to place information in a format accessible to most. Information can be produced in a variety of 'common languages'.

Criticism

Criticism has long been used as a tool to help evaluate and explore scientific experiments. It is suggested that criticism in the design of experiments and of their interpretation is the most useful tool we have (Underwood 1998). Scientists are used to having their work questioned by others to ensure its quality and robustness. However, criticism carried out in all aspects of life can be entirely negative and result in conflict. Criticism should be constructive and balanced by praise and positive feedback.

Faulty decision-making processes

Faulty decision-making processes can also lead to extreme decisions being made. Faulty decision-making may occur from in-group pressure such as:

- group polarisation;
- being a highly insulated group with limited outside feedback; and
- management crisis and external threats or pressures.

McKnight and Sutton (1994) list several indicators of faulty decision-making.

1. Illusion of invulnerability

While it is important that decision-making groups have a feeling of power and authority, a group that believes that any decision they make will be successful is being influenced by an illusion of invulnerability. This illusion can create excessive optimism and may encourage extreme risk-taking.

2. Belief in the inherent morality of the group

We all like to believe that we are acting in the best interests of our group and that our choices are the correct ones. The extreme example of this symptom is "God is on our side". Such notions help us abdicate responsibility for accounting for our decisions rationally and are a self-protective mechanism.

3. Rationalisation

While it is normal to play down limitations and pitfalls of one's chosen course of action, a problem arises in groups where members, raising legitimate objections, are discounted because of a perceived negative reaction to any member disagreeing with the group.

4. Stereotypes of 'outgroups'

Often groups tend to characterise outgroups in stereotypical ways and make decisions based upon false stereotypes. The result of such 'us' and 'them' thinking is that groups can become less receptive to constructive criticisms from sources outside the group.

5. Self-censorship

The most common form of censorship is that which we impose on ourselves. In this process our reasons may be linked to group loyalty, organisational policy etc.

6. Direct pressure

Group pressure on individuals to conform can take many forms. In many groups, members are conditioned to remain silent if they have opposing views. What becomes apparent is that expressed dissent against a group's argument is contrary to the interests of the group, or even perceived as being disloyal.

7. Mind guards

Mind guards are typically self-appointed and are not part of the group itself. They deliberately keep facts, opinion, data and other information, which may have direct relevance to the group's decision-making process, away from the group. Often these individuals justify their actions by arguing a time factor, that the material is irrelevant for the group, or that a decision has already been reached.

Some of the things to watch out for in decision-making are:

- Illusion of invulnerability
- Belief in the inherent morality of the group
- Rationalisation
- Stereotypes of 'outgroups'
- Self-censorship
- Direct pressure
- Mind guards
- Illusions of unanimity

(from McKnight and Sutton 1994)

Consensus

It is unlikely that there will be full and total agreement for each decision the team makes.

Consensus is a form of decision-making in which individuals and groups work towards developing a solution to a common problem. If there is still disagreement then this should be recorded with the reasons why. It is important to remember that consensus does not necessarily mean compromise.

Questions for Establishing the Vision*

The vision of the future

It is five years after the beginning of the project and the project has been very successful. Using these questions as a basis, describe what you see and paint a clear picture — a shared vision — of the site or catchment following river restoration.

1. Who are the stakeholders five years from now?
2. How has the project benefited them?
3. How is the project perceived within the community?
4. What does the river look like?
5. What flora and fauna are now found in the rivers that were not there before?
   What is the abundance and distribution of keystone and/or indicator species?
   What is the abundance and distribution of threatened or endangered species?
   What is the abundance and distribution of recreational or commercially valuable species?
   What is the level of species richness?
6. What is the level of aquatic ecosystem production?
7. What is the percentage of interstitial fine sediment?
8. How heterogeneous is the substrate?
9. What is: the level of dissolved oxygen; the pH; total suspended sediment; and the heavy metal concentration?
10. What is the current make-up of the restoration team?
11. How do the important elements of the project infrastructure interact?
12. In what ways is the river an important resource and an integral part of the infrastructure of the community?
    How do we know that the restoration process will be maintained?
    What has been done to ensure the future health of the riverine ecosystem for us?
    What has been done to ensure the future health of the riverine ecosystem for our grandchildren?
13. What is the role of the project in the community?
14. What is the role of the community in the project?

