Ex-Post Evaluation of Selected Research Projects

Report of a commissioned study
undertaken for LWRRDC
by Sloane Cook & King Pty Ltd

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Abbreviations

ACTFR	Australian Centre for Tropical Freshwater Research
AEAM	Adaptive Environmental Assessment and Management
ASRRF	Australian Special Rural Research Fund
AWRAC	Australian Water Research Advisory Council
BLG	Burdekin Landcare Group
BRIA	Burdekin River Irrigation Area
BRIATAC	Burdekin River Irrigation Area Technical Advisory Committee
BRT	Burdekin River Trust
BSES	Bureau of Sugar Experiment Stations
CALM	Department of Conservation and Land Management
CEAH	Centre for Environmental Applied Hydrology
CLWMP	Coleambally Land and Water Management Plan
CIA	Coleambally Irrigation Area
CSIRO	Commonwealth Scientific and Industrial Research Organisation
DAWA	Department of Agriculture WA
DLWC	Department of Land and Water Conservation
DWR NSW	Department of Water Resources NSW
LCDCs	Land Conservation District Committees
DPIE	Department of Primary Industries and Energy
EPA	Environmental Protection Authority
EPE	*Ex-Post* Evaluation
E&WS	Electricity & Water Supply (South Australia)
GA	Greening Australia
GRDC	Grains Research and Development Corporation
GW	Gippsland Water
HVCT	Hunter Valley Catchment Trust
JCU	James Cook University
LWRRDC	Land & Water Resources Research & Development Corporation
MDBC	Murray–Darling Basin Commission
MIA	Murrumbidgee Irrigation Area
ML	megalitre (1 million litres)
MREC	Murray Research and Extension Committee
NOELs	no observable effect levels
NSCP	National Soil Conservation Program
NSWF	NSW Forests
PAC	Project Advisory Committee
PISA	Primary Industry South Australian (formerly Department ofAgriculture SADA)
QDEH	Queensland Department of Environment and Heritage
QDPI	Queensland Department of Primary Industries
QDPI–WR	Queensland Department of Primary Industries – Water Resources
QWRC	Queensland Water Resources Commission
RIACT	Riverina Irrigated Agriculture Chemical Taskforce
RIRDC	Rural Industries Research and Development Corporation
RRC	Rice Research Committee
SEPP	State Environmental Protection Policy
TCM	Total Catchment Management
WQMS	Water Quality Management Strategy
WCMP	Waterwatch Community Monitoring Program
UNE	University of New England
UWA	University of Western Australia

1 Executive Summary

To improve the management of R&D programs, LWRRDC commissioned an *ex-post* evaluation of nine completed research projects, all of which were considered to have achieved their intended R&D outcomes. The consultants surveyed key beneficiaries of the R&D to identify the actual outcomes and benefits that had resulted from the projects to users of natural resources and to the Australian community. There were two irrigation, three water, three land and one vegetation project. All operated between 1989 and 1994.

1.1 Findings

Project planning

01 The stated objectives in a number of the projects were generally imprecise and sometimes vague, highlighting the problem that at least some objectives may not have been sufficiently thought through. There was confusion between goals, objectives, inputs and outputs. In most instances the confusion in the objectives meant that they were inadequate for the purpose of *ex-post* evaluation.

02 The current application form for research grants calls for 'project objectives' only. At no stage does it ask for the expected outcomes. This leaves room for confusion, particularly between objectives and outputs. The form requests that objectives be quantified, however it is the outputs which should be quantified, not the objectives.

03 To overcome the potential for confusion and to provide a basis for any later evaluation, the Corporation should consider using an objective approach to define the goal, purpose and outputs for each project, This would require applicants to state the overall context for the research, why it is being done and what it will produce in quantifiable terms.

04 The evaluations suggest that at the planning stage there is often a failure to think through how the adoption process will work-that is, to identify the forces which might drive adoption. There is confusion between scientific and adoption objectives which appears as vaguely-stated adoption objectives which do not lead to any particular outcome. This situation can lead to a self-defeating allocation of resources, where most of the budget is built around the scientific component. When the adoption objectives are imprecise, some token activity can show that the objective was addressed, even if nothing much was achieved.

05 Ensuring adoption requires an understanding of potential adopters' perceptions of the relative importance of the research output to all the other things that they do. Adopters will not change their practice until they feel there are sufficient reasons for them to do so.

06 Not all projects, or their principal researchers, lend themselves to actively promoting their results. However, every project should be examined at the planning stage for the adoption/ extension implications of its potential outputs.

07 The development by LWRRDC of programs and the appointment of individual Program Mangers is a major positive step in the direction of fitting adoption activity to a group of projects, rather than each trying to work on its own. Adopting an objective approach could provide the opportunity for a coordinated hierarchy of goal, purpose and output at both the program and project level. Increasing the emphasis on adoption outputs at the program level would provide the opportunity to plan broader strategies for encouraging adoption and to marshal resources on the appropriate scale and time frame.

Risks

08 The evaluations suggest three obvious risks for research managers. One is that a project will follow a blind alley and not discover that it is doing so until too late. Another may be to misallocate resources of money or time between

elements of a project requiring a top-up of funds and/or more time to get it finished. The third may be that sound, usable results are not taken up for reasons which are external to the project and the Corporation.

09 The experience of the evaluations suggests that the first two problems can generally be controlled by the research managers and that LWRRDC already has procedures in place to deal with them. The difficulty is to know what to do when the perception of the blind alley is marginal or the alternative proposals are not particularly intellectually robust. External forces can frustrate the adoption process for many reasons and are often beyond the control of the research managers. Addressing the issue of adoption pathways from the planning stage onwards can help to see such problems coming and suggest forestalling action which might be taken.

10 The evaluations highlight the importance of the mid-term review process to the ultimate success of projects. It should attract a sufficient proportion of the Corporation's resources to ensure that it is successful. The Corporation is aware of this and has for several years used a project review form with a series of questions which must be completed by the reviewer. Changes to the format of the review form are considered essential to strengthening the effectiveness of the process.

11 External changes which inhibit the uptake of project results are largely outside the control of research managers. The examples given raise the philosophical question as to how far a funding body should go in using its resources to encourage adoption of specific research outputs. The problem is that there is rarely any certainty that further direct support will necessarily produce results. Neither is it always clear what would be the appropriate actions to stimulate wider adoption if the process has stalled or is frustrated by external events.

Project management

12 Communication is a key issue in the research process, both between the Corporation and projects and between projects and potential adopters. The surprise is the broad range of people who are interested, willing and probably able to contribute to projects in progress, or to translating project outputs into community action.

13 Where communication is good at the project level, the response is obvious. However, good communication does not always lead to the right adoption result. The outcome is much more predictable where the communication process is underdeveloped, or low-key. Varying degrees of limited communication can generally be linked back to slow or limited adoption. However, it may not always be easy, or perhaps even prudent, to develop a wider group of involved observers or participants. This is especially so in those projects with relatively complex science where interpreting the results may take time and a high level of professional skill.

14 LWRRDC has a positive role as a network facilitator. Much of this is simple, such as notifying a principal researcher of someone working in a kindred field, or an idea that might strike a spark. There was always favourable feedback on formal communication activities such as workshops.

15 The importance of communication with principal researchers by LWRRDC as the research manager may be underrated. There was some undertone that more life-of-project contact would have been welcomed by principal researchers. Certainly none wanted less. The move to external Program Mangers will facilitate contact between the Corporation and projects and can only be beneficial.

External involvement

16 One issue which came through strongly in the reviews was the extent to which potential adopters and others felt excluded in some degree from the research process. Even in the case of projects which had good interaction with potential adopters, a significant number of questionnaire respondents indicated that they thought that the links from projects to potential users of the output were inadequate.

17 Care has to be taken in interpreting these results. Certainly these responses were coloured by hindsight. However, there appears to be more to the response than just some feeling of having been left out. A genuine and responsible level of interest in the research process is being expressed. This is particularly so in environmental projects.

18 Two elements can be seen in this finding. One is that there is a wider awareness that research in specific areas is needed and is being done, but

that such work is no longer considered to be the exclusive preserve of scientists or professional/ technical managers. It is apparent that beyond the immediate group of professional scientists or resource managers, there are people who are capable of dealing with scientific data and how this is interpreted into recommendations or management regimes which affect their professional area, their livelihood and/or their perception of community good.

19 The other element is that, to be effective, it may be necessary to carry the interaction with potential adopters beyond the life of the project, at least to a point where it can include some interpretation of the results or assessment of the consequences. However, most projects run to tight time schedules, so that further communication with those who have earlier contributed ideas to the project is an additional task for which usually neither time nor resources are provided.

20 The possibility of including some wider group of concerned individuals begs the question of how such interaction might be done, or what it might achieve if it were done? It appears that it is not access or involvement in generating the data that was perceived to be lacking. Rather, it could be seen more as a concern at the lack of involvement or awareness of the conclusions drawn and what was being done about the consequences of those conclusions.

21 The evaluations provided no generalised answer as to what to do in communicating with wider special interest or community groups in the research process. However, the fact that these concerns appear consistently through so many of the evaluations highlights the need to be aware that they exist and play a role in the community acceptance and adoption process.

Project support groups

22 Two projects had strong project support groups which provide examples of the strengths and weaknesses they can contribute to the research process. In both cases the group provided strong intellectual support to the project. However, in the end, neither provided a particularly useful vehicle for transmitting project outputs beyond the confines of the project. In one case it may even have shielded the project from perceiving a need for wider communication.

23 The adoption process may operate on a different time scale to the research process. This may mean seeing the chain of activities from initial hypothesis to adoption in terms of several phases rather than a single project. There is a need to think through the extension process at the beginning and then to keep reassessing the needs during the life of the project. This should happen at least at the mid-term review stage, or with a checklist at each milestone report, including the final report. The prospect of additional funds at the end of the project, specifically for extending the project outputs, should always be a possibility.

24 Virtually all principal researchers commented favourably on the mid-term review process. The mid-term review was a turning point for a number of the projects reviewed. The review reports are necessarily short. Most focus more on the standards of science being applied and the likelihood of achieving the expected outcomes It is suggested that the process might be improved if more attention were given to identifying the perceptions of potential adopters to the anticipated outputs and evaluating what that might mean for the uptake of project results. The use of objective criteria would assist the review process. It may be necessary to keep a reserve fund to top-up project budgets for more specific activity on communication or adoption.

25 One of the major barriers to adoption highlighted by the evaluations is institutional inertia. This is particularly so when there is a need to bring about changed approaches to resource management. The extent to which projects should see an obligation to ‘push’ their findings on management matters is debatable issue. Changing management practices may require the balancing of a number of complex issues, of which the findings from the research may be only part.

26 Tackling the matter should start with the project objectives. If it is an objective of the project to influence management practice, then the objective must be accompanied by a statement as to how this will be done. Inputs and activities directed at the adoption of recommendations should be included in the original project document and be an issue of concern the mid-term review. Once indicative results are available, the project should address what implications these might have for management practice and how could they be effectively presented to decision makers.

Table 1. Summary of issues highlighted by projects

Type of project	Irrigation		Water			Land			Veg
Topic highlighted by project	CWN2	CWN5	UME8	JCU1	UAD1	DAW3	QPI1	UNE8	NDW1
Clarifying objectives									
– Different objectives at end than at beginning					✓			✓	
– Objectives formally revised			✓			✓			
– Objectives and outputs confused	✓	✓							
Adoption objective									
– Adoption result limited or disappointing	✓								
– Results picked up by other work				✓	✓			✓	
– Results could be used more widely		✓	✓				✓		
– Adoption result strong						✓			✓
Possible risks			✓			✓			
Communications with potential adopters									
– Strong with good adoption result						✓			✓
– Strong, but adoption result could be better	✓	✓	✓						
– Could have been more effective					✓		✓	✓	
Role of Project Support Groups		✓	✓	✓					
Implementing changed management practices	✓	✓	✓	✓		✓	✓		✓
Phasing projects	✓	✓	✓			✓	✓		

1.2 Recommendations

It is recommended that:

01 The Corporation require a more rigorous statement of objectives for projects seeking funding. The logical framework (logframe) is one such approach which could be adopted. Such an approach would see: the *goal* for any project as the theme of the program into which it fitted; the *purpose*, why the project was being undertaken; the *outputs* to state in quantified form what the project would produce; and the statement of *inputs* and *activities* to cover the resources to be committed and the methodology for achieving the outputs.

02 To reflect this approach, the Application for Grants form be revised to break Part 6a into goal, purpose and outputs, with applicants to state the overall context for the research, why it is being done and what it will produce in quantifiable terms. The statement of benefits requested in Part 6e (iv) should be linked to the quantified outputs to be stated in the revised Part 6a. These last two should draw together the information required in the present Part 6c of the application and a summary of the detailed information provided separately in Parts 11–17.

03 That the review process be treated as a major management tool and attract sufficient of the Corporation's resources to ensure that the overall investment in research is successful.

04 That the project review form to be completed in advance by the reviewer and the principal researcher be tightened, with a view to establishing objective criteria for project performance at the outset and linking these to the achievements perceived at the time of the review.

05 That more emphasis be placed on formal procedures to identify potential adopters and develop an understanding of their perceptions and priority rankings of likely project or program outputs. This will provide a better guide to the planning and conduct of follow-up or support activities to enhance the adoption of project or program outputs.

06 Recognition be given to the fact that research and adoption may operate on different time scales. There should be formal, objective procedures with a checklist, starting at least at the mid-term review stage and continuing to or past the project end, to assess needs and achievements in adoption. The prospect of additional funds to meet a different time scale should always be a possibility. This may be best approached through a program rather than individual projects.

07 There is a role for ongoing *ex-post* evaluation. Having explored the field generally in this evaluation, further work could be targeted at particular elements of the research or adoption process. More resources should be provided to undertake evaluations than were provided in this case.

2 Introduction

2.1 Background

The Land & Water Resources Research & Development Corporation (LWRRDC) is one of fifteen R&D corporations within the Commonwealth Primary Industries and Energy portfolio. The formal mission of LWRRDC is to improve the long-term productive capacity, sustainable use, management and conservation of Australia's land, water and vegetation resources through a directed, integrated and focused research and development effort. The purpose of the Corporation is to identify and fund research and development activities aimed at maintaining the natural resource base used by, or affected by, the rural primary industries. The natural resources concerned include soils, water resources and vegetation.

As part of an ongoing effort to improve the management of R&D programs, the Corporation commissioned an *ex-post* evaluation of nine completed research projects. The projects were all selected on the basis that their intended R&D outcomes had been achieved and that significant benefits were thought to have come from them. The consultants were to survey the key beneficiaries of the R&D to identify the actual outputs, outcomes and benefits that have resulted from the projects to users of natural resources and to the Australian community in general. The consultants were to report their findings to the Corporation in terms of the lessons learned from the projects reviewed, with particular reference to the planning and management of future R&D.

Sloane Cook & King Pty Ltd was selected to undertake the assignment, which began in December 1995 and was completed in August 1996.

2.2 Terms of Reference

The objectives of the assignment were to carry out an *ex-post* impact analysis for each of nine completed research projects selected by LWRRDC, related to Australia's natural resources. The impact analyses were to include:

- description of technical outputs achieved (products, processes, improved management techniques or other information);
- the likelihood of each project achieving such technical outputs and the main risks involved;
- linkages between technical outputs achieved and how they have been used to manage resources and to effect change;
- profiles of adoption of such technical outputs by resource users and managers in order to effect change; and
- how the research organisation was able to manage the main risks involved to achieve such technical outputs.

2.3 Projects Reviewed

Nine projects were reviewed. Two were irrigation projects (NSW Riverina), three were water projects (Vic, SA and Qld), three were land projects (WA, Qld and NSW) and there was one vegetation project (NSW). All commenced between 1989 and 1991 and all were completed by December 1994. Brief details of the projects follow, including the project name, research organisation, operating dates and funding, and a short synopsis of the main activity and outputs. The individual *ex-post* evaluation reports appear in Appendix 2.

Irrigation projects

1. CWN2. Reducing Groundwater Accessions under Rice
   Dr Liz Humphries, CSIRO Division of Water Resources, Griffith.
   January 1991 to December 1993. Funding: Total project $948,000, LWRRDC $180,100.

This project developed a specific farming practice—puddling flooded bays with a rotary hoe—which limited excessive water loss in growing flooded rice

on soils which had a high capacity for deep percolation losses. The project had a high level of interaction with potential adopters and the outputs were recognised by cooperating farmers. However, despite these positive features, the technique has not been generally adopted because farmers do not feel sufficiently threatened by the problem of excessive water loss to change their farming practice and adopt puddling.

2. CWN5. River Pollution with Agricultural Chemicals Used in Irrigated Agriculture
   Dr Kath Bowmer, CSIRO Division of Water Resources, Griffith.
   January 1992 to December 1994. Funding: Total project $593,000, LWRRDC $150,000.

This project addressed the concerns over the movement of agricultural chemicals into the off-farm environment, with adverse effects on water quality. It provided quantified risk assessments and demonstrated that a combination of chemical and ecotoxicological techniques is required to fully assess the impact of drainage water contaminated by pesticides used in agriculture. The outputs are recognised by the irrigation industry and government water management and environmental regulators. By incorporating the toxicology work it has provided information on the 'cocktail' effect of pesticides which had hitherto been understated. The uptake of the outputs has been limited by a combination of government inertia and lack of resources.

Water projects

3. UME8. Mitigation of Sediment and Nutrient Movement from Sources in the Latrobe River Catchment to the Gippsland Lakes
   Dr Rodger Grayson, Centre for Environmental Applied Hydrology, Melbourne University.
   January 1991 to June 1994. Funding: Total project $232,500, LWRRDC $120,500.

This project tested the hypothesis that run-off from poor land management practices was a prime cause of sediment build-up in the Gippsland Lakes. It proved the original assumptions incorrect and identified a number of point sources of nutrient and sediment run-off from which an overall catchment management concept was developed. The project worked closely with key regulators for the Latrobe Region. However, the adoption of outputs was limited by the reorganisation of responsibilities within a number of government agencies and because some of those with whom the project had worked being moved to different areas or going to other jobs.

4. JCU1. Limnology and Classification of Tropical Floodplain Wetlands with Particular Reference to the Effects of Irrigation Drainage
   Dr Robert Congdon, James Cook University, Townsville.
   April 1990 to March 1994. Funding: Total project $131,000, LWRRDC $65,484.

The project considered the impact of drainage water from the Burdekin River Irrigation Scheme on downstream wetlands. It collected significant baseline data and was able to use these and ongoing data collected to assist in developing a much sharper approach to management of the environmental consequences of the irrigation scheme.

5. UAD1. Phosphate and Pesticide Movement through Soils into Ground and Stream Movement
   Dr David Chittleborough, Waite Agricultural Research Institute, Adelaide.
   April 1990 to July 1993. Funding: Total project $67,300, LWRRDC $67,300

The project was able to demonstrate: that fissured subsoils were important in the throughflow of water; that immobile elements in colloidal forms are transported in the throughflow; and that land use, such as cultivation or pasture, can have a significant effect on the transport of colloids. The concepts developed by the project have long-term land management implications.

Land projects

6. DAW3. Forage Plants for Recharge Control
   Mr Ted Lefroy, Department of Agriculture WA.
   August 1991 to August 1994. Funding: Total project $318,300, LWRRDC $171,300.

This project assessed and ranked 188 woody herbaceous perennials as autumn fodder sources for livestock. It developed a system of ecological analysis for determining and ranking possible ecological indicators for sustainable agriculture, and developed a strategy for revegetation of the WA wheatbelt in a systematic approach to overcoming land degradation. This led to a system of agroforestry (alley farming) which is ecologically and commercially sustainable under a range of conditions.

7. QPI1. Herbicide Management and Herbicide Residues in Conservation Cropping
   Dr Steven Walker, Queensland Wheat Research Institute, Toowoomba.
   January 1991 to June 1994. Funding: Total project $1.21 million, LWRRDC $317,400.

