

NPSI Project UMO45
Delivering Sustainability through Risk Management
Milestone 2 Report
27 August 2004

Milestone	Progress
<i>Milestone Report No 1</i>	
Project team in place with all necessary skills	• Some initial delays in appointing research staff due to unavailability until 2004 • Dr Carmel Pollino (0.5 time) and Ms Naomi Mautner (0.4 time) commenced 1 January 2004 • Dr Jan Carey (0.5 time) will commence during February 2004 <i>Update - Jan Carey commenced 1 March 2004, but transfered to another project in June 2004. Dr Terry Walshe has been appointed as a replacement.</i>

Regional Awareness Seminar presentations developed and meeting schedule organised.	- Decided to run three types of awareness seminars/workshop: - Level 1 – half-day awareness seminar for key decision makers and influencers - Level 2 – 1-3 day workshops for those staff who will be undertaking risk assessments or will commission risk assessments - Level 3 – specialist workshops for practitioners (e.g. Bayesian modelling). - First one-day awareness workshop held in Brisbane 9 December 2003 for 20 people associated with DNRM, Qld EPA, CRC Irrigation Futures, etc - Meeting schedule still evolving (expect next will be in Deniliquin (Feb 2004) for staff from MIL, NSW EPA, DIPNR, and possibly other organizations Update <i>Regional awareness seminar schedule has been developed (see Attachment 1) and is being implemented.</i> <i>At the Steering Committee meeting Dr Mathew Durak (Director CRC for Irrigation Futures) suggested there was considerable potential for collaboration between this NPSI Project and the CRC. In particular, the CRC could assist in encouraging the use of risk-based approaches in the irrigation industry and with stakeholder interactions. It was suggested that the CRC could run an ERA training course that was accredited by Monash/Melbourne Universities. This would need a good facilitator with background in maths, ecology & social science. The program might consist of 3-6 days training in hazard elicitation and ranking, conceptual model development and the development of the required technical expertise.</i> <i>The Steering Committee recommended that the Project Team articulate more clearly the objectives for each of the awareness tools and develop a program for the 1-2 hr presentations that specifically targets 'leaders of influence' in industry, government and the community. Both these recommendations are being implemented.</i>
At least one Steering Committee meeting held.	- Steering Committee appointed (see below) - First meeting scheduled for February 2004 - Other meetings will be in August 2004 and August 2005 Update – First Steering Committee meeting held 5 March 2004 (minutes at Attachment 2)
Steering Committee to agree on the Regional Awareness Seminar and consultation.	Steering Committee has not yet met Update – see above and Attachment 2

Planning with Key Case Study partners commenced.	• Two meetings have been held – first on 22 October 2003 in Shepparton scoped the possible project, the second meeting was in Albury (15 December) where phase 1 of the project was discussed in some detail • Project plan has been developed and agreed to (see attached). • First stakeholder workshop planned for March 2004 • Discussion paper on MIL being prepared for this workshop (Carmel Pollino completed first draft on 19 January 2004) • Stakeholder map being prepared by Naomi Mautner as prerequisite for the Stakeholder workshop • Update – see below
Sustainable Irrigation projects contacted.	<i>Goulburn-Broken Irrigation Futures</i> (Dr QJ Wang) – ran workshop in Tatura (27 October 2003) to discuss possible interaction – summary of outcomes is available – seems best interaction will be for our project to assist with the Stakeholder Workshops – Prof Chris Cocklin is liaising with QJ Wang and Leon Soste <i>Northern Australia Irrigation Futures</i> (Dr Keith Bristow) – one short meeting held at the ANCID Conference - agreed to have more full discussions in February 2004 when Dr Bristow returns from South Africa <i>Use of reclaimed effluent water in Australian Horticulture</i> (Dr Anne-Maree Boland) – short meeting held in October 2003 – agreed to work together where possible
Fact Sheet 1 containing plain English summary of the current project.	• Plain English summary of the project has been prepared and widely distributed
Logframe for evaluator signed off.	• Achieved (note: due to delays in commencing project, milestone completion dates were all shifted forward by 3 months – contract modified accordingly)
Final outputs confirmed.	• Delayed pending Steering Committee meeting • Update – Steering Committee recommended approval of Phase 2 of the project

<i>Milestone Report No 2</i>	
Attendance including presentation and poster display by Principal Investigator at annual Sustainable Irrigation Program Forum (October 2003).	- Prof Barry Hart attended the annual Sustainable Irrigation Program Forum, held in Shepparton, Sunday 19 October 2003 - BTH also attended the ANCID Conference in Shepparton 20-22 October and presented two papers (Gaining consensus on the ecological risks of irrigation and Ecological risks associated with new irrigation schemes in Northern Australia) (copies of these talks are available on request) - The paper on <i>Ecological risks associated with new irrigation schemes in Northern Australia</i> has been written up and submitted to the peer-reviewed journal Ecological Management & Restoration. It was published in the August 2004 edition (copy is at Attachment 3)
At least half the Regional Awareness Seminars undertaken - including presentations to HO regulators and regions with associated projects.	- The Regional Awareness Seminar program was delayed by the late appointment of Dr Jan Carey and then her transfer to another project. - We have recently appointed Dr Terry Walshe to lead this component of the project. - Dr Walshe has now contacted all key parties and a schedule of workshop dates agreed (see Attachment 1). - Dr Walshe is currently (August 2004) preparing the workshop material and will finalise details of each workshop during site visits to be conducted prior to each workshop. - The evaluation process to be used to assess the success of these workshops is still being developed – we expect this to be completed by 17 September 2004 (see below).

- Arrangements with Sustainable Irrigation projects and Case Study finalised.

MIL Case study (MIL, NSW EPA)

Phase 1

- Project business plan developed and agreed
- Stakeholder map has been prepared
- First stakeholder workshop run in Deniliquin on 31 March 2004
- Further work with stakeholders on-going
- Report on Phase 1 (Attachment 4) and draft Phase 2 plan prepared July 2004

Phase 2

- Discussions with MIL, NSW EPA and Murray CMA held in Deniliquin on 11 August 2004
- Decision to focus Phase 2 plan on development of Bayesian decision networks on two aspects:
 - Wetland model - develop a decision support tool for management of Blackbox wetland communities
 - River health model - develop a decision support tool for management of native fish and their habitats
- Report on Phase 2 plan prepared (Attachment 5) August 2004.

Other

- BTH & CP facilitated a workshop for MIL environment staff on 11 August 2004 – objective to develop a risk-based approach to determine risks to and from irrigation drains, with view to using this information to develop a new drainage management plan (this is a good example of the industry taking up risk-based approaches).
- BTH will make presentation to MIL Board at appropriate time in future.

Lower Loddon ERA Case Study

- We have signed an agreement with the Victorian EPA to undertake a 12 month ERA project focused on the Lower Loddon catchment in Northern Victoria.
- The project, which commenced in July 2004, will involve the NPSI team, EPA Victoria, Goulburn-Murray Water and the North Central CMA.
- A draft project plan has been prepared and the project is underway (Attachment 6).
- Two staff each working 0.5 time on this project: Terry Chan (WSC Monash Univ) and Anne-Maree Westbury (EPA Vic).

Sustainable irrigation projects

• Third party cost share achieved.	• Third party input achieved to date is summarised in Attachment 7. • It was anticipated that MIL would contribute \$50,000 cash to this project. We have not pressed them on this commitment until the initial round of stakeholder workshops are completed and the presentation is made to their Board. We expect to complete negotiations with MIL by end of September 2004.
• Fact sheet 2: summary of project and how it will assist the various projects completed.	• We are not happy with the Fact Sheet concept. They take a long time for LWA to complete and there is little evidence that anyone seeks them (certainly we have had no feedback which is rather surprising). • We propose to establish a series of regular Newsletters to update progress. • The first of these newsletters will be published 1 September 2004 and two-monthly from then.
• Evaluation process specified.	• A particularly important element of this project is a requirement that the effectiveness of these awareness tools and strategies be assessed. • Questionnaires have been developed and were used during the MIL stakeholder workshop to gauge what participants know about risk assessment and how their knowledge and attitudes change following exposure to workshops. • Further evaluation tools are being developed to assess the effectiveness of the Regional Awareness Seminars. • We expect this to be completed by 17 September 2004.
• Steering Committee provide advice to the Sustainable Irrigation Management Committee whether the arrangements are sufficiently robust and to proceed to Stage 2.	• Steering Committee met 5 May 2004 and discussed project in detail (minutes at Attachment 2). • Out of session they recommended project proceed to Stage 2. • A plan for Phase 2 is attached (Attachment 8).
• Sustainable Irrigation project confirmed to commence Stage 2	
• Other	• Notes from recent UMO45 Team Meeting attached (Attachment 9).

Attachments

1. Region awareness seminar series timetable
2. Steering Committee minutes

3. Paper 'Ecological risks associated with new irrigation schemes in Northern Australia' to be published in Ecological Management & Restoration August 2004
4. Report - 'MIL Case Study – Phase 1 Report'
5. Report – 'MIL Case Study – Phase 2 Plan'
6. Draft project plan for 'Lower Loddon Ecological Risk Assessment'
7. Third party cost share
8. Phase 2 project plan
9. Notes from Team Meeting held

Prof Barry Hart

26 August 2004

Attachment 1: Region awareness seminar series timetable

Date	Location	Participants	Local contact	Organiser*	Run by
Dec 2003	Brisbane	DNRME, Qld EPA, Irrigation Futures CRC	Dr George Rayment	Burgman/Hart	Burgman/Hart
Mar 2004	Deniliquin	MIL, NSW EPA, etc	Alex Marshall/Brett Tucker	Pollino/Mautner	Carey
20 Oct 2004	Mildura	DPI, EPA, SA Water, irrigation groups	Dr Geritt Schrale Dr Anne-Maree Boland	Walshe	Walshe (Hart)
10 Nov 2004	Townsville	Through Northern Australian Futures - focus on irrigation sustainability measures	Dr Keith Bristow	Walshe	Walshe (Hart)
12 Nov 2004	Townsville	Through Northern Australian Futures - stakeholder workshop	Dr Keith Bristow	Walshe	Walshe (Hart)
17 Nov 2004	Shepparton (Tatura)	GMW, Vic EPA, G-B CMA, NE CMA, NC CMA, DPI, DSE, Irrigator Groups	Pat Feehan/Dr QJ Wang	Walshe	Walshe
24 Nov 2004	Bunbury	Harvey Irrigation, DPI, Ord, Waters & Rivers Commission,	Ken Moore	Walshe	Walshe (Grace?)

		Irrigator groups			
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* Chris Cocklin and Naomi Mautner will be involved in setting up the evaluation process for each of these workshops

NPSI Project UMO45

Delivering Sustainability Through Risk Management

Steering Committee Minutes

When: 1000 – 1500h, 5 March 2004

Where: Monash University, Clayton

Present: See below

1. Outline of the project

- Barry Hart outlined the objectives of the project, the project team and the link with the CRC for Freshwater Ecology (this is Associated project D728) (Powerpoint presentation at Attachment A).
- The role of steering committee was discussed and ToRs agreed (see Attachment B).

2. Regional awareness seminars

- Mark Burgman outlined the objective of this activity and progress to date.
- The project will provide three vehicles for disseminating ideas about Ecological Risk Assessment:
 - (i) a short 1-2 hr presentation for senior managers, community leaders and people with ‘threshold’ interest.
 - (ii) a 1-1.5 day workshop for stakeholders (agencies, irrigators, regulators, green groups, etc) that will cover ideas about uncertainty, hazards, conceptual models, subjective judgements, qualitative and quantitative tools for making risk assessments more robust.
 - (iii) a 3-6 day course for those who want to develop skills to perform risk assessments and for accreditation.
- A particularly important element of this project is a requirement that the effectiveness of these awareness tools and strategies be assessed. Questionnaires have been developed to gauge what participants know about risk assessment and how their knowledge and attitudes change following exposure to workshops.
- An initial workshop has been conducted in Brisbane (December 2003) through Qld DNRME, and another workshop will be held in Deniliquin in March 2004 as part of the MIL Case Study.
- Other workshops are being planned (see Attachment C).
- Discussion:

- Is the program focussed enough? Might be better to target specific industry sectors (e.g. cotton, sugar), although this could potentially lead to missing the influence of other activities in an area.
- Also we have the potential to raise expectations in an area, but not deliver any outcomes.
- Could perhaps target areas where there is a contentious issue (making sure all key people are available to attend seminar). BUT what we need is a good project to showcase during seminars (have to make sure the process works).
- Currently trying to raise broad awareness of the usefulness of ERA in natural resource management. Perhaps the project should consider more a bottom up approach (e.g. get landholders thinking about ERA).
- Need to target 'leaders of influence' in industry, government and the community, particularly through the short 1-2 hr presentations.
- In Victoria, two projects that might be useful to link with are: (i) the Macallister Irrigation District (MID) neighbourhood improvement plan if it is adopted, and (ii) the potential re-use of treated effluent from the Werribee treatment plant (NPSI Re-use project).
- Interest groups: Policy makers, CMAs, Local planning groups, Irrigator groups.
- CRC for Irrigation Futures:
 - Mathew Durack indicated there was considerable potential for collaboration between this NPSI Project and the CRC.
 - In particular, the CRC could assist in encouraging the use of risk-based approaches in the irrigation industry and with stakeholder interactions.
 - It was suggested that the CRC could run an ERA training course that was accredited by Monash/Melbourne Universities. This would need a good facilitator with background in maths, ecology, social science. The program might consist of 3-6 days training in hazard elicitation and ranking, conceptual model development and the development of the required technical expertise.

Steering Committee Action:

- **Approved the program for regional awareness seminars.**
- **Strongly recommended that the Project Team articulate more clearly the objectives for each of the awareness tools.**
- **Recommended that the Project Team develop a program for the 1-2 hr presentations that specifically targets 'leaders of influence' in industry, government and the community.**

3. Case study partnership – MIL/NSW EPA

- Chris Cocklin outlined the objectives of this part of the project, which are listed in the Business Plan (Attachment D).
- Progress to date:
 - Business Plan has been negotiated with MIL and NSW EPA.

- Phase 1 of project, the Problem Formulation and Hazard elicitation has commenced.
- A stakeholder mapping exercise is underway with approx. 30 individuals (20 groups) being interviewed (either face-to-face or phone).
- The first Stakeholder workshop will be held in Deniliquin on 31 March 2004.
- Phase 2 of this program will be defined on the basis of the Phase 1 results.

Steering Committee Action:

- **Approved the Phase 1 program.**
- **Will consider Phase 2 program at next meeting.**

4. Possible other case study partnerships

- Barry Hart reported that discussions are on-going with the Victorian EPA and Qld DNRME regarding possible Case Study projects in Victoria and Queensland respectively.
- The Victorian project would be based around the High Level Operating Agreement and would likely involve the EPA, Goulburn-Murray Water and the North Central CMA.
- The Queensland project would be focused on irrigation and deep drainage issues in the Border Rivers region.

Steering Committee Action:

- **Supported the Project Teams endeavours to establish these two additional Case Studies, but cautioned the Team not to take on more than it can handle.**

5. Links with other NPSI projects

- Barry Hart outlined progress with the third overall objective of this project, which is to add value to other NPSI Irrigation Futures projects where possible. The aim is to link where possible with 5 NPSI Irrigation Futures projects.
- ***Goulburn-Broken Futures (Leader: Dr QJ Wang)***
 - A joint workshop was held in Tatura in October 2003 to discuss possible linkages
 - Due to different project timelines, anticipate a role in assisting with stakeholder interaction only (not modelling)
- ***North Australia Irrigation Futures (Leader: Dr Keith Bristow)***
 - Initial contact was made with the project leader (Dr Keith Bristow) at the ANCID Conference in October 2003.
 - This project is only just getting started (March 2004) and there appears to be good potential for cooperation between the projects
 - BTH will make contact with Keith Bristow in the next month.
- ***Tri-State project- Impact of Salinity on Lower Murray Horticulture (Leader: Dr Gerrit Schrale)***

- One discussion has taken place.
- The project has been delayed due to difficulties in obtaining staffing.
- It is expected that more detailed discussions will be held in May 2004.
- ***Use of reclaimed effluent water in Australian horticulture (Leader: Dr Anne-Maree Boland)***
 - An initial meeting was held with the Dr Boland in August 2003.
 - This project is already using risk-based approaches and it does not seem that there is much to be gained from any formal linkage between the two projects.
 - However, it is possible that the NPSI Risk Management project could assist with the stakeholder interactions that will be necessary to identify the main hazards (human and ecological) that will be associated with re-use of treated effluent for horticulture. Discussions
- ***Harvey District Irrigation Futures (Leader: Ken Moore)***
 - At the time of the Steering Committee meeting no contact had been made with Ken Moore.
 - Subsequently, Barry Hart and Mike Grace met with Ken Moore in Perth to discuss the project. At this meeting it was agreed that there would be value in linking the two projects.
 - It was agreed that the NPSI Risk Management project team would run a 1-day workshop on risk assessment and management in Western Australia in June or July 2004.
 - It may be possible to also invite stakeholders associated with the Ord irrigation district to this workshop (or perhaps run a separate workshop while in WA).

Steering Committee Action:

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| <ul style="list-style-type: none"> • Supported the Project Teams endeavours to establish meaningful links with the five nominated NPSI Irrigation Futures projects. |
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6. Project promotion

- Given that the main objective of this project is to enhance the adoption of risk-based approaches, four activities were seen as important:
 - Regional awareness seminars and the ability to report on case studies of relevance to the irrigation industry.
 - Linkages with CRC's, particularly Freshwater Ecology, Catchment Hydrology and Irrigation Futures.
 - Project fact sheets.
 - Feed into NPSI communications strategies.

7. Budget

- Little to report on budget since major expenditure had only just begun.

- Committee will seek a more detailed discussion on the budget at the next meeting.

8. General Discussion

- Need for greater resolution on how the project success will be measured.
- Since project seeks to create a demand for ecological risk assessment, need to determine specifically who are the people of influence to be targeted.
- Some thought the name - ecological risk assessment – would turn many off.
- Committee felt that the project could more clearly define exactly what is to be achieved, i.e. need to defined more clearly the product!