Current reality

Now come back to the current year, look at the river restoration/catchment management practises today.

1. What do we know (that we need to know)?
   What don’t we know (that we need to know)?
2. What are the critical forces in the riverine ecosystem?
3. Who are the current stakeholders?
   What changes do we perceive taking place among our stakeholders?
4. What are the most influential trends with regard to river usage and restoration?
5. What aspects of current catchment management practise empower people?
6. What aspects of current catchment management practise disempower people?

After each vision session

Many shared vision sessions involve listening to other people’s presentations of what they want the project to be. After hearing a presentation, we often need to focus our reactions and to decide whether these ideas make sense to us as individuals. You may use these questions for this purpose.

1. What, for you, are the key words in this vision statement?
2. How did you first feel at the moment when you saw the vision?
3. How do you feel about it now?
4. How does it strike your sense of identification? (Do you feel that you could own it?)
5. If no, how would it have to change for you to feel a sense of ownership for it?
6. How does it strike your sense of meaning and purpose? (Do you feel that it is a meaningful vision?)
7. If no, how would it have to change to be meaningful for you?
8. Based on your own reactions and feelings, what implications do you see, from this vision statement about the visioning process?

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* The material in this chapter is adapted from Senge *et al.* (1994).

Restoration versus Rehabilitation

> What's in a name? A rose by any other name is but a rose
>
> (Shakespeare: *Romeo and Juliet*)

Much of the debate about whether we are only able to restore rivers or rehabilitate rivers is chiefly concerned about definitions and having a clear idea of what we currently believe we are able to achieve.

Restoration can be defined as:

> Returning the system to its original or former condition. Returning the system to a state of health. The state of being restored, rehabilitated, renewed.

Rehabilitation can be defined as:

> To restore to a former state. To make a system useful to society again.

There are also many other words that have been debated for their suitability and used to describe restoration-type activities (eg. remediation and improvement). Some will argue that restoration to original condition is not possible for three reasons:

1. waterways may have changed to such an extent that it is impossible to restore them to their original condition;
2. it is difficult to determine what the original condition was; and
3. waterways are constantly changing in response to many interacting factors. This makes it difficult to predict whether manipulating those factors will produce desired outcomes.

Others will argue that restoration to original condition is possible. They may say that the ability to restore a waterway will depend on the degree of change, the nature of the disturbance or pressures on it, and its resistance and resilience will determine its ability to recover. If a whole river system cannot be restored, then components, such as aquatic species or flows, or sections, (for example, lowland or upland), of the system may be able to be restored. For example, a salmon stream in British Columbia, Canada, which had been diverted away from its original estuary is being restored to its original path (Bob Newbury, *pers. comm*. 1999). As restoration ecology is in its infancy, we cannot categorically state that it is not possible to return a reach, waterway or ecosystem to original condition. What was believed impossible in the past may be commonplace now days.

As can be seen from the adjacent two definitions there are considerable overlaps, with the exact definitions varying between dictionaries, and as language is not static, words change meaning and evolve over time. At present, usage of both terms interchangeably may be acceptable but with a clear understanding of the aims and assumptions of what is being examined and how it is examined. In the context of achieving better river systems, arguments over such definitions are pointless.

'Restoration' is used in this framework because:

1. Restoration is an admirable aim and may be possible in some cases or at least in part.
2. Restoration is in popular usage. It is felt that 'restoration' as a word appeals to more people and therefore is likely to remain the main word to describe fixing rivers.
3. Getting caught up in definitions may prevent or delay further planning and works.
4. Many practitioners use the term 'restoration/rehabilitation' which gives recognition to both points of view and shifts debate away from definitions onto the actual activity.
5. It is more important to concentrate efforts on the essence of what to aim for in reversing degradation and then to do it.

The authors define river restoration as aiming to protect and rehabilitate the physical and biotic processes of a river in a way that is conducive to the progression of ecosystems toward their natural state (Koehn *et al.* 1997). In heavily modified rivers, this definition can be translated into: choosing restoration planning and rehabilitation works which do not cause further damage to the river system and enable functions such as habitat availability and fish migration to recommence if they have been affected. It also recognises that there may be situations where there is currently no flexibility to alter some ecosystem components.