The project was able to make recommendations of mixtures of herbicides which effectively and cheaply control broadleaf and grass weeds, including quantified statements as to the degrees of sensitivity of specific crops to carryover residues, conditions under which crop responses in the field might occur, and safe levels for recropping intervals. It appraised the accuracy and usefulness of commercially-available immunoassay kits in determining the presence of herbicide residues in soil and water and provided information on the environmental impact of chemical residues.

8. UNE2. Pneumatic Application of Lime to Agricultural Subsoils
   Mr Simon Murray, Resource Engineering Department, University of New England.
   March 1991 to August 1993. Funding: Total project $9,860, LWRRDC $4,860.

This project: analysed the theoretical and empirical design methods for pneumatic conveyancing of powdered lime; defined and tested air and mass flow rates for reliable conveying of lime; analysed the distribution patterns of injected lime in soil; and undertook a brief economic analysis. The work has provided a useful input into other projects developing mechanical methods of lime application.

Vegetation project

9. NDW1. Use and Management of Native Vegetation for River Bank Stabilisation and Ecological Sustainability
   Mr John Gardiner and Mr Allan Raine, NSW Department of Water Resources.
   October 1991 to February 1994. Funding: Total project $208,150, LWRRDC $120,100.

This project developed a systems approach to riverine corridor management based on vegetation management. It developed a user's guide to effective and inexpensive river maintenance practices, community programs and channel stabilisation techniques, together with an accompanying explanatory video and a list of species suitable for planting for riverine bank stabilisation in individual catchments. The project had a high level of community involvement.

2.4 Methodology

The task was to undertake a desk study of the nine projects selected, to highlight their technical outputs, and how they have linked to resource users, and to specify the modes and patterns of uptake and the risks and risk management practices that accompanied the project.

The steps in the evaluation were:

- Consultants were briefed by LWRRDC staff on the background of the selected projects followed by a review of all reports and project documentation relevant to the selected projects.
- An outline of each project was obtained by telephone discussion with the principal researchers. This included a description of the technical outputs, identification of the perceived/likely beneficiaries and their linkages to the project, perceptions of the adoption pathways and rate, and the researchers' views on the risks associated with the project at the outset and with the benefit of hindsight.
- A description of the technical outputs of each project was prepared and the likely/expected linkages to perceived/likely beneficiaries and other resource users/managers and the actual/expected patterns of uptake/implementation. Descriptions were referred to the principal researchers for verification and comment.
- With the assistance of the principal researchers, address lists of perceived/likely beneficiaries and other resource managers to be contacted were prepared.
- For each project, a project description and an evaluation questionnaire were prepared. In each case the questionnaire was based on a standardised format which was varied to meet the particular technical issues of the research project. Personal contact was made with all those on each project contact list. This was to ensure their awareness of the project evaluation being undertaken and their willingness to participate, and to provide information on the specific project, their responses to project technical outputs, their perception of the actual/likely adoption of these technical outputs and their perceptions of the risks associated with the project and the technologies associated with the specific outputs.
- Questionnaires were mailed/faxed to respondents with individual telephone follow-up to ensure a response to the questionnaire.
- Responses were analysed and draft evaluations prepared. These were referred to each principal researcher for comment.

- A draft report on findings was prepared for discussion with LWRRDC.

2.4 Acknowledgments

This study has involved the assistance of many people. The principal researchers of each of the nine projects reviewed have all provided full cooperation with background information, names of potential adopters, and in reviewing and commenting on draft reports. Some 124 people were approached to answer questionnaires and 80 took the trouble to complete them, many with lengthy and considered comments. The staff of LWRRDC, particularly Dr Phil Price, Mr Richard Price, Dr Nick Schofield and Mr Sandy Lolicato all provided support and assistance which ensured the completion of the task. Assistance from all these individuals is gratefully acknowledged.

3 Findings

3.1 Overview

The *ex-post* evaluations are of projects which largely pre-date the present operational format of LWRRDC. Most started under its predecessors, the Australian Water Research Advisory Council (AWRAC) and the National Soil Conservation Program (NSCP), with the balance starting in the first operational year of LWRRDC. Comments on the planning and structure of projects which follow should be seen in this context. Because the emphasis is on projects early in the life of the Corporation, the evaluations do not fully draw out the extent to which planning and management procedures have evolved in recent years.

This report comprises an overall evaluation drawing on experiences across all nine projects, together with the individual project evaluations which have been prepared on a stand-alone basis. The main report is based on the findings and conclusions of each of these individual reports, which given in Appendix 2. Within the individual project evaluation reports there are no cross-references to similar experiences or outcomes in other projects that have been reviewed. The main report, however, is cross-referenced to individual projects by using the project code number (see Section 2.3 pp 6–7) and assumes that the reader will go to any individual project report if more detail is required to understand any particular finding.

Setting out the lessons from past projects in their own context serves two purposes. Firstly, it is a guide to appropriate future action. Equally importantly, it can reinforce those current actions of the Corporation which show that many of the lessons of the past are already being taken-up in the planning and management of projects and programs.

3.2 Project Planning

3.2.1 Clarifying objectives

The objectives in a number of the projects were vague or otherwise not well stated. In two cases (UAD1 and UNE2) the objectives in the final report differed from those in the initial submission. In both of these projects, the investigation itself led to a clarifying of the issues, which in turn led to a restating of the objectives. In a third case (DAW3), the objectives were also different at the end from the beginning. However, this project had undergone a radical change of direction following the mid-term review. The original objectives were leading to a negative outcome. Detailed discussions with LWRRDC had led to a project revision, which in turn led to a successful outcome.

An imprecise statement of objectives for a project creates three problems. Firstly, the objectives may not have been sufficiently thought through. If it is necessary to do some research into the issue before the final objectives can be stated, then that should be an objective of the project. The second problem is that, in many of the stated objectives, there is confusion between goals, objectives, inputs and outputs. This creates the third problem, which is that in most instances the confusion in the objectives meant that they were inadequate for the purpose of *ex-post* evaluation. To deal with this particular problem, the objectives for each evaluation were rewritten in the logical framework format to provide a more specific basis against which to make an evaluation.

The logical framework (logframe) format requires a goal, a purpose and specified outputs, inputs and activities. The *goal* should reflect the rationale, which would generally be the theme or objective of a broader program of which the project is part. The *purpose* is why the project is being undertaken and the *outputs* are what it intends to achieve in terms of deliverable results which can be quantified. The *inputs* and *activities* define how the project will be undertaken and the resources which will be used. A brief outline of the logical framework concept is given in Appendix 1.

The current approach of LWRRDC to submissions for research funding is tighter and more objective than was the case under the previous AWRAC/NSCP arrangements. However, the current application form for research grants calls only for ‘project objectives’ (Part 6a). Part 6e asks a series of questions about the

expected benefits of the project, particularly issues addressed, how the outcomes will lead to improved resource management, who will be the beneficiaries and for some form of benefit/cost analysis. Yet, at no stage does it ask for an actual statement of the expected outcomes. There is therefore still room for confusion, particularly between objectives and outputs. The form asks for objectives to be quantified, but it is the outputs which should be quantified, not the objectives.

It is recommended that the form for Application for Grants be revised to break Part 6a into goal, purpose and outputs. This will require applicants to state the overall context for the research, why it is being done and what it will produce in quantifiable terms. The statement of benefits requested in Part 6e (iv) should be linked to the quantified outputs to be stated in the revised Part 6a. This should both reinforce the need to think through the value of the outputs and to highlight any potential confusion between objectives and outputs.

Using the logframe approach, the *goal* for any project could be the theme (or variation thereon) of the program into which it fitted. The *purpose* would state why the project was being undertaken, while the *outputs* would state in quantified form what the project would produce. The statement of *inputs* and *activities* would cover the resources to be committed and the methodology for achieving the outputs. These last two would draw together the information required in the present Part 6c of the application and a summary of the detailed information provided separately in Parts 11–17. Each of the evaluation reports has the objectives rewritten in the logical framework format (Section 2.1 Design), which provide examples of how this system could look in practice.

3.2.2 The adoption objective

The issue of linking scientific research and the adoption of new technology comes at both the planning and implementation phase of projects. At the planning stage, the experience of the evaluations suggests that the issue can be seen at three levels. The essential thread linking these is the failure to think through how the adoption process will work, that is, to identify the forces which will drive adoption. The most obvious failure is vaguely stated adoption objectives which give the impression that something will be done, but do not lead to any particular outcome. This can lead to a self-defeating allocation of resources, where most of the budget is built around the scientific component. With competitive bidding for scarce funds causing most bids to be finely tuned, in many instances the human, financial and time resources of projects end up fully committed to achieving the scientific outcomes. When the adoption objectives are imprecise, some token activity can show that the objective was addressed, even if nothing much was achieved.

The objectives of eight of the nine projects evaluated were essentially directed at the underlying science, while only one (NDW1) was adoption-orientated. Two had no mention of adoption in their objectives (UAD1 and UNE2). The others variously had objectives to ‘demonstrate and promote’ (CWN2), ‘report to agencies to facilitate adoption’ (CWN5), ‘develop action plans’ (UME8), ‘provide recommendations’ (JCU1) and ‘disseminate by relevant activities’ (QPI1).

Successful adoption requires an understanding of potential adopter’s perceptions of the relative importance of the research output to the adopter’s own priorities. In the case of CWN2, the farmers recognised that the puddling technique would reduce groundwater accessions under rice. However, they saw the technique as having relevance only for specific leaky paddocks or bays and even then, to be used only on an occasional basis. They did not feel sufficiently threatened by rising watertables. Neither did they see sufficient economic benefit to warrant change to current farming practice. They did not see preventing rising watertables as their personal responsibility.

In the case of CWN2, the potential adopters indicated that they would not change their farming practice until they came under sufficient administrative or economic pressure to make them do so. Their response was in no way connected to the quality of the research or the general benefit which might accrue if the technique was widely adopted. It was based on personal perceptions of how the research outcomes impinged on their own activities.

A research project which was built around adopters perceptions was NDW1. It was a bottom-up activity with some adopters already being switched-on to the issue before the research started. The principal researchers understood what motivated the landholders. They realised that at least some of the potential adopters were already searching for a solution and built from there. The result has been wide acceptance and adoption of the project outputs.

Research proposals are prepared by scientists, whose primary interest is science. This is evident from the objectives in most of the projects reviewed. Fairly

obviously more thought and experience has gone into planning the science than the adoption. Not all projects, or principal researchers, lend themselves to actively promoting their results. UAD1 and UNE2 are cases in point. Both were highly technical projects where the outputs were largely of interest only to other workers in the field. However, it does not negate the fact that at the planning stage, the potential outputs of every project should be examined for their flow-on potential and for adoption or extension implications.

The development by LWRRDC of programs and the appointment of individual Program Mangers is a major positive step in the direction of fitting adoption activity to a group of projects, rather than each trying to do its own thing. Adopting the logframe approach could provide the opportunity to have a coordinated hierarchy of goal, purpose and output at both the program and project level. Increasing the emphasis on adoption outputs at the program level would provide the opportunity to plan broader strategies for the adoption process and to marshal resources on the appropriate scale and time frame.

It may be appropriate to rethink Part 6e of the application form at two levels. One would be to assist applicants to link the adoption of their project outputs to a program level activity. This may require some interaction between applicants and the respective Program Mangers to make the applicants aware of what is already in the pipeline, especially in the area of adoption. The other element of a revised Part 6e would be to look more closely for what will drive the adoption process. As the example of CWN2 shows, farmers (or other potential adopters) will not adopt something just because it is good science or will improve environmental management. The present Part 6e still sees the world from a science perspective. It does not really seek to find out why adoption will happen, what are the perceptions of potential adopters and what, if any, are the forces which will drive the process.

3.2.3 Possible risks

The project evaluations suggest three obvious risks for research managers. One is that a project will follow a blind alley and not discover that it is doing so until too late. Another may be to misallocate resources of money or time between elements of a project requiring a top-up of funds and/or more time to get it finished. The third may be that sound, usable results are not taken up. In this context, UME8 is an interesting project because it faced all three of the risks outlined above and survived to produce a strong result.

The experience of the evaluations suggests that the first two problems can generally be controlled by the research managers and that LWRRDC already has procedures in place to deal with them. For many reasons, however, the last problem may be beyond the control of the research managers. The best defence against this situation is to address the issue of adoption pathways from the planning stage onwards and regularly review the position. This can help to see possible problems coming and suggest forestalling action which might be taken to avert unsatisfactory outcomes.

Blind alleys

The most prominent example of a project that went up a blind alley is DAW3. It is also shows that such a problem can be put right. This project used failure of its initial hypothesis as the springboard to approach the underlying problem from a different perspective. In this case it was the review process which rescued the project. By the end of the second field season, the principal researcher realised that none of the 188 native perennials he was evaluating would produce a result better than some known imports. Faced with the failure of his initial approach he put forward an alternative approach to the review panel. His justification of the new approach was strong enough to convince the Corporation that a significant change in the direction of the project was warranted. In this case it worked. In others it might be harder, firstly to recognise that a project was possibly heading up a blind alley and then to provide the necessary intellectual rigour or guidance to reorientate it in a more productive direction.

UME8 had a similar problem to DAW3, in that an early output of this project was to disprove its original hypothesis. It found that a widely held view that the in-stream sources of nutrient and sediment flows in the Latrobe River were not as significant as a range of point sources in the valley. The project used this finding to highlight the concept of integrated valley management which was then developed to be the second project output. In turn, this led to changed perceptions on the problems associated with the transport of solids in the river and action to manage them. The feedback from some professionals associated with the project was that these changed perceptions had been achieved because the principal researcher had been able to maintain a broad view of the objectives of the project and to keep an overall perspective of its context. He also had a strong review panel with particular professional interests in that area of work to provide ongoing support.

The experience of both DAW3 and UME8 offers no specific formula of what to do when this dilemma is

encountered. In both cases the principal researcher evolved his own solution and was able to justify it to a mid-term review or a project review panel and it led to a strong result. It would be harder to know what to do when the same situation was encountered, but where the perception of the blind alley was more marginal or with alternative proposals which were less intellectually robust.

Perhaps the real lesson is how important the mid-term review is to the ultimate success of projects. It is therefore important that the review process attracts the right proportion of the Corporation's resources to ensure that the overall investment in research is successful. The Corporation is aware of this and has for several years used a project review form with a series of questions which must be completed by the reviewer. This form is sent to the principal researcher a month before the actual review to allow time for adequate preparation of responses to the issues for the review.

The form has several questions which could be tightened, especially if the original application form is revised as suggested above. Questions 2(b), (c) and (f) inquire into objectives, methodology and outputs, the inter-relationship of which have already been discussed. If the original objectives are imprecise, as they were in many of the projects reviewed, the process of reviewing whether they are being achieved is much more difficult. If there is no initial statement of expected outputs, then it is hard to say whether they are being achieved or not.

These review questions in their present form allow for subjective, rather than objective answers. Question 2(i) relates to adoption. The same situation of subjective versus objective responses applies here. While it asks if the adoption process has been thought through, it still allows the answer to by-pass the vital factors of how do the potential adopters see the project outputs, what forces will drive the adoption process and what objective criteria there might be to justify the answers given.

Resource misallocation

Among the nine projects reviewed, UME8 provides an example of this situation, though the misallocation was largely outside the control of the project. Its problem was that its funding was cut at the outset as part of across-the-board reductions to all projects at the time. This left the project with insufficient funding in the final stages to complete the job. The project was able to finish only because the principal researcher went out and generated income from other consulting work. While it completed its task, however, it was not able at the time to finalise some other flow-on work which had been planned at the outset and this was seen to have limited the extent of the adoption of project outputs.

A number of those associated with the project expressed frustration that, although the project had changed perceptions and highlighted the need for integrated catchment and river management, these concepts were not carried through into practice from within the project. The cuts in project funding limited the momentum built up by the project. When this came up against the significant reorganisation of regional administration of land and water resource management in Victoria, it led to a loss of impetus and some loss of institutional memory. Significantly, it led to less utilisation of the management concepts developed by the project.

Again, it is the mid-term review which provides the best protection for managers in assessing performance. As before, the process will work better if there are objective statements of expected output against which to weigh-up ongoing performance in terms of the time and resources expended.

External factors

External changes which inhibit the uptake of project results are often, though not always, outside the control of research managers. In the case of UME8, it was the major reorganisation in 1992 of regional land and water management responsibilities by the new Victorian Government. The project worked closely with a number of senior water and land resource managers only to find that by the time its outputs were ready for implementation, many of these individuals had changed jobs or had their responsibilities transferred to others. The project had developed all the right institutional linkages, only to find them broken or distorted by government decisions which had nothing to do with policy areas in which the project operated. A similar fate has influenced the rate of adoption of the RIVERCARE system developed by NDW1. Here senior officers of the government department involved appear to have adopted the project outputs as their own. In doing so, they have altered the way it is being implemented, with results that are seen as less than desirable by the original researchers.

A different perspective of this problem arises from CWN5. Here an elegant piece of research produced several directly implementable outputs in the field of monitoring agricultural chemical run-off in irrigation drainage water. However, there was an implied criticism in the feedback which suggested that the project stopped too soon. That is, it developed the scientific base for the testing procedures, but could

have gone further towards ensuring the wider implementation of the techniques. The comments were in no way critical of the research itself. Rather they raised the philosophical question as to how far a funding body should go in using its resources to encourage adoption of specific research outputs. In this case, the project held a successful technology transfer workshop to demonstrate its testing procedures which was widely attended by industry and scientific professionals. It played a significant role in establishing an industry body, Riverina Irrigated Agriculture Chemicals Taskforce (RIACT) to facilitate further development of its outputs. To that extent, it took positive and successful steps in encouraging adoption.

In this case the problem was self-perpetuating inertia among other government regulatory or advisory bodies. How to get new ideas off the ground and into industry practice? The research outputs were being taken up, but apparently only slowly and unevenly. Could it have happened more quickly and effectively if more effort were put into a program to facilitate the adoption of best practice management programs involving irrigators and water managers and environmental regulators? The experience of CWN5 offers no certainty that further direct support would produce results. Neither is it clear what actions would be appropriate to stimulate wider adoption of the combined immunoassay/toxicology testing approach as the basis for developing industry best practice in pesticide management.

Almost by definition, it is often not possible at the planning stage to clearly define how some research projects will operate, what they will find, or when they will find it. Similarly, it is not always possible to define the adoption pathways, or to accurately assess the pressures which might drive the adoption process. Research by its very nature is exploratory and these are the inherent risks. When initial outcomes are uncertain it is more likely that they can be better defined at the mid-term review stage, or even later towards the end of a project when the implications of the outputs are better understood.

The important thing is to recognise that the review process is the best defence against risk and to act positively at each possible review stage. If it is agreed that particular outputs, or the adoption process, are not clearly defined at the outset, then there must be a positive decision to set a time to rethink the situation and the follow it through. This applies both to individual projects and to programs.

3.3 Project Management

The project management issues highlighted by the evaluations overlap those of the project planning process. They include matters such as project reviews and the difficulties with external influences on the adoption process. Other relevant issues for project management include communication, assessing the attitude of adopters, the role of support groups such as steering committees and the phasing of projects to balance possibly differing time frames for research and adoption.

3.3.1 Communication

Communication emerges from the evaluations as a key issue in the research process. This is both between the Corporation and projects, and between projects and potential adopters. The evaluation surveys showed that there is a broad range of people who are interested, willing and able to contribute to projects in progress.

At the project level, where communication is good, the response is obvious. It is partly a function of personality. The principal researchers in UME8, DAW3, NDW1 and CWN2 were all good communicators and it shows in attitude and awareness of the potential adopters who responded to questionnaires about these projects.