9. Next meeting

- Next meeting will be held in August 2004 – specific date to be determined.

Steering Committee

Name	Organisation	Email	Attend
Christine Forster (Chairperson)	Victorian Catchment Management Council	forster@netconnect.com.au	yes
Gary Whytcross	NSW EPA, Queenbean	whytcrossg@epa.nsw.gov.au	no
Brian Wild	NSW EPA, Albury	wilddb@epa.nsw.gov.au	yes
Dr Matthew Durack	Irrigation Futures CRC, Townsville	durackm@usq.edu.au	yes
Tom Vanderbyl	Qld DNRME, Brisbane	tom.vanderbyl@nrm.qld.gov.au	yes
Doug Newton	Vic EPA, Melbourne	doug.newton@epa.vic.gov.au	yes
Dr Rob Thomas	SARDI, Chief Scientist, Adelaide	thomas.r@saugov.sa.gov.au	no
Dr. Gerrit Schrale	SARDI, Adelaide	schrale.gerrit@saugov.sa.gov.au	yes
Dr Keith Hayes	CSIRO Marine Research, Hobart	keith.hayes@csiro.au	yes
Pat Feehan	Goulburn-Murray Water, Tatura	patf@g-mwater.com.au	yes
Murray Chapman (NPSI Coordinator)	RuralPlan, Benalla	rplan@benalla.net.au	no
Brett Tucker	Murray Irrigation Ltd, Deniliquin	brett@murrayirrigation.com.au	no
Tom Davison	Dairy Australia, Melbourne	tdavison@dairyaustralia.com.au	no

Attachment A: Powerpoint presentation of the project objectives

Attachment B: Steering Committee Terms of Reference

Attachment C: Regional Awareness Workshops

Attachment D: Business Plan for the MIL Case Study

Environmental Risks Associated With New Irrigation Schemes in Northern Australia

Barry T. Hart

Introduction

Any future expansion of irrigated agriculture in Australia is likely to occur in northern Australia. The region of Australia north of the tropic of Capricorn has abundant water resources — over 60% of the nation's surface water run-off (NLWA 2001). However, there are concerns that in the rush to develop this new bonanza we will simply make the same mistakes that plague existing irrigation systems. These include: water logging, salinization, soil acidification, erosion, polluted runoff, changes to the flow regimes in rivers, and so on.

It will be important that any decisions to develop new irrigation systems on or associated with Australia's northern tropical rivers, are based on rational decision-making using the best available knowledge, and a precautionary approach where knowledge is lacking. Considerable knowledge already exists on the best (and worst) features of irrigation schemes in tropical regions. Much of Asia has been growing rice for centuries using various forms of irrigation. We must learn from this experience.

This article considers the possible environmental risks that could be associated with proposed irrigation developments in northern Australia, and what we need to do to ensure these risks are properly assessed and then minimized. Our focus is on the risks to aquatic ecosystems (rivers, wetlands, estuaries, and coastal zones). This

article first overviews the possible risks to these tropical ecosystems from new irrigation schemes, and concludes that the currently insufficient ecological knowledge of these systems will restrict any risk-based assessments. Then a possible way forward is suggested to ensure that any new irrigation systems in northern Australia are sustainable. This includes a consideration of four factors: (i) adoption of a robust risk-based decision-making process, (ii) an urgent need to improve the ecological understanding of tropical aquatic systems, (iii) development of a set of practical guidelines for the key landscape attributes that will need to be considered, and (iv) the potential use of 'scenario planning', in conjunction with risk-based approaches, to scope some innovative and environmentally sustainable new irrigation schemes.

Environmental risks

Any new irrigation systems established in northern Australia must be environmentally, socially and economically sustainable. While some old-style irrigation systems already exist in the north (such as on the Ord), 'Modern' irrigation systems are characterized by pressurized supply, trickle feed lines, and minimal drainage — a far cry from those inefficient and environmentally damaging, gravity fed, flood irrigation systems that are dominant in the southern part of the country. Additionally, it is anticipated that future developments would not consist of stand-alone irrigation schemes. More likely, they would combine irrigation, food processing, tourism and grazing.

These modern irrigation schemes can still have adverse environmental impacts if they are not planned and managed effectively, and in assessing the environmental risks associated with new schemes, it will be necessary to take a whole-system approach. This will include consideration

of the risks to soils, surface and ground-water resources, vegetation, biodiversity, and terrestrial and aquatic ecosystems. Put simply, a sustainable irrigation scheme must not degrade the health of either the catchment or the waterways.

Aquatic ecosystems at risk

Four types of aquatic ecosystems will be at risk from possible irrigation ventures in northern Australia: rivers, wetlands, estuaries and coastal areas. A number of tropical and subtropical rivers already have extensive irrigation ventures on them. These include the Fitzroy (Qld), the Burdekin (Qld) and the Ord (WA) rivers. Additionally, a number of others have also been suggested in recent times (e.g. Mitchell (Qld), Daly (NT), and Fitzroy (WA)).

Unfortunately, there has been only limited study of these Australian tropical aquatic ecosystems (Connell & Hawker 1992), with the consequence that we have rather poor knowledge of their ecology. Along the north-eastern coast there has been some study of a number of rivers, particularly those that feed into the Great Barrier Reef, and the Great Barrier Reef itself has also been extensively studied (Brodie *et al.* 2001; Mitchell *et al.* 2001; McCulloch *et al.* 2003). However, with the exception of Magela Creek (located in Kakadu National Park), there has been little study of the rivers and wetlands along the northern Australian coast (Hart *et al.* 1987; Gardner *et al.* 2002). Equally, aquatic systems in the north-west tropics of Australia have received little study, even the Ord River which feeds a major irrigation region (Kinhill 2000; Doupe & Pettit 2002). However, by coupling the scant information on Australian tropical rivers and wetlands (Finlayson *et al.* 1988, 1999; Gardner *et al.* 2002; Rovis-Hermann *et al.* 2002) with information from world literature (e.g. Payne 1986; Lewis 1987; Amarasekera *et al.* 1997), it is

Professor Barry Hart is Director, Water Studies Centre, Monash University (PO Box 23, Clayton Victoria 3800 Australia. Tel. + 61 3-9905 5532, Email: barry.bart@sci.monash.edu.au). This article has arisen from a need to ensure any new irrigation systems considered for northern Australian rivers are based on sound decision-making processes, using the best available knowledge and a precautionary approach where knowledge is lacking.

possible to summarize some of the key features of these tropical ecosystems.

- 1 Most of the northern Australian rivers and wetlands are situated in the wet-dry tropics, meaning that they receive high rainfall during the summer months (Dec–Mar/Apr) and little additional rainfall for the remainder of the year.
- 2 This results in these rivers having characteristically highly-variable flow regimes, with very high flows in the wet season and low or no flow in the dry season. In the wet-dry tropical regions flow occurs each year, although there can be considerable variability within the wet season. In the more arid regions, rivers may not flow for several years.
- 3 Because of the low level of development of their catchments (except for extensive cattle grazing), most of the northern rivers still have good connectivity with their floodplain and the associated wetlands. But the importance of these interactions is still poorly known (Robertson *et al.* 1999; Clapcot & Bunn 2003). However, in the Mekong River, it has been well established that the annual flooding of extensive areas of Cambodia is vital for fish production in this system (Coates 2001).
- 4 Because these rivers are located at low latitudes, temperatures are generally much higher than those experienced by rivers and wetlands in southern Australia. This results in higher primary production and generally higher fish biomass in these systems (Finlayson *et al.* 1988; Bayley 1995).

It is possible to conclude that these tropical northern rivers will have significantly different hydrology to those better studied rivers in the south of the country, possibly leading to a greater importance of the connectivity with the floodplain and associated wetlands. However, in general there is insufficient understanding of these ecosystems. This general lack of knowledge will be a major impediment when assessing the risks due to any proposed developments.

It is clear that there is an urgent need for targeted research to improve the ecological understanding of the northern Australian rivers, wetlands and estuaries likely to be impacted by new developments, including

irrigation schemes. In particular, it is important that the current ecological character of these systems (i.e. the biological, chemical and physical components, ecological processes, and ecological services provided or derived) be well described to provide a benchmark against which change can be assessed (Finlayson 2002).

What needs to be protected?

Most of the rivers and wetlands in southern Australia are in poor biological condition, due to the major changes that have occurred to their catchments and to the rivers themselves (So 1996; NLWA 2002). In comparison, rivers and wetlands in northern Australian are relatively unmodified, although as Storrs & Finlayson (1997) point out, extensive degradation has occurred through weeds, feral animals, grazing, and changes to fire regimes. Nevertheless, it is sensible for the Australian community to want to protect the essential ecological values of these northern systems while this is still possible.

The key management objective for these northern ecosystems will be that they are able to sustain the social, economic and environmental aspirations of the Australian community. In particular, any developments must occur in a way that ensures these remain ecologically healthy. Unfortunately, there are few clear definitions of what constitutes an ecologically healthy ecosystem. However, one that does exist, the Victorian River Health Strategy (VRHS 2002), considers that an ecologically healthy river will have flow regimes, water quality and channel characteristics such that:

- 1 In the river and riparian zone, the majority of plant and animal species are native and the presence of exotic species is not a significant threat to the ecological integrity of the system.
- 2 Natural ecosystem processes are maintained.
- 3 Major natural habitat features are represented and are maintained over time.
- 4 Native riparian vegetation communities exist sustainably for the majority of the river's length.
- 5 Native fish and other fauna can move and migrate up and down the river.

6 Linkages between river and floodplain and associated wetlands are able to maintain ecological processes.

7 Natural linkages with the sea or terminal lakes are maintained.

8 Associated estuaries and terminal lake systems are productive ecosystems.

Similar sets of attributes are being developed for wetlands, estuaries and the coastal zone. These attributes will provide guidance on what features of the aquatic systems, potentially at risk from irrigation developments, need to be assessed.

In addition to maintaining these ecosystems in a healthy state, it will also be important that other 'environmental or ecosystem services' provided by these key natural assets, are not diminished (Binning *et al.* 2001; VCMC/DSE 2003).

Threats to ecological values (ecosystem services) from irrigation

Any assessment of the threats to river and wetland ecosystems from new irrigation ventures must also take into account threats from other catchment activities (e.g. pastoral, mining, tourism, urban).

The major threats to river and wetland ecosystems, and their associated catchments, from irrigation are likely to be (Begg *et al.* 2001):

- 1 Water extraction (both groundwater and surface water): this activity could change flow regimes in rivers and wet/dry cycles in wetlands.
- 2 Water impoundments: the adverse effects of dams and weirs are now well-known, and include changes to the river flow regime, reduced connectivity with floodplains and associated wetlands, barriers to migratory fish, release of colder water, and reduced flows to downstream estuaries.
- 3 Development of inappropriate land: opening-up of low lying coastal land can result in disturbance of acid sulphate soils, such as has occurred extensively in the Mekong Delta (Minh *et al.* 1997).
- 4 Unnecessary clearing of land: leading to loss of vegetation and biodiversity, and possible additional erosion (particularly during the wet season).

- 5 Contaminated run-off: most existing irrigation systems have extensive drainage systems to prevent increases in groundwater tables, which can lead to increased waterlogging and salinization. In addition to salt, this drainage water can also contain contaminants such as nutrients, pesticides and suspended particulate matter. New irrigation schemes are likely to have much less run-off, but this possibility still needs to be assessed.
- 6 Introduction of pest plants and animals: this could lead to problems in both the catchment and the waterways.
- 7 Changes to the natural fire regime: which would potentially change the vegetation communities, adversely affect the terrestrial biodiversity, and lead to increased erosion.

The threats briefly discussed above are largely focused on local effects in the catchment, rivers and wetlands. It is also possible that new irrigation ventures may result in adverse ecological effects in downstream estuaries and even further offshore. The Great Barrier Reef region is perhaps the most notable example where land-based human activities are causing adverse ecological effects offshore (Baker 2003).

The identification of these threats is essential if we are to clearly and transparently assess their risks. A subsequent risk assessment will then inform decisions to modify (or even scrap) development plans or introduce adequate management actions to minimize the risks.

A possible way forward

As noted above, any new irrigation systems established in northern Australia must be ecologically, socially and economically sustainable. For too long (and still in many areas), the environmental services provided by the land and water resources have not been adequately considered or costed, and as a consequence have been degraded.

Thus, it is vital that decisions to develop new irrigation systems in northern Australia are based on rational decision-making using the best available knowledge, and a precautionary approach where knowledge is lacking (Harding & Fisher 1999). The precautionary principle underpins ecologically

sustainable development principles, and is now codified in over 100 Australian laws and many hundreds of policies (Stein 2000).

Four suggestions on activities that will assist in ensuring that any new irrigation systems are ecologically sustainable, are made: (i) adoption of a robust risk-based decision-making process, (ii) urgent need to improve the ecological understanding of tropical aquatic systems, (iii) development of a set of practical guidelines for the key landscape attributes that need to be considered, and (iv) use of scenario planning in conjunction with risk-based approaches to scope some innovative and environmentally sustainable new irrigation schemes.

Risk-based decision-making process

A logical, rigorous and transparent decision-making process will be needed to assess the ecological risks if new irrigation schemes are to be developed in the north. This article suggests that the environmental risk assessment framework may be appropriate to provide such a logical analysis pathway for identifying and assessing risks. Environmental risk assessment is well accepted and used overseas (Suter 1993; Calow 1995; USEPA 1998), and is increasingly being used in Australia for a range of activities (AS/NZS 1999; Hart *et al.* 2001, 2003a,b; Rovis-Hermann *et al.* 2002; Burgman 2004; van Dam *et al.* 2004), including irrigation (see www.wsc.monash.edu.au).

Ecological risk is the product of the 'consequence' if the ecological effect or hazard occurs and the 'probability or likeli-

hood' of the effect occurring. Thus, risk assessment goes beyond the normal hazard assessment by including a consideration of the likelihood of the hazard occurring. The risk management plan normally focuses on this likelihood component in attempting to manage actions that increase the probability of adverse effects occurring. It is also the estimation (prediction) of the likelihood that is the most difficult step for the risk assessment team.

The majority of ecological risk assessments still focus on qualitative assessments that address single issues and a limited number of stressors or threats (AS/NZS 1999; Burgman 2001, 2004). However, there are now a number of initiatives aimed at further developing ecological risk assessments frameworks that are more quantitative and can consider a wider number of interacting stressors within a catchment or river basin context (Cormier *et al.* 2000; Hart *et al.* 2001; Leuven & Poudevigne 2002; Burgman 2004).

The main steps involved in an ecological risk assessment (problem formulation, analysis of effects and extent (or likelihood), and risk characterization) and the subsequent risk management plan and monitoring program are shown in Fig. 1, and are fully discussed in USEPA (1998), Hart *et al.* (2003a) and Burgman (2004).

Improve the ecological understanding

As noted above, a requirement for knowledge-based decision-making will be difficult in the case of possible risks to

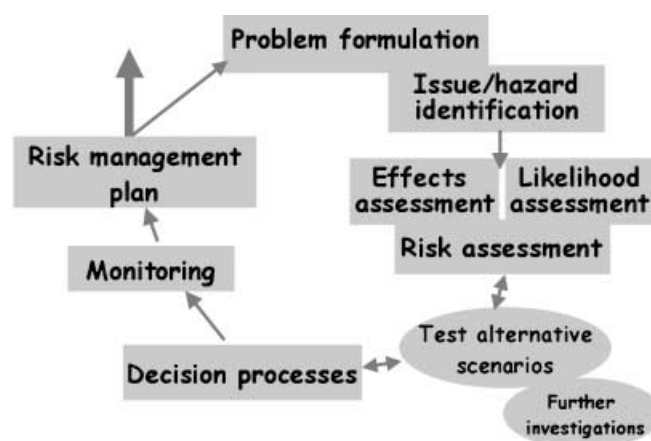


Figure 1. Diagram showing the steps involved in undertaking an ecological risk assessment and then developing a risk management plan.

tropical Australian rivers, wetlands and estuaries, because of the generally insufficient ecological understanding of these systems. The necessary research on the ecology of these northern Australian aquatic systems needs to be undertaken urgently. One model for structuring this knowledge-generation task would be to integrate data collection (inventory), assessment (risk), and monitoring required to inform possible management or development actions (see Finlayson 2002).

A start has been made. Land & Water Australia are funding an initial assessment of the ecological character of tropical rivers, floodplains and wetlands that should be completed by the end of 2003 (M. Finlayson, pers. comm., 2003). Additionally, the Environmental Research Institute of the Supervising Scientist is undertaking a landscape-scale project in the Alligator Rivers Region, where data and information are being gathered at suitable scales (a multiscale hierarchical format) for assessment and monitoring. This information will be able to be aggregated or disaggregated as needed.

Key landscape attributes that need to be considered

Using currently available knowledge (from Australia and overseas) it should be possible to establish a set of practical guidelines on what features/factors should be taken into consideration when new irrigation schemes are being considered. This objective is the focus of a new National Program for Sustainable Irrigation funded project on Northern Australia Irrigation Futures: Building a basis for developing sustainable irrigation across tropical Australia (www.lwa.gov.au/irrigation/research).

The project will build an understanding of key landscape attributes, including soil and water resources, climate, vegetation, rivers, wetlands and near-shore marine environments, relevant to sustainable irrigation in tropical systems. This knowledge will be used to deliver a framework based on sustainability indicators and management criteria at a range of scales (field, farm, district, scheme, and catchment) to support planning, development, implementation and management of new schemes, and if necessary, modification

of existing schemes across northern Australia.

Scenario planning

Obviously, any planning for new irrigation developments in northern Australia will rely on assumptions about an uncertain future. Decision-makers must try to imagine what the future will be like and to use this to decide on the best course of action. However, uncertainty remains, and the further into the future we need to project the more uncertain will be our predictions.