Stream Ecology*

Rivers and streams in their natural state provide habitat for a complex of biological interactions. Such flowing waterways are self-contained ecosystems that are subject to a one-way downstream flow. Four primary variables and their interactions can influence the biota of riverine ecosystems. Those four variables are: water quality, flow regime, nutrient sources and habitat structure. Changes to any of these variables will undoubtedly influence the aquatic biota in some way.

Water quality

Water quality is often only associated with toxic pollutants, but alterations to water temperature, dissolved oxygen concentrations, pH, suspended sediments, salinity and other chemicals may have subtle but crucial effects on fish populations and the aquatic ecosystem.

Flow regime

The biota of Australia's streams has evolved in naturally variable flow regimes dictated by seasonal rainfall and run-off. This century many of these natural flow regimes have been altered.

Water storages and diversions often cause dramatic reductions in the amount of water in the system, especially while the storage facility or impoundment is filling.

The demand for irrigation water means that many rivers must accommodate constant high flows during summers, whereas their pre-impoundment summer flows were low. Such reversals to the flow regime can affect various aspects of the life cycles of aquatic fauna (eg. the spawning and migration of many fish species).

Reduced flooding also means that highly productive floodplain areas that produce plankton blooms are not utilised. The production of such an abundant food supply is necessary for the rearing of fry, and the floodplain habitat provides nursery areas for the juveniles of many species.
Nutrient sources

Aquatic organisms in streams depend on the flow of nutrients through the food chain. Nutrients can enter the system either by photosynthesis occurring in green plants growing in the stream (eg. algae and reeds) or by decomposition of organic material from outside the stream.

Microbes in the water begin the decomposition of organic matter such as leaves, twigs, bark and in-stream plants. This material is then processed by a variety of stream invertebrates. These invertebrate processors have evolved to utilise debris from native vegetation rather than introduced species.

Within a stream, there is a cycling of matter, a flow of energy in ecosystems and food chains comprising producers, decomposers and consumers.

Nutrient cycles are made up of the actions of three categories of species. Some species can be defined as *producers*. They are able to take inorganic materials, such minerals, and produce organic materials. A plant is typically a producer. Some species, *decomposers*, break down organic materials. Bacteria and fungi are able to decompose waste products and dead remains. Some species can be defined as *consumers*. They eat the organic materials created by producers. Consumers include macroinvertebrates and fish. Consumers can be grouped into herbivores (primary consumers) or carnivores. Consumers may be further categorised as first level carnivores, second level carnivores and third level carnivores.

Habitat structure

The distribution of both invertebrates and fish is related to the availability of suitable habitat. Throughout the length of the stream, microhabitats within the stream are the most important. In-stream habitats include a diversity of channel configuration, water velocity, water depth, substrate and objects providing cover. In-stream objects such as rocks and aquatic vegetation are particularly important habitat structures.

Succession

Succession is a change in communities of organisms over time. Primary succession is the change in communities that occurs when a disturbance completely removes all

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* The material in this chapter is adapted from Koehn and O'Connor (1990).

existing species. Species then start to inhabit the area again until a climax community has been reached. Initially, short-lived species colonise the area but these are eventually replaced by longer-lived perennial species.

Sometimes the natural processes occurring in a waterway can prevent succession from progressing beyond the initial stages of colonisation. Disturbances such as the building of dams may change the succession processes that may be happening at a site or may completely alter the succession species.

Evolution

Evolution is the change in characteristics in successive generations of organisms due to differential inheritance of genes. Evolution is a process that has led to the present diversity of species.

Evolution may also describe changes in physical or habitat structure such as changes in channel morphology.

Major evolutionary changes occur over long time frames and are unlikely to occur in the space of the restoration plan and subsequent monitoring. Nevertheless, some points regarding evolution are relevant to river restoration:

- Species may be at particular threshold levels at this particular point in time. Threshold changes are also important in physical systems (Koehn *et al.* 1997).
- Populations and ecosystems can change in rapid, catastrophic and surprising ways as key thresholds are crossed (Bernstein 1992).
- Genetic variation is important to the conservation of a species. Genetic analyses of species with low or fragmented populations should be made and genetic diversity should be considered as part of the restoration plan.
- Large-scale changes, such as global climatic changes, may cause evolutionary changes to biological systems (Gosz *et al.* 1992).