However, good communication *per se* does not always lead to the right result, as was shown by CWN2. The outcome is much more predictable where communication is under-developed, or low-key. Projects such as UNE2, QPI1, UAD1 and JCU1 all show varying degrees of limited communication beyond the confines of the project, leading to limited adoption. However, it is not always easy, or perhaps even prudent, to develop a wider group of involved observers or participants, especially in highly technical projects. In the case of CWN5, three of five survey respondents thought that farmers were potential users of the project output. Yet the findings of this project are highly scientific, needing careful interpretation to be useful. In these projects there is a greater need for certainty of outcomes, than say DAW3, where farmers took over general tree planting concept and did their own adaptation to assist in developing the ideas into workable systems.

The role of LWRRDC as a network facilitator emerges several times in project reviews, always positively. Much of the facilitation is simple, such as notifying a principal researcher of someone working

in a kindred field, or with an idea that might strike a spark. The feedback on formal communication activities such as workshops was always favourable.

The importance of communication with principal researchers by LWRRDC as the research manager may be underrated. While the comments on LWRRDC management were always positive, there were hints that more life-of-project contact would have been welcome. Certainly none wanted less. This is a matter for balance in allocating the Corporation's scarce resources. It is quite clear that the principal managers have heavy workloads, so it is not sensible to think that they should, or could, do more. The move to external Program Coordinators will facilitate contact between the Corporation and projects and can only be beneficial.

3.3.2 Adoption surveys

It has already been said that more attention should be given at the project design stage to understanding what forces might drive adoption. The evaluations show that in cases such as CWN2, CWN5 and QPI1, good scientific outcomes do not automatically lead to potential adopters taking unilateral action. Indeed, they show that, from the perspective of the adopter, there may be good reasons for not taking action.

It may be important to find out what are the attitudes of the potential adopters. As this may not be possible until some later stage of the research, identifying the prospect of doing so should become part of the review process. Such surveys need not necessarily be complicated or expensive. CWN2 had 16 farmer cooperators who, at one stage or another, had puddled irrigated rice fields in association with the project. It was assumed that having done so successfully, they would continue to do so, but they did not. It seems that no one actually asked them what conditions they would need to make them shift their normal farming practice to incorporate puddling and then followed that answer through to consider what changed circumstances might be needed to meet those conditions.

QPI1 appraised the accuracy of commercially available immunoassay herbicide residue tests kits in determining the presence of herbicide residues in soil and water. Of the six questionnaire responses received for this project, all from people who had some professional role in the agricultural chemicals industry, only one was from a person who had actually used these kits and he was a laboratory-based research scientist. The survey did not attempt to find out why the kits were not used, but there appears to be an information gap between what the researchers have produced and what the field operators see as important.

A number of projects were considered to have altered generally accepted views on resource management in the technical area in which that project worked (CWN5, UME8, JCU1). Yet there were difficulties in most of these cases in having the altered perceptions taken up as best practice at either industry or government level. It is considered that one reason for the poor performance is that while researchers or others associated with the project wanted it to happen, there was no clear idea of how this might be achieved, or that it might require a specific separate activity. CWN5 can provide an example. This project set up a network of directly interested parties in the agricultural chemical and environmental fields in Riverina irrigated agriculture and presented their results to them in directly usable form. However, to date nothing has been done to bring about changes in monitoring regulations and/or gaining the commitment of government agencies to provide funds and equipment for the staff to introduce this technique on a best-practice basis.

From the point of view of the Corporation, it may be that such issues are better tackled at the program level than project-by-project. However, getting the facts is probably best done through individual projects. It may be difficult to know what approach is appropriate at the initial stages. It may be better addressed in the mid-term review (JCU1), or even towards the end (QPI1) when the full impact of project findings is better understood.

3.3.3 External involvement in research

One issue which came through strongly in the reviews was the extent to which potential adopters and others felt excluded in some degree from the research process, or from decisions or consequences which were perceived to have flowed from the projects reviewed.

Each project questionnaire asked who the respondent thought would be the potential users of the project outputs. A series of options was provided, such as farmers, advisory or regulatory officers, etc. depending on the project. Respondents were then asked if they thought that there had been sufficient involvement of others beyond the research team, such as those indicated in the previous question. They were offered three optional responses. Whether there had been adequate involvement of all those with a direct interest (in the work of the project); whether some

groups had been well represented but others not; or that there had been inadequate linkages between the project and the potential users of the output.

The surprise was the extent to which respondents, even in the case of projects which had good interaction with potential adopters, thought that the links from the project to others with an interest in the topic were either uneven, or inadequate.

Care has to be taken in interpreting these results. In a number of reviews, the survey groups included people who said that they had not been aware of the project while it was in progress, or were aware or involved only in its later stages. Certainly these responses were coloured by hindsight. The respondents were saying that they were willing to answer the questionnaire, but would have been interested to have been involved at an earlier stage. However, there appears to be more to the responses than some feeling of having been left out. There is genuine and responsible level of interest in the research process being expressed. This is particularly so in projects which have an 'environmental' flavour.

An interesting example is JCU1, which was an environmental project collecting baseline data on the effect on local wetlands of drainage from the newly constructed Burdekin irrigation scheme. By the end of the project it was able to make recommendations on environmental management of the irrigation scheme based on its findings. These findings were taken seriously by the scheme managers and were adopted into environmental management planning.

For this project, only one of the nine survey respondents thought there had been adequate involvement by the project of the full range of those with a direct interest in its outcomes, Three specifically said *No* to this proposition. Five of the nine respondents thought that the linkages between the project and others interested in the technical area were not as well developed as they might have been, or were inadequate.

The conclusion was that the concerns expressed relate not so much to awareness of the findings *per se*, but to the consequences of the findings. The survey suggested that the project results were perceived to have implications for a broad group associated with the Burdekin River Irrigation Area and the Barrattas swamp, and that there could have been more interaction with this broad group, rather than some narrower scientific group. Yet the project did work with a wide group of potential users. From an early stage it interacted with a number of key bodies including the Department of Primary Industries, and the Department of Environment and Heritage, the Burdekin Landcare Group, the Bureau of Sugar Experiment Stations and the Burdekin River Trust.

Two elements are seen in this apparent contradiction. One is that there is a wider community awareness that research in specific areas is needed and is being done, but that such work is no longer considered to be the exclusive preserve of scientists or professional/ technical managers. It is apparent that beyond the immediate group of professional scientists or resource managers, there is a group of people who are capable of dealing with scientific data and how this is interpreted into recommendations or management regimes which affect their professional area, their livelihood and/or their perception of community good.

The other element is that to be effective, it may be necessary to carry the interaction with potential adopters beyond the life of the project, at least to a point where the interaction can include some interpretation of the results or assessment of the consequences. Most projects run to tight time schedules, so that finishing the task and publishing the results by the due date ultimately becomes a major effort. Going round the communication loop with those who have earlier contributed ideas to the project is an additional burden for which their is usually neither time nor resources. In JCU1 much of the early interaction was to prioritise ecological areas and the design of a multiple-use, land-use framework. A flood plain management workshop was held some time after the project finished. The project outputs were discussed at this workshop, but it does not seem to have met the perceived need for involvement expressed in the survey responses.

The possibility of including some wider group of concerned individuals begs the question of how such interaction might be done, or what it might achieve if it were done? Several of those who did not know the results of JCU1 said that they knew where they were and expected that they could get them if they needed them. A number had attended the tropical floodplain management workshop. It is therefore not access or involvement in generating the data that was perceived to be lacking. Rather, it could be seen more as a concern at the lack of involvement or awareness of the conclusions drawn and what was being done about the consequences of those conclusions. The concern appeared to be more that things might not be done, or that people may make environmental mistakes, because they were not aware of the findings of the project.

Perhaps the biggest surprise was the responses to this question on the degree of involvement for NDW1. This was a project with a high level of adopter involvement and strong adoption response. Yet only half of the 18 survey respondents thought that there had been adequate involvement of the full range of those with a direct interest in the project. The remainder were equally divided (5/18 and 4/18) on the view that some groups were well represented and others not, or that there had been inadequate linkage between the project and potential users. Again, these responses are interpreted as highlighting a willingness or concern to be actively involved in research on environmental issues, rather than a feeling of having been left out of this particular project.

The evaluations provide no generalised answer as to what to do in communicating with wider special interest or community groups in the research process. However, the fact that these concerns appear consistently through so many of the evaluations highlights the need to be aware that they exist and play a role in both the community acceptance of the research and adoption process.

3.3.4 Project support groups

Two projects, JCU1 and UME8, had strong project support groups or steering committees. The performance of these groups provides examples of the strengths and weaknesses which they can contribute to the research process. In both cases, the project support group provided strong intellectual support to the project. However, in the end, neither provided a particularly useful vehicle for transmitting project outputs beyond the confines of the project. In the case of JCU1 it may have even served to shield the project from perceiving a need for wider communication to groups who saw themselves as having a genuine interest in the area under investigation.

Typically a project support group or steering committee will include people with specialised knowledge who can provide guidance and back-up to the project and provide linkages to groups with a specific scientific or other interest in its work. In the case of JCU1 the project worked closely with the Burdekin River Irrigation Area Technical Advisory Committee (BRIATAC), which was a statutory body and responsible for the oversight of the scientific issues arising from the Burdekin River Irrigation Area (BRIA) development. Its membership included all the major locally-based scientific organisations with an interest in irrigation and regional development issues. This interaction was considered a major strength for the project and is reported to have led to the rapid absorption of its findings into routine environmental assessment and planning.

However, the evaluation survey identified concerns over the lack of project/community interactions expressed by farmers and people from government instrumentalities, some of whom were represented on BRIATAC. It might be inferred that while the steering committee may have had strong interactive links with the project, they may have also served to shield the project from looking beyond the immediate scientific/ water management group with which it was working.

The experience of the evaluations is that a steering committee should not be seen as the principal vehicle for communicating project results, other than in a limited technical sense to kindred agencies. There is little evidence that information transferred from the project to the steering committee flows through to any addition to institutional memory/capability in the organisations with which steering committee members are associated.

For UME8 there was a project review panel to assist in implementation and regular review to ensure that the objectives were achieved. Several members of the panel formed a close association with the project. They provided strong intellectual support which undoubtedly assisted in the process of recognising the need to adapt the approach when the project disproved its original hypothesis. However, it is reported that much of this effectiveness was in the regular informal contacts with the principal researcher, rather than through any formal process.

It appears that, in the end, the support group members for UME8 did not manage to embed much institutional memory in their respective organisations. When they changed jobs, or their responsibilities in the water management field were reassigned to others, the impact of the project went with them. This suggests that the mere presence of a representative of an organisation on a project steering committee does not, of itself, guarantee that knowledge or understanding of a project will automatically flow to that organisation. If the membership of the steering committee is meant to be a conduit whereby information flows from the project to others, then more formal processes may be necessary to ensure that the transfer of knowledge goes past the immediate individual concerned.

3.3.5 Phasing projects

Adoption may operate on a different time scale to research. This may lead to the need to perceive the

chain of activities from testing an initial hypothesis to adoption, in terms of several phases rather than as a single one-off project. QPI1 provides two lessons in this regard, both of which relate to the extension flow-on from scientific research. One is that it may not be possible to develop extension outputs while the research is in progress. The other is that developing usable extension messages does not automatically flow from scientific research. It may therefore be best to approach some projects on the basis that the initial project would be a first phase, with an ongoing phase to be prepared at some time between the mid-term review and project completion when more was known about project outputs.

There is a simple logic which says that, at best, usable material for extension emerges in the later stages of a research project. Prudent scientific method requires results to be confirmed before recommendations can be made. Thus, even if preliminary information were available as a project progressed, it would not necessarily be likely that extending it to a wider field of potential adopters would take place until the later stages of a project, or even as a post-research project activity.

In QPI1, the extension activities were listed last in the work plan as taking place in the fourth and final year. The plan called for the dissemination of the project information widely by way of field days, press releases and formal publications. In the end, the project timetable became very tight and although the scientific objectives were met, less was done by way of extension than had been envisaged when the project was planned, because time ran out.

The principal researchers fulfilled their obligations to disseminate the findings and the people to whom these messages were directed saw them. Yet at the same time, the majority of the survey respondents expressed degrees of doubt or uncertainty as to project outputs and their immediate usability, which suggests that an information gap remained and that further work was needed to fill it. This provides the second lesson from QPI1, which is that extension/ information flow does not automatically appear from a research project. It is a specific activity and, if it is a project objective, suitable resources and time should be provided to ensure that it happens. This could be done either at the project planning stage, or at some time after the mid-term review.

There were no special plans for dealing with adoption in QPI1. No funds were allocated for adoption, notwithstanding that there was a general adoption objective. It can only be assumed that the expectation was that the scientists would find time to develop the extension messages as part of their scientific work. This they did and the messages were seen and reported on by those at whom they were directed. However, more was needed. This was identified after the project was completed and a well presented technical brochure was prepared by QDPI in 1996.

The lesson of this project is the need to think through the extension process at the beginning and then to keep reassessing the needs and achievements as the project progresses: who is responsible, who will actually do it, when should it happen and what resources will be needed to achieve the desired result? It may not always be possible to predict this with accuracy, so these questions should be revisited during the life of the project. This should happen at least at the mid-term review, or with a checklist at each milestone report, including the final report. Allocation of additional funds at the end of the project, specifically for extending the project outputs, should always be a possibility. This is currently done by LWRRDC as the need is perceived. However, it may be that a more formal approach to identifying extension needs and implementing extension action is warranted. The program approach, whereby extension activity can utilise the outputs of several projects, may provide some opportunities for economies of scale.

3.3.6 Project reviews

Project reviews are a significant tool for research managers. This fact has been highlighted a number of times in this report. They are also important to principal researchers. Virtually all principal researchers commented favourably on the mid-term review process. The mid-term review was a turning point for DAW3, to refocus the project to resolve the problem from a different perspective. A number of other projects (UME8, UAD1, QPI1 and UNE2) went through some degree of refocusing, or at least a restructuring of their objectives, which emphasises the importance of the mid-term review. The review reports are necessarily short. However, only one (JCU1) specifically raises the issue of getting the message to adopters. Most focus more on the standards of science being applied and the likelihood of achieving the expected outcomes.

The mid-term (or other) review process could be made more rigorous. This would be firstly in terms of assessing the achievement of planned outputs and secondly in reviewing potential or actual actions in respect of the adoption process.

Greater rigour in reviewing the achievement of planned outputs should start by requiring a more objective statement of outputs in the initial applications for funding. The present form allows confusion between objectives and outputs, which makes the review process more difficult. The prospect of altering the Applications for Grants form to deal with this issue was discussed in Section 3.2.1. The review process can be further improved by tightening questions in the project review form to develop more rigorous linkages between objectives, methodology and outputs.

The review is currently used to assess steps towards adoption. However, it is considered that the present review form allows the matter to be treated subjectively. A more objective approach, especially to assessing the perceptions of likely adopters is recommended. The process would be improved with more attention given at the mid-term stage to identifying the perceptions of potential adopters to the anticipated outputs and evaluating what that might mean for the uptake of project results. It may be necessary to keep a reserve fund to top up project budgets for specific communication and adoption activities.

3.4 Ongoing Evaluations

A role is seen for ongoing *ex-post* evaluations. Such evaluations would be conducted to gain more information or understanding about, for example:

– workability of objective criteria as measures of project effectiveness or success;

– specific aspects of communication activities in the adoption process, ie.. community consultation;

– procedures to embed successful project outcomes in implementing institutions or to deal with the problems of institutional inertia;

– better perceptions of adopters' goals;

– assessing the impact of programs as distinct from projects; and

– assessing project linkages within programs, particularly as they impact on the adoption process.

Whatever is done, considerably more time and resources would be needed than have been allowed for this *ex-post* evaluation of nine projects which has taken 300 hours of professional time plus 40 hours of support time. As it is not possible to see how meaningful analyses could be done in much less depth than the present case, then time of the order of 30 to 40 hours per review should be seen as the benchmark in assessing what resources might be needed.

This review has taken no account of costs and benefits, for two reasons. Firstly, because there was little data available for most of the projects and no time or resources to generate original data. Secondly, few of the projects reviewed would have lent themselves easily to straightforward economic analysis. CWN2 would have been possible at both macro (regional) and micro (individual farm) level because the technology was definite and could be costed and the benefits specific and measurable. The same could be done for DAW3 and some major attempts had been made by others to do that. The benefits of UNE2 could have been 'guesstimated' at micro (farm) level and extrapolated from there, but there was no idea of the commercial cost of the equipment. Other projects such as NDW1, UME8, JCU1 and UAD1 all faced problems of valuing ecological benefits with varying degrees of difficulty in definition of just what those benefits were.

If economic appraisals are to be undertaken in the future, care would be needed in selecting projects which would allow an objective and reasonably accurate analysis. There are a number of methodologies now available for estimating ecological and community benefits. To achieve a valid result, it would be important to select projects or programs which gave a chance of allowing for rational analysis and providing a believable answer.

Appendix 1

Logical Framework Matrix

The following brief description of the logical framework matrix was prepared in the context of international development assistance. It is considered that while the examples cited are not those of scientific research, the explanation of the format given is relevant to the research context.

1. Logical Framework Matrix

The Logical Framework Matrix (log-frame) has been adopted by many development agencies as a design, planning and evaluation tool. The log-frame was first developed by the United States Agency for International Development (USAID) in 1970 as a project improvement tool which could assist in the design of better development projects. Since then, it has evolved to facilitate project implementation, planning, monitoring and evaluation. The Australian International Development Assistance Bureau, for example, links the log-frame to the implementation schedule and to project costing, and uses the log-frame as the basis for its project monitoring and control. The development of new technology, particularly computers, has enabled the log-frame to be developed further as an evaluation tool.

Misuse of the log-frame as a blueprint which prescribes rigid formulae for project implementation has brought the methodology into disrepute in some quarters. However, the logical framework matrix can be a guide or tool which can make a valuable contribution to the evaluation process. Used in this way, the log-frame assists the systematic and logical analysis of the key elements or issues which emerge from project experience.

2. Core Concepts

Evaluation is concerned with assessing project or program achievements against stated objectives. Effective evaluation thus requires that the original objectives are clearly defined. Where the logical framework matrix was used to assist project/program design, the planning documents should specify:

- clear measurable and time specific objectives;
- the linkages between different levels of objectives and overall development goals;
- the indicators of success;
- key target groups;
- the key assumptions on which the design is based;
- the means of verifying the progress of the project; and
- the resources required for implementation.

If the project design does not follow a logical framework format, then it can be difficult for the evaluator to identify the criteria against which achievement is to be measured. In these circumstances, the use of log-frame concepts can assist in the process of clarifying or interpreting what the project designers expected the project to achieve.

The log-frame helps designers think through the key steps of sound project design. It recognises that projects may well be planned and carried out under situations of limited knowledge and high risk as to the outcomes. It is therefore appropriate to build mechanisms to test whether ideas for change (hypotheses) work as expected. The hypotheses describe what planners think will occur as a result of a planned activity. Thus, from one perspective, a project can be seen as a structured process for learning about what produces results. This learning occurs through evaluating outcomes.

The main concept underlying the log-frame is cause and effect. The logic is that *if* we produce certain outcomes, *then* we can expect certain other outcomes to result. For example, if we cause a road to be constructed, then the expectation may be that farmers will gain improved access to markets. The better the cause and effect linkages between objectives, the better the project design. While the log-frame can help the design process, it does not guarantee good design. The validity of the cause and effect logic depends on the quality and experience of the design team.

3. Hierarchy of Objectives

The design of development projects is based on the concept that objectives can be specified in a logical order of linkages between means and ends (eg., a hierarchy of objectives). Past experience from similar situations (project learning) provides a valuable guide to establishing hypotheses, or causal links, which are practical and realistic.