A logical approach to coping with uncertainty is to try to make decisions that are robust under a range of possible futures. Unfortunately, most strategic planning processes focus on a single, most plausible future. However, Van der Heijden (1996) introduced the use of scenarios (or sets of stories about the future) as an alternative method. 'Scenario planning' involves thinking about a wide range of plausible futures, factoring in both well-known trends and uncertainties, and using this information to establish several stories to guide the decision-making process.

A particular advantage of scenario planning is that it trains one to expect the unexpected and to be on the lookout for the resulting opportunities (Van der Heijden 1996; Bennett *et al.* 2003; Peterson *et al.* 2003).

I see great potential in using scenario planning, in conjunction with risk-based approaches, to scope some innovative and environmentally sustainable new irrigation schemes. For example, a think-tank could develop a number of scenarios, each of which could be assessed for the environmental risks. This would have the benefit that any proposed irrigation scheme could be assessed against a number of possible futures, and allow decisions to be made on the scheme that stood up under a number of these possibilities.

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NPSI Project¹: Delivering Sustainability through Risk Management

Murray Irrigation Limited: Case Study

Phase One: Outcomes of Problem Formulation

Project Summary

The **Delivering Sustainability through Risk Management** project is designed to raise awareness of adopting risk-based environmental management approaches in the irrigation industry. The adoption of risk-based approaches is considered to be vital if the Australian irrigation industry is to achieve its goal of long-term sustainability.

This project aims to achieve an improved level of adoption of risk assessment and risk management approaches in environmental management and a greater capacity to use such approaches, within both the irrigation industry and regulatory authorities in Australia.

An important component of this project will be focused on a case study being undertaken in the Murray Irrigation Ltd (MIL) irrigation region. The case study is designed to:

- Trial the application of risk-based approaches to identify system environmental values/assets;
- Quantify threats/hazards to system environmental values/assets; and
- Prioritise threats/hazards system environmental values/assets according to their degree of importance.

This knowledge will then be used to develop a state-of-the-art sustainable management plan for the scheme. While the importance of social and economic issues are recognised as being of importance in the MIL area, the focus of the case study is on environmental issues.

The project is being undertaken in two phases:

- Phase 1 (9 months, Oct 2003 – June 2004) will focus on training key personal in risk assessment procedures, and undertaking a broadly focused environmental assessment of the MIL operation.
- Phase 2 (13 months, July 2004 – Aug 2005) will see the key risks associated with the MIL system quantitatively assessed, a risk management plan to minimise these risks developed, and the success of the project professionally assessed.

¹ CRCFE associated project (D728)

The project partners are Murray Irrigation Ltd, NSW EPA/DEC and the NPSI Risk Management project team (from Monash and Melbourne Universities).

What is an Environmental Risk Assessment?

Environmental Risk Assessment is a quantitative process for determining the level of risk posed by stressors, such as salinity, pesticides, nutrients, land clearing, to the health of ecosystems. Risk-based approaches evolved from the need to develop processes that better deal with the complexity of aquatic ecosystems, particularly when taking into account difficulties in assessing multiple stressors for a wide range of species within inherently variable ecosystems. The risk assessment process not only incorporates complexity and uncertainty into the decision making process, but also avoids ambiguity as it is transparent and clearly defines the problem and desired outcomes.

Risk-based approaches are increasingly being adopted by industries, environmental agencies and research bodies for evaluating adverse ecological effects. The level and method of investigation of risk is dependant on consideration of a number of factors, including: the perceived level of risk posed to the ecosystem, conservation issues, available resources, cost-benefit analysis and community concern.

The initial phase of a risk assessment is **problem formulation**, which involves *identifying and ranking the existing and potential threats or hazards to the environment* as a result of the irrigation activities. This normally involves undertaking the following:

- gathering and integrating available information from key stakeholders (e.g. community groups, irrigators, conservation groups, system managers, government agencies),
- developing a conceptual model of the issue(s),
- developing a plan for the next stage of the assessment, being the risk analysis stage.

The **risk analysis** stage further investigates the priority hazards or threats by investigating the likelihood (probability) of the adverse effect occurring and the consequences if such an event did occur. The outcomes of the analysis stage will be used to inform the environmental management processes of regulatory bodies and the irrigation industry.

Description of Case Study Area

Murray Irrigation Limited is located in southern NSW and stretches from Mulwala in the east, to Moulamein in the west, and covers over 716,000 hectares of farmland north of the Murray River.

Traditional owners of the Murray Catchment area

It is believed that Aboriginal people have occupied the Murray-Darling Basin for at least 40,000 years. Several large Aboriginal communities lived in the Murray area, including the Banggarang, Yorta-Yorta, Baraba-Baraba, Wamba-Wamba, Wadi-Wadi and the Dadi-Dadi (Eardley, 1999).

The area was central to the Aboriginal way of life providing a rich concentration of food resources and communities that lived along the rivers would have controlled access to the water and its resources, the rights to this occupation handed down from ancestors (Eardley, 1999).

European settlement and commencement of irrigation

Between 1835 and 1839, pastoral runs of between twenty and forty thousand hectares were established along the Murray and Murrumbidgee Rivers, as far west as Hay. In 1915 the River Murray Waters Agreement provided for the construction of 26 and the supply of water for irrigation became the main river focus (Eardley, 1999).

Operation of Murray Irrigation Limited

MIL is a private irrigation company formed in 1995 under the Irrigation Corporations Act (1994) when the State Government of New South Wales transferred ownership of the Berriquin, Denimein, Deniboota, Wakool, and Tullakool irrigation areas and districts to irrigators. Ownership in MIL shares is held in proportion to the water entitlements owned by each irrigator.

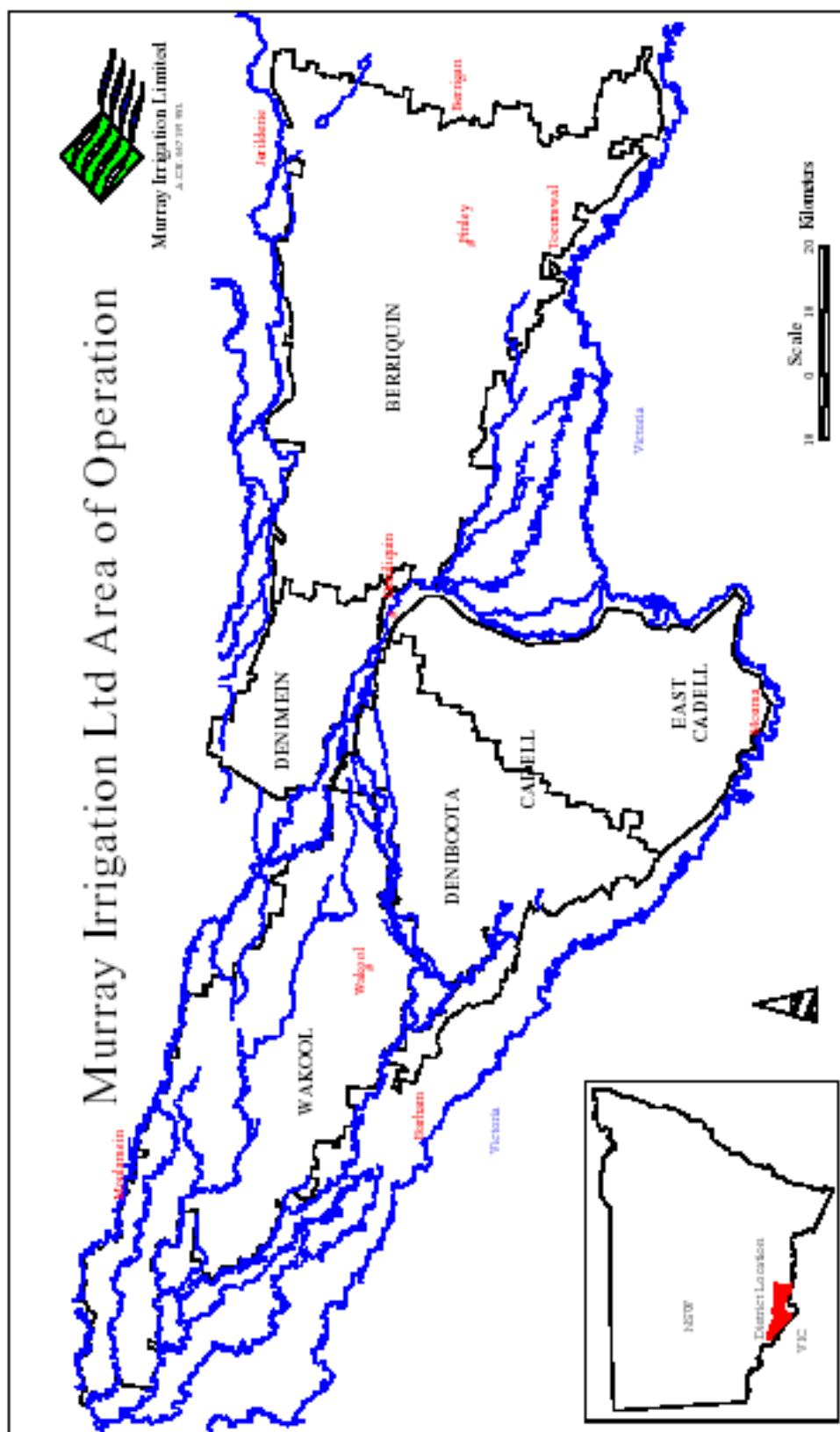
MIL provides irrigation and drainage services for its shareholder irrigators across 748,000 ha of farmland, which stretches from Mulwala in the east to Moulamein in the west. The system is composed of 2,952 km of eastern supply channels and 1,222 km of stormwater escape channels. There are 19,000 structures in the supply and drainage system with a replacement value of \$500 million.

MIL operations are licensed by the Department of Infrastructure, Planning and Natural Resources (DIPNR) for the diversion and delivery of irrigation water (Irrigation Corporation Water Management Works License) to Murray irrigation shareholders. The NSW Department of Environment and Conservation (formerly Environmental Protection Authority) issues a license for the discharge of waters from the MIL area of operation.

Since the company's inception in 1995, MIL has sought to address the environmental issues of salinity, water quality and biodiversity (MIL, 2003). MIL focuses on environmental issues associated with operations at a broad scale and at a farm scale via the Murray Land and Water Management Plans (LWMPs). LWMPs are in operation at the Berriquin, Cadell, Denimein and Wakool districts (Figure 1). Within these districts, a total of 49% of the land has been developed for dryland farming and 51% for irrigation (MIL, 2003), although this varies each year according to water availability.

Land and Water Management Plan Areas

LWMPs are integrated catchment management plans developed by the local community with support by Local, State and Federal governments. The plans are a mixture of on-farm management initiatives and regional scale programs which seek to address the full spectrum of land and water sustainability issues including irrigation supply, on-farm irrigation, best farm management practices and district drainage.



The LWMP timeframes are 30 years with government and landholders expecting to invest \$473 million. Government funding for the plans were secured for 15 years. The plans form the basis for environmental management on private land. Each LWMP district is characterised by its own landscape, with different farming activities and intensities of farming. Farming activities also change from year to year, given different circumstances.

Given the 4 regions, spatially explicit information was obtained for each area in the stakeholder consultation phase, but issues were common to each, but the extent of the problem often changed according to the area examined.

- **Cadell LWMP**

An estimated 14,800 people live in Cadell, of which the rural population is 4,750 (Cadell LWMP Working Group, 2001). The district covers 299,090 ha with 996 landholdings (MIL, 2003). In the district rice is the dominant industry, followed by wool, wheat, prime lambs and beef cattle (Cadell LWMP Working Group, 2001). In 1994 the total production generated by the major enterprises was estimated at \$40 million.

- **Wakool LWMP**

The Wakool district has a population of only 880 people, of which 350 live in the township of Wakool and 500 in Moulamein (Wakool LWMP Working Group, 2001). The district covers 210,694 ha with 381 landholdings (MIL, 2003). In the district rice, wool, meat, cereals and milk are the main industries (Wakool LWMP Working Group, 2001).

- **Denimein LWMP**

The Denimein district has a population of over 350 people, of which 15% of Denimein landholders live in the township of Deniliquin (Denimein LWMP Working Group, 2001). The district covers 53,809 ha with 190 landholdings (MIL, 2003). Approximately 80% of landholders have been directly involved in an LWMP incentive. In the district rice is the dominant industry, followed by grazing, vegetables, dairy and piggeries (Denimein LWMP Working Group, 2001). There are also a large number of hobby farms.

- **Berriquin LWMP**

The Berriquin district has a population of 19,445 (Berriquin LWMP Working Group, 2001). The district covers 341,546 ha with 1,490 landholdings (MIL, 2003). The gross value for production in Berriquin was \$144 million in 1991/1992. The main contributors were rice, milk, wool, vegetables, hay and cattle.

Existing catchment targets and plans

The Biodiversity catchment target in the Murray Catchment Blueprint (2003) focuses on vegetation:

“No net loss of all broad vegetation types (as mapped in 2001) and by 2012 restore 52,000 ha of under-represented broad vegetation types with the goal of achieving a minimum of 30% of their original extent and composition type by the year 2052.”

The target aims to protect and effectively manage existing remnant vegetation and to undertake long-term restoration of depleted “ecosystems” (Murray Catchment Blueprint, 2003). The target also aims to have environmental, social and economic benefits:

- Environmental: support greater variety of plants and animals; ecosystem services (greenhouse gases reduction, prevent land degradation, improve soil health and water quality, control of runoff).
- Social: landscape aesthetics; opportunities for recreation, tourism, research, education; cultural identity and spirituality; protection of Aboriginal sites.
- Economic: control of land degradation; increased productivity; increased income sources.

Across the MIL region, vegetation cover is at approximately 10%, although cover varies considerably between the LWMP regions (e.g. approximately 6% vegetation cover remains in the Berriquin area versus approximately 17% in the Wakool area).

Environmental Information

The availability of water and the highly fertile nature of the soils of the riverine floodplain make the area productive for plant growth. These factors have influenced human activities and land use in the region. The impact of land use has been an extensive modification of the natural distribution and condition of vegetation cover (Eardley, 1999).

Access to water for irrigation allowed for intensive agricultural production on lands adjacent to the Murray River, which has resulted in a complete modification and fragmentation of the landscape. In turn, the modification of the river systems to support intensive agriculture has resulted in altered hydrological regimes, water logging, salinity, land degradation, vegetation decline and fragmentation which has directly impacted upon and continues to threaten biodiversity (Eardley, 1999).

The Murray Catchment Blueprint (2003) contains a biodiversity catchment target for vegetation, and biodiversity management targets for maintaining and restoring native vegetation, maintaining and restoring riparian vegetation, improving the extent and quality of habitat for fish and aquatic species, recovery of threatened species, and maintaining (and where possible, increasing) locally threatened fauna species.

Soil quality

Soil acidity is a key indicator of soil condition. There is anecdotal evidence suggesting that the pH of soil has changed over time, with a trend in increasing acidity.

Watertables and Salinity

According to the MIL (2003), the most serious threat to the environment in the region is rising watertables. Given that the groundwater in much of the MIL region is naturally saline, the increased height of watertables causes waterlogging and mobilises salt through soils. High watertables and associated increases in soil salinity

can adversely affect agricultural production, biodiversity, river health and infrastructure. Biodiversity impacts include the loss of species, the simplification of vegetation composition and change in vegetation structure. During the 2002/2003 period, salinity levels within the stormwater escape system varied between 45 EC and 139,000 EC, with median levels between 62 and 4,220 EC (MIL, 2003).

High watertables were reported in the western areas of the region during the 1950s and again in the 1970's. Over the past few years, there has been a general decline in the area affected by high watertables. Lower than average rainfalls, reduced water allocation, and LWMPs have potentially contributed to this fall. There are some areas in the region that continue to rise, particularly in the far east of the region.

Quality of surface water

The MIL system has a stormwater drainage network, and to ensure that license requirements are being met, the system is routinely monitored for salinity, nutrients, turbidity and pesticides. Trends of discharge surface water quality in 2002/2003 indicate that parameters are trending in the right direction (MIL, 2003). However, this may be partially the result of by reduced irrigation activities in the region given that there was a drought during the 2002 - 2003 season.

Nutrients/ Algal Blooms

Previously, it has been stated that given the high nutrient irrigation wastewater discharged from MIL, algal blooms are likely to occur (NSW EPA, 2002). Blue-green algal levels reached high alert levels in March and April 2003 in the Berriquin, Deinmein and Deniboota districts (Table 2) (MIL, 2003) but as stated previously, the bloom originated in the Hume Dam, and was transported through the MIL region via the Mulwala Canal. The bloom was a first for the supply system.

Pesticides

MIL operates a chemical contingency plan to prevent unacceptable levels of agricultural chemicals reaching receiving waters through the company's stormwater escape system. Escapes are monitored during October to December. Action is taken by MIL if unacceptable levels of chemicals are detected. During the 2002/2003 monitoring period, with drainage flows at a minimum there were no detectable levels of chemicals in the stormwater escapes.

Changes to wetland and floodplain flora

River regulation, while providing a reliable and constant source of water for growing crops has altered the delicate balance of the natural wetting and drying cycle and extent and duration of flooding. These changes have affected native flora and fauna habitat. Water regulation has promoted a compositional change of riverine vegetation by the expansion of some communities to the exclusion of others (Eardley, 1999).

Water regulation and altered hydrological regimes have impacted on wetland habitats and in particular waterbird breeding cycles. Australia wetlands have a natural process of drying and refilling to which native flora and fauna have adapted. The increase in

water flow during dry periods stops the natural drying of rivers and breaks the wet/dry cycle favoured by fauna for breeding while the reduced height, frequency and duration of inundation of low to medium floods have in turn reduced waterbird breeding opportunities (Eardley, 1999).

River regulation and associated high summer river levels have led to the development of semi-permanent wetlands in some low-lying areas. While this provides habitat for waterbirds during dry seasons it results in the death of River Red Gum (*Eucalyptus camaldulensis*) (Smith and Smith, 1990), Black Box (*E. largiflorens*) and Lignum (*Muehlenbeckia florulenta*) which require periodic drying events and are used by fauna as habitat for breeding (Eardley, 1999).