Ecosystem health

The endpoint of river restoration is to aim towards improved 'river health'. Health in an ecological sense may include the following elements:

- *Diversity and/or complexity* – measured by species richness of a community or an area. Diversity is important in comparisons of community structure. Complexity results from the non-equilibrium nature of our river systems, temporal and spatial scales, site specific interactions and indirect effects.
- *Resilience and recovery* – healthy organisms are those that have the ability to withstand disease organisms and recover quickly after stress.
- *Vigour and scope for growth* – the energy flow of a system is greater than the energy flow required for maintenance.

Key problems and management strategies

A natural stream is a dynamic, diverse ecosystem that contains a variety of species and habitats. Each stream is also part of a larger ecosystem, which includes its catchment.

Interactions within the stream ecosystem and between the stream, its surrounding vegetation and the catchment are complex and not always understood. Nevertheless, one concept is indisputable: changes to one part of any ecosystem may easily affect other parts. Indeed, a stream is a function of the run-off from its catchment, so treatment of the catchment will be reflected in stream condition. Thus, the quality of a stream is not only a reflection of its management but of management of the catchment as a whole.

The ecological and physical processes that operate in an ecosystem produce the physical structure of the stream. Structure provides habitat for aquatic species; for example, snags and woody debris are habitat for Murray cod. Structure influences the processes that occur within the waterway. Causes of stream problems can be determined by understanding the structures and processes within the stream and the functional relationships between them.

Riparian

The vegetation zones along the sides of a river or stream act as a buffer from surrounding activities and have continuous interactions with the stream. These buffer zones supply in-stream habitat in the form of fallen logs and smaller debris, organic inputs and root systems thereby providing habitat, nutrients and bank stability to prevent erosion.

Barriers to fish passage

The unimpeded passage of fish throughout streams is crucial for spawning migrations, recolonisations, general movement and habitat selection. Fish passage problems are primarily a result of dams, weirs, drop structures, causeways and road crossings that physically block stream movements.

Introduced species

Through predation and competition, introduced species can also have detrimental effects on native fauna. Many successful introduced species have wide habitat preferences and high tolerances to environmental degradation which give them a competitive advantage over native species in modified river habitats.

Stream Geomorphology and Hydrology

Geomorphology

Rivers and streams in Australia can be characterised by their variability, hydrology, geomorphology and ecology. These all vary across the continent due to the diversity of climates and landforms. Stream hydrology and geomorphology form the physical aspects (the physical template) of the stream including the make up of aquatic habitats. An understanding of these aspects of your river is important before restoration can be undertaken. Unfortunately, most models of these physical stream attributes are based on temperate regions in south-eastern Australia and are not directly applicable to other areas. Regional seasonality (four seasons or wet and dry seasons), soil types, land and channel forms and rainfall patterns are all important characteristics. Changes in stream characteristics also occur as you move downstream; for example, channel form usually increases in size.

Simplified models of natural stream systems typically define three geomorphic zones (Kapitzke *et al*. 1998). These relate to the three primary geomorphic processes that are involved with water flow: erosion, sediment transport and sediment deposition.

1. The sediment production or source zone – usually steep upland areas where sediment originates through erosion but is not stored.
2. The sediment transfer zone – downstream of the source zone, where stream gradients have decreased but sediment deposits are usually temporary.
3. The deposition zone – here, sediment supply exceeds the transport capacity of the stream and deposition is long term.

Streams are dynamic, and change their geomorphic form in relation to a range of variables including: discharge, sediment load and boundary conditions such as geology, vegetation and landform. The occurrence, magnitude and location of erosion processes affect the amount of sediment transported in the stream. Erosion can be cyclical or episodic and often is accelerated greatly by human processes. Sediment transport is related to the particle size and composition, and the power of the stream to move particles. Fine grained particles are more easily carried in suspension whilst larger particles may be carried as bed load through rolling, skipping or sliding actions.

Channels can be straight (rare), meandering (common) or braided. Each of these types has a different effect on channel processes. Channel composition and landform units include: bedrock, alluvial, channel slope, bar types, sand sheets, pools and riffles. Channel size is determined by sediment discharge, sediment particle size, streamflow and stream slope. The channel slope, measured as the difference in elevation between two longitudinal points, directly impacts on stream velocity and power. The relationships between these parameters and soil type determine the natural erosion processes that occur, including bank erosion, channel incising or deepening and channel evulsion (moving to a new channel).