Project objectives and causal linkages can be described at different levels. The log-frame methodology uses four levels of objectives, as follows:

a. Goal: describes the higher level objectives which provide the ‘project rationale’. Usually this is a program or sector objective which

describes the benefits or development impact which the project aims to bring about. Goals may be improvement in the national balance of payments, increased farm income, greater employment opportunities, improved nutrition, enhanced participation by women or conservation of natural resources. Often several projects will share a common goal. Measurement of the goal objective may show how the project has contributed to the development of target groups or to broader macro-economic objectives.

b. Purpose: which defines WHY the project is being carried out. This is the desired change that the project is intended to bring about. At this level, objectives are often concerned with changes in behaviour by target groups (eg. farmers) as the result of the project. Purpose objectives describe the desired state, the quantity of change and a timescale. For example, the purpose of an irrigation project might be to increase rice production and farm incomes to stated levels within two years of commissioning. The purpose of a road project may be to reduce transport costs for people and goods. Some projects have several objectives, which are sometimes complementary or conflicting which may pose problems to the evaluator who has to decide what weight to attach to each objective.

c. Outputs: which describe WHAT the project is to accomplish. They are expressed in deliverable results for which the project can be held directly accountable. An irrigation project might have as its outputs an operating irrigation scheme to the tertiary network level. Unless a rice farm is part of the project, the project itself cannot directly achieve its purpose level objective. It can only provide the means for farmers to produce more rice.

d. Inputs and activities. These define HOW the project will be undertaken, the main action groups and the resources which will be made available to the project. Inputs are listed in the project budget and the tasks to ensure their timely delivery are under the direct control of project management.

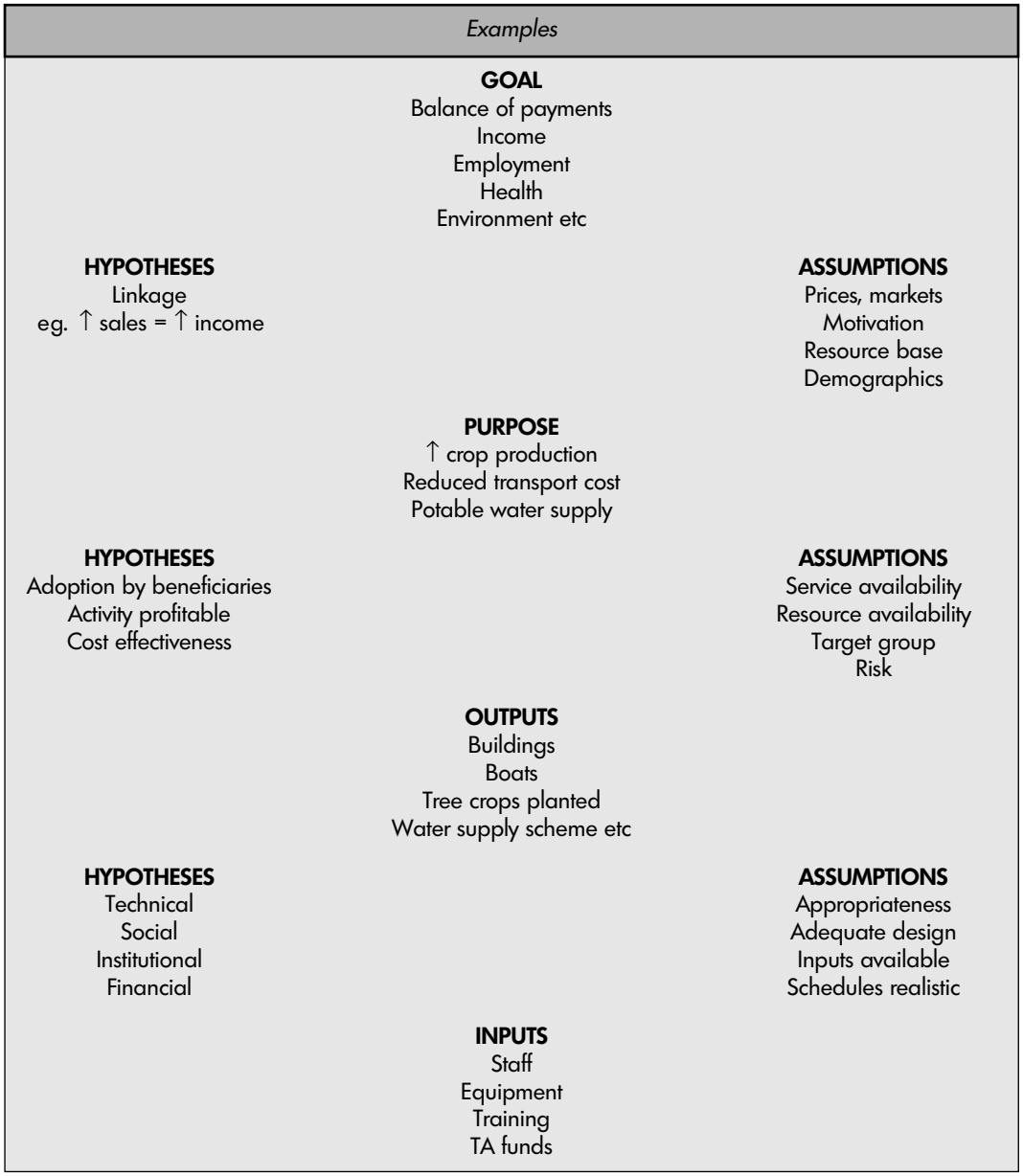
These objectives are defined in a logical hierarchy (ordered steps) of linkages. The first linkage is that if certain inputs are provided and managed well, then predicted project outputs will result. The second linkage predicts the social and economic changes which will occur as a result of the project outputs.

This describes the purpose of the project. The third order linkage describes the contribution of project purpose objectives to certain broad goals embodied in provincial and national development plans. The linkages are illustrated in Figure 1.

Projects should be designed so that achievement of the objectives at one level logically leads to the next level of objectives. If objectives are not achieved at the output level, then the purpose of the project cannot be attained. This logic facilitates evaluation. Some projects which nave not been subjected to analysis of this type at the design stage contain fundamental gaps in their logic. Thus, a credit scheme may assume that the on-lending rate is the real rate of interest to be paid by borrowers. Other costs such as time, travel and the need to pay commission (bribes) may increase the effective interest, possibly making borrowing more expensive and less flexible that non-institutional finance.

The main difficulty experienced by planners (and evaluators) is differentiating between project outputs and purposes. The main factor to bear in mind while attempting to classify the various levels of objective is the extent to which the project itself has control over the outcome.

Figure 1. The log frame hierarchy of objectives



Appendix 2

Evaluation Reports

Evaluation No 1. Ref. No: CWN2

Reducing Groundwater Accessions Under Rice

Contents

List of Tables

1 Background

1.1 Rationale

The problem addressed by this project is the excessive loss to the subsoil of irrigation water from flooded rice bays. The problem is part of an overall environmental issue of rising watertables and increasing soil salinity as a result of agriculture. The issue is particularly evident in irrigation areas where rice is grown under flooded conditions. There is also a specific problem for individual farmers who are being limited to 16 ML of irrigation water per ha. As a consequence of this limitation, farmers are being restricted from growing rice in high water-use paddocks. In addition, the increasing cost of irrigation water means that unnecessary water use is an added cost for farmers. Apart from any environmental benefit, reducing water use will provide a financial saving to farmers and improve the returns to rice production.

1.2 Project Arrangements

The formal project arrangements were:

Implementing agency:
CSIRO divisions of Water Resources (Griffith) and Soils (Canberra)

Principal investigators:
Dr E Humphries, CSIRO Division of Water Resources, Griffith
Dr A Ringrose-Voase, CSIRO Division of Soils, Canberra
Dr J Kirby, CSIRO Division of Soils, Canberra

Submission date:
Originally submitted to National Soil Conservation Program in 1989

Start/finish dates:
1 January 1991 to 31 December 1993

Third parties:
Rice Research Committee
Australian Special Rural Research Fund (ASRRF)
Rural Industries Research and Development Corporation (RIRDC)

1.3 Objectives and Scope

Scope of the project

The area sown annually to irrigated rice is some 120,000 ha, mostly in the Murrumbidgee Irrigation Area (MIA) and Districts, the Coleambally Irrigation Area (CIA) and the Murray Irrigation Districts. In the MIA and Benerembah District, watertables in large parts have been close to the surface for some time. As a consequence, rice water-use has decreased considerably and average water-use for individual farms has not been routinely calculated for several years.

Watertables in the CIA have been rapidly rising. Over the last ten years the area with watertables within two metres of the soil surface has increased to two-thirds of the landscape. Where the watertables are now near the surface, rice water-use has decreased. Rice is grown on 25% of the landscape in the CIA.

In the CIA, farm average rice water-use (ie. the average of all paddocks growing rice on a farm in a given year—typically one to four paddocks) exceeded 16 ML/ha on about 25% of the farms each year in the half dozen years up until 1991–92. During this period, more than 80 farms recorded a farm average rice water-use over 20 ML/ha on one or more occasions. Thus, the problem of high water-use rice paddocks was widespread and it also moved around the landscape as farmers rotated their paddocks.

In the Murray valley, rice growing is generally less intensive. Rice water-use is monitored routinely and where detected, paddocks exceeding the target are banned from growing rice. The 16 ML/ha limit is monitored more closely and applied more strictly.

Assuming average rice water-use is 14 ML/ha, net evaporation (ET–rain) is 11 ML/ha and 1 ML/ha is used to saturate the soil and/or lost as surface run-off, then 2 ML/ha are added to the watertable. Over the entire rice area, if deep percolation were reduced by 0.5 ML/ha through puddling, the theoretical reduction in accessions to the watertable would be 25%. Assuming 25% of the CIA averages 18 ML/ha (average accessions 6 ML/ha) and the rest averages 14 ML/ha (average accessions 2 ML/ha), then puddling to bring the 18 ML/ha paddocks down to 16 ML/ha would reduce total accessions from 2.75 to 2.5 ML/ha, a reduction of less than 10%. Reducing

accessions on a few high water-use paddocks may have a relatively small effect on the regional water balance, although there may be site-specific benefits.

Objectives

The objectives of the original proposal were:

Overall objective:
To reduce accessions to the groundwater under flooded rice by developing commercially viable methods of modifying the soil structure.

Specific objectives:

a) Develop and evaluate mechanical methods for their effectiveness in reducing deep percolation on a variety of rice soil types. The treatments will be evaluated in full-size rice bays and in small-plot replicated field trials. Performance indicators will include measurements of deep percolation, soil structure and rice growth and yield. Economic comparisons will be made.

b) Determine the longevity and reversibility of the soil modification treatments with regard to (i) the need to repeat the treatments for successive rice crops, and (ii) return to non-rice crops such as wheat and pasture.

c) Demonstrate and promote the use of the preferred techniques.

The timetable in the original submission was:

1990–91

a) Bay test. Rice, wheat after rice and rice after rice.

b) Yield trial: implement by N rate, rice, wheat after rice.

c) Implement design and construction.

1991–92

a) Assess other soils (bay tests, yield trials)

b) Evaluate implements

c) Demonstration and extension

1992–93

a) Further refinement (implement design, operating conditions)

b) Further assessment of effect of soil structure for non-rice crops

c) Demonstration, extension and publication

1.4 Financing Arrangements

The original budget was $739,645. The funding application was to the National Soil Conservation Program (NSCP) requesting $177,677 over four years (24.0%). A further application was lodged with the Rice Research Committee (RRC) and the ASRRF for $318,696 (43.1%) and the CSIRO Division of Water Resources was committed to $243,272 (32.9%). A summary of overall projected expenditure is given in Table 1. The initial submission made no statement concerning the sharing of any intellectual property income.

A comparison of budget and actual expenditure is made in Section 2.6.

1.5 Completion

The LWRRDC commitment to the project concluded at the original deadline of 31 December 1993. A final report was submitted in April 1994. The project was

Table 1. Original budget for funding sources and expenditure

Budget	1990–91	1991–92	1992–93	1993–94	Total	Percent
LWRRDC	40,673	58,716	60,142	18,146	177,677	24.0
CSIRO Division of Water Resources	69,000	71,070	73,202	30,000	243,272	32.9
Rice Research Committee	104,438	105,858	108,400		318,696	43.1
Total funding	214,111	235,644	241,744	48,146	739,645	100.0

Source: Original Funding Submission 1989

extended to 30 June 1994 under Rural Industries Research and Development Corporation (RIRDC) funding to allow for the finalisation of data collection and analysis and write-up.

1.6 *Ex-Post* Evaluation

This evaluation report focuses on pertinent aspects of the project and presents the findings of the *Ex-Post* Evaluation (EPE). The evaluation is based on documents provided by LWRRDC as listed below, detailed discussions with the principal investigators and a survey by questionnaire of identified potential users of the project outputs and from other acknowledged sources of information.

In preparing the evaluation, the reviewers have had access to the following documents:

1. Dec 1995—Project schedule
2. Undated (1990?)—Original application to NSCP/ DPIE
3. June 1991—Project milestone report #1.
4. Dec 1991—Project milestone report #2
5. July 1992—LWRRDC project review—March 1992
4. Dec 1992—Project milestone report(not numbered)
6. June 1993—Project milestone report (not numbered)
7. April 1994—Project final report

* * * * * * *

2 Implementation Performance

2.1 Design

To facilitate an objective review of the project, the original objectives set out in Section 1.3 are restated in terms of the logical framework (log-frame) approach.

Goal:
To improve the quality of the environment by limiting the rise of watertables resulting from inefficient use of irrigation water.

Purpose:
To reduce accessions to the watertable from flooded rice.

Outputs:
Mechanical methods developed and evaluated for their effectiveness in reducing deep percolation on a variety of rice soil types

Determination of the longevity and reversibility of the soil modification treatments with regard to (i) the need to repeat the treatments for successive rice crops, and (ii) return to non-rice crops such as wheat and pasture.

Demonstration and promotion of the use of the preferred techniques in commercial rice crops.

Inputs and activities:
Experiments will be carried out in farmers' paddocks where rice water-use is high (> 16ML/ha). A combination of full scale bays tests and in small plot (15 m × 20 m) replicated field trials.

Data obtained will include evaluation of the effect of the different treatments on deep percolation both within treated areas and under banks, soil structure both during and after the rice cropping phase, rice growth and nitrogen economy and the growth and yield of wheat sown after rice. Economic comparisons will be made.

The Rice Research Committee, the Irrigation Research and Extension Committee (IREC) and the Murray Research and Extension Committee (MREC) will be regularly informed of progress with the work.

Farmers will be encouraged to visit sites informally and on field days. Articles will be prepared for the IREC Farmer's Newsletter and for the local press and scientific papers will be submitted to the *Australian Journal of Soil Research*.

2.2 Outputs

The output of the project is considered to be:

Output:
A specific system of farming practice which, if adopted, will limit excessive water loss in growing flooded rice on soils which have a high capacity for water loss through deep percolation.

Key element:
The key element of this system is puddling flooded bays with a rotary hoe.

Required practices:
The system has a number of specific rules of practice which must be adopted to produce satisfactory results. These practices include the use of a rotary hoe wide enough to cover the tractor wheel tracks, limiting the depth of water while puddling and managing the process to minimise the amount of turbid water.

Benefits:
The benefits are reduced water-use (environmental benefit, cost saving) and one-pass cultivation (cost and energy saving). These benefits have been quantified by a NSW Agriculture economist.

From the results of the survey of irrigation and rice industry people associated with the project reported in Section 3, the outputs as defined are recognised by cooperating farmers and have been put into practice. There are no adverse reports from those who have used the technique, either as to its efficacy or in respect to difficulties of application.

2.3 Organisation and Management

The response of the project to LWRRDC administration was very positive. There was both direct and indirect feedback from LWRRDC to the project during its life, including correspondence on policy issues related to the project. There was an on-site review which was considered to be a positive experience. Funding was increased during the last year to allow additional work to be carried out on the consequences on non-rice crops of puddling before rice.

2.4 Contact with Potential Output Adopters

The project made a particular effort to develop and maintain contact with potential output adopters. The following industry contacts, demonstration and promotions were made during the life of the project.

Rice Research Committee:
Agronomy Sub-committee
Jim Wilson, Farm 99, Coleambally
Graeme Menzies

Rice Environmental Policy Advisory Group:
Department of Land and Water Conservation
NSW Agriculture
Rice Growers Association
Land and Water Management Plans
CSIRO

NSW Agriculture:
Don McCaffery, CIA District Agronomist, Griffith
Geoff McLeod, Special Agronomist Irrigation and Salinity
Annette McCaffery, Salt Action Officer
Graeme Marshall, Economist (cost/benefit analysis)

Coleambally Land and Water Management Plan Committee:
Lilian Parker, Coordinator
Sub-committee No 2. (Control Groundwater).
Presentation on Landforming.

NSW Water Resources:
David Mittlehauser, DWR Special Projects
Adrian Thompson, DWR Regional Manager, MIA
Ary van der Lely, Senior Scientist, MIA

INCITEC:
Jeff Kraak
Keith Jordan

Cooperating Farmers:
Thirteen farmers were said to have puddled more than one bay during the period of the research (1990–91 to 1993–94).

Rice Grower Discussion Groups:
Meetings at Coleambally

2.5 Dissemination of Results

The results of the project were disseminated in a number of ways. There were local area activities including farm walks and discussion groups with farmers and Landcare groups, together with local newspaper articles. During the life of the project, three articles were published in technical journals including one in the NSW Agriculture Rice Check Book, five papers submitted to scientific journals and seven papers appeared in conference proceedings or books on rice or soils. Four articles were published in local farmers' periodicals.

2.6 Actual Cost and Financing

The information provided by LWRRDC is that the project was financed jointly by LWRRDC as successor to NSCP, the CSIRO–DWR and the RRC. From data provided by LWRRDC, total funding was $948,000 which was shared 58.7% by CSIRO, 22.2% by the Rice Research Committee and 19% by LWRRDC. A summary of overall expenditure and details of that by LWRRDC are given in Table 2. It was agreed that any intellectual property income would be shared on the basis of 85% to the CSIRO/ Rice Research Committee and 15% to LWRRDC.

The data provided by LWRRDC do not entirely tally with that from the project itself. Information provided by the principal researcher gives overall project costs as $1.78 million over five years, with LWRRDC contributing 11.6%, the rice industry 12.3%, ASRRF/ RIRDC 9.4% and CSIRO 66.7%. Details are given in Table 3.

Table 2. LWRRDC summary of actual funding sources and annual outlays

Item	1990–91	1991–92	1992–93	Total	Percent
Salaries	62,716	52,142	30,182	145,040	80.5
Operating	10,255	6,000	13,563	29,818	16.6
Capital		2,000	1,000	3,000	1.7
Travel			2,282	2,282	1.3
Adoption				0	0.0
Total LWRRDC	72,971	60,142	47,027	180,140	19.0
CSIRO Division of Water Resources	226,301	229,146	101,302	556,749	58.7
Rice Research Committee	104,908	105,908		210,816	22.2
Total funding	404,180	395,196	148,329	947,705	100.0

Source: Project Schedule (Document 1)

Table 3. Project summary of funding sources and outlays

Item	1989–90	1990–91	1991–92	1992–93	1993–94	Total	Percent
LWRRDC		40,673	58,716	60,142	47,027	206,558	11.6
Rice Industry	27,500	50,000	52,455	52,954	35,774	218,683	12.3
RIRDC			52,455	52,954	35,774	141,183	7.9
ASRRF	27,500					27,500	1.5
CSIRO Division of Water Resources	231,738	218,995	226,301	229,146	282,705	1,188,885	66.7
Total funding	286,738	309,668	389,927	395,196	401,280	1,782,809	100.0

Source: Principal Researcher

3 Adoption of Results

3.1 Survey

A survey was undertaken of 24 persons identified as having had direct or indirect contact with the project during its operation and likely to be interested in the adoption of the project output. These included 13 cooperating farmers, the three members of the agronomy sub-committee of the Rice Research and Development Committee, the chairman of the Coleambally Land and Water Management Plan (CLWMP) and representatives of the Coleambally Irrigation Board, NSW Agriculture, the Department of Land and Water Conservation and Coleambally Irrigation.