The flooding requirements of the River Red Gum community means its distribution is restricted to the floodplains of the main river systems and their tributaries. The River Red Gum understorey is largely herbaceous comprising perennials, annuals and post flooding ephemerals (Eardley, 1999).

Adjacent to the River Red Gum on the higher, more saline heavy grey and brown clays of the outer parts of the floodplain is Black Box Woodland (*Eucalyptus largiflorens*). The Black Box understorey comprises salt tolerant grasses, daisies and saltbushes. The common understorey shrubs include Lignum (*Muehlenbeckia florulenta*) and Nitre Goosefoot (*Chenopodium nitrariaceum*), Old Man Saltbush (*Atriplex nummularia*) and Bladder Saltbush (*Atriplex vesicaria*). It is a community, which has been extensively cleared for cropping (Eardley, 1999).

Throughout the MIL region, there are 4 wetlands listed in the Directory of Important Wetlands in Australia on the Environment Australia website (<http://www.ea.gov.au>). These are located in the Weraï Forest, the Millewa Forest, the Kondrook and Perricoota Forests, and the Wakool-Tullakool Evaporation Basins.

Vegetation mapping and bird survey have been in the MIL region as part of the Wetland Watering Program, a joint initiative between the NSW Wetlands Working Group, MIL and private landholders. Wetland watering trials was commenced in the MIL region in 2001. The trials are focussed on providing water to wetlands, Black Box depressions and creek and stream runners (MIL, 2003) and are aimed at improving biodiversity in the region. Water birds and regeneration of native vegetation have been observed at wetland sites.

Changes to terrestrial vegetation

Remanent vegetation has been lost throughout much of the region, and is still declining in some parts. Native vegetation clearance is the single greatest threat to terrestrial biodiversity (EPA, 1997). Vegetation clearing and grazing reduce or modify natural habitat. Grazing in the MIL area has modified the saltbush plains. Apart from the impacts of clearing, cropping practices cause substantial changes in soil structure.

Many bird species that utilise the vegetation as habitat are listed as being threatened. It is not only habitat loss from clearing that has caused the decline in bird populations, but also the fragmentation of habitat. Fragmentation results in the fauna increasingly

relying on smaller patches of habitat for survival, and may lead to habitat simplification and habitat degradation. Those species which can compete successfully for reduced nesting sites, adapt to more open conditions and co-exist with feral predators tend to survive (Eardley, 1999).

The native grasslands of the Riverina are nationally important because the lowland grasslands of south-eastern Australia are among the most threatened and poorly conserved ecosystems (Eardley, 1999).

Changes to fauna

The riverine forests form a relatively narrow strip of wetland habitat along the river system, and are particularly important habitat features in a landscape largely lacking tree cover. The Riverine Forest provides habitat for those species dependent upon trees for food, cover and nesting sites. Significant species known to inhabit the riverine forests include the Superb Parrot (*Polytelis swainsonii*), Sugar Glider (*Petaurus breviceps*), Feathertail Glider (*Acrobates pygmaeus*), Squirrel Glider (*Petaurus norfolcensis*), Brush-tailed Phascogale (*Phascogale tapoatafa*), Koala (*Phascolarctos cinereus*), Carpet Python (*Morelia spilota*), Freckled Duck (*Stictonetta naevosa*) and Peregrine Falcon (*Falco peregrinus*) (Eardley, 1999).

Wetlands support a diversity of waterbirds many of which are migratory, and several which are listed as vulnerable under the *NSW Threatened Species Conservation Act, 1995* such as the Australasian Bittern (*Botaurus poiciloptilus*), Freckled Duck and Painted Snipe (*Rostratula benghalensis*) (Eardley, 1999).

The Black Box Woodlands provide important habitat for a variety of birds such as the Bush Thickknee (*Burhinus magnirostris*) and the Superb Parrot. The Superb Parrot is a threatened species and only nest in River Red Gum that are within 10 km of Box Woodland (Eardley, 1999).

Grasslands and shrublands provide food and shelter habitat for a number of species including the threatened Plains-wanderer (*Pedionomus torquatus*) (Eardley, 1999).

Problem Formulation and Identification of Values and Hazards

The problem formulation phase of this study was undertaken via short phone interviews, pre-workshop one-to-one interviews, a stakeholder workshop and post-workshop one-to-one interviews.

Phone interviews

An initial list of potential stakeholders was provided by MIL and this was expanded through a snowball sampling method, where stakeholders were asked to identify other individuals or organisations that they regarded as important. From that exercise 19 groups/ organisations were identified as important stakeholders. Sixteen of these were contacted by phone and given a short phone interview. The remaining stakeholders were contacted by email. Using information from these initial conversations a stakeholder map was produced (Excel worksheet).

Stakeholders were sent a letter of invitation to the workshop, background information about the MIL area of operation and a fact sheet containing background information about Ecological Risk Assessment and the project.

One-on-one interviews

Following the initial conversations, 8 one-on-one interviews were held. In the interviews stakeholders were asked to:

- Identify the aspects of the environment in the system they regard as of value/are being threatened/are unsustainable
- Identify the hazards to the key values
- Consider whether they thought current land and water use practices in the region were sustainable

The interviews also attempted to engage the interviewee in a conversation to elicit conceptual models (inc. spatial/temporal scales)

Stakeholder workshop

A workshop was held on 31 March 2004 in Deniliquin.

The objectives of the day were to:

- 1) Introduce the participants to the process of subjective risk ranking, the first stage of a complete ecological risk assessment;
- 2) Demonstrate the importance of language, context and motivation in determining judgments of risk;
- 3) Elicit a reasonably comprehensive set of hazards, defined as threats to things that the participants valued;
- 4) Identify the most important issues from among the full list;
- 5) Draft one or two conceptual models, to demonstrate the direction that an ERA may take.

The outcomes of the workshop are detailed in Appendix 1.

Further stakeholder interviews

Following the workshop it was agreed that more discussion with stakeholders was required before the project could proceed to Phase 2. It was decided that additional in-depth individual stakeholder interviews were needed. Stakeholders from a number of groups were interviewed (Table 1) using the same format described above. Note that the categories of stakeholder groups in Table 1 (Environment, Irrigator etc) may not be that clearly distinct in practice.

The outcome of the value elicitation process from interviews are summarised in Table 2. The outcomes of the value and threat elicitation process for each individual interview can be found in Appendix 1.

Table 1: Target Groups for Interviews.

Group	Organisation
Environment	Riverina Environment Council
	Nature Conservation Working Group
	Nature Conservation Council
	Environment Victoria
	Murray Wetlands Working Group
Indigenous	Deniliquin Aboriginal Land Council
	Friends of the Earth
	Yorta Yorta Nations Aboriginal Council
Irrigator	Southern Riverina District Council
	Berriquin LWMP
	Cadell LWMP
	Denimein LWMP
	Wakool LWMP
	Groundwater Users Assoc.
Industry	MIL
Regulatory	NSW EPA
	NSW Fisheries
	DIPNR
	NSW Dept. of Agriculture
	NSW State Forests
	Murray CMA
Research	CSIRO

Table 2: Summary of elicitation of values from stakeholders, including number of references by stakeholders.

Value	No. of references
Environmental / Ecological	
Good Land Management	1
Viable Environment	4
Barmah (incl Barmah lakes one also mention of Pericotta)	4
Terrestrial Vegetation (includes flora and fauna, grasslands, native veg and remnants)	17
• Fauna (birds: Barking Owl, Plains Wanderer [T], Superb Parrot [T]) Marsupial: Brush-tailed Phascogale)	4
Wetlands (Black Box depressions)	13
River Health (In stream Health)	7
• Fish	3
• Fishing	2
• River Redgums/ Floodplain forests	7
• Surface Water Quality	6
Soil Quality/ Health/ Productivity	6
Groundwater Quality	2
Air Quality	1
Whole Ecosystem	1
Economic*	
Sustainable Farming / Good Land Management	4
Productivity of Region	7
• Crop Production	2
Water Availability	1
Irrigation Industry	1
Social / Community*	
Public Perceptions of Farming	1
Cultural Integrity (Aboriginal)	1
Cultural Landscape (Aboriginal)	1
Sustainability of Region (services etc)	4

**Questions asked during interviews were targeted towards Environmental/Ecological values ONLY, and thus this study does not demonstrate the true reflection of Economic or Social /Community types of values.*

NPSI Project²: Delivering Sustainability through Risk Management

Murray Irrigation Limited: Case Study

Phase Two: Plan for Risk Analysis

Priority Issues from Phase 1:

The following environmental values featured prominently during Phase 1:

- Terrestrial vegetation and fauna
- Wetland vegetation and fauna
- River “health” (including floodplain)

Conceptual diagrams, based on stakeholder interviews in phase 1, have been constructed. These are based on stakeholders’ views on environmental, social and economic factors that influence system functions and contribute to important cause and effect interactions within the MIL system.

Figure 1 is specific for remnant terrestrial flora and fauna, Figure 2 for wetland and floodplain forest flora and fauna and Figure 3 for river “health” related issues.

Stakeholder interactions

Murray Irrigation Limited, Land and Water Management Plan Chairs and staff, Murray Catchment Management Authority, Murray Wetland Working Group, Department for Infrastructure Planning and Natural Resources, NSW State Forests, NSW Department of Agriculture, Yorta Yorta Nations Aboriginal Council, Riverina Environment Council, Nature Conservation Working Group, Murray Darling Basin Commission, Murray Darling Freshwater Research Centre, CRC for Freshwater Ecology

Information sources

It is anticipated that there will be difficulty in obtaining data given that the Eardley (1999) Riverina bioregion study suffered from the lack of primary biological data, the inconsistency and quality of data, and the inaccessibility of some of the existing data sets.

The lack of primary biological data will be addressed by using expert opinion. A considerable amount of stakeholder interaction is expected in Phase 2. The inconsistency and quality of data will be problematic, but will be treated accordingly

² CRCFE associated project (D728)

in data analyses. The inaccessibility of data related to Eardley (1999) having difficulty convincing stakeholders that the sharing of data will on balance be beneficial to all, and there was some reluctance by data-holders to share their datasets. The expertise of MEI will hopefully assist in overcoming this problem.

Potential Issues for consideration in Phase 2:

A range of options were considered for investigation in Phase 2 of the case study:

- a) Building on the work of Eardley (1999) and investigating the relationship between extent of vegetation types and how this affects fauna indicators (e.g. threatened species such as Superb parrot [river red gum and Black Box habitat], plains wanderer [grassland habitat]);
- b) Investigating relationships between vegetation maps, water table maps and disturbance processes;
- c) Developing a decision support framework for revegetation in each of the LWMP areas (relate to historical vegetation, soil types, geomorphology, etc.);
- d) Populate the wetland conceptual model;
- e) Populate the floodplain conceptual model;
- f) Populate the terrestrial conceptual model;
- g) Investigating the relationship between “river health” indicators (riparian, water quality, flows) and wetland biota (birds, macrophytes, fish, macroinvertebrates) found in the region;
- h) Investigating the relationship between “river health” indicators (riparian, water quality, flows) and aquatic biota (macrophytes, fish, macroinvertebrates).

All of the case study options were assessed against a set of criteria (below). The outcomes of this process are shown in Table

Criteria for consideration in Phase 2:

1. Is focus within our area of expertise?
2. Is focus relevant to MIL operations?
3. Is focus relevant to local landholder activities?
4. Is focus relevant to identified values of local landholder stakeholders?
5. Is focus a priority issue in the MIL area of operation?
6. Are we adding value (not just replicating what is already being done)?
7. Can the focus be targeted towards improving practices in the area, while being realistic about the competing activities and values in the area (recognising what is achievable)?
8. Is data or the mechanistic understanding of relationship available?
9. Will output be publishable?
10. Is the project achievable in timeframe?

Table 1: Selection criteria versus case study options.

	1	2	3	4	5	6	7	8	9	10
A	N	Y	Y	Y	Y	Y	Y	some	Y	Y
B	N	Y	Y	Y	Y	Y	Y	some	Y	N
C	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
D	Y	Y	Y	Y	Y	N	Y	some	?	N
E	N	Y	N	Y	Y	?	Y	some	Y	Y
F	N	Y	Y	Y	Y	Y	Y	?	?	N
G	Y	Y	Y	Y	Y	Y	?	some	Y	Y
H	Y	Y	Y	N	Y&N	Y	?	some	Y	Y

Priority Issues for Further Study

The focus for Phase 2 was discussed with representatives of MIL, the NSW EPA/DEC and the Murray CMA. Given the limited expertise of the NPSI project team, the 2 options selected for further investigation were:

- *Populate the wetland conceptual model (ie. Develop a decision support tool for management of Black Box communities);*
- *Investigating the relationship between “river health” indicators (riparian, water quality, flows) and aquatic biota (macrophytes, fish, macroinvertebrates).*

Activities will include:

- Develop and refine conceptual models based on priority issues identified in Phase 1 (Individual consultations);
 - Develop and parameterise model(s) (Individual consultations);
 - Verification of model(s) (Workshop 2 and individual consultations).
- **Populate the wetland conceptual model (ie. Develop a decision support tool for management of Black Box communities)**

The proposed study is the development of a model that can be used as a decision support tool to aid MWWG, MIL, and potentially the Murray CMA, in the management of activities that threaten the sustainability of Black Box (*Eucalyptus largiflorens*) depression communities. Communities incorporate the Black Box vegetation community, aquatic community and potentially the bird community (to be discussed).

The project would seek to undertake either part or all of the following (where possible, utilising knowledge [MWWG, MDFRC] already available):

- a) Further demonstrate that certain regimes for watering (how often? time of year? duration?) are more optimal than others for regeneration of Black Box and maintenance of Black Box depression communities;
- b) Further demonstrate how certain landholder activities (use as storage? unmanaged grazing? laser levelling? aerial spraying?) affect the ecological integrity of wetlands;
- c) Scenario test alternative management strategies for wetlands (eg. watering? grazing? fencing?):
 - i) Probabilistically predict the outcomes of alternative management regimes;
 - ii) Identify high risk activities and communicate those risks to stakeholders;

- iii) Quantify the uncertainty associated with predictions;
- d) Assist in prioritising watering of wetlands by demonstrating that the environmental conditions of certain Black Box wetland areas (soil type? groundwater height? proximity to drains? soil salinity?) are more optimal for watering than others (MIL);
- e) Assist in strategically selecting and targeting Black Box depressions on private land for watering (MIL) (include landholder attitude?);
- f) Develop a shared conceptual understanding of the factors influencing Black Box depressions amongst different stakeholder groups;
- g) Bring together past and present datasets (physical, chemical and ecological), and disparate datasets of MIL, DIPNR, MWWG, MDFRC;
- h) If relevant, connect existing NRM models (eg. hydro and water quality models) with ecological outcomes;
- i) Identify key knowledge gaps and make recommendations for improved monitoring and targeted investigations.

After screening of landholder applications by MIL, one of the MWWG selection criteria for selecting a wetland for watering on private land is “landholder attitude and motivation” (Nias et al., 2003). The model could potentially incorporate these “landholder attitude” measures into the model.

It is intended that the final model will be simple enough to be used by any interested group, be scientifically robust, and to be transparent in the assumptions made. The modelling methodology to be utilised in this study is Bayesian networks. Bayesian networks are not a “blackbox” modelling technology, but are tractable.

Using the Bayesian network approach, it is hoped that a shared conceptual and quantifiable understanding of the Black Box depression environment and the threats to the Black Box depression communities will be achieved. The model will also enable the testing of management scenarios, predict outcomes of different management scenarios and set priorities for management.

Beneficial uses of model by MWWG:

- Assist in determining the likelihood of an improved biodiversity outcome;
- Document community attitudes towards wetland watering.

Beneficial uses of model by MIL:

- Assist in screening landholder applications for wetland watering;
- Enable strategic approaches for selecting wetlands for watering.

Project/Model scope

Bayesian networks are able to represent and ‘learn’ from specified mechanistic relationships, data, and, where these don’t exist, expert knowledge. Data and knowledge relevant to the entire MIL area will be utilised in this study. The predictive time frames can fit in with the Murray Catchment Blueprint (2003) targets, being 1 year (now), 10 year, and 50 year.

Data sources

MWWG, MDFRC, MIL, DIPNR

Studies by Slavich et al. (1999a; 1999b) have investigated and modelled the interaction between watertables, soil salinity and flooding, and the impacts these have on the health of Black Box vegetation. These studies were specific for the Chowilla floodplain (lower River Murray of South Australia), but are likely to assist in quantifying relationships in this study.

To undertake such a project, it is vital that a close working relationship is established between the MWWG, MDFRC and the WSC. The potential for working with the MWWG is being explored. The MDFRC (Ben Gawne and Daryl Nielsen) are currently undertaking a study with the MWWG looking at Black Box wetlands. There is no intention to repeat the work of the MDFRC (which is using multivariate statistics to test biological responses of wetlands to alternative watering regimes – Deb/Daryl is this correct?).

For the WSC project to proceed, the support of the MWWG and MDFRC is essential. The WSC project would entail using knowledge and data from the MWWG and the MDFRC. All acquired knowledge and data would be attributed to the owner. Knowledge will be used to refine conceptual model developed in Phase 1 of the project, and to specify the probabilistically relationships between the different components of the model, particularly where there is no data or data gaps.

This study will utilise existing datasets, no further data collection will be required to complete the case study.

- **Investigating the relationship between “river health” indicators (riparian, water quality, flows) and aquatic biota (macrophytes, fish, macroinvertebrates)**

The proposed study is the development of a model that can be used as a decision support tool to aid MIL, and potentially the Murray CMA, in the management of irrigation activities that threaten river ‘health’. As the project time line is limited, it is proposed that a modelling tool be constructed that investigates the management of native fish communities and their habitat only. Stakeholder interactions in Phase 1 of the study clearly demonstrated that there were conflict between groups in determining whether native fish communities in the MIL area are under threat.

The study will investigate the major threats to fish communities upstream and downstream of the MIL area of operation and within the MIL area of operation. The product will be a tool that can assist MIL in recognising and managing the threats to native fish in their focus area. The tool will also acknowledge those activities that are beyond the control of management by MIL.