Stream systems are dynamic over their length, adjusting to changes in slope, location on the floodplain and cross-sectional form (the width and depth of the stream). Streams can be classified in many ways. For example, River Styles™ (Brierley *et al.* in press) provides a geomorphic summary of river character and behaviour, with each style characterised by a distinctive set of attributes, analysed in terms of channel geometry, channel planform, and the geomorphic units that make a river reach (eg. landforms such as pools, riffle, levees, floodplains, etc.). Assessment of the assemblage of geomorphic units within a river reach, and interpretation of their form–process relationships, provide a basis for analysis of river behaviour. Rosgen (1994) presented a classification system of rivers based on the morphological arrangement of stream characteristics and organised them into homogeneous stream types. He described morphologically similar stream reaches divided into seven major categories that differ in entrenchment, gradient, width/depth ratios and sinuosity in various landforms. Frissel *et al.* (1986) used a series of general variables to classify stream habitats. This produced a hierarchical classification system entailing an organised view of spatial and temporal variation among and within stream systems. Stream habitat systems were defined and classified on several scales, associated with catchment geomorphic features and events.

Whilst such classification systems may be useful in a general understanding of your site and some geomorphic processes, they are not universal for all river systems. They are based on and address geomorphic issues, but they do not relate these to the habitat needs of the aquatic fauna and ecosystem; and this is a key reason for undertaking the restoration. Each site needs some assessment on an individual basis that focuses on both the biological and the physical attributes of the stream and adjacent riparian zone.

Hydrology

Stream hydrology is mainly determined by the physical nature of the catchment and the climate. The hydrological cycle and rainfall variations play a major factor in stream hydrology. Variability occurs over both space (site to site) and time (interannual, seasonal, etc.). Water reaching the stream is determined by overland and subsurface flows. The magnitude and frequency of flooding then influence the formation and stability of stream channels. In addition, the rise and fall and duration of floods and the shape of hydrographs influence stream form and function.

The contributing pathways to streamflow can be categorised by two components:

1. Stormflow – precipitation which reaches the stream quickly through overland and underground routes;
2. Baseflow – precipitation which moves slowly, percolating through the groundwater. Streamflow at any one time can consist of water from one or both sources.

Hydraulic conditions within the stream are determined by flow and structure. In particular, flow and depth distributions play a major part in ecological processes and the provision of aquatic habitats. Flow and depth distributions are influenced by channel form, slope and in-stream objects such as substrate particles and woody debris. Structure within the stream may occur in patches on a longitudinal (see the zones described above) or reach scale. Examples of reach habitat patches include riffles, pools, woody debris, aquatic plants, islands and point bars. Stream structure, especially at this scale, changes with time, determined by the stream hydrology, often changing rapidly with larger flood events.

It is important to understand these processes as they are likely to be affected by many river restoration activities. Rates of channel change may have been altered significantly by human activities and larger changes (such as channel evulsion) often occur when certain geomorphic thresholds have been reached. River restoration activities can both impact and utilise these processes. River restoration must be conducted in conjunction with these process to achieve the best outcomes. More detailed descriptions of these processes may be found in texts such as *Stream Corridor Restoration Principles, Processes and Practices* (Federal Interagency Stream Restoration Working Group 1998) and the manuals of Kapitzke *et al*. (1998) and Newbury and Gaboury (1994).

Experimental Design

Experimental design procedures can be followed to ensure assessment is undertaken on a sound scientific basis. These procedures allow evaluation of alternative, competing models describing how some part of the world works (Underwood 1997).

Propose a hypothesis

Describe the problem and an action to solve the problem before assessment is undertaken. The hypothesis should be derived from the vision and written in terms of a managerial problem. For example, a hypothesis may be "Fish abundance will increase if the barrier is removed" or "An increase in awareness of geomorphic processes will occur if stakeholders attend a particular field day".

Collect data

Collect data relevant to deciding whether the hypothesis is correct or not. Thought must be given to the way in which the data can be examined to judge the hypothesis. The collection of data will be determined by:

- the scale of the problem being addressed by the hypothesis;
- time available to make the decision;
- whether it is part of an ongoing program or is a one-off study;
- the type of expertise available;
- the type of waterway ecosystem that is being tested;
- the type of equipment available; and
- the type of tools available to analyse the data

Other considerations that may need to be taken into account include time of year, and local and climatic conditions.