A total of 13 responses was received, with nine from farmers and four from government regulators and/or advisers. The response rate from farmers was relatively higher being nine out of 14 (13 plus the chairman of the CLWMP who is a farmer), while there were four responses from the 10 government and administrative persons approached for feedback on the project. The detailed results of the survey, including respondents comments, are given in Appendix 1. The numbers used in the analysis represent specific responses to options offered ie. Yes/ No/Possibly. In most questions the options were not mutually exclusive, nor were the respondents required to mark every option. The numbers therefore represent the conscious choice of respondents indicating their attitude on a specific matter. For most questions, respondents were offered space to record a comment to supplement or expand their response. All the respondents comments are included in the analysis of the questionnaire Annex 1.

3.2 Findings

There was significant recognition by potential adopters of the problem of ‘high water-use’ paddocks as an issue in the early 1990s. Ten of the 13 responders identified high water-use as a (Coleambally) district problem in the early 1990s. They were equally divided as to whether it was a problem for their own farm and/or for other farms.

There was a high level of awareness that research was being conducted on puddling of soils in response to the problem of high water-use. This awareness came through a broad spectrum of sources including local radio and newspapers, the Farmers Newsletter, discussions with other farmers and government officers and from public meetings. Several of the farmers responded to the publicly available information on the project by actively seeking out the principal researcher and making further enquiries or volunteering to cooperate with the project.

Three-quarters of the responders saw the project as likely to provide an answer to the problem of high water-use paddocks or bays. Again, they were relatively equally divided between whether the benefit would be to themselves or to other farmers. While the survey group is necessarily biased towards an awareness of the project and its outcomes, the overall impression is of an effective communication campaign managed by the project and a high level of interaction between the researchers and potential adopters of any project output.

The effectiveness of communication comes through in the high level of awareness of the project results. All respondents said that they were aware of the results of the research. A range of sources for the results was cited, but 10 of the 13 responders were actively involved with the researchers and heard it from them.

Virtually all the farmers said that they would like to identify leaky bays or areas and cited a range of practical reasons such as minimising the cost of water, having more water available for other crops and to avoid adding to net recharge. Of the 13 respondents, 11 said they knew how to identify leaky bays or areas, while the others offered no response to that question.

Ten respondents said that they knew enough about puddling to do it if they wanted to. Five respondents had actually carried out puddling, one for four years, two for three years and one each for two and one years. All those who had puddled rice paddocks cited high water-use as the reason for doing so. All indicated that water savings were the principal perceived benefit, while opinion was divided as to what might have been other benefits. The most commonly identified problems were preparation for sowing and management.

Four farmers said that they would puddle again, while two said that it was a possibility. The major reasons offered were generally to reduce the impact of high water-use on the watertable, to reduce deep percolation from paddocks using more than 16 ML/ha or to keep a

paddock in rice production that would otherwise be banned from rice growing. Only one farmer indicated that he would not puddle, commenting that if he had to puddle, he would not grow rice.

Five responses were included in the non-rice grower category through the inclusion of an industry representative grower in this group. Four of the five non-farmer respondents had suggested or recommended puddling to growers, indicating the reason as control of high water-use or retaining the use of leaky paddocks. All respondents cited better water-use as the principal benefit. Opinion was widely divided over a range of other benefits, with only economics attracting two positive responses. By contrast, three of this group indicated economics as a potential problem, suggesting that the benefit might be break-even only and noting the costs associated with additional equipment needed, while two suggested there were management problems with additional labour requirement and the difficulty of working with dirty water. Overall there was somewhat more scepticism in this group than the farmers, with a higher number of responses in the 'possibly' option, rather than the yes/no options.

The outcome of the project was summed up in one response which said that farmers are slow to take up the technology because they are not being forced into adoption. They are still able to get away with high water-use without having to face the consequences of reclassification of paddocks or to pay the environmental cost. There are indications of similar views among the farmers. Their responses suggest that they would puddle only if necessary. Puddling is seen as a specific technology for individual paddocks or bays and is not necessary as a regular production practice. Farmers see other options available such as production of alternate crops, or taking particular paddocks out of rice. The emphasis throughout is on the environmental benefit rather than any perceived economic benefit; that is, the environmental cost is seen more as a community cost than as a personal cost to the farmer. It appears that the farmers generally do not feel sufficiently threatened at this stage to widely adopt the technology.

* * * * * * *

4 Conclusions

4.1 Overall Assessment

This has been a successful project. The project met its scientific objectives and has produced directly implementable technical practice. If the adoption of the technology developed were widespread, there is the theoretical potential to reduce the accessions of rice water through deep percolation in the Murrumbidgee irrigation areas by up to 25%. A more conservative estimation suggests that total accession could be reduced to 10% if the technology were widely adopted on the 25% of the area which has water use in excess of 16 ML/ha. At a total cost of $1.78 million over five years, the potential environmental payoff ratio would seem to be relatively high in relation to the investment.

However, at this stage adoption rates are low. As can be expected, the farmers take a much narrower view of threats and benefits than that of the broad scientific view. All acknowledge that leaky paddocks increase the accession of rice irrigation water to the watertable and that the puddling technology will mitigate this problem. However, no farmer has indicated that he would adopt this technique on a regular basis. Of those who have used it and say they would do so again, they see its use as being in a specific frame of reference related to individual leaky paddocks or bays. In short, it seems that no farmer feels sufficiently threatened by the problem to incorporate the technique into regular farm practice for irrigated rice production. It is seen as a specific sub-technique to be used only when necessary. There is no significant perception by farmers of personal economic benefits through using the technique.

4.2 Lessons Learned

It is possible to build an effective research–industry team to implement field level research. The project team worked hard at building general industry awareness of what it was doing and the success of this is reflected in the comments of a number of farmers

who sought out the principal researcher in response to information seen in local newspapers or at meetings. It is also reflected in the high number of survey respondents who were aware of the project results and who cited the project team as the source of their information.

However, success in building such industry cooperation does not, of itself, lead to technology adoption. A number of the cooperating farmers have tried the technique, found that it works and then put it on the shelf to be used only when necessary.

The lesson must be in matching perceptions. The research perception is that a technique has been developed which has the potential to measurably reduce accession of rice water to the watertable. It has been successfully implemented by a number of farmers. The technique is well defined and the steps for successful implementation are clearly understood. The farmer's perception, however, is that while this is a useful addition to the production system, it need only be used under quite specific circumstances. No farmer has indicated that they see the necessity of regularly using this technique. Neither has any farmer indicated that they see a need to personally contribute to the reduction of accessions to the watertable. They see the technique as being able to save them from having a paddock withdrawn from rice production or saving on excessive cost of water. They see no need to use the technique unless those threats are immediate.

If it is the intention of LWRRDC that the technology be adopted widely, then there is another set of activities which must be undertaken. Farmers' attitudes to the risks associated with the rising watertables should be assessed and more detailed information on the farm level benefits developed, or at least made public. The quickest way to gain greater adoption would be to have more rigid application of the water use limits at 16 ML/ha. If farmers knew that high use paddocks would be forced out of production by irrigation authorities, then there would be a much greater direct interest in the use of puddling.

4.3 Follow–up Actions

In a general sense, the technology development has been done. It is understood that the principal researcher would like some extension of the work to fine-tune certain aspects of the technique. However, the main efforts would need to be put into identifying those aspects which would motivate growers to use the technique. Some of this would be in the form of public education, especially on the matter of rising watertables. The main effort, however, should be directed at identifying and quantifying the payoff from this technique to individual farmers and to ensuring that this was well understood in the community.

Annex 1. Project Questionnaire and Responses

Questionnaires sent: 24
Responses received: 13 (nine farmers, four government advisers/researchers)

1. Awareness of the Research

	Yes / No
Were you aware in the early 1990s that research was being conducted on puddling soils?	11 / 0 Not indicated 2
If yes, how did you become aware of the project?	*Yes / No*
– Local news (local radio, newspaper)	3 / 2
– Farmers Newsletter	7 / 0
– Discussion with other farmers	6 / 2
– Department of Water Resources Officer	2 / 2
– Local Agronomist	6 / 1
– Direct approach from CSIRO to participate/cooperate with project	7 / 1
– Public meeting	6 / 2
– Other *(please specify)* (i) Scientific meeting (ii) RIRDC	2 / 1
– Unaware of the project	0 / 1

Comments:

- Widely known in CIA due to meetings, active local agronomist and farmers newsletter etc.
- There was plenty of publicity as the project was new and interesting
- We have a high water-use problem and sought ways that might help to solve the problem
- One of the projects were conducted on our farm
- Member of Rice Research Committee
- Contacted Liz Humphries after reading article
- Field days
- Principal source was direct contact with CSIRO

	Yes / No
In the early 1990s did you see 'high water-use' rice paddocks as a problem for	
your district	11 / 1
your farm	7 / 3
other farms	8 / 0
Do you consider that at the time of the field research there was adequate publicity of the research activity directed at 'high water-use' paddocks/bays in the local area?	8 / 4
Did the reporting of the project excite interest as likely to provide an answer to the problem of high water-use bays of paddocks:	
– to you	10 / 1
– to other farmers	6 / 2
If so, did you do anything about finding out more?	8 / 0

If so, how?

- Contact with Dr Liz Humphries and leakage tests on own farm
- Made regular contact with Dept of Water to find out my rice usage of water
- Regular discussion with research project leader
- Participated in trials and field work conducted by CSIRO
- Attending field days felt informed on project
- Contact with Dr Humphries
- I rang Liz and asked to be included
- Attended field day
- Had one paddock which had a high usage of water on rice and after reading article on puddling felt it was for us
- Go to meetings, talk to scientist, read report
- Talk to Liz and attend field days
- Contacted Dr Liz Humphries for more information
- I maintained direct contact with CSIRO about the research outcomes

If not, why not?

- Research focused on the Murrumbidgee Valley and did not relate to soil types in the Murray Valley

2. Involvement in the Project

How were you involved with the project?	*Yes / No*
– Through field days, farm walks and/or growers meetings	6 / 2
– Through Land and Water Management Planning Group	3 / 3
– As a cooperating farmer	7 / 1
– As a government adviser (1), regulatory officer or researcher (1)	4 / 2
– Other *(please specify) Rice Research Committee*	1 / 0
– Never involved	0 / 1

Comments

- Attended field day results and currently chair of local LWMP
- I attended two field days on site and went to public meeting to discuss findings and summaries
- My farm didn't leak at the time

3. Awareness of the Results

	Yes / No
Are you aware of the results of the project?	13 / 0
If yes, how did you find out?	
– Don't know what the final results were	1 / 3
– Another farmer told you	2 / 1
– District Agronomist told you	4 / 2
– Through field days	6 / 2
– Read, or heard of the results through local sources *(please specify)*	5 / 2
– At public or grower meetings	7 / 2
– Had previously heard about the project and decided that you wanted to know what had happened, so made it your business to find out	2 / 1
– Were actively involved with the researchers and heard about it from them	11 / 0
– Trialling the puddling technique yourself and making your own observations	4 / 3
– Other *(please specify)*	0 / 1

Comments:

- There was ample results made public at the time
- Access to research reports (government researcher)
- Findings and summaries published in Farmers Newsletter
- Did puddling technique under Liz Humphries supervision
- Milestone reports to RIRDC

	Yes / No
Do you know enough about puddling to do it if you want to?	11 / 0
Do you need more information on puddling?	6 / 5
If yes, what kind of information	
– Effects of leaking soils which being under rice banks are not puddled	
– Range of soil types applicable, longevity in different situations, how to target ie. where to do it	
– Ground speed and depth of working	
– Economics of application	
– We need to define areas of relatively high percolation rates, eg. bay tests or EM31	
– Rotor speeds of rotary hoe and long-term effect on soil	
– How does it specifically relate to the range of common soil types and longer term benefits	
– Do you know how to identify leaky bays/areas?	12 / 0

If yes, how?

- Bay tests.
- By doing bay tests whereby water is held in the bay and measurements taken over time.
- Watch the water use in bays. Soil structure should also give you a clue (high water-use) as we have self–mulching soils.
- Bay tests and observation
- Bay tests, heavy cut areas could be suspect.
- Bay tests and EM survey.
- Assess change in water depth over 2 hours or longer.
- Monitor water usage.
- Ponding tests/infiltrometer.
- Bay tests or EM31.
- Dept of Ag trialled an EM31 machine across farm. Results look very encouraging.
- Monitor water use/depth.

Would you like to be able to identify leaky bays/areas?	8 / 0
– Cost of water, adding to net recharge	
– Have more water available for other crops	
– To reduce water getting into watertable	
– To be able to do something with them	
– To avoid growing rice on them. That type of soil may well be suited to other crops	
– To be able to remove them from production or to ameliorate them	

4. Adoption of Research Results (Rice Growers Responses)

	Yes / No
Have you ever tried puddling?	6 / 3
– If yes, what area did you puddle	
– One or two bays	1 / 0
– several bays	0 / 0
– majority of paddock	1 / 0
– more than one paddock	4 / 0

If yes, over how many years?

- 4 years including 2 years of trials
- 2 years
- 4 years
- 3 years
- 1 year
- 3 years

Why did you puddle?

- Offers a partial solution to water usage, seems to work
- High water-use paddocks
- To reduce water use
- Try to reduce water use
- High usage of water
- My farm is well over the environmental limit (16 ML/ha) for rice growing. This idea was new and we already had a rotary hoe for our stubble retention

What were the benefits?

Please tick line to indicate which aspects of rice cropping benefited from puddling and comment on how.

2	preparation for sowing	*No*
		Easier on rotary hoe
		No nitrogen loss
2	management	*No*
		No slime problems in rice or dark water (different from turbid water).
2	crop	*No*
		Seems to grow more robust
6	water use	*Reduction of usage from high 20s ML/ha to acceptable range*
		Reduces water use except for this year. Not sure why, maybe insufficient working
		Reduction of 18 ML/ha to 15 ML/ha
		Used less water
2	economics	*?*
		Lower water and fuel costs
1	other	*Longer grazing of pastures by sheep. Less fuel required by tractor*

What were the problems?

Please tick line to indicate which aspects of rice cropping were more difficult/less satisfactory with puddling and comment on why.

4	preparation for sowing	*The application of pre-sowing fertiliser if we have a wet winter*
		Early preparation essential
		Dirty water as a result of puddling gave some crop establishment problems
2	management	*Possibly have to grow short season varieties*
		Turbid water a problem, also couch grass a major problem
1	crop	*Establishment sometimes poor*
	water use	
	economics	
	other	

	Yes / No / Possibly
Will you ever puddle again?	5 / 0 / 2

If yes, why

- Puddling, when combined with other management techniques seems to be able to control water usage and therefore helps make these paddocks more environmentally sustainable
- If paddock requires and management improves
- We have some leaky paddocks
- To keep high water-use paddocks in rice production
- The technology is now available to use when it is required
- Easier on machines and cheaper to prepare pasture ground for rice sowing

If you will not puddle again, or have never puddled, why?

Tick lines and add comments where appropriate

1	Not necessary because no high water-use paddocks
	I don't like the idea of driving around in the mud
	The puddling process is too slow
	I don't have suitable equipment *(please specify)*
	I am concerned about damaging the soil
	I am not convinced it saves water
	I am not convinced it will help the watertable problem
	I am concerned that rice yields will be lower
	Other *(please specify)*

Comments

- If I had to puddle I would not grow rice (simple solution)

What reasons would cause you to use puddling?	*Yes / No / Possibly*
– To keep a rice paddock that would otherwise be banned from rice growing because of high rice water-use	7 / 0 / 0
– To reduce water-use bills in a high water-use paddock	5 / 1 / 0
–No – Farm sustainability is more important	
– To reduce the impact of a high water-use paddock on the watertable	6 / 1 / 0
– To reduce deep percolation from an identified leaking area in a paddock that uses more than 16 ML/ha	7 / 0 / 0
– To reduce deep percolation from an identified leaking area in a paddock that uses less than 16 ML/ha	0 / 1 / 1
– To reduce water use from 16 ML/ha to (say) 15 ML/ha	1 / 0 / 1
– Other (please specify)	0 / 0 / 1
– *Possibly – stop channel beds leaking*	

I would never use puddling, because:

- We shouldn't be growing rice on such soils. There are plenty of other options
- I would use puddling method again only if necessary. Since rice crop 1993–94, the paddock has been lasered and is sown down to sub pasture and will be out of rice for four years.

5. Knowledge and Adoption of Research Results

Non-rice growers eg. extension officers, policymakers, industry leaders, regulatory authorities and rice growers who wear two hats (ie. as an industry representative).

	Yes / No
Have you ever suggested/recommended puddling to a rice grower?	4 / 1

If yes, why?

- RWU › 1 6 ML/ha, puddling offers grower opportunity to remain growing rice on a particular piece of land that might be restricted
- To allow rice growing on an otherwise too permeable area. Only one–two rice growers in total
- Problem existing

What are the benefits of puddling?

Please tick line to indicate which aspects of rice cropping benefit from puddling and comment on how.

1	preparation for sowing	*One pass preparation*
1	management	*To keep fields below water use limit so they may retain rice growing*
5	crop water use	*Less RWU, less $$ cost of water, less accessions to watertable*
		Reduced
		Reduced water use at $40/ML
		Reduces excess water use but not under bank lines
		Primary benefit
2	economics	*Secondary benefit*
1	other	*Reduced accessions to groundwater*

What are the problems?

Please tick line to indicate which aspects of rice cropping are more difficult/less satisfactory with puddling and comment on why.

1	preparation for sowing	*Under water causes problems*
2	management	*Extra labour and work for puddling and muddies water*
		Is more difficult with dirty water
1	crop water use	*May only solve part of leakages problem*
3	economics	*Cost involved*
		May not have equipment
		Breaking even only. Equipment to be purchased.
1	other	*Longer term impacts on soil structure and effect on subsequent non-rice crops in rotation*

What reasons would cause you to recommend puddling?	*Yes / No / Possibly*
– To keep a rice paddock that would other wise be banned from rice growing because of high rice water-use	3 / 0 / 1
– To reduce water-use bills in a high-water-use paddock	2 / 0 / 3
– To reduce the impact of a high-water-use paddock on the watertable	4 / 0 / 1
– To reduce deep percolation from an identified leaking area in a paddock that uses more than 16 ML/ha	4 / 0 / 2
– To reduce deep percolation from an identified leaking area in a paddock that uses less than 16 ML/ha	1 / 1 / 4
– To reduce water use from 16 ML/ha to (say) 15 ML/ha	1 / 0 / 3
– Other (please specify)	

I would never recommend puddling, because: *tick lines and add comments where appropriate*

	Not necessary because no high-water-use paddocks
	I don't like the idea of farmers driving around in the mud
	The puddling process is too slow
	Many farmers don't have suitable equipment *(please specify)*
1	I am concerned about damaging the soil

1 I am not convinced it saves water *on all soil types*
I am not convinced it will help the watertable problem
I am concerned that rice yields will be lower
Other *(please specify)*

Comment

- Farmers are slow to uptake because they are not being forced to adopt the technique. They are still getting away with high water-use without having to face the consequences (reclassification) or pay the environmental cost.

6. Other

Are there any other comments about the puddling research and extension or the puddling technique that you would like to add?