Although the project will seek to address similar elements contained in the Murray Flow Assessment Tool (MFAT) and Native Fish Strategy (NFS), it will seek to incorporate quantitative relationships in addition to the expert knowledge utilised in MFAT and the NFS. This project will be also focus on a smaller scale, unlike MFAT and the NFS, which addressed the entire Murray Darling Basin. Thus, activities examined will have greater focus on upstream and downstream of the MIL area of operation and within the MIL area of operation.

Importantly, the model will seek to:

- a) Demonstrate how certain irrigation activities (drainage returns? altered flows? de-snagging? channel activities?) affect native fish communities;
- b) Investigate how recreational activities (stocking of artificially high numbers of native fish? angling? boating?) affect native fish communities;
- c) Scenario test alternative management strategies (eg. channel operations? drains?):
 - i) Probabilistically predict the outcomes of alternative management regimes;
 - ii) Identify high risk activities and communicate those risks to stakeholders;
 - iii) Quantify the uncertainty associated with predictions;
- d) Develop a shared conceptual understanding of the factors influencing native fish communities amongst different stakeholder groups;
- e) Bring together past and present datasets (physical, chemical and ecological), and disparate datasets of MDFRC, MIL, DIPNR, NSW Fisheries;
- f) If relevant, connect existing NRM models (eg. hydro and water quality models) with ecological outcomes;
- g) Identify key knowledge gaps and make recommendations for improved monitoring and targeted investigations.

Project/Model scope

Bayesian networks are able to represent and 'learn' from specified mechanistic relationships, data, and, where these don't exist, expert knowledge.

The model will use the existing Goulburn Fish Bayesian Network as a starting point (NPSI project, completed March 2004; Pollino *et al.*, (in review)). The model will incorporate data relevant to upstream and downstream of the MIL area of operation and within the MIL area of operation. The model will also be expanded to produce endpoints for the recognised 4 types of native fish communities in the Murray Darling Basin (as in MFAT), as opposed to the single endpoint for abundance and diversity in the existing model. The potential to incorporate extended timescales will also be investigated (currently only 1 year and 5 year predictions).

The project will incorporate knowledge and data from the following systems and reaches:

- Murray River
 - Hume Dam to Yarrawonga Weir
 - Yarrawonga to Tocumwal
 - Tocumwal to Edward offtake (Picnic Point)
 - Edward offtake (Picnic Point) to Barmah
 - Barmah to Torrumbarry Weir
 - Torrumbarry Weir to Narrung
- Edward River
 - Edward offtake (Picnic Point) to Stevens Weir
 - Stevens Weir to Murray confluence
- Wakool River
- Tuppal Creek

The predictive time frames can fit in with the Murray Catchment Blueprint (2003) targets, being 1 year (now), 10 year, and 50 year.

Data sources

MWWG, MDFRC, MIL, DIPNR, NSW Fisheries

The detailed consultation of experts documented in MFAT and the NFS will circumvent the need to widely consult fisheries experts, although it will not do away with this process in entirety (model verification).

The MDBC will soon be commencing a study investigating improving fish habitat between Hume Dam and Yarrawonga Weir (under the NFS banner) (Barrett, 2004).

Construction of Bayesian networks

Developing Bayesian network models is an iterative process shown in Figure 4, and as outlined in Woodberry *et al.* (accepted).

For each model, the first phase will be to refine the conceptual models for each endpoint. These will be based on those developed in Phase 1, but will be supplemented with additional variables and interactions after consultations with experts. It is anticipated that the parameterisation of the models will be both qualitative and quantitative given the paucity of data that is likely to be available.

Model verification/validation

Each of the following steps will be conducted with each model prototype, until an accurate and acceptable model is developed.

To test model accuracy, four tests (in no particular order of importance) will be used:

- Model predictions versus real data;
- Stakeholder review of the model;
- Sensitivity analyses;
- Predictive accuracy tests.

The first two tests are qualitative. Where possible, model predictions showing relationships between existing land uses, existing environmental conditions and ecological endpoints will be plotted against existing data. The second test will be a model review, which will be conducted with key stakeholders. Stakeholder feedback will be used to test if the model output is reasonable, and where further effort is required to improve the model quantitatively and qualitatively.

The following tests are quantitative. Two types of sensitivity analysis will be used to identify sensitive parameters: sensitivity to findings and sensitivity to parameters. Both are used to identify potential errors in the quantitative and qualitative components of the model. The sensitivity to findings results can also be used to identify and rank risks to model endpoints. The predictive accuracy test is conducted by splitting the dataset so that 80% will be used to train the model and 20% of the data set will be used to test model predictions.

Project output

Using Bayesian networks, the major risks to:

- **Black Box depression communities**
- **River health endpoint(s): Native fish and their habitat**

will be identified and characterised.

The models will also have the ability to test the outcomes of alternative management scenarios, prioritise the management of risks, identify key knowledge gaps and recommend where existing monitoring programs can be improved.

On completion, for the models to have an extended lifespan, they need to be updated using data/information as it becomes available, particularly after management actions have been undertaken in the catchment. The maintenance of the models is to be done by the model users. The incorporation of new data and information improves the predictive accuracy of the models, and the models 'learn' to better represent existing relationships or new relationships. Model analyses will identify key knowledge gaps and provide assistance in meeting current planning strategies and informing future planning processes.

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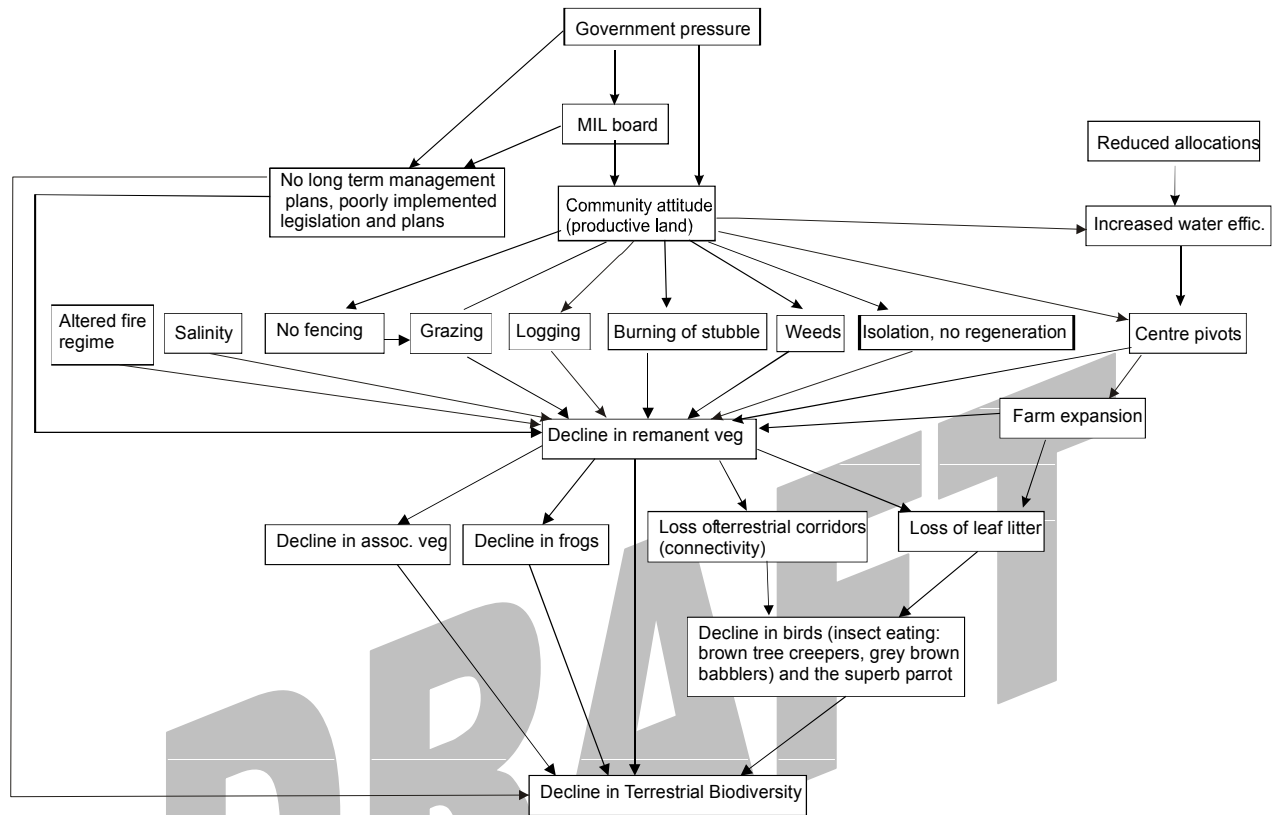


Figure 1: Remnant terrestrial flora and fauna conceptual model.

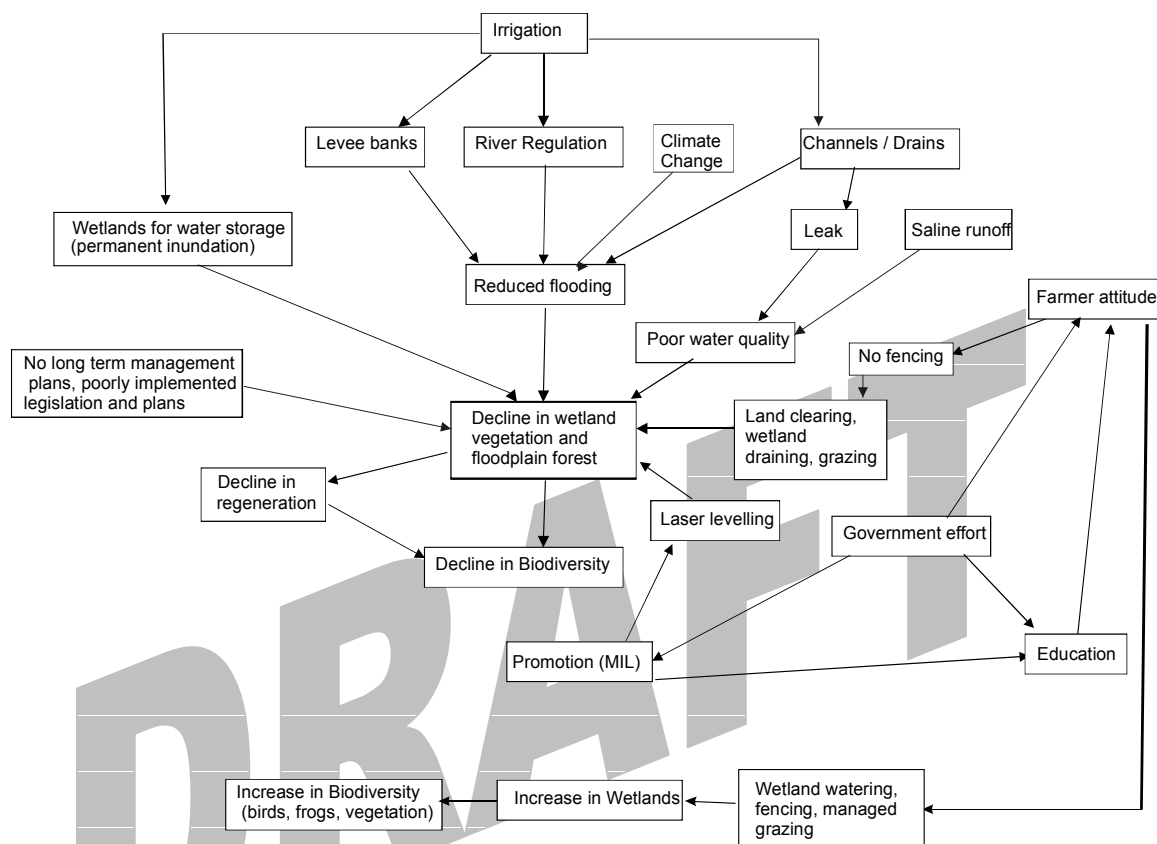


Figure 2: Wetland and floodplain forest flora and fauna conceptual model.

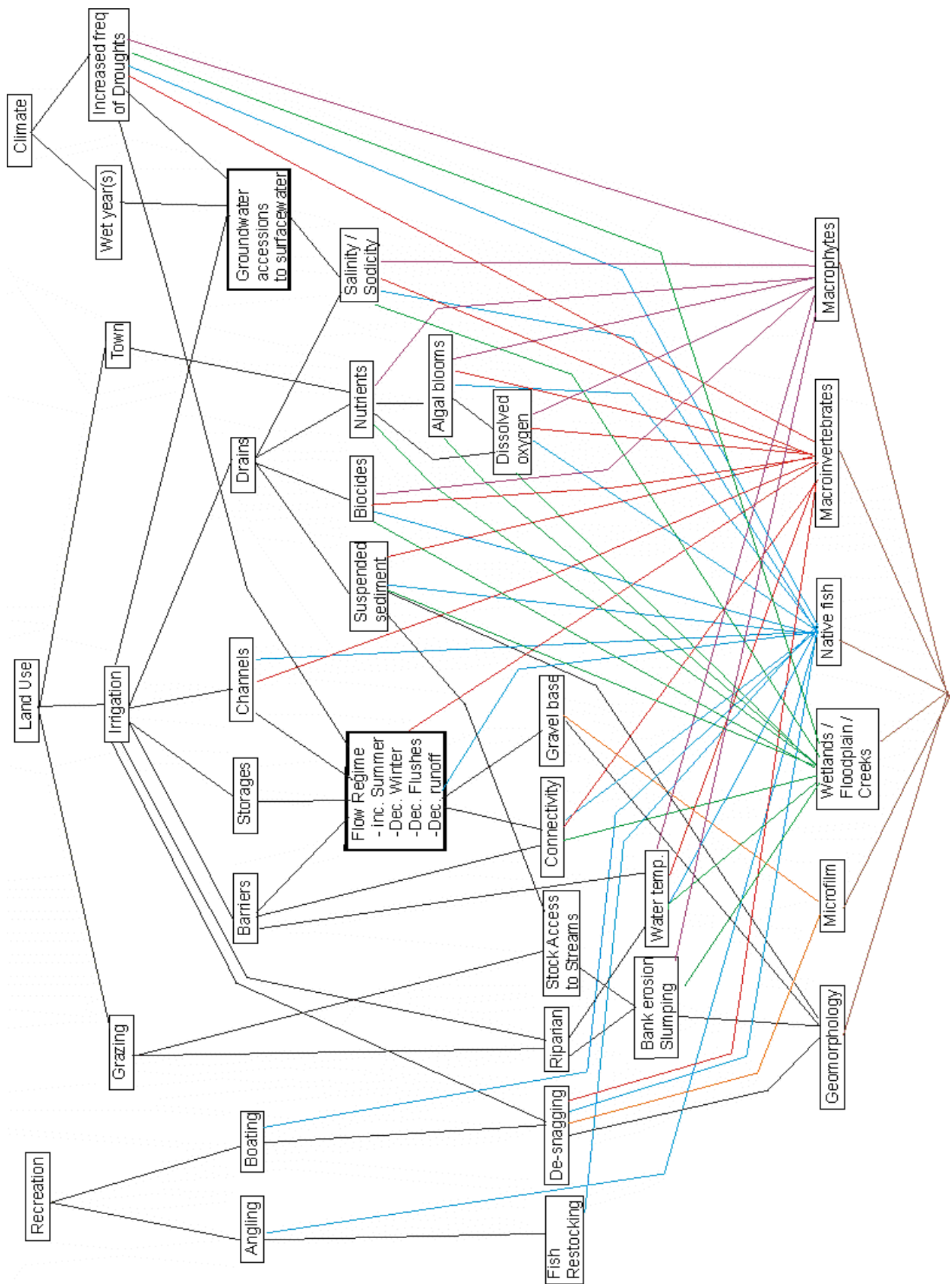


Figure 3: River "health" conceptual model.

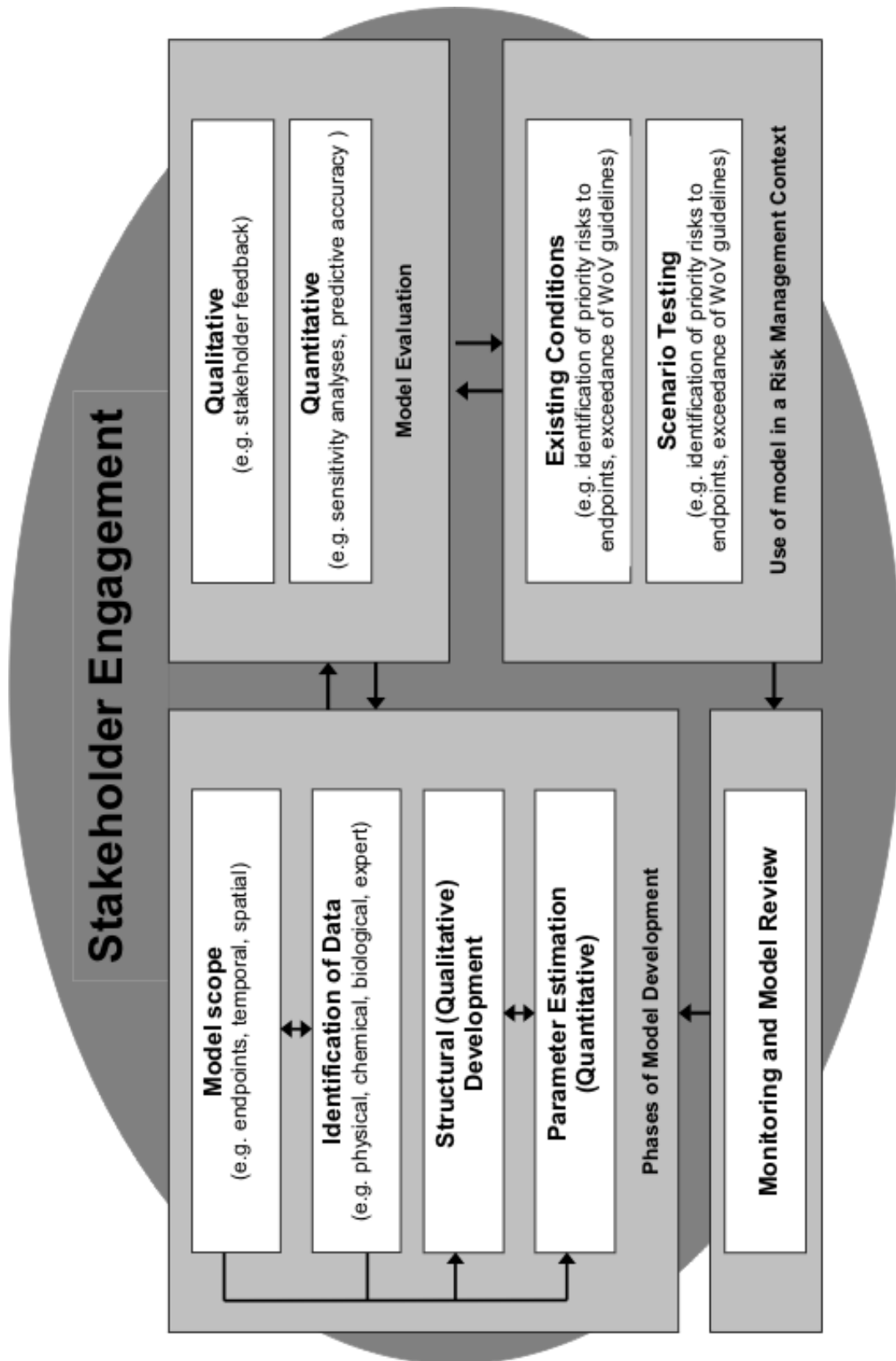


Figure 4: Major phases in Bayesian network model development and use.