Test hypothesis

Evaluate the data collected utilising some method that will enable the hypothesis to be tested; for example, statistics and probability analysis.

Three key elements for effective experimental design procedures:

- propose a hypothesis;
- collect data; and
- test the hypothesis.

Indicators

A variety of indicators can be used to measure improvements in biophysical health.

Benchmarks

A benchmark is the criterion used to establish whether an indicator is reaching the desired endpoint of the restoration activity. It can be a measurement of the waterway ecosystem before the source of degradation.

Broad ecological benchmarks include:

- *return to original condition* – indicators may be compared to pre-disturbance measures; and
- *return to natural processes* – indicators may be compared with a similar waterway ecosystem that is in a healthy state or with pre-disturbance measures.

These indicators need to be selected at a level where they will clearly measure the results of an activity. If the objective of an activity is to increase fish abundances then the clearest measurement of this (the indicator selected) is the number of fish in that population before and after the restoration activity. The benchmark may be fish numbers at a certain level.

Selecting and interpreting indicators

There are a number of factors that must be taken into account when choosing indicators and interpreting the results of indicator studies. Types of indicators include biological, physical and/or chemical. Biological indicators provide a very good measure of ecosystem health. The biological indicator(s) that is selected will vary with the type of restoration problem and the knowledge about the indicator. For example, macroinvertebrates can reflect water quality changes.

The reasons for selecting macroinvertebrates as indicators include the following:

- They are good indicators of local waterway conditions.
- They integrate the effects of short-term environmental variations.
- Experienced biologists can often detect degraded conditions with only a relatively brief examination of the macroinvertebrate community.
- Sampling macroinvertebrates is relatively easy, requires few people and inexpensive gear, and has no detrimental effect on the resident biota.
- They serve as a primary food source for many recreational and commercially important fish.
- Aquatic macroinvertebrates are abundant in most streams.
- A large proportion of the biological survey data collected in rivers to date has focused on macroinvertebrates (O’Connor and Cameron 1998).

What should be measured?

The following questions may help answer this:

- How easy is it to measure the indicator?
- What does the indicator represent?
- Who will be doing the measuring?
- Can the indicator be used across a number of catchments or bioregions?
- Can the indicator be used to help educate people about the water ecosystem as well as provide measurements about the restoration activity?

Multiple indicators

Indicator species may be sensitive to one or more environmental factors which, when present, can be indicative of a particular environmental condition or set of conditions. Multiple indicators can give a better quality result by being able to give a more integrative picture of the disturbance over time. The use of multiple indicators will help to determine whether there has been an overall improvement in the state of health of a waterway ecosystem or assess the progress of the restoration activity. An indicator system that measures more than one component of the system is more robust as it can detect not only changes to more than one component of the system, but also can help detect changes that occur from unpredictable effects resulting from the activity.

Other reasons for using multiple indicators include the following:

- If there is a large number of components affected within the system, then using a range of indicators is advised.
- Some indicators, such as diversity, will increase and decrease along a successional gradient (Bernstein *et al.* 1992). In such instances the value of any single indicator is ambiguous and it is the overall pattern of several indicators taken together that reflects the state of the system.
- One indicator may be on the verge of a threshold change, the impacts of which may be felt less immediately on other indicators.
- Error measurements of individual elements can be very high.
- Indicators should include those that reflect an understanding of the processes and mechanisms that drive change.

Site selection for indicators

Considerations for site selection for indicators include:

- representativeness of the site;
- scales that are being investigated;
- replicability; and
- having control(s) and treated sites.

Indicator responses may vary due to many factors. What an indicator represents may also change over time depending on the underlying mechanisms it is associated with. Therefore it is necessary to check that underlying mechanisms have not changed and that the indicator is still measuring what it is supposed to.

Some indicators reach maximums at different stages over time. A predicted trend line based on pre-disturbance data may not be linear until the maximum is reached; for example, percentage vegetation cover.

Long lag times may be present before some indicators respond to a disturbance or stress. If a quick decision is required, choose an indicator that responds to stress or the restoration activity quickly.

Populations and ecosystems can also change in rapid, catastrophic and surprising ways as key thresholds are crossed. Linear approximations used to predict system behaviour if the disturbance had not occurred may become almost useless near such transition points.

Sampling times can vary depending on the type of disturbance, the restoration activity and the likely responses of species and physical components affected. Sampling times for water quality should consider the type of pollutant resulting from a disturbance.