- Too much extra work for farmers, easier for farmers to select alternative site. The new EM31 water/s oil suitability project which identifies leaking areas is much better way to go.
- The results of puddling work will be used in the future when: (i) environmental issues become more defined and more pressing; (ii) small areas in fields can be defined eg. EM31. More work with EM machines should have been included in the project to help define areas of economic use. This is now in another project with the Dept of Ag etc.
- I would like to see an easier way other than using a rotary hoe

Evaluation No 2. Ref. No: CWN5

River Pollution with Agricultural Chemicals Used in Irrigated Agriculture

Contents

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1 Background

1.1 Rationale

Contamination of the river systems by irrigation drainage is seen as an important environmental and agricultural issue. Problems can arise through the widespread use of persistent or toxic compounds which are transported from irrigated agriculture to the river systems and which may have impacts on aquatic life and drinking water quality. The problems identified could lead to restrictions on the use of such compounds or on the drainage of water where these compounds have been used.

To deal with the problems in a responsible scientific manner, it is necessary to define and quantify the patterns of use and the persistence and fate of short-lived problem compounds. Providing quantified risk assessments could help avoid any unnecessary restriction on the use of agricultural chemicals, with economic benefit to various irrigated agricultural enterprises. It should also lead to improvement in design and efficacy of monitoring programs for the Murray–Darling Basin Commission, State water agencies and even farmers.

This project is part of a larger program of research being supported by the Murray–Darling Basin Commission, together with CSIRO and LWRRDC.

1.2 Project Arrangements

The formal project arrangements were:

Implementing agency:
CSIRO Division of Water Resources, Griffith

Principal investigator:
Dr Kathleen Bowmer (to July 1993)
Dr Wolfgang Korth (from July 1993)

Submission date:
July 1991

Start/finish dates:
1 January 1992 to 31 December 1994

Third party:
Murray–Darling Basin Commission
CSIRO Division of Plant Industry

1.3 Objectives and Scope

Scope of the project

There are widespread community concerns over the movement of agricultural chemicals into the off-farm environment, with potentially deleterious effects on water quality. The project set out to provide quantified risk assessments which could form the basis for the development of best management practices for both farmers and water managers. Within the range of chemicals tested, the techniques developed would be transferable of other irrigation areas.

Objectives

The objectives of the original proposal were to:

a. develop rapid methods for collection and analysis/assay of key pesticides used in irrigated crops and report to monitoring agencies;

b. describe the release of selected pesticides from at least two systems of irrigated land use into surface waters/rivers, and assess the biological impact of these pesticides using key aquatic organisms;

c. use this information to develop improved management practices which will reduce pollution by, and the effects of, these pesticides;

d. identify any production systems which use agricultural chemicals but represent a low risk to the environment, as a guide to avoiding unnecessary regulation; and

e. make this information available to, and promote adoption by, State water management agencies and departments of agriculture, and irrigation industry groups.

The timetable established for the project was:

1991–92

a) Review previous work including monitoring data previously collected.

b) Work up methods for selected key pesticides and test against immunoassay methods if available.

c) Begin monitoring selected catchments (probably rice and horticulture) including tile drainage.

1993–93

a) Work up methods for testing key organisms (*Daphnia*, chironomids) for assay of waters with cocktail of toxins and apply to suspect water.

b) Attempt to reproduce lethal/sublethal effects from environmental concentrations.

1993–94

a) Complete work on spiralling of key pesticides in drainage systems (selection dependent on previous results).

1.4 Financing Arrangements

Total project budget was estimated at $593,000 over three years, 1991–92 to 1993–94. LWRRDC funding was $150,000 (25.3%), with a further $60,000 (10.1%) third party funding from the Murray–Darling Basin Commission. CSIRO Division of Water Resources was to contribute $383,000 (64.6%). Details are given in Table 1. There was no comment on intellectual property/property income in the original submission.

1.5 Completion

The project was completed on the target date of 31 December 1994.

1.6 *Ex-Post* Evaluation

This evaluation report focuses on pertinent aspects of the project and presents the findings of the *Ex-Post* Evaluation (EPE). The evaluation is based on documents provided by LWRRDC as listed below, detailed discussions with the principal investigators and a survey by questionnaire of identified potential users of the project outputs and other acknowledged sources of information.

In preparing the application the reviewers have had access to the following documents:

1. December 1995—Project schedule
2. July 1991—Original application to LWRRDC
3. February 1992—Minutes of first advisory committee meeting
4. August 1992—LWRRDC project review report (review March 1992)
5. December 1992—First progress report
6. May 1993—Press release on monitoring techniques for pesticide presence, CSIRO Division of Water Resources
7. December 1994—Project final report

Table 1. Budget for funding sources and projected annual outlays

	1991–92	1992–93	1993–94	Total	Percent
LWRRDC					
Salaries	47,420	43,790	43,790	135,000	90.0
Operating	5,000	5,000	5,000	15,000	10.0
Total LWRRDC	52,420	48,790	48,790	150,000	25.3
CSIRO Division of Water Resources					
Salaries	58,060	110,085	118,847	286,992	74.9
Operating	30,000	20,000	20,000	70,000	18.3
Capital	26,000			26,000	6.8
Total CSIRO DWR	114,060	130,085	138,847	382,992	64.6
Murray-Darling Basin Commission	20,000	20,000	20,000	60,000	10.1
Summary					
Salaries	105,480	153,875	162,637	421,992	71.2
Operating	55,000	45,000	45,000	145,000	24.5
Capital	26,000			26,000	4.3
Total funding	**186,480**	**198,875**	**207,637**	**592,992**	**100.0**

Source: Original Submission July 1991

2 Implementation Performance

2.1 Design

To facilitate an objective review of the project, the original objectives in Section 1.3 are restated in terms of the logical framework (log-frame) approach.

Goal:
To improve the quality of the environment by reducing the contamination of rivers and waterways by agricultural chemicals

Purpose:
To assist in the improvement in the design and efficacy of river and waterway quality monitoring programs as a basis for limiting unnecessary restriction on the use of agricultural chemicals.

Outputs:
Description of the release of selected pesticides from at least two systems of irrigated land uses into surface waters/rivers, and an assessment of the biological impact of these pesticides using key aquatic organisms.

Specification of rapid methods for the collection and analysis/assay of key pesticides used in irrigated crops.

Quantified risk assessments of the persistence and fate in rivers and waterways of short-lived problem compounds used in irrigated agriculture.

Specification of any production system which uses agricultural chemicals, but represents a low risk to the environment

Report on findings to agencies responsible for pesticide monitoring, river and waterway management and irrigation industry groups to facilitate the adoption of other project outputs.

Inputs and activities:

i) Survey and literature review.

ii) Select catchments with different irrigated cropping use and monitor run-off close to source.

iii a) Work up analytical methods for key compounds (chlorpyrifos, diazinon, bensulfuron, molinate, atrazine, diuron, acrolein), test against immunoassay if available.

iii b) Work up bioassay using *Daphnia*, chironomids for study of toxin cocktails.

iv) Investigate spiralling of key compounds in irrigation drainage system.

v) Investigate fate and life of compounds in river system, en-route storage and evaporation basins.

vi) Investigate methods for ‘sourcing’ water (eg. isotopes, bromide tracer) to separate clean water escape and contamination from different land uses.

vii) Advise on possible management options to avoid/reduce pollution, including compatibility with management of salt and nutrients.

2.2 Outputs

Findings:

– A combination of chemical and ecotoxicological techniques is required to fully assess the impact of drainage water contaminated by pesticides used in agriculture;

– Rapid field test kits based on the enzyme immunoassay (ELISA) technique are successful in the detection of molinate, chlorpyrifos and organophosphorous pesticides;

– The findings of rapid field test kits can be supplemented by the use of *Ceriodaphnia* sp. as an indicator organism to assess the toxicity levels in drainage water;

– There is an advantage in having a sufficiently frequent monitoring regime to detect short-term pesticide contamination events (two–three day pulses); and

– No agricultural practices which used pesticides as part of their management strategy and that generated drainage water after their application were identified as low-risk to the environment.

Output 1.
A specific system or approach for the detection, tracking and quantification in drainage water of pesticide residues from irrigated agriculture.

Output 2.
A series of options or recommendations for industry best management practices to minimise the volume and contamination of drainage water by chemicals used in irrigated agriculture.

Key element:
The project demonstrated that a combination of chemical and ecotoxicological techniques is required to fully assess the impact of drainage water contaminated by pesticides used in agriculture.

Required practices:
The use of rapid field test kits based on the enzyme immunoassay (ELISA) technique for the detection of molinate, chlorpyrifos and organophosphorous pesticides.

- There is an advantage in having a sufficiently frequent monitoring regime to detect short-term pesticide contamination events (two–three day pulses).
- The findings of rapid field test kits can be supplemented by the use of *Ceriodaphnia* sp. as an indicator organism to assess the toxicity levels in drainage water.
- Best practice options where possible are: retention of first watering/storm water; retention of rice flood water to allow for *in-situ* dissipation; recirculation of drainage water; dilution with uncontaminated drainage water or supply water; diversion to off-site storages and more precise aerial application to avoid spray drift or overspray.
- Options for water managers are to: develop a sufficiently frequent sampling protocol to detect pulse events from accidental spills, storm events, overspraying or intentional releases, particularly during periods of high pesticide application; incorporate an ecotoxicological component as part of their monitoring strategy to assess the toxicity of drainage effluent and adopt best management practices to improve drainage water quality and minimise its quantity.

The outputs as defined are recognised by irrigation industry and government regulators associated with water management and environmental issues. In particular, the combination of chemical and ecotoxicological techniques is seen having focused attention of the industry on the impact of pesticides in drainage water. By incorporating the toxicology work it has provided information on the ‘cocktail’ effect of pesticides which had hitherto been understated. The project is also seen as having been significant in the formation of the Riverina Irrigated Agriculture Chemical Task Force (RIACTF) and the implementation of locally based pesticide monitoring programs.

2.3 Contact with Potential Output Adopters

The project made a significant effort to build working relationships across a wide spectrum of those involved in the irrigation industry in the Riverina. The evaluation survey found that most respondents considered there was adequate involvement of the full range of those with a direct interest in the project. A Project Advisory Committee (PAC) was established to provide direct links between the research workers and potential adopters and to monitor progress of the research. The members of the PAC were:

Alistair Buchan
NSW Department of Water Resources, Leeton

Debbie Love
NSW Department of Water Resources, Deniliquin

Ian Kelly
NSW Department of Water Resources, Grafton

Mark Neeson
MIA Council of Horticultural Associations, Leeton

Bernard Whelan
Rice grower, Whitton

David Davis
Regional Liaison Officer, NSW Agriculture, Yanco

A technology transfer workshop was held in December 1993. This was seen as a significant activity by a number of respondents to the project questionnaire. Those organisations represented at the workshop and which subsequently became inaugural members of the Riverina Irrigated Agriculture Chemicals Taskforce are marked ‘RIACT’.

- NSW Department of Water Resources (RIACT)
- CSIRO Division of Water Resources
- CSIRO Division of Plant Industry
- Environmental Protection Authority, Albury and Griffith (RIACT)
- Environmental Protection Authority, Marine and Estuarine, Sydney
- NSW Agriculture (RIACT)
- Department of Agriculture, Victoria

– NSW Fisheries, Narranderra

– Health Departments (local Shire Councils)

– Murrumbidgee Land and Water Management Plan Group (RIACT)

– Rice Growers Association (RIACT)

– Charles Sturt University

– NSW Department of Conservation and Land Management

Additional inaugural members of the Riverina Irrigated Agriculture Chemicals Taskforce not represented at the technology transfer workshop were:

– Coleambally and Murray Land and Water Management Plan Groups

– MIA Council of Horticultural Associations

2.4 Dissemination of Results

The project submission indicated that the results would be transferred by direct reporting to the Murray–Darling Basin Commission, State water and agricultural agencies and agricultural industry groups on:

i) status of water quality for pesticides

ii) design of monitoring programs

iii) identification of problem (pollution producing) agricultural enterprises or practices, including prospects for isolating or avoiding water contamination.

By the end of the project there was widespread awareness of the principal findings of the project. There is now significant activity in implementing these findings, which is discussed in Section 3.2.

2.5 Actual Cost and Financing

Actual project outlays were $593,000 which was exactly as budgeted (see Table 1). However, there was a six-month time lag with the project spreading over four, rather than three financial years. The shares between the parties remained unchanged with LWRRDC funding at $150,000 (25.3%), $60,000 (10.1%) third party funding from the Murray–Darling Basin Commission and CSIRO Division of Water Resources contributing $383,000 (64.6%). Details are given in Table 2. Intellectual property/project income was divided 33% to LWRRDC/Murray–Darling Basin Commission and 67% to CSIRO Division of Water Resources.

Table 2. Summary of actual funding sources and annual outlays

	1991–92	1992–93	1993–94	1994–95	Total	Percent
Salaries	23,710	43,790	43,790	23,710	135,000	90.0
Operating	2,500	5,000	5,000	2,500	15,000	10.0
Capital					0	0.0
Travel					0	0.0
Adoption					0	0.0
Total LWRRDC	26,210	48,790	48,790	26,210	150,000	25.3
CSIRO Division of Water Resources	127,664	127,664	127,664		382,992	64.6
Murray-Darling Basin Commission	20,000	20,000	20,000		60,000	10.1
Total funding	**173,874**	**196,454**	**196,454**	**26,210**	**592,992**	**100.0**

Source: Project Schedule (Document 1. December 1995)

3 Adoption of Results

3.1 Survey

A survey was undertaken of 14 persons identified by the project as having had direct or indirect contact during its operation and likely to be interested in the adoption of the project output. These included all the members of the Project Advisory Committee and covered the Department of Land and Water Conservation (DWLC) two persons, the Environmental Protection Authority (EPA) three persons, two from local councils in the MIA, a manager and a water quality officer from local irrigation authorities, three rice industry representatives and two academics in the field of chemical pollution and monitoring.

Six responses were received. These were from DWLC (1), EPA (1), municipal council (1), water quality officer from local irrigation authority (1) and from the academics (2). It has not been possible to elicit responses from some of those who were considered closest to the project during its operation. The detailed results of the survey, including respondents comments, are given in Annex 1. The numbers used in the analysis represent specific responses to options offered, ie. Yes/No. In most questions the options were not mutually exclusive, and the respondents were not required to mark every option. The numbers therefore represent the conscious choice of respondents indicating their attitude on a specific matter. For most questions, respondents were offered space to record a comment to supplement or expand their response. All the respondents comments are included in the analysis of the questionnaire in Annex 1.

3.2 Findings

There was a general awareness among the respondents of the problem of waterway pollution from chemicals used in irrigated agriculture. The awareness was largely through their professional work, though technical and scientific journals and media and public discussion were also cited as sources of information. One respondent suggested that up until the time of the project the problem was considered in generic terms rather than relating to specific impacts from individual crop types and irrigation methods. He suggested that one benefit from the project was that it sharpened the focus on the problem. All respondents saw the problem as needing specific action, with four of the six ranking it as urgent. Only two respondents indicated any direct connection with the project, but there was wide awareness of the research being conducted, mostly through professional work, but also through discussion with professional colleagues.

Potential users of the project output were considered to cover a community-wide spectrum. It was considered that farmers should be included alongside agricultural and environmental advisory and regulatory officers and scientists as potential users of project output. While the application of the testing techniques would be in the hands of scientific officers, it is seen as important to use the results of the combined ELISA/toxicology tests to raise the awareness of farmers about the consequences of specific actions at specific times or locations.

Among the respondents there was a general awareness of the results of the project, but less knowledge of the specific detail. This partly reflected the limited contact between the respondents and the project, with only two persons having had direct formal contact. One respondent who had come into the technical field after the project was completed suggested that a generic paper discussing the findings of the study on pesticide cocktail toxicity would be useful for workers in the field.

The project outputs were considered to be ready to be put into practice. There was strong feedback that it was time to move into the paddock with grower involvement and education and field level monitoring. A marketing campaign to present results and product to environmental and community-based groups and government authorities was suggested. It was pointed out that irrigation organisations in southern NSW had already purchased ELISA kits from the USA for use in the 1994–95 season. This practical application has exposed some problems with the analytical method related to sample collection, storage and preservation which were not fully explored during the development phase.

4 Conclusions

4.1 Overall Assessment

The overall feedback on the project is very positive. By developing directly usable methods of identifying contamination levels, the project was seen as having provided the means to focus the attention of the irrigation industry on the consequences of pesticide use and the implications of using cocktail mixes of chemicals. This was seen as a way to provide industry-wide education and to involve grower groups and regulatory bodies in the development of management regimes.

4.2 Lessons Learned

There is an implied criticism in the feedback which suggests that the project stopped too soon. That is, it developed the scientific base for the testing procedures, but could have gone further towards ensuring the wider implementation of the techniques.

This is no criticism of the research itself. Rather it raises the question as to how far a funding body should go in using its resources to encourage adoption of specific research outputs. In this case the project held a successful technology transfer workshop to demonstrate its testing procedures which was widely attended by industry and scientific professionals. It played a significant role in establishing an industry body (RIACTF) to facilitate further development of its outputs. To that extent, it has taken positive steps in the adoption process and these have been successful.

However, there remains a problem of self-perpetuating inertia: how does one get new ideas off the ground and into industry practice? The research outputs are being taken up, but apparently only slowly and unevenly. Could this happen more quickly and effectively if more effort were now put into a program to facilitate the adoption of best practice management programs involving irrigators and water managers and environmental regulators? There is no certainty that further direct support will produce immediate results. Neither is it entirely clear what would be the appropriate actions to stimulate wider adoption of the combined immunoassay/toxicology testing approach as the basis for developing industry best practice in pesticide management.

4.3 Follow-up Actions

In a strict sense there is little that needs to be done to follow-up on the project CWN5. All the objectives were met and the outputs were directly implementable. However, while the standards were developed by the project, it seems that more could be done to assist in adoption of industry best practice in pesticide management. Whether that is warranted would depend on overall program priorities for LWRRDC.

Annex 1. Project Questionnaire and Responses

Questionnaires sent: 14 Responses received: 6

1. Awareness of the Problem

Yes/No

Prior to 1992 were you aware of possible or actual problems from chemicals used in irrigated agriculture creating downstream pollution of waterways? 6 / 0

If yes, how did you become aware of the problem?

- Through media and public discussion 4 / 2
- Technical or scientific journals 4 / 1
- Through your professional work 5 / 1
- Other *(please specify)* 2 / 1
- Unaware of the problem 0 / 3

Comments:

- Prior to 1992 I was studying B Nat Res at the University of New England, my understanding of chemical pollution at this time was limited.
- Main source of information through my professional work
- The problem was considered in generic terms with little information relating to specific impacts from individual crop types and irrigation method

If you were aware of the problem did you see it as being *Yes/No*

- Not a serious issue 0 / 4
- An important issue which would resolve itself over time 0 / 4
- An important issue needing specific action to define solutions 4 / 1
- An urgent matter needing critical action 4 / 2

Comments:

- My lack of full understanding of the extent of agricultural chemical pollution caused me to think the problem was not serious.
- Urgent matter was the most important response
- I saw the issue as an important issue where there was little information detailing the exact nature of the problem.

If you were aware of possible or actual problems from agricultural chemicals creating downstream pollution in waterways, after 1992 were you aware that specific research was being conducted to define appropriate field tests and farmer practices? *Yes/No* 5 / 1

If yes, how did you become aware of the project?

- Through media and public discussion 2 / 1
- Technical or scientific journals 1 / 2
- Discussion with professional colleagues 4 / 0
- Directly through your professional work 5 / 0
- Other *(please specify)* 1 / 1

Comments:

- Through workshop announcement
- My PhD project to some extent

2. Connection to the Project

Yes / No

Were you connected to the project in any way 2 / 1

If yes, how were you connected?