NPSI Project¹: Delivering Sustainability through Risk Management

Murray Irrigation Limited: Case Study

Phase Two: Plan

Priority Issues from Phase 1:

The following environmental values featured prominently during Phase 1:

- Terrestrial vegetation and fauna
- Wetland vegetation and fauna
- River “health” (including floodplain)

Conceptual diagrams, based on stakeholder interactions in phase 1, have been constructed. These are constructed based on the opinion of stakeholders as to what the interactions in the system are based on conversations during interview.

Figure 1 is specific for remnant terrestrial flora and fauna, Figure 2 for wetland and floodplain forest flora and fauna and Figure 3 for river “health” related issues.

Stakeholder interactions

Murray Irrigation Limited, LWMP Chairs and staff, Murray Catchment Management Authority, MWWG, DIPNR, NSW State Forests, NSW Department of Agriculture, Yorta Yorta Nations Aboriginal Council, Riverina Environment Council, Nature Conservation Working Group, MDBC, MDFRC, CRC FE

Information sources

As yet, no group has been approached regarding data but literature and agency databases have been investigated. It is anticipated that there will be difficulty in obtaining data given that the Eardley (1999) study suffered from the lack of primary biological data, the inconsistency and quality of data, and the inaccessibility of some of the existing data sets.

The lack of primary biological data will be addressed by using expert opinion. A considerable amount of stakeholder interaction is expected in Phase 2. The inconsistency and quality of data will be problematic, but will be treated accordingly in data analyses. The inaccessibility of data related to Eardley (1999) having difficulty convincing

¹ CRCFE associated project (D728)

stakeholders that the sharing of data will on balance be beneficial to all, and there was some reluctance by data-holders to share their datasets. The expertise of MEI will hopefully assist in overcoming this problem.

Potential Issues for consideration in Phase 2:

A range of options were considered for investigation in Phase 2 of the case study:

- A. Building on the work of Eardley (1999) and investigating the relationship between extent of vegetation types and how this affects fauna indicators (e.g. threatened species such as Superb parrot [river red gum and black box habitat], plains wanderer [grassland habitat]);
- B. Investigating relationships between vegetation maps, water table maps and disturbance processes;
- C. Developing a decision support framework for revegetation in each of the LWMP areas (relate to historical vegetation, soil types, geomorphology, etc.);
- D. Populate the wetland conceptual model;
- E. Populate the floodplain conceptual model;
- F. Populate the terrestrial conceptual model;
- G. Investigating the relationship between “river health” indicators (riparian, water quality, flows) and wetland biota (birds, macrophytes, fish, macroinvertebrates) found in the region;
- H. Investigating the relationship between “river health” indicators (riparian, water quality, flows) and aquatic biota (macrophytes, fish, macroinvertebrates).

All of the case study options were assessed against a set of criteria (below). The outcomes of this process are shown in Table

Criteria for consideration in Phase 2:

- 1. Is focus within our area of expertise?
- 2. Is focus relevant to MIL operations?
- 3. Is focus relevant to local landholder activities?
- 4. Is focus relevant to identified values of local landholder stakeholders?
- 5. Is focus a priority issue in the MIL area of operation?
- 6. Are we adding value (not just replicating what is already being done)?
- 7. Can the focus be targeted towards improving practices in the area, while being realistic about the competing activities and values in the area (recognising what is achievable)?
- 8. Is data or the mechanistic understanding of relationship available?
- 9. Will output be publishable?
- 10. Is the project achievable in timeframe?

Table 1: Selection criteria versus case study options.

	1	2	3	4	5	6	7	8	9	10
A	N	Y	Y	Y	Y	Y	Y	some	Y	Y
B	N	Y	Y	Y	Y	Y	Y	some	Y	N
C	N	Y	Y	Y	Y	Y	Y	Y	Y	Y
D	Y	Y	Y	Y	Y	N	Y	some	?	N
E	N	Y	N	Y	Y	?	Y	some	Y	Y
F	N	Y	Y	Y	Y	Y	Y	?	?	N
G	Y	Y	Y	Y	Y	Y	?	some	Y	Y
H	Y	Y	Y	N	Y&N	Y	?	some	Y	Y

Priority Issues for Further Study

The focus for Phase 2 was discussed with representatives of MIL, the NSW EPA/DEC and the Murray CMA. Given the limited expertise of the NPSI project team, the 2 options selected for further investigation were:

- *Populate the wetland conceptual model (ie. Develop a decision support tool for management of Blackbox communities);*
- *Investigating the relationship between “river health” indicators (riparian, water quality, flows) and aquatic biota (macrophytes, fish, macroinvertebrates).*

Activities will include:

- Develop and refine conceptual models based on priority issues identified in Phase 1 (Individual consultations);
- Develop and parameterise model(s) (Individual consultations);
- Verification of model(s) (Workshop 2 and individual consultations).

• **Populate the wetland conceptual model (ie. Develop a decision support tool for management of Blackbox communities)**

The proposed study is the development of a model that can be used as a decision support tool to aid MWWG, MIL, and potentially the Murray CMA, in the management of activities that threaten the sustainability of Blackbox (*Eucalyptus largiflorens*) depression communities. Communities incorporate the Blackbox vegetation community, aquatic community and potentially the bird community (to be discussed).

The project would seek to undertake either part or all of the following (where possible, utilising knowledge [MWWG, MDFRC] already available):

- a) Further demonstrate how certain landholder activities (use as storage? unmanaged grazing? laser levelling? aerial spraying?) affect the ecological integrity of wetlands;
- b) Further demonstrate that certain regimes for watering (how often? time of year? duration?) are more optimal than others for regeneration of Blackbox and maintenance of Blackbox depression communities;

- c) Prioritise watering of wetlands by demonstrating that the environmental conditions of certain Blackbox wetland areas (soil type? groundwater height? proximity to drains? soil salinity?) are more optimal for watering than others (MIL);
- d) Assist in strategically selecting and targeting Blackbox depressions on private land for watering (MIL);
- e) Scenario test alternative management strategies (eg. watering? grazing? fencing?):
 - i) Probabilistically predict the outcomes of alternative management regimes;
 - ii) Identify high risk activities and communicate those risks to stakeholders;
 - iii) Quantify the uncertainty associated with predictions;
- f) Develop a shared conceptual understanding of the factors influencing Blackbox depressions amongst different groups;
- g) Bring together past and present datasets (physical, chemical and ecological), and disparate datasets of MIL, DIPNR, MWWG, MDFRC;
- h) If relevant, connect existing NRM models (eg. hydro and water quality models) with ecological outcomes;
- i) Identify key knowledge gaps and make recommendations for improved monitoring and targeted investigations.

After screening of landholder applications by MIL, one of the MWWG selection criteria for selecting a wetland for watering on private land is “landholder attitude and motivation” [Nias, 2003 #198]. The model could potentially incorporate these “community attitude” measures into the model.

It is intended that the final model will be simple enough to be used by any interested group, be scientifically robust, and to be transparent in the assumptions made. The modelling methodology to be utilised in this study is Bayesian networks. Bayesian networks are not a “Blackbox” modelling technology, but are tractable.

Using the Bayesian network approach, it is hoped that a shared conceptual and quantifiable understanding of the Blackbox depression environment and the threats to the Blackbox depression communities will be achieved. The model will also enable the testing of management scenarios, predict outcomes of different management scenarios and set priorities for management.

Beneficial uses of model by MWWG:

- Assist in determining the likelihood of an improved biodiversity outcome;
- Document community attitudes towards wetland watering.

Beneficial uses of model by MIL:

- Assist in screening landholder applications for wetland watering;
- Enable strategic approaches for wetland watering.

Project/Model scope

Bayesian networks are able to represent and ‘learn’ from specified mechanistic relationships, data, and, where these don’t exist, expert knowledge. Data and knowledge

relevant to the entire MIL area will be utilised in this study. The predictive time frames can fit in with the Murray Catchment Blueprint (2003) targets, being 1 year (now), 10 year, and 50 year.

Data sources

MWWG, MDFRC, MIL, DIPNR

To undertake such a project, it is vital that a close working relationship is established between the MWWG, MDFRC and the WSC. The potential for working with the MWWG is being explored. The MDFRC (Ben Gawne and Daryl Nielsen) are currently undertaking a study with the MWWG looking at blackbox wetlands. There is no intention to repeat the work of the MDFRC (which is using multivariate statistics to test biological responses of wetlands to alternative watering regimes – Deb/Daryl is this correct?).

For the WSC project to proceed, the support of the MWWG and MDFRC is essential. The WSC project would entail using knowledge and data from the MWWG and the MDFRC. All acquired knowledge and data would be attributed to the owner. Knowledge will be used to refine conceptual model developed in Phase 1 of the project, and to specify the probabilistically relationships between the different components of the model, particularly where there is no data or data gaps.

This study will utilise existing datasets, no further data collection will be required to complete the case study.

- **Investigating the relationship between “river health” indicators (riparian, water quality, flows) and aquatic biota (macrophytes, fish, macroinvertebrates)**

The proposed study is the development of a model that can be used as a decision support tool to aid MIL, and potentially the Murray CMA, in the management of irrigation activities that threaten river ‘health’. As the project time line is limited, it is proposed that a modelling tool be constructed that investigates the management of native fish communities and their habitat only. Stakeholder interactions in Phase 1 of the study clearly demonstrated that there were conflict between groups in determining whether native fish communities in the MIL area are under threat.

The study will investigate the major threats to fish communities upstream and downstream of the MIL area of operation and within the MIL area of operation. The product will be a tool that can assist MIL in recognising and managing the threats to native fish in their focus area. The tool will also acknowledge those activities that are beyond the control of management by MIL.

Although the project will seek to address similar elements contained in the Murray Flow Assessment Tool (MFAT) and Native Fish Strategy (NFS), it will seek to incorporate quantitative relationships in addition to the expert knowledge utilised in MFAT and the NFS. This project will be also focus on a smaller scale, unlike MFAT and the NFS, which addressed the entire Murray Darling Basin. Thus, activities examined will have

greater focus on upstream and downstream of the MIL area of operation and within the MIL area of operation.

NOTE: *There is the potential for conflict between the WSC model and MFAT [used in Living Murray Process of which MIL is highly critical of]. Project could also potentially conflict with the Native Fish Strategy (MDBC). VERY POLITICAL!!!*

Importantly, the model will seek to:

- a) Demonstrate how certain irrigation activities (drainage returns? altered flows? de-snagging? channel activities?) effect native fish;
- b) Investigate how recreational activities (stocking of artificially high numbers of native fish? angling? boating?) effect native fish communities;
- c) Scenario test alternative management strategies (eg. channel operations? drains?):
 - i) Probabilistically predict the outcomes of alternative management regimes;
 - ii) Identify high risk activities and communicate those risks to stakeholders;
 - iii) Quantify the uncertainty associated with predictions;
- d) Develop a shared conceptual understanding of the factors influencing native fish communities amongst different groups;
- e) Bring together past and present datasets (physical, chemical and ecological), and disparate datasets of MWWG, MDFRC, MIL, DIPNR, NSW Fisheries;
- f) If relevant, connect existing NRM models (eg. hydro and water quality models) with ecological outcomes;
- g) Identify key knowledge gaps and make recommendations for improved monitoring and targeted investigations.

Project/Model scope

Bayesian networks are able to represent and 'learn' from specified mechanistic relationships, data, and, where these don't exist, expert knowledge.

The model will use the existing Goulburn Fish Bayesian Network as a starting point (NPSI project, completed March 2004). The model will incorporate data relevant to upstream and downstream of the MIL area of operation and within the MIL area of operation. The model will also be expanded to produce endpoints for the recognised 4 types of native fish communities in the Murray Darling Basin (as in MFAT), as opposed to the single endpoint for abundance and diversity in the existing model. The potential to incorporate extended timescales will also be investigated (currently only 1 year and 5 year predictions).

The project will incorporate knowledge and data from the following systems and reaches:

- Murray River
 - Hume Dam to Yarrawonga Weir
 - Yarrawonga to Tocumwal
 - Tocumwal to Edward offtake (Picnic Point)
 - Edward offtake (Picnic Point) to Barmah

- Barmah to Torrumbarry Weir
 - Torrumbarry Weir to Narrung
- Edward River
 - Edward offtake (Picnic Point) to Stevens Weir
 - Stevens Weir to Murray confluence
- Wakool River
- Tuppall Creek

The predictive time frames can fit in with the Murray Catchment Blueprint (2003) targets, being 1 year (now), 10 year, and 50 year.

Data sources

MWWG, MDFRC, MIL, DIPNR, NSW Fisheries

The detailed consultation of experts documented in MFAT and the NFS will circumvent the need to widely consult fisheries experts, although it will not do away with this process in entirety (model verification).

The MDBC will soon be commencing a study investigating improving fish habitat between Hume Dam and Yarrawonga Weir (under the NFS banner).

Construction of Bayesian networks

Developing Bayesian network models is an iterative process shown in Figure 3, and as outlined in Woodberry *et al.* (in prep.).

For each model, the first phase will be to refine the conceptual models for each endpoint. These will be based on those developed in Phase 1, but will be supplemented with additional variables and interactions after consultations with experts. It is anticipated that the parameterisation of the models will be both qualitative and quantitative given the paucity of data that is likely to be available.

Model verification/validation

Each of the following steps will be conducted with each model prototype, until an accurate and acceptable model is developed.

To test model accuracy, four tests (in no particular order of importance) will be used:

- Model predictions versus real data;
- Stakeholder review of the model;
- Sensitivity analyses;
- Predictive accuracy tests.

The first two tests are qualitative. Where possible, model predictions showing relationships between existing land uses, existing environmental conditions and ecological endpoints will be plotted against existing data. The second test will be a model review, which will be conducted with key stakeholders. Stakeholder feedback will be used to test if the model output is reasonable, and where further effort is required to improve the model quantitatively and qualitatively.

The following tests are quantitative. Two types of sensitivity analysis will be used to identify sensitive parameters: sensitivity to findings and sensitivity to parameters. Both are used to identify potential errors in the quantitative and qualitative components of the model. The sensitivity to findings results can also be used to identify and rank risks to model endpoints. The predictive accuracy test is conducted by splitting the dataset so that 80% will be used to train the model and 20% of the data set will be used to test model predictions.

Project output

Using Bayesian networks, the major risks to:

- **Blackbox depression communities**
- **River health endpoint(s): Native fish and their habitat**

will be identified and characterised.

The models will also have the ability to test the outcomes of alternative management scenarios, prioritise the management of risks, identify key knowledge gaps and recommend where existing monitoring programs can be improved.

On completion, for the models to have an extended lifespan, they need to be updated using data/information as it becomes available, particularly after management actions have been undertaken in the catchment. Incorporation of new data and information improves the predictive accuracy of the models, and the models 'learn' to better represent existing relationships or new relationships. Model analyses will identify key knowledge gaps and provide assistance in meeting current planning strategies and informing future planning processes.