A single threshold value may be useless for setting benchmarks, as some are adaptable to changes in parameters over time.

One universal benchmark figure for a particular parameter ignores the heterogeneity and natural variation of the different components of an ecosystem. The benchmark figure needs to be derived for the biogeographic area in which the restoration activity is being undertaken. Communities may not shift in response to a stress as one, but individual species may respond at different rates. Therefore, there is a need to understand the functional response of a species to change in physical parameters. Indicators derived on the basis of community parameters such as diversity or food web connectivity, may lose their utility as environmental changes induce fundamental alterations and discontinuities in community structure. Multiple impacts that result in new ecosystem configurations, often occur simultaneously, interacting in ways that defy simple prediction.

Thus, in ecological systems where heterogeneity, stochasticity, and multiple unmeasured variables have confounding effects on those variables or indicators that are measured, it is important to take into account as many variables as possible. Assessing qualitatively, if not quantifying, the impacts of structural and functional components of the ecosystems and processes via which interactions occur is very important.

A hierarchy of organisms can be viewed.

Particular organisational levels are:

Species – the chief defining characteristic of a species is that individuals within it are able to breed, and hence share genes.

Populations – a population is the number of organisms of a single species located at a particular area within an ecosystem. Indicators at this organisational level can monitor characteristics such as density, sex ratio, age-class structure and rates of migration.

Communities – a community is a grouping of populations that occur together in space and time. A community may be all the species occupying a particular area at a particular time or it may be limited to one particular taxonomic group. For example, all the macroinvertebrates at a particular location and time or all the grasses at a particular location and time.

A community is the sum of its lower levels of organisation plus the sum of the interactions between the lower levels of organisation, that is, the sum of its individuals and populations plus the interaction between individuals and populations.

Indicators that measure such factors as species diversity, community biomass and productivity measure the collective properties of the lower levels of organisation. Indicators that measure the structure of the food web, predator–prey dynamics or energy and nutrient flow are indicators of interactions. Interactions cannot be measured at the lower levels of organisation.They can be seen only when the focus is on the community.

Other considerations

- Use of multiple indicators to cope with: multiple stressed systems; changes of indicators over time; and dealing with multiple impacts that occur simultaneously, interacting in ways that defy simple prediction and result in new ecosystem configurations. Need to re-evaluate the indicators and ensure the use of multiple indicators.
- Integrative indices measuring the key variables are likely to give an indication of the state of the waterway ecosystem as a whole.
- How easily measurable is the indicator and what is known about what it represents?
- Indicator species are sensitive to one or more environmental factors which, when present, can be indicative of a particular environmental condition or set of conditions. They can give a better quality result by being able to give a more integrative picture of the pollutant over time.
- Include indicators that reflect an understanding of the processes and mechanisms that drive change (Bernstein 1992).
- What are the underlying mechanisms?
- Scaling factors and lag times before an indicator responds.
- Threshold changes – can be rapid, catastrophic and surprising.
- Are sampling times appropriate to what is being measured?
- What criteria can be used to evaluate the indicator?
- Are criteria available from the biogeographic region you are in?
- What is the functional response of species to change?
- Identify reference sites.
- What quality control mechanisms can be used?
- How will the data be analysed?

SECTION VI: GLOSSARY, ACKNOWLEDGMENTS AND REFERENCES

Glossary

Basin: An area in which the ground level dips from all directions towards a common central point. A river basin is the area drained by a river and its tributaries.

Biomass: The weight of living material. The total weight of all organisms in a particular habitat or area.

Biota: All living organisms, usually used for all the living organisms in a place (eg. the Australian biota).

Biotic: A description of the living components of ecosystems.

Catchment: The area from which a river, stream, lake or other body of water receives its water.

Channel: The part of a stream or river confined between banks, or a deeper passage through a lake or harbour.

Cobble: Substrate particles with a diameter of 64 mm to 256 mm.

Dam: A wall or other structure holding water back.

Decomposers: Organisms (eg. bacteria and fungi) in an ecosystem which convert dead organic material into simple compounds that primary producers can use.

Detritus: Organic debris from decomposing material.

Discharge: Flow of a river, usually measured in millions of litres (megalitres) per day.