- through farm-based activities such as Land and Water Management Planning Group 1 / 3
- as a government adviser or regulatory officer 3 / 2
- a watching brief on behalf of my employer 1 / 2
- as a member of the Project Advisory Committee 0 / 3
- as an attendee at the technology transfer workshop 3 / 1
- other *(please specify)* 1 / 1
- Never involved 0 / 2

Comments:

- I became involved in workshops/meetings through my employment with the NSW Department of Water Resources after the project had been running for some time
- Brief discussion with one of the researchers
- Prof Bowmer was my PhD supervisor. Dr Wolfgang Korth provided much technical support, both were involved in the project
- My involvement was post-project, late 1994, as a government agency water quality officer. With the project, the industry groups, extension persons etc, were not aware as to the extent of the problem and hence the development of 'rapid' methods for pesticide detection were considered good ideas, but were not considered of 'great' practical importance. It was only after one season of semi-commercial use of the test methods developed by the research team, that the extent of the original problem was appreciated. Unfortunately this then coincided with the ending of the financial support for the project.

Who do you think would be the potential users of the output of the project?

- Irrigation farmers 3 / 2

- Agricultural advisory and/or regulatory officers 5 / 0
- Environmental advisory and/or regulatory officers 5 / 0
- Agricultural chemical companies 4 / 1
- Scientists and/or researchers 5 / 0
- Other *(please specify)* 1 / 0

Comments:

- Each of these groups likely to use some aspect of the project's findings to improve agricultural chemical practices
- Have not seen final research and I should have-Senior Programs Officer ERA engaged in many activities in irrigation industry. Am aware of rapid assay techniques.
- Community groups such as WaterWatch and community-based environmental groups
- Perhaps public health officers
- Community groups/community members who through the research on pesticide movement off farm have made people more aware about chemical movement and toxicity of chemical cocktails.
- With sufficient media action, most farmers would be made more aware of their involvement in water pollution. Most farmers are, I hope.

If you were connected to the project, do you think that there was sufficient involvement of others beyond the research team, such as those listed in the question above, to ensure awareness and information transfer to those who could use, or contribute to the practical adoption of the research results?

Yes / No

- there was adequate involvement of the full range of those with a direct interest 3 / 0
- some groups were well represented, but others were not 1 / 1
- there was inadequate linkage between the project and the potential users of the research output 0 / 2

Comments:

- Not correct.
- Not applicable.
- There appeared to be so, but my involvement was too superficial to know for sure.
- The potential of the project was not fully realised due to the fact that outcomes were not fully understood until 12 months after completion of the project.

3. Awareness of the Results

Yes / No

Are you aware of the results of the project? 2 / 3

If yes, how did you find out?

- don't know what the final results were 0 / 1
- a professional colleague told you 2 / 0
- through the technology transfer workshop 1 / 1
- through formal contact with the project 2 / 0
- participation in the Riverina Irrigated Agriculture Chemicals Taskforce (RIACT) 1 / 1

Comments:

- I am not fully aware of the project outcomes as I left the area and have not actively pursued the outcomes. Through workshops/meetings during the time of the project I am aware of a large proportion of the outcomes.
- Not aware apart from the workshop
- Various meetings. Some results presented at ASE meeting in '94, personal contact.
- Several reports and papers have been prepared documenting findings of the study. These reports are extremely useful in the immediate study area, but the 'implications' or linkage to other irrigation areas are not immediately apparent. It would be helpful that a generic paper discussing findings of the study re pesticide cocktail toxicity be produced.

In becoming aware of the results, do you feel that you were able to

- comprehend them because they were presented in an easily understood manner 3 / 0
- they were understandable because of your professional training in this technical area 3 / 0
- they were not easily understood 0 / 1

Comments:

- Not applicable
- However, like all results there are still questions that need answers

4. Adoption of Research Results

Yes / No

Are you likely to utilise that results of the project in your professional work? 4 / 0

If yes, do you consider that you have had adequate access to the results to directly use them? 2 / 2

If yes, how did this come about?

Comments:

- Probably if have seen.
- I know both Kath Bowmer and W Korth.
- Direct contact with project team. We became involved in field trials during which we identified the potential of the technology and hence sought to further utilise the work.

If not, why not?

- Although aware of the principal outcomes of the work, I would appreciate written project reports to reference suggested agricultural chemical management and to ensure that I fully understood the outcomes.
- Results not sent to attendees from information seminar after final market testing

Do you consider the results of this project are ready to be put into practice?
If yes, how?

- Yes, marketing of ELISA test kits could improve their use across the State, management recommendations could be adopted by irrigator groups and used by regulatory bodies to place appropriate conditions on drainage.
- Yes, marketing strategy to present results and product to environmental groups, government authorities, local community-based groups.
- Time is ripe to gain chemical user involvement. Need grower involvement, education, community involvement, field level monitoring. Needs movement into 'paddock', prepare management
- Yes and are doing so now! The irrigation areas of southern NSW have made a substantial investment in technology that has been developed by the project. Two laboratories have purchased equipment that can be used for rapid assessment of pesticides in drainage water. In the 1994–95 season, these organisati ons purchased ELISA kits from the USA (direct from the manufacturers) to use with this technology. Appreciation of this technology has come about only through this direct practical involvement. The arrangements to purchase the ELISA equipment were made by the irrigation organisations with no commercial companies in Australia taking up the 'commercial opportunity' that the technology presented.

If not, what else needs to be done for the findings to be put into practice?

- They need to be more directly accessible to those groups across the State/nation
- Copies widely circulated. CSIRO needs to liaise with all relevant regions of EPA on this issue (researchers). Mainly concentrate close to home.
- After the first commercial use of this technology in the 1994–95 irrigation season, we have become aware of some problems with the analytical method developed by the project which was not fully explored during the original development phase. (With the benefit of this season's experience the project could have been considered too short.) We have had to investigate methods of sample collection, sample storage and preservation etc, all of which have not been considered as part of the original project, but have become apparent after initial involvement with the program.

	Yes / No
Are you aware of other people, farmers or professional colleagues who are using the results of this project in their work?	1 / 3

If so, how is it being used?
Comments

- Unfortunately I moved to South Australia
- Persons from northern irrigation areas are interested in the results of the project re rapid analytical methods for pesticides.

5. Evaluation Assessment

	Yes/No
Do you think that the restated objectives in logical framework format accurately reflect the perceptions of the project during its course?	4 / 1

If no, what do you suggest will make them more accurately reflect the situation at the time?
Comments:

- Yes and No. In the original design of the project, the implications of the second objective-impact of pesticide and investigation into the extent of contamination-were not duly recognised. In the reworded goal statement, this implication is still not fully expressed. Monitoring of pesticides for the 'public good' has the implied responsibility of providing information in a responsible manner, this reworded goal still does not recognise this.

Do you think that the statement of outputs in the Appendix accurately reflects your perceptions of the results of the project	3 / 1

If no, what do you suggest would be a more accurate statement of the outputs?
Comments:

- The results statement sells the project short. It has focused the irrigation industry (whether it likes it or not) on the impact of pesticides in drainage water. By using toxicology work, it has provided information on the 'cocktail' effect of pesticides, which when considered in perspective of 'the big picture' has been sorely neglected.
  - specific information relating to irrigation of crops has yet to be published and this will provide further benefits to industry;
  - the development of the Riverina Agricultural Chemical Taskforce and Pesticide Monitoring Programs in the southern irrigation areas of NSW has been in part facilitated by this research work;
  - the failure of irrigation areas in other parts of NSW and from the rest of Australia to appreciate the inspiration from the findings of this work is a bit of concern; and
  - the project has identified the lack of suitable monitoring methods for pesticide in irrigation drainage and responded to this, but it has not also passed on the finding of the lack of suitable scientific support for persons involved in the industry.

Evaluation No 3. Ref. No: UME8

Mitigation of Sediment and Nutrient Movement from Sources in the Latrobe River Catchment to the Gippsland Lakes

Contents

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1 Background

1.1 Rationale

The Gippsland Lakes system is at the end of the Latrobe River catchment. An integral part of the lakes system are wetlands of international, national and State significance, some of which are subject to JAMBA, CAMBA and Ramsar Convention obligations. The preservation and improved management of these assets is reliant on good water quality. However, they are under threat from an estimated 142,000 tonnes of sediment and its accompanying nutrient load, which are exported to the lakes system by the Latrobe River and its tributaries.

The project tackled a problem which can be solved only by the integration of the efforts of land, water and vegetation management agencies. It aimed to increase the understanding of the processes of sedimentation and nutrient availability and movement in multiple-use catchments. The project was designed to provide technical information for the integrated management of the Latrobe River catchment, to use this information to determine key management actions and to discuss monitoring of the system to test the performance of management actions. The study proposal was timely in that it came only two months after the formation of the catchment-based Latrobe River Water Authority (LRWA) which offered the opportunity to pursue integrated catchment management ideals.

1.2 Project Arrangements

Implementing agency:
Centre for Environmental Applied Hydrology, Department of Civil and Agricultural Engineering (now Department of Civil and Environmental Engineering), Melbourne University

Principal investigator:
Dr Rodger Grayson

Submission date:
9 August 1991

Start/finish dates:
1 January 1992 to 30 June 1994

Third parties:
Latrobe Region Water Authority
Centre for Water Studies

Other bodies:
Environmental Protection Authority, Rural Water Commission, Department of Conservation and Environment, and Latrobe Regional Commission

1.3 Objectives and Scope

Scope of the project

The Latrobe River flows south-west from the Baw Baw plateau to the Gippsland Lakes, collecting water en route from a series of significant tributaries. The catchment of the river and its tributaries has an area of some 5,000 km^2 (8,600 km^2 including the Thompson River catchment). Rainfall in the catchment varies from a low of 600 mm/year in the east to 1,800 mm/year in the higher north-western areas. The valley displaysa range of basal rocks and soil types, including a flat floored alluvial plain in the lower reaches.

The valley includes a wide range of land uses, many of which involve the use of fertiliser and chemicals or which generate a range of pollutants. Agriculture comprises high productivity irrigated and rainfed dairying, beef raising and horticulture, with extensive grazing in the lower rainfall regions. There is large-scale industry in the form of open-cut coal mining, electricity generation and paper manufacturing. There are six major towns with a combined population of 130,000 together with significant residential concentrations scattered throughout the catchment.

It is claimed that the Latrobe River contributes 87% of the suspended solids and 75% of the phosphorus and the majority of the nitrogen input to the Gippsland Lakes. The disproportionate contribution from the Latrobe River, as well as general community concern over river water quality, has focused attention on catchment management and control of industrial and urban discharges. The public perception is that the water quality in the Latrobe River is very poor.

Objectives

Project objectives were as follows.

1. Determine the contributions of sediments and nutrients from all significant sources

2. Investigate the movement of sediments and nutrients from source to lake

3. Develop action plans to mitigate adverse effects of sediment and nutrient production and movement.

4. Develop an ongoing monitoring program to evaluate the effectiveness of action plans

5. Generalise results to other catchments.

1.4 Financing Arrangements

Total project cost was estimated at $232,473. Of this, $184,473 (79.3%) was to be provided by LWRRDC and $48,000 (20.7%) by third parties. The Latrobe Region Water Authority was to provide $17,000 for data handling and $14,000 for liaison and coordination on action plans, the Centre for Water Studies $15,000 for water quality analysis and access to GIS data, while the input of other associated bodies was estimated at $2,000 for the provision of data. Details are summarised in Table 1. The project submission proposed intellectual property/property income to be divided on the basis of LWRRDC 50%, the research organisation 25% and third parties 25%.

1.5 Completion

The project was completed on the target date of 30 June 1994. A substantial final report was published in September 1994 by the associated research organisation, the Centre for Environmental Applied Hydrology (CEAH) of Melbourne University.

1.6 *Ex-Post* Evaluation

This evaluation report focuses on pertinent aspects of the project and presents the findings of the *Ex-Post* Evaluation (EPE). The evaluation is based on documents provided by LWRRDC as listed, detailed discussions with the principal investigators, a survey by questionnaire of identified potential users of the project outputs and other acknowledged sources of information.

In preparing the evaluation, the reviewers have had access to the following documents:

1. December 1995—Project schedule

2. August 1991—Original application to LWRRDC

3. August 1991—Letter from Victorian EPA in support of project

4. June 1992—Milestone report #1.

5. October 1992—LWRRDC response to milestone report #1.

6. June 1993—Milestone report #2.

7. July 1993—LWRRDC response to milestone report #2

8. September 1993—LWRRDC project review

9. AEAM fact sheet (draft)

10. October 1994—Project final report

Table 1. Original budget for funding sources and expenditure

	1991–92	1992–93	1993–94	Total	Percent
Salaries	32,206	52,337	20,130	104,673	56.7
Operating	9,300	37,500	22,000	68,800	37.3
Capital				0	
Travel	3,500	5,000	2,500	11,000	6.0
Adoption				0	
Total	45,006	94,837	44,630	184,473	79.3
Research Organisation				0	0.0
Third Party (in kind)	19,500	17,000	11,500	48,000	20.7
Total funding	**64,506**	**111,837**	**56,130**	**232,473**	**100.0**

2 Implementation Performance

2.1 Design

The study approached the management issues for multiple-use catchments from first principles. It postulated three questions. For what purpose is the catchment being managed? Are the issues stated as being important, real or perceived? What are the key issues and how best can they be addressed? These questions were approached through a series of targeted field and simulation studies which were built around the notion that sources and transport processes must be viewed on the basis of different flow regimes, as these will need different management actions.

In addition to the technical issues, consideration was given to the wider constraints to improved catchment management. It was considered that social or political constraints were often more pressing than lack of scientific knowledge, which was rarely utilised to its utmost in management.

To facilitate an objective review of the project, the original objectives in Section 1.3 are restated in terms of the logical framework approach.

Goal:
To maintain and improve the quality of the environment through the development of integrated strategies for land, water and vegetation management in river catchments.

Purpose:
To determine the contribution of sediments and nutrients to the Gippsland Lakes system from all significant sources in the Latrobe River catchment.

Outputs:
The pattern of movements of sediments from source to lake identified and quantified.

Actions plans to mitigate adverse effects of sediment and nutrient production and movement developed in conjunction with the appropriate management authorities.

Ongoing monitoring program to evaluate effectiveness of action plans developed.

A generalised statement of principles of management of sediment and nutrient flow applicable to other catchments.

Inputs and activities:
Review of existing data on suspended sediment, algal and nutrient data, hydrographic data aerial photography, land capability mapping, hydrologic data etc. from EPA, DCE, SECV, LWRA, RWC, DARA and the Latrobe Regional Commission.

Establish benchmark conditions and develop hypotheses on sediment and nutrient sources and movement.

Collect specific additional data relevant to hypotheses.

Analyse physical processes to test hypotheses. Document sediment and nutrient sources and movement. Develop models of catchment and stream processes.

Utilising whole catchment integrated management principles, develop management options to mitigate effects of sediments and nutrients on the Gippsland Lakes, including possible community involvement programs, planning works and revegetation.

Develop action plans in consultation with resource managers

Develop monitoring program to evaluate effectiveness of action plan.

2.2 Outputs

Output 1.
The principle sources of phosphorus and total suspended solids were identified and quantified in relation to various levels of river flow.

Output 2.
Management actions to limit or mitigate particular forms of sediment or nutrient flows were specified for various subsectors of the catchment;

Output 3.
Changed perceptions from those at the outset of the project, of the problems associated with transported solids and nutrients in the Latrobe River and the methods of dealing with them, viz:

– the potential hazards arising from transported solids were not as great as had originally been thought;

– while sediment sources were catchment-wide, they were best perceived as distributed point sources, rather than non-point or general run-off sources;

– any approach to dealing with water quality problems in the catchment required the setting of management priorities, which in turn required clear management objectives; and

– the management priorities and objectives must be clearly articulated in order that technical information can be used effectively in environmental management and monitoring.

This was an interesting project in that a key output was a disproof of the original hypothesis, which was a widely held view on the sources of nutrient and sediment flows in the Latrobe River. Output 1 found that the in-stream sources of nutrients were not as significant as a range of point sources in the valley. This finding highlighted the concept of integrated valley management developed in Output 2 and led to the changed perceptions described in Output 3. The feedback from some professionals associated with the project was that these changed perceptions had been achieved because the principal researcher had been able to maintain a broad view of the objectives of the project and to keep an overall perspective of its context.

A number of those associated with the project expressed some frustration that, although the project changed perceptions and highlighted the need for integrated management, these concepts were not carried through of into practice from within the project. The cuts in project funding limited the momentum built up by the project and the significant reorganisation of regional administration of land and water resource management led to a loss of impetus and some institutional memory.

2.3 Organisation and Management

The principal researcher reports that LWRRDC was helpful and responsive to the work of the project. The project review was considered to be useful and the verbal feedback at the time of the review was particularly helpful. However, the project did suffer from the funding cutbacks at the outset. These led to the project running out of funds six months short of the completion date. It could be completed only because the CEAH, and in particular the principal researcher, undertook other consulting work to raise additional funds, which diverted effort from the principal activity.

There were to be two further outcomes from the project. Apart for the main project report, there was a paper published on adaptive environmental management which was a summarised version of the project report (LWRRDC Occasional Paper 1/95). A further report summarising the project outcomes as a whole was proposed. Letters were written to gain approval for this activity, but time passed and the idea lapsed. Carrying out the concept was complicated by the fact that the commercial manager for LWRRDC left and there was a delay in filling that post and LWRRDC were unable to provide support.

2.4 Contact with Potential Output Adopters

A review panel was to establish and carry out a program for implementation and regular review to ensure the objectives were achieved.

Ms Patricia Geraghty (Chair)
Department of Conservation and Natural Resources

Prof Brian Finlayson
Dept of Geography, Melbourne University

Prof T A McMahon
CEAH, Melbourne University

Dr Christopher Gippel
CEAH, Melbourne University

Prof Barry Hart
Monash University

Mr Russell Hawken
Gippsland Water

Mr John Tilleard
Ian Drummond & Associates

Mr Bruce Weston
Department of Agriculture

Mr Trevor Blake
Environmental Protection Authority

Mr Ken Ashton
Department of Conservation and Natural Resources

Others invited to some meetings were:
Mr Noel Morgan

Mr David Haynes

Mr John Turner

The project worked closely with a range of potential output adopters. In the project survey, a number of respondents commented favourably on the accessibility of the principal researcher to interested groups and the willingness to adapt to the circumstances in developing linkages which led to the transfer of information developed by the project. There was also comment on the generally high level and clarity of reporting of the project.

2.5 Dissemination of Results

The project was originally intended to result in a series of management actions for implementation by catchment managers. However, in mid–1992 it became apparent that the Victorian EPA was undertaking a review of their State Environmental Protection Policy (SEPP) for the region and that a Water Quality Management Strategy (WQMS) would be part of that review. The overlap between those activities and the project led to a sharing of project information and involvement of the project in the technical working group for WQMS.

This led to the direct transfer of information on both a formal and informal basis throughout the course of the project. This was achieved as follows:

With Gippsland Water (GW)

- seminars to present the latest project results to staff of GW;
- direct involvement of senior GW staff on the project management committee, which ensured regular updates of project progress through the reports presented at those meetings;
- inclusion of current results from the project in workshops organised by GW; and
- ongoing informal discussions with GW staff on monitoring programs, experimental work and technical issues.

With the community:

- discussions with key community members enabled an important injection of local knowledge about catchment problems and responses; and
- contact with the Waterwatch Community Monitoring Program (WCMP) enabled checks on whether the broader scale data corresponded with their detailed information and provided greater confidence in project conclusions based on limited data.

With environmental managers:

- liaison with the EPA's manager of the SEPP review and author of the WQMS ensured that key project findings were considered in the wider processes; and
- the application of project data and experience to the utilisation of the Adaptive Environmental Assessment and Management (AEAM) to assist in setting the water quality targets for the new SEPP and in the evaluation of catchment-wide impacts of major management actions, particularly in relation to the timing, volume and quality of point-source discharges. The project final report cited four benefits of the AEAM process, which were said to be:
- formation of cross-disciplinary links between researchers, managers and the community;
- definition of achievable management options and agreement on important indicators of the system;
- an appreciation of where, and in what form, technical information is useful to others. This has highlighted areas where information is lacking and where the form of the information is not appropriate for use by others; and
- development of an integrated model of water quality which enables the impact of management actions to be simulated. This has been developed by a group of people, all of whom have an interest in, and experience of, various aspects of the system.