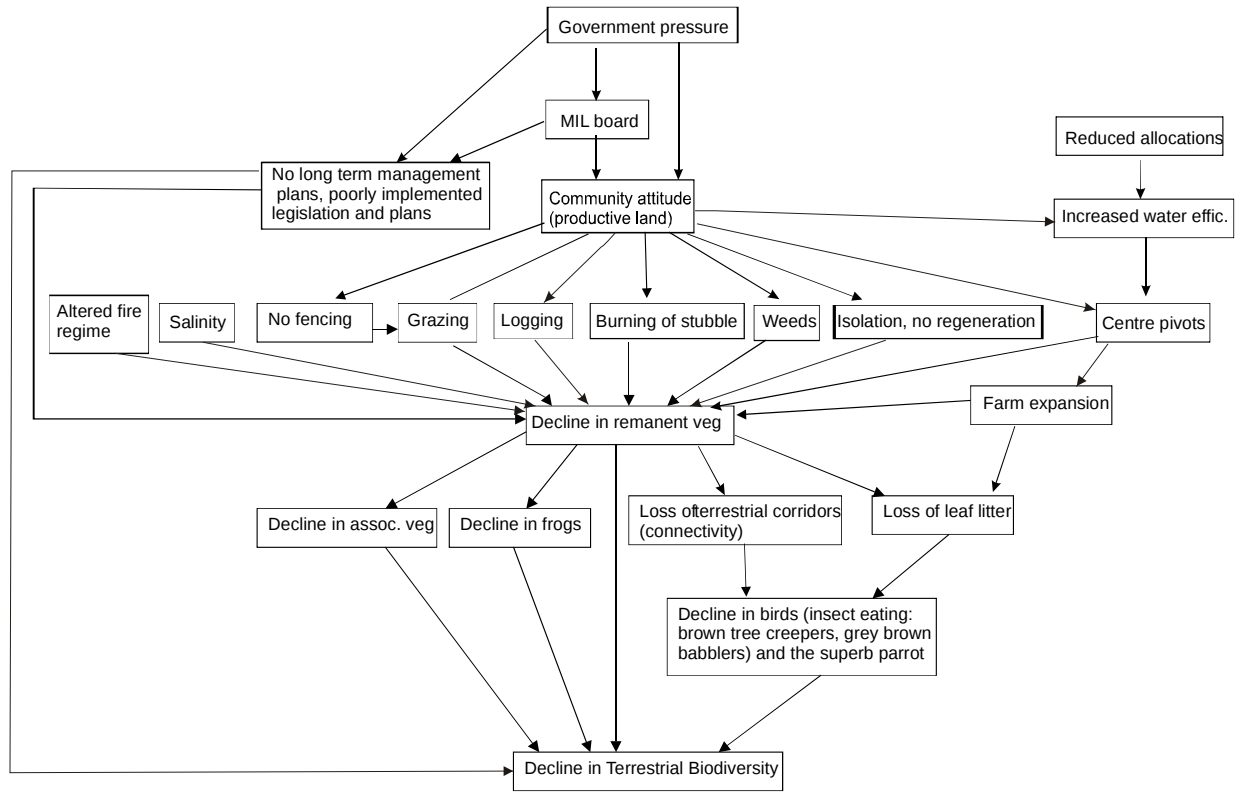


Figure 1 Remnant terrestrial flora and fauna.

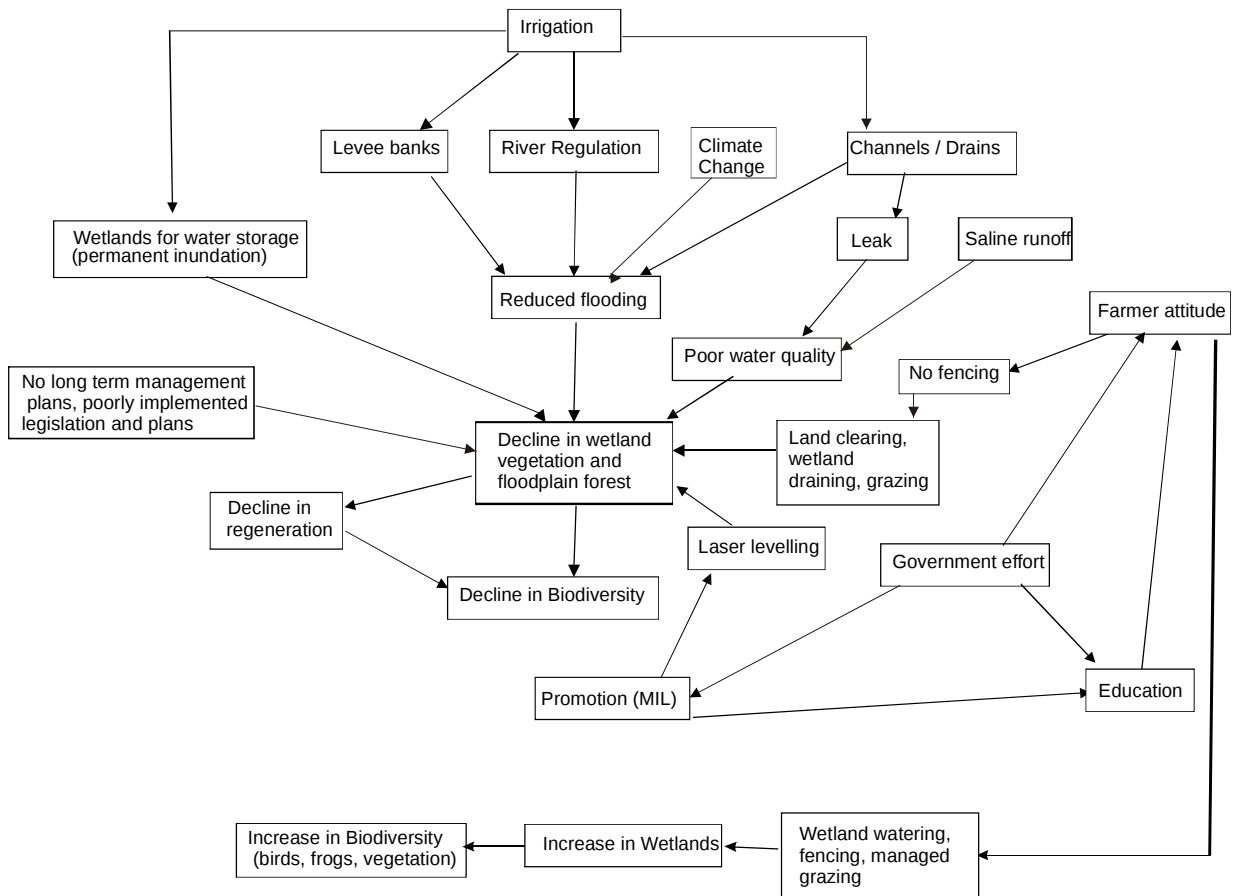


Figure 2: Wetland and floodplain forest flora and fauna.

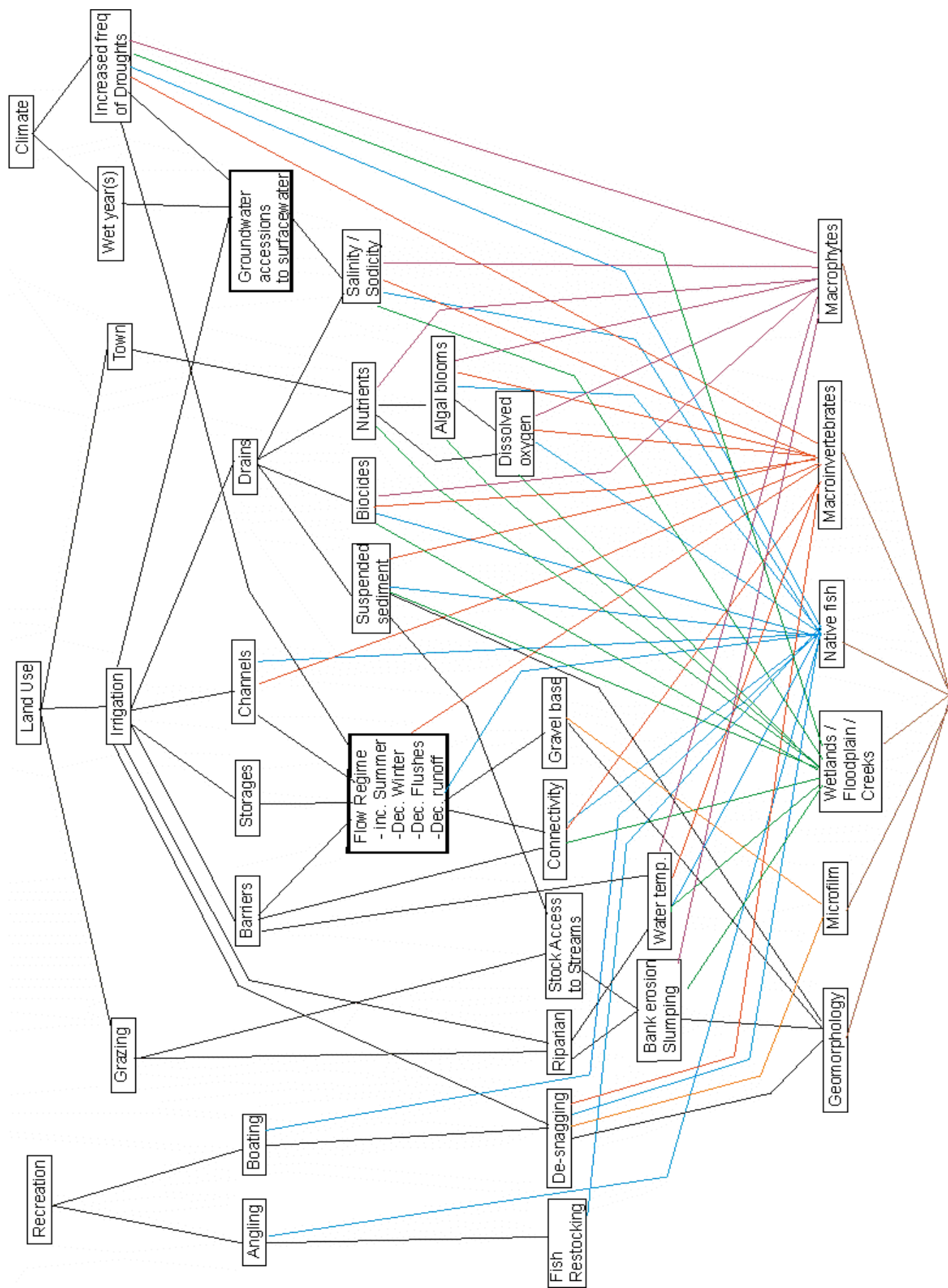


Figure 3: River "health".

LOWER LODDON ECOLOGICAL RISK ASSESSMENT

1. INTRODUCTION

This is a collaborative project between staff from Water Studies Centre, Monash University, EPA Victoria, North Central Catchment Management Authority and Goulburn Murray Water. The project is assisted by funding from the joint commonwealth and state partnership for the National Action Plan for Salinity and Water Quality and the National Program for Sustainable Irrigation (NPSI).

It is proposed that an ecological risk assessment (ERA) will be conducted in the lower Loddon irrigation region, which we will define as the catchment downstream of Bridgewater (see Figure 1). This project aims to:

- provide quantitative information to assist in natural resource management in the region,
- raise awareness about risk-based assessment methods, and
- provide a practical case study on the implementation of an ecological risk assessment (ERA) process.

Background

Ecological Risk Assessment

Ecological Risk Assessment (ERA) is a formal process for determining the level of risk posed by hazards (stressors, threats) to the health of ecosystems. ERA evolved from the need to develop processes that better deal with the complexity of aquatic ecosystems, that is, the difficulties in assessing multiple stressors for a wide range of species within inherently variable ecosystems.

The ERA process not only incorporates complexity and uncertainty into the decision making process, but also avoids ambiguity as it is transparent and clearly defines the problem and desired outcomes. It also involves all key stakeholders. Where appropriate, this approach is increasingly being adopted by resource managers, environmental agencies and research bodies for the evaluation of adverse ecological effects. Such assessments provide an explicit and transparent process for coming to terms with the need to make management decisions for complex ecosystems that may not always be fully understood.

National Program for Sustainable Irrigation (NPSI)

The National Program for Sustainable Irrigation (NPSI) is currently funding a project *Delivering Sustainability through Risk Management*. This is an integrated research project to raise awareness of adopting risk-based environment management approaches in the irrigation industry and develop and apply a generic framework for assessing the ecological risks associated with irrigation systems.

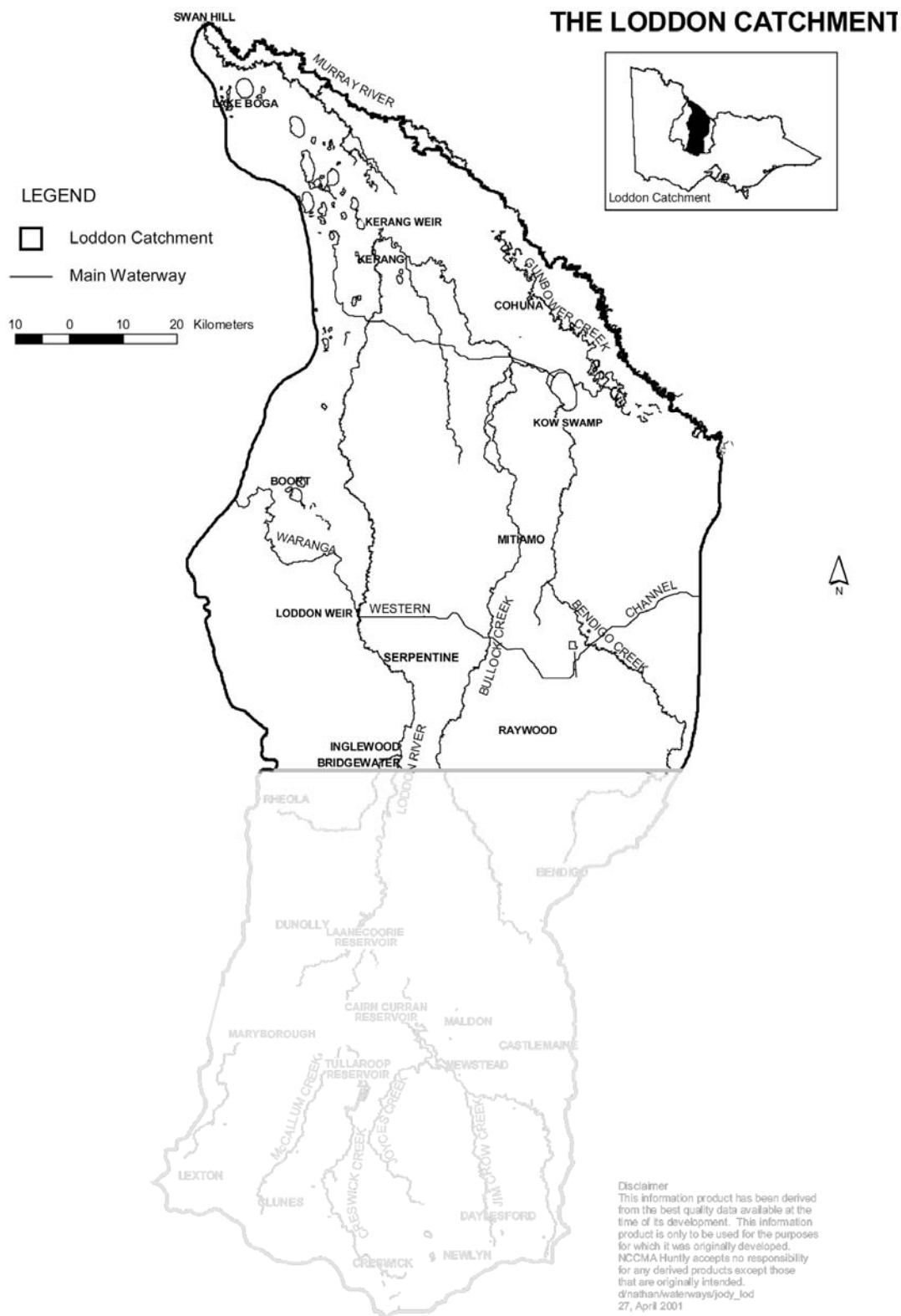


Figure 1. The lower Loddon River catchment. Adapted from Loddon River Environmental Flows Scientific Panel, 2002.

State environment protection policy Waters of Victoria

A risk-based approach was developed under the National Water Quality Management Strategy – *Australian and New Zealand Guidelines for Fresh and Marine Water Quality* (ANZECC and ARMCANZ, 2000). This approach has been adopted in the State Environment Protection Policy, Waters of Victoria (SEPP (WoV)). Under this approach, the SEPP (WoV) environmental quality objectives now represent levels at which there is a potential risk that adverse ecological effects may occur. Where the environmental quality objectives are not met, a risk-based assessment needs to be conducted to ascertain if there is an adverse risk to the ecosystem.

The outcomes and information from these risk assessments can then feed directly into regional planning decision-making processes. For example, the information and understanding of risks to catchment ecosystems will assist in setting targets in Regional Catchment Strategies and Regional River Health Strategies, and prioritising and determining catchment works in subsequent action plans.

Lower Loddon Catchment

It is proposed that this project focus on the lower Loddon catchment, downstream of Bridgewater (see Figure 1). The major land uses in this region are irrigated and dryland agriculture. The irrigated agriculture is predominately dairy, horticulture and mixed farming, and the dryland agriculture is predominately cropping. The major urban communities are Kerang, Cohuna, Pyramid Hill, Boort and Swan Hill.

The Loddon river flows in a single thread from Laanecoorie Reservoir to just south of Serpentine, where the river enters the Loddon Fan. Here the Loddon becomes a series of anastomosing distributary streams flowing northwards across the Plain. The Bulldog Creek-Pyramid Creek in the east of the lower catchment enters the Loddon at Kerang. Barr Creek enters further downstream, and is slightly unusual in that it drains relatively high salinity groundwater. The lower Loddon flows through the Murray River floodplain before draining into the Murray River in the north.

The lower Loddon is significantly affected by the operation of Torrumbarry Weir. Some of the wetlands in this area are used as irrigation system storages, and some as evaporation basins (e.g. Lake Tutchewop) for reduction of salt discharge into the Murray River.

Approximately half the flow in the entire Loddon catchment is diverted for irrigation or for stock, rural, and domestic uses. There are more than 60 water storages, most are small (<5,000 ML), with only 3 with storage capacities greater than 50,000 ML, and only one of these (Kow Swamp) is in the lower Loddon catchment. The greater part of the water use in the Loddon catchment is imported from the Murray River and Waranga Western Main Channel and the Coliban supply system. The use of 110,000 ML from local surface water resources (mainly the upper

catchment) accounts for about 8% of total use. About 95% of the total is used for irrigation, 3% for rural, stock, and domestic purposes, and 2% for urban and industrial uses.

There are a number of processes already in place in the lower Loddon catchment that have identified threatened environmental values (assets). For example, the Regional Catchment Strategy (RCS), Regional River Health Strategy (RRHS), Loddon Murray Land and Water Management Strategy, the Bulk Water Entitlement (BE) conversion process and the Kerang-Swan Hill Future Land Use Pilot Project. The values (assets) identified include the internationally significant Ramsar listed sites, Gunbower Forest and Kerang wetlands, Johnsons and Hirds Swamp, and Lakes Tutchewop, William, Cullen, Charm and Kelly. Previous studies have also identified vulnerable remnant vegetation ecosystems, and threatened species such as platypus, Silver perch and Murray hardyhead.