Ecologically sustainable development (ESD): defined by the 1992 Brundtland Report by the World Commission on Environmental and Development as “development which meets the needs of the present without compromising the ability of future generations to meet their own needs”.

Ecology: The study of the interactions of organisms with their physical environment and with one another, including results of such interactions.

Ecosystem: All the organisms (biotic) in a community together with the associated physical environment (abiotic) factors with which they interact (eg. a rockpool ecosystem, a forest ecosystem, a wetland ecosystem).

Erosion: The act or process of eroding, especially the wearing away of the land surface by sun, wind, water, frost or ice.

Fish ladder: A structure which provides fish passage over a barrier.

Fish passage: Ability for fish to move unimpeded up and down the river system.

Fishway: A structure which provides fish passage past an obstruction in a stream.

Fluvial: Of, or produced by, a river.

Food chain: Pathway of energy.

Food web: The linking and inter-linking of many food chains as may be found in a complex ecosystem with several trophic levels (eg. lake, eucalypt forest).

Gravel: Substrate particles with a diameter range of 2 mm to 16 mm.

Groundwater: Water that is found beneath the surface of the ground, usually in porous rock known as an aquifer.

Habitat: The place normally occupied by a particular organism, group or population of species (eg. nesting habitat, freshwater habitat).

Hydrology: The study of water on, or under, land.

Indigenous: Native, although not necessarily restricted, to an area.

Invertebrate: An animal without a backbone (for example, worms, insects).

In-stream use: Ways of using water which do not require it to be removed from the stream.

Macroinvertebrate: An animal without a backbone (for example, worms, insects) and large enough to be seen with the naked eye.

Macrophyte: Large aquatic plant.

Organism: Any living thing, animal, bacterium or plant, whether one celled or many celled.

pH: A measurement to indicate the level of acidity or alkalinity of a solution, where pH 1 is highly acidic, pH 7 is neutral and pH 14 is highly alkaline.

Population: A group of animals of a particular species occupying an area where they are subject to the same broad environmental or management conditions.

Precipitation: The process by which water falls from the atmosphere, as rain, hail, sleet, snow or dew.

Predator: An organism that captures and feeds off another organism.

Reach: A homogeneous section of stream channel, characterised by uniform discharge, gradient, channel morphology, channel confinement and stream bed and bank materials. There is usually a repetitive pattern of structural features (eg. pool–riffle sequences) within a reach (Johnston and Slaney 1996).

Reservoir: A place for storing water; or the water which is stored in it.

Riffle: Relatively shallow, fast-flowing section of a stream.

Riparian: Of or on the river bank.

River: A large, permanent streamflow of water in a natural channel with banks, which flows into the sea, or a lake.

Saline: Of or containing salt.

Salinity: The concentration of various salts dissolved in a volume of water.

Silt: An earthy deposit laid down by a river, lake, or other water body, which is finer than sand but coarser than clay.

Species: Group of interbreeding individuals not breeding with another such group and which has characteristics which distinguish it from other groups.

Stream: A small river. First-order streams have no tributaries, second-order streams are formed by the confluence (flowing together of two streams) of two first-order streams, third-order streams from the confluence of two second-order streams, etc.

Substrate: The solid bottom of a water body to which an animal may be attached, on which it moves about or with which it is otherwise associated.

Taxon: A unity of biological classification, such as species, genus or class; a group of organisms sharing common characteristics (plural taxa).

Taxonomy: The science of classification of animals and plants.

Temperate: Having a mild climate between tropical and polar.

Thalweg: The line at which the two slopes of a river intersect.

Transect: An imaginary line drawn through an ecosystem in order to help ecologists sample and describe a biological community.

Trophic level: Herbivores on one level as plant consumers. Carnivores on another level as animal eaters.

Turbid: Not clear or transparent — water muddy with suspended silt or sediment.

Turbidity: A measure of the amount of suspended solids (usually fine clay or silt particles) in water and thus of the degree of scattering or absorption of light in the water; level of cloudiness in the water.

Watershed: A boundary between areas drained by different river systems.

Water body: Any water habitat, ocean, lake, steam, wetland.

Water table: The top level of water in the ground that occupies spaces in rock or soil and lies above a layer of impermeable (non-porous) rock.

Weir: A dam across a watercourse, over which the water may flow.

Wetland: An area of soft, permanently or intermittently wet ground, often with coarse grass or reeds. Also called a marsh or swamp.

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