2. PROJECT TEAM

Terry Chan - WSC, Monash University;

Anne-Maree Westbury - EPA Victoria;

Prof Barry Hart – WSC, Monash University;

David Tiller - EPA Victoria;

To be determined – North Central Catchment Management Authority;

To be determined – Goulburn Murray Water.

3. STAKEHOLDERS

Steering Committee

- Prof Barry Hart – WSC, Monash University;
- David Tiller, EPA Vic;
- John Williamson, EPA Vic;
- Pat Feehan, GMW;
- Gavin Hanlon, NCCMA;
- Dr Jane Doolan? (or Dr Stuart Minchin?), DSE.

General Stakeholders

Organisations:

- NCCMA;
- GMW;
- EPA;
- DSE;
- DPI;
- Local government;
- Coliban Water;
- Lower Murray Water.

Community Groups:

- Indigenous groups (the Barapabarapa from Boort to Kerang, and the Wamba Wamba from Kerang to River Murray);
- NCCMA Loddon/Campaspe Irrigation Implementation committee;
- Community working group on the Kerang-Swan Hill Future Land Use Pilot project;
- Loddon Murray Community Leadership Program members;
- “Loddon Murray 2000 plus” community members
- Irrigators and other agricultural groups;
- Landcare;
- Waterwatch.

4. PROJECT PLAN

Phase 1 – Planning

Prepare current scope document – completed.

SCOPING TASKS:

- Identify spatial scale: lower Loddon irrigation region;
- Temporal scale: to be determined during ERA process, taking into consideration 2-3 year decision making timescale and RCS/RRHS 5-10 year reviews and targets;
- Identify stakeholder groups;
- Identify current catchment information;
- Provide an outline of the project plan.

Phase 2 - Problem Formulation

OBJECTIVES:

- Identify and discuss priority threatened environmental values (assets) in the lower Loddon irrigation region that stakeholders want to protect, maintain and rehabilitate;

- Identify the key hazards/threats to these priority values;
- Develop conceptual model(s) ('knowledge maps') that show stakeholder understanding of the above key risks;
- Determine risk analysis plan.

METHOD:

- Gather available data and information;
- Stakeholder Consultation:
 - Collect information from previous stakeholder consultation processes where community members have identified environmental/waterway values, threats, targets and priority activities in the lower Loddon catchment. These include the RCS and RRHS processes, the Kerang-Swan Hill Future Land Use Pilot project, Loddon Murray Land and Water Management Strategy;
 - Telephone and face-to-face interviews/surveys;
 - Stakeholder workshop;
- Based on the consultation outcomes, select 1-2 key threatened environmental values/assets on which to conduct a detailed risk analysis.

Phase 3 - Risk Analysis**OBJECTIVES:**

- For the key risks identified in the problem formulation stage:
 - quantitatively determine the level of risk posed to lower Loddon ecosystems, and
 - provide analysis, information and tools to assist in the management of the risks, understanding of the factors influencing the consequences and likelihood of the risk.

METHOD:

- The type of analysis to be conducted will be determined during the problem formulation phase. It is anticipated that this may include the development of Bayesian network models (see below for brief introduction) for selected key risks.

Phase 4 – Risk communication / Reporting

- Hold a concluding workshop to report project outcomes to stakeholders and discuss with them the implications;
- Prepare final report;
- Incorporate ERA information into regional planning decision-making processes.

Bayesian Networks

It is likely that the quantitative risk analysis (Phase 3) involved in this project will use Bayesian networks (e.g. Figure 2). Bayesian nets are ideally suited as tools to aid in natural resource management decision-making, where problems are complex and data often scarce and uncertain. Bayesian models allow explicit representation of causal interactions, despite any incompleteness in our understanding of the system. They can also incorporate data from varying spatial and temporal scales, make model assumptions more transparent, and provide output directly applicable to risk management. Bayesian networks are particularly good for representation of uncertainty, which can be very large in ecological systems.

Because Bayesian networks are a type of graphical model, their representation provides an easily understandable interface for stakeholders with varying backgrounds (familiarity with the region, problems, system, and/or science). These models can also be easily updated when more information becomes available. Bayesian nets are particularly appropriate in management situations as they can be extended to take into account “Decision Theory”.

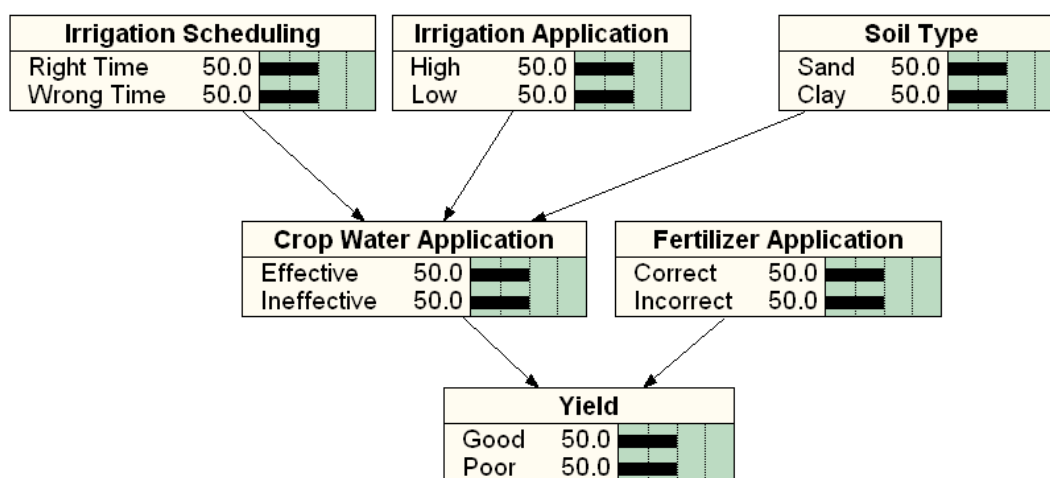


Figure 2. An example of a Bayesian network showing factors determining crop yield (after Cain, 2001).

5. TIMELINE

	2004						2005					
	July	August	September	October	November	December	January	February	March	April	May	June
Phase 1 – Planning												
Phase 2 – Problem Formulation												
Stakeholder Consultation and Workshop Planning												
Stakeholder Workshop												
Risk Analysis Plan												
Phase 3 – Risk Analysis												
Phase 4 – Risk Communication and Final Report												

NPSI Project UMO45

In kind contributions

Organisation	Staff Time	Y1	Y2	Total
		Jul03-Jun04	Jul04-Jun05	
Monash*	0.2	\$62,400	\$62,400	\$124,800
Monash*	0.1	\$21,000	\$21,000	\$42,000
Monash**	0.5	\$25,200	\$50,400	\$75,600
Monash**	0.5	\$0	\$45,000	\$45,000
Monash*	0.1	\$32,200	\$32,200	\$64,400
Monash**	0.3	\$13,500	\$27,000	\$40,500
Univ Melb*	0.15	\$48,300	\$48,300	\$96,600
Univ Melb**	0.6	\$32,400	\$32,400	\$64,800
MIL*	0.05	\$12,000	\$12,000	\$24,000
MIL*	0.05	\$10,000	\$10,000	\$20,000
NSW EPA*	0.05	\$12,000	\$12,000	\$24,000
Vic EPA*	0.5	\$0	\$90,000	\$90,000
Vic EPA*	0.1	\$0	\$24,000	\$24,000
Total		\$269,000	\$466,700	\$735,700

* Salary x 3.0

** Institution on costs only (salary x 1.8)

NPSI Project UMO45

Delivering Sustainability through Risk Management

Phase 2 Research Plan

Project title: Delivering Sustainability through Risk Management – Phase 2

Duration: 18 months, May 2004 – September 2005

Objectives:

- Undertake at least six regional workshops to raise the awareness of risk-based management processes, with a focus on irrigation enterprises.
- Undertake training courses for the case study teams (and selected agency staff) using newly developed ERA training modules, which will develop (or strengthen) the capacity within the selected organisation to use risk management procedures.
- Undertaken a program of activities that will lead to adoption of risk management procedures within both the case study partnerships and each of the selected Sustainable Irrigation projects.
- Develop and implement an evaluation procedure to assess the effectiveness of the training program and the engagement of the case study teams in the ecological risk assessment activities.

Activities

Activity 1: Regional Awareness Workshops

Objective: Undertake six regional workshops to raise the awareness of risk-based management processes, with a focus on irrigation enterprises

Staff involved: Dr Terry Washe, Prof Barry Hart, Prof Mark Burgman

Program: See attached

Outputs: Workshop material (powerpoint presentations, will also develop a web-based version of the training material)

Report on feedback obtained during the workshops

Evaluation of the success of the workshops (see also Activity ?)

Activity 2: Training workshops

Objective: Undertake training courses for the case study teams (and selected agency staff) using newly developed ERA training modules

Staff involved: Dr Terry Washe, Prof Mark Burgman, Prof Barry Hart, Dr Carmel Pollino, Dr Mike Grace

Program: Training workshops will be run for key staff associated with case studies (MIL, NSW EPA, GMWater, North Central CMA and others as appropriate)

Outputs: Training modules (powerpoint presentations, will also develop a web-based version of the training material)

Report on feedback obtained during the workshops

Activity 3: Case study partnerships

3.1 MIL Case Study

Objectives: To undertake an ecological risk assessment for the MIL region of operation

To develop a capacity within the partner organizations to use ecological risk assessment techniques to improve environmental management

Staff involved: Dr Carmel Pollino, Prof Barry Hart, Prof Chris Cocklin, Prof Mark Burgman, Naomi Mautner

Program: Phase 1 Problem Formulation completed (see Phase 1 report)

Phase 2 – see Phase 2 plan attached

Outputs: Phase 1 & 2 reports

Bayesian network decision support tools to quantify the risks to Black Box wetlands and native fish communities

3.2 Lower Loddon ERA Case Study

Objectives: To provide quantitative information to assist in natural resource management in the Lower Loddon region

To provide a practical case study on the implementation of an ecological risk assessment (ERA) process

To raise awareness about risk-based assessment methods

Staff involved: Anne-Maree Westbury, David Tiller (Vic EPA), Dr Terry Chan, Prof Barry Hart (Monash)

Program: See attached project proposal

Outputs: Final report

Two workshops (problem formulation, final risk communication workshop)

Bayesian network models for selected key risks

Activity 4: Sustainable Irrigation Projects

Objective: To undertake a program of activities that will lead to adoption of risk management procedures within each of the selected Sustainable Irrigation projects

Staff involved: Prof Barry Hart, Dr Mike Grace, Dr Mark Burgman, Dr Terry Walshe

Program: Project team will interact with 5 Sustainable Irrigation projects to determine how ERA techniques might assist these projects. Projects selected are:

- Goulburn–Broken Irrigation Futures (Dr QJ Wang)
- Northern Australia Irrigation Futures (Dr Keith Bristow)
- Tri-State Project: Impact of Salinity on Lower Murray Horticulture (Dr Gerrit Schrale)
- Use of reclaimed effluent water in Australian horticulture (Dr Anne-Maree Boland) [May also include a new NPSI project – Open Hydroponics System)
- Best practice irrigation in the South West (Harvey) Irrigation Area (Ken Moore)

Outputs: Report on each interaction

Activity 5: Combined workshop

Objective: To run a workshop in early 2005 with the Case Study Partnership team and the Sustainable Irrigation project teams, to share experiences with the risk management approaches trialled

Staff involved: All project team

Program: To be determined

Output: Short report on the outcomes of the workshop

Activity 6: Evaluation process

Objective: To develop and implement procedures to evaluate the effectiveness of the regional awareness workshops and the training modules

To evaluate the success (and learnings) from the case study projects and the interactions with the Sustainable Irrigation projects

Staff involved: Dr Chris Cocklin, Naomi Mutner

Program: See attached

Output: Report on lessons learned in gaining adoption of the new knowledge

Activity 7: Final report

Objective: To produce a final report on the project

It is intended that an independent review of the project will be undertaken before the final report is completed

Staff involved: All project team

Program: The final report will include what was done, who was involved, how effective the process was, and what might be done to improve the process in the future. Additionally, the final report will contain a section on possible strategies for long-term adoption of risk management approaches into the irrigation (and associated) industry. It is likely that this will involve: (a) identifying people in the various organisations who can provide technical support for

others, (b) establishing a network of risk managers (email links etc), (c) establishing an annual meeting, workshop or conference targeted at ERA and its applications in the irrigation industry, and (d) providing ongoing access to cutting edge advances in ERA (e.g. at Monash and Univ Melbourne).

Output: Final report

Timeline

See attached Gannt Chart

B.T. Hart

1 September 2004

NPSI Project UMO45

Activity	2003			2004			2005							
	Jul-Aug	Sept-Oct	Nov-Dec	Jan-Feb	Mar-Apr	May-Jun	Jul-Aug	Sept-Oct	Nov-Dec	Jan-Feb	Mar-Apr	May-Jun	Jul-Aug	Sept-Oct
Phase 1														
Phase 2														
1. Awareness workshops														
2. Training workshops														
3.1 MIL Case Study														
3.2 Lower Loddon ERA Case Study														
4. Interaction with NPSI Projects														
5. Combined workshop	★													
6. Evaluation process														
7. Final report														
Milestone reports	1234													
Steering Committee meetings	★ ★ ★													

NPSI Project UMO45

Delivering Sustainability Through Risk Management

Team meeting notes

When: 0930 – 1230h, 2 August 2004

Where: Water Studies Centre meeting room, Monash University, Clayton

1. Irrigation ERA Framework

The NPIRD ecological risk assessment guidelines are nearing completion and a draft will be circulated to the group shortly.

Keith Hayes (CSIRO Marine) and Peter Davies (U of Tasmania) are to review the documents

2. Regional awareness seminars

Terry Walshe has been employed to undertake this component of the project.

Progress to date and Future program

Terry has identified 6 priority locations for 1-day workshops. All are located in the regions relevant to the other NPSI projects (see attachment 1).

- Shepparton workshop is scheduled for 17 November
- Adelaide workshop is to target Anne-Maree Boland and Gerrit Schrale projects, as well as AgNSW (Mildura)
- Perth – Make contact with Col Creighton (groundwater ecosystem study?)

Evaluation

The evaluation component of the seminars is still very unfocussed.

Need to focus on undertaking some benchmarking:

- Gauge the difference between 'us' (academic view of risk assessment) and regulators who undertake risk assessments to assist decision-making (and normally just focus on the AS/NZA)
- Are the differences between groups worth investigating further?

Need to sell to regulators why they should go that extra mile (not just undertake qualitative assessment) when undertaking a risk assessment

- Perhaps look at using a tiered approach – tiers of rigour (attachment 2)

Project reports and responsibilities (attachment 3)

Three reports:

- a. Workshop evaluation (TW, CC, NM)
Include evaluation of workshops and the process (including addressing the barriers to adoption)

Need to decide:

- How to do the evaluation?
 - How broad should the evaluation be?
 - Investigate barriers to quantitative approaches in ERA
 - Why do we undertake an ERA?
 - What are the motivations?
 - Have you influenced the right people
- a. Acceptance of ERA (CC, NM, TW)
Critique the ERA approach, which has been criticised for being reductionist – involvement of stakeholders
Report still undefined and unfocussed
- b. Case study and stakeholder interactions (CP, BTH)

3. Case study partnership – MIL/NSW EPA

Progress to date

Problem formulation component of study is nearing completion. Activities to date are contained in attachment 4. The original focus of the study was to investigate the NSW EPA license of MIL operations, but at a meeting in Nov 2003 at the NSW EPA offices (Albury), it was decided that the focus of the case study would be broader than this.

To undertake the problem formulation component of the study, a range of stakeholders were consulted via one-on-one interviews and a workshop. Interviews were conducted prior to and following the workshop. The workshop itself was of mixed success. The interviews proved to be the best avenue in consulting stakeholders.

Broadly, the priority ecological/environmental issues/values of focus for the MIL case study can be categorised as terrestrial flora and fauna, wetland flora and fauna, and “river health” aspects. Interestingly, local landholders predominately focussed on terrestrial and wetland related issues, but not “river health” issues.

Future actions (case study & MIL drainage RA)

The quantitative issue(s) of focus for the case study are to be decided in collaboration with project partners, being MIL and NSW EPA. Representatives from the Murray CMA will also be consulted.

Update: Two potential projects are now being scoped as a result of the Monash/MIL/NSW EPA/Murray CMA meeting in Deniliquin. The first being a model to assist decision-making for watering of Blackbox wetlands, of which most are on private land, and the second being the relationship between “river health” and biota. The meeting proved to be very constructive in focussing the case study for the “risk analysis” phase.

MIL have recently commenced a risk assessment focussed on drains in the MIL area as a component of developing a 'Drainage Management Plan'. A “problem formulation” workshop was held in Finley in June, Carmel assisted in this process. Barry and

Carmel will be assisting MIL further during the “risk analysis” component of the study.

Update: A very useful methodology for qualitatively defining probabilities was trialled during the MIL meeting. The methodology has great potential in enabling MIL to undertake the risk assessment. Further opportunities to build on the approach adopted by MIL are to be explored.

4. New case study partnership - Vic EPA/GMW/NCCMA

Case study is likely to focus on the lower Loddon. Anne Maree Westbury (Vic EPA) and Terry Chan are to undertake the case study over the next 12 months. A workshop is to be held shortly for the problem formulation phase of the project.

5. Links with other NPSI projects

- North Australia Irrigation Futures
- G-B futures
- Tristate
- Horticulture
- Harvey

Workshops are being conducted by Terry Walshe.

6. Project promotion

Tim Lester (LWA)

7. Budget

All happy

8. Steering Committee

For the next meeting, the evaluation component of the project needs to be focussed and refined. Specifically, how does the evaluation of the specific components and tasks of the project fit together? An update needs to be sent to the steering committee prior to the next meeting.

Next steering committee meeting: 1 October

9. Next meeting 17 September