The project became involved in the first application of AEAM in Victoria and one of the few in Australia which have not relied on imported expertise. The activity was a strong learning experience, but there was insufficient feedback for the bulk of the participants on the primary objectives of the application and the use of the final product. Because the application was part of a wider process, some participants had problems identifying the benefits to them, given that their main interest was in local issues.

2.6 Actual Cost and Financing

The initial budget was $232,473, made up of $184,47 from LWRRDC and $48,000 contributions in kind from associated technical bodies. The principal researcher reports that the funds-in-kind were delivered, at least in full, if not more so. Details are

given in Table 2, together with a comparison of budget and actual outlays in Table 3. The final agreed intellectual property/project income was LWRRDC/ Funding parties 50% and Research Organisation and Third party 50%.

Early in the life of the project LWRRDC contribution was cut by one third, to $120,504 due to funding difficulties at the time. These cuts applied to all then current LWRRDC projects. The cuts eventually created problems for UME8, in that the project ran out of funds six months before the scheduled completion date. The project could be finished because the CAEH raised additional funds through the principal researcher undertaking other consulting activities. The comparison of budget and actual shows a shortfall of $63,969 (34.7%) from LWRRDC contribution. Although there is no specific record of the contribution-in-kind, it is shown as received in full on the advice of the principal researcher.

Table 2. Summary of actual funding sources and annual outlays

	1991–92	1992–93	1993–94	1994–95	Total	Percent
Salaries	18,600	31,000	2,399	7,101	59,100	49.0
Operating	7,000	29,000	16,904		52,904	43.9
Capital					0	
Travel	2,700	3,800	2,000		8,500	7.1
Adoption					0	
Total	28,300	63,800	21,303	7,101	120,504	71.5
Research Organisation					0	0.0
Third Party (in kind)	19,500	17,000	11,500		48,000	28.5
Total funding	**47,800**	**80,800**	**32,803**	**7,101**	**168,504**	**100.0**

Source: Project Schedule

Table 3. Comparison of budget and actual outlay

		1991–92	1992–93	1993–94	1994–95	Total	Percent
LWRRDC	Budget	45,006	94,837	44,630	0	184,473	
	Actual	28,300	63,800	21,303	7,101	120,504	
	Difference	−16,706	−31,037	−23,327	7,101	−63,969	−34.7
Third Party	Budget	19,500	17,000	11,500	0	48,000	
	Actual	19,500	17,000	11,500	0	48,000	
	Difference	0	0	0	0	0	0.0
Total	Budget	64,506	111,837	56,130	0	232,473	
	Actual	47,800	80,800	32,803	7,101	168,504	
	Difference	−16,706	−31,037	−23,327	7,101	−63,969	−27.5

Source: Data in Tables 1 and 2

3 Adoption of Results

3.1 Survey

A survey was undertaken of 13 persons identified as having had direct or indirect contact with the project during its operation and likely to be interested in the adoption of the project output. These included the members of the project review panel and a range of professionals in the field of water and other resource management in the Gippsland region. Ten responses were received. Since 1992 the management of natural resources in the Gippsland region had gone through a major reorganisation. One consequence of this is that 7 of the 13 persons asked to complete the questionnaire had taken up their posts after the project had been completed or been associated with the project but had changed jobs in the interim, sometimes to different technical areas.

The detailed results of the survey, including respondents' comments, are given in Annex 1. The numbers used in the analysis represent specific responses to options offered, ie. Yes/No. In most questions the options were not mutually exclusive, and neither were the respondents required to mark every option. The numbers therefore represent the conscious choice of respondents, indicating their attitude on a specific matter. For most questions, respondents were offered space to record a comment to supplement or expand their response. All the respondents comments are included in the analysis of the questionnaire in Annex 1.

3.2 Findings

All the respondents were aware of the problems of sedimentation and nutrient flow in the Latrobe River. There were a few indications of awareness through media, public discussion or land ownership, but the common theme for all was their professional involvement in natural resource management issues in the Gippsland region. There was strong support (8/10) for the proposition that the issue of sedimentation and nutrient flow in the Latrobe River was important, needing specific action to define solutions, though only three respondents considered the matter urgent.

Eight of the ten respondents had been connected to the project and several had multiple linkages. At one time or another seven respondents were involved in the project review panel and a number participated in project seminars or working groups associated with developing SEPP and WQMS strategies based on project findings.

The project outputs of technical papers and workshops were recognised by virtually all respondents. It is significant that seven of the ten respondents considered that an identifiable output of the project had been changed attitudes among those associated with the management of the Latrobe River towards a greater recognition of the need for an integrated approach to the management of run-off problems in the river system. In identifying this output, it was considered that the major influence in changing attitudes had been the development of the water quality management strategy for the region which coincided with the later stages of the project. By quantifying the situation and disproving some commonly held beliefs on the source and quantity of run-off, the research project had been an essential element in changing attitudes and providing the base on which the strategy could be built.

The respondents identified a broad spectrum of potential users of the project outputs. All respondents included government or statutory authority advisory and/or regulatory officers and private professional advisers in agriculture, environmental science or engineering, and scientists, engineers and/or other researchers. A smaller number (three) thought that farmers or other landowners would also be able to utilise the project outputs and that community involvement was important to the strategy development process.

There was some divergence of opinion as to whether there was sufficient involvement of others beyond the research team to ensure awareness and information transfer to those who could use or contribute to the practical adoption of the research results. Opinions were divided (6/4) between those who considered there had been an adequate involvement of the full range of those with a direct interest and those who argued that some groups were well represented and others were not. The distinction rested in part on attitudes to community involvement. One respondent suggested that the potential contribution of the community was initially underestimated, while another suggested that there were limits to direct involvement of the community in research because of the necessity to maintain scientific rigour. There was also some difference of opinion as to whether the AEAM modelling was a

stimulant to participation, or limited community involvement. The principal researcher and the person responsible for the development of the management strategy saw the AEAM process as a positive experience.

The high level of interaction between the respondents and the project ensured that all but one knew the results. The one respondent who was unaware had moved into a water management position after the completion of the project. Most respondents (7) considered that the results were presented in an easily understood manner. A number commented on the good level of personal communications with the principal researcher and the well written published material.

Most respondents (7/10) considered that they would use the project results in their professional work. The others (3/10) generally expressed the view that the only reason they did not do so was that the focus of their work was in a different area. Most considered that at the time they were published the results were ready to put into practice. This was highlighted by the perceived high level of interaction with potential users through the workshops and the AEAM modelling process. This interaction was seen as contributing significantly to the ability of the project to reorientate its focus as its findings emerged. Once it was clear that the original thesis was not proven, the project was able to concentrate on identifying the actual sources of sediment and nutrient and highlight the consequences of these for river valley management.

* * * * * * *

4 Conclusions

4.1 Overall Assessment

This has been a successful project, particularly because it was able to adapt its focus once the initial hypothesis disproved. This adaptive process was greatly assisted by the high level of interaction between the research team and key professionals with a direct interest in the project outcome.

4.2 Lessons Learned

In part, the effectiveness of project outcomes relies on the ability to recognise the import of interim findings and, if necessary, to adapt the thrust of the project where the interim findings suggest an alternative line of attack. In the case of UME8, once the initial hypothesis was found to be not proven, the project adapted to identify the actual sources of sediment and nutrients and developed these findings into an overall management approach. It is not the ability or willingness to change course which is important. It is the ability to recognise when interim findings have shown how the original objectives can be met more effectively by a changed approach.

It is not easy to recognise the point at which a change or a fine-tuning of objectives or approaches would strengthen project outcomes. It rarely happens as a single event, more often it is an emerging consciousness that the trend of events is pointing in a different direction.

A number of features can contribute to this process. Interaction with potential users of the project outcomes can greatly strengthen the effectiveness of a research project in identifying whether it is heading in the right direction. In the case of UME8, the interaction with professional staff in key agencies helped it to recognise the flow-on consequences of disproving its initial hypothesis. It was able to shift its emphasis from sources and movement of sediment to the management of the sources identified and the development of overall management strategies.

Another aspect of external interaction is the role and effectiveness of project advisory or steering committees. In this case there was a project review panel to assist in implementation, and regular review to ensure that the objectives were achieved. Several members of the panel formed a close association with the project and provided strong intellectual support which undoubtedly assisted in recognising the need to adapt the approach. However, it is reported that much of this effectiveness was in the regular informal contacts with the principal researcher, rather than through any formal process.

This was possible because of some unique features of UME8 which would not necessarily be repeatable in other projects. The project was particularly timely. There was considerable interest in the problem under investigation, so there were key professionals directly interested in the project outcome. There were close geographic links between the project based at Melbourne University and the Latrobe Valley. The principal towns in the valley are easily accessible from Melbourne, which assisted face-to-face interaction between the project and potential professional users of the project outcome. The principal researcher is a good communicator. A number of survey respondents commented on his accessibility and his willingness to contribute to workshops and other collaborative activities. The published material is also of a high quality and readability which can again be attributed to the principal researcher.

The issue highlighted by this project is where to make the cut-off point and whether is worth 'going the extra mile' to see the project outcomes properly taken up. This project is considered to have changed perceptions on the problems associated with transported solids and nutrients in the Latrobe River. It led to the view that any approach to dealing with water quality problems in the catchment required the setting of management objectives. In turn, this required clear articulation of management objectives and priorities to ensure the effective use of technical information in environmental management and monitoring.

In the event, these last elements were not as fully developed as the project team would have wished. There were major structural changes in environmental management in the Gippsland region under way during the later stages of the project. The intention was to publish a paper on adaptive environmental management based on the project final report, which would have been particularly timely. However, funding was not available and the idea eventually lapsed. With the benefit of hindsight, this was an opportunity lost to develop a set of general principles with wider application based on the work of this project.

4.3 Follow-up Actions

There is little left to be done by way of follow-up actions from the project. There are opportunities for other work, especially on the management implications of the point source concept of sediment and nutrients in rivers. However, while these might be based on the concepts developed in the project under review, they would have to be seen as new projects rather than as immediate follow-on activities from UME8.

Annex 1. Project Questionnaire and Responses

Questionnaires sent: 13 Responses received: 10

1. Awareness of the Problem

What has caused your awareness of, or involvement in, the problems of sedimentation and nutrient flow in the Latrobe River valley? *Yes / No*

- Through media and public discussion 2 / 1
- Technical or scientific journals 2 / 1
- As a farmer or landowner in the region 1 / 1
- Through your professional work 10 / 0
- Other *(please specify)* 1 / 0

Comments:

- I was one of the authors of the original application to LWRRDC and was involved in the project throughout.
- Work involves natural resource management and particularly land use impacts on the Gippsland Lakes.
- Became aware of it during the preliminary work on the development of a Water Quality Management Strategy for Central Gippsland.
- From 1967–83 I managed APM's (AMCOR) Maryvale water and waste-water systems much of which discharge into the Latrobe River ie. I have a long-term technical background associated with the Latrobe River
- As Dr Grayson's supervisor, I was involved at an early stage in discussing the project proposal
- As Project Manager for Victorian EPAs review of State Environmental Protection Policy for Latrobe and Thompson River catchments 1991–95
- Professional work associated with Regional Water Authority responsible for monitoring stream flow and quality and responsible for waterway management

If you were aware of the problem did you see it as being:

- Not a serious issue 0 / 1
- An important issue which would resolveitself over time 0 / 2
- An important issue needing specific action to define solutions 8 / 0
- An urgent matter needing critical action 3 / 0

Comments:

- Need to be able to quantify the issue in order to determine priorities.
- Water Quality Management Strategy developed in conjunction with SEPP review
- Awareness that certain parameters were improving and others worsening requires strategic long-term approach

2. Connection to the Project

Yes / No

Were you connected to the project in any way? 8 / 0

If yes, how were you connected?

- Through local land-based/farming activities or public discussion groups 1 / 1
- As a professional adviser or regulatory officer with government or statutory body 2 / 2
- A watching brief on behalf of your employer 1 / 1
- As a member of the project review panel 7 / 1
- As an attendee at one or more project seminars 4 / 1
- Other *(please specify)* 3 / 0

Comments:

- Involved in the project from the original conceptions.
- Only a late addition to the project review panel.
- In the input of results into the development of a simulation model for the Water Quality Management Strategy.
- As convener of the working group developing a water quality management strategy I was invited to some review panel meetings
- I attended some project review panel meetings as a university representative
- Considerable interaction and cooperation with Rodger Grayson to develop synergy with SEPP/WQMS projects
- A member of the original group to define the project

What do you see as the output of the project? *Yes / No*

- Some technical papers describing and quantifying sediment flows in the Latrobe River 9 / 0
- Seminars and technical meetings which informed local technical officers, farmers and others associated with the area about the results of the project 8 / 0
- A changed attitude among those associated with the management of the Latrobe River towards a greater recognition of the need for an integrated approach to the management of run-off problems in the river system 7 / 1
- Other *(please specify)* 0 / 0
- None of the above 0 / 0

Comments:

- The aim of much of the work carried out in the Latrobe catchment to reduce sediment loads was to prevent Lake Wellington being infilled with sediment. One of the major outcomes of this project was to show that despite widespread erosion, there has been no increase in delivery to Lake Wellington in the post-settlement period.

- Gave some clues as to the scale of the problem and again the priority areas to tackle.
- This project gave direct input to the development of a Water Quality Management Strategy. The strategy was the vehicle for changing attitudes, but the strategy required the research results.
- The development of a water quality management strategy (involving 80 community people over 15 months) separate to this LWRRDC project was the major influence. This included community monitoring. The LWRRDC project aided and complemented this process.
- Bringing together of interested professional parties and awareness of all
- Attitude change and community mobilisation were key features of the SEPP/WQMS
- Unfortunately the main resource manager at the time (Gippsland Water) has now lost the authority to put in place the actions defined
- Hard to determine if changed attitude achieved. Major structural changes in water industry means organisational responsibilities have changed along with personnel.

Who do you think would be the potential users of the output of the project?	*Yes / No*
– Farmers or other landowners	3 / 1
– Government or statutory authority advisory and/or regulatory officers	10 / 0
– Private professional advisers in agriculture, environmental science or engineering	10 / 0
– Scientists, engineers and/or other researchers	9 / 0
– other *(please specify)*	1 / 0

Comments:

- Farmers are ultimately impacted but the messages will have to be sold to them before they respond to the findings.
- Users would include Catchment and Land Protection Boards, Waterway Management Authorities, river man agement consultants, EPA.
- As above, the use of the project information is connected with separate community action
- Some scientists, engineers, etc.
- Potential users of AEAM methodology
- Study provided some information on water quality and nutrient/sediment loads which has complemented other investigations to support WQ planning
- A broad range of individuals and organisations, but the 'momentum' would have to be rebuilt

If you were connected to the project, do you think that there was sufficient involvement of others beyond the research team, such as those listed in the question above, to ensure awareness and information transfer to those who could use, or contribute to the practical adoption of the research results?

	Yes / No
– there was adequate involvement of the full range of those with a direct interest	6 / 2
– some groups were well represented, but others were not	4 / 0
– there was inadequate linkage between the project and the potential users of the research output	2 / 0

Comments:

- While agencies were well represented at the time, the restructuring and staff changes which have occurred since the time of the project mean that most of the transferred knowledge has been lost.
- The findings of the work have not been extended and I am not aware of any action plans that relate directly back to the project.
- Adequate involvement of most, rather than full range of those with a direct interest.
- This is a complex issue. There is a limit to direct involvement of community if research because of necessary scientific rigour. However, the potential contribution of community was initially under-estimated.
- The comment that there was inadequate linkage between the project and the potential users of the research output was emphasised
- The use of AEAM methodology ensured all relevant persons participated
- A key output of the project instigated at my suggestion and in cooperation with EPA and many others, was the development of an AEAM computer simulation model of WQ in the Latrobe catchment
- There was good linkage with other processes, such as the regional water quality management strategy, which ran in parallel-this strategy provided indirect involvement with others

3. Awareness of the Results

	Yes / No
Are you aware of the results of the project?	9 / 1
If yes, how did you find out?	
– Don't know what the final results were	1 / 0
– From a professional colleague	0 / 1
– Through one of the project seminars	1 / 0
– Through formal contact with the project	6 / 0
– Participation in the project review panel	5 / 0

Comments:

- New strategies for the catchment are being developed, but the awareness of the results may not be picked up unless strongly pushed by an agency involved in the project.
- Invited to some review panel meetings. Have a full copy of the report.
- I was a member of the project review panel and actively cooperated with Dr Grayson
- To my knowledge the final report was not prepared for distribution

In becoming aware of the results, do you feel that you were able to:

- comprehend them because they were presented in an easily understood manner 7 / 0
- they were understandable because of your professional training in this technical area 4 / 0
- they were not easily understood 0 / 0

Comment:

- Given my involvement, it is not really possible to answer this.
- Overall felt that the presentation was good.
- More through personal communication with researcher.
- I am a qualified industrial chemist with experience in water chemistry and management
- The seminars were excellent for communicating results
- Although the written documentation was not written for a large audience, at least the main report is quite readable.
- Would have been better technical transfer if the West Gippsland Catchment and Land Protection Board had been in place during this project
- Presentation within the review panel and at other forums was clear and concise

Do you have any other comments on the presentation of the results of this project?

- We are still submitting papers to journals from the data collected in this project.
- May have benefited from the distribution of a newsletter through the life of the project.
- Good presentation during project at various associated conferences. However, the final report could have been better promoted, particularly as it finished up in partnership with very detailed community monitoring
- Dr Grayson made himself highly available in participating in lay seminars and government technical committees to convey the results of his project and to pursue cooperative initiatives.
- As above, I am not aware of final documentation which could be used in future as a reference point for recommencing strategy implementation

4. Adoption of Research Results

	Yes / No
Are you likely to utilise that results of the project in your professional work?	7 / 3
If yes, do you consider that you have had adequate access to the results to directly use them?	6 / 1

If yes, how did this come about?

- As a member of the project team, professional work in my case means research and teaching.
- Published reports
- Results are not relevant to my work. My work involves making sure the local management groups have access.
- Have full copy of report and authors are available and willing to discuss results
- In the sense that I see AEAM methodology (which was applied here) as a useful approach in many other problems
- Dr Grayson provided results progressively to me to assist the preparation of the Latrobe/Thompson SEPP and the Central Gippsland WQMS.
- By being directly involved in the project and keeping in contact with Dr Grayson
- Refer above. My career direction has changed, but may have the opportunity in future to use the results.

If not, why not?

- Not aware of the findings/benefits that must have been concluded
- My current role has changed from catchment management

Do you consider the results of this project are ready to be put into practice?

If yes, how?

- In terms of changed goals for catchment management and redeployment of resources. This project was also instrumental in introducing the AEAM process into catchment management in Australia and this has since been widely adopted (including by LWRRDC).
- Yes, by being able to concentrate on new information and seeking to re-order resources to priority areas.
- The results of this project have influenced our WQMS which was currently being implemented. (eg. major new sewage treatment plant at Moe is nearing completion). Also action starting on reducing irrigation area (Macalister area) run-off to the Latrobe River.
- Catchment managers need to adopt the findings in their daily business practice
- Yes! Many of the results were examined during the workshop sessions
- The development of AEAM models for the Latrobe catchment has catalysed the development of similar models for a range of other catchments
- Minor application

If not, what else needs to be done for the findings to be put into practice?

- Needs an overall policy/strategy context put into place which is currently under way.
- Results are not being properly utilised mainly because of a complete change in institutional arrangements and management personnel. This has nothing to do with the researcher. Most relevant management groups were involved at the time, but three years later they are not the same people.
- More information. Advise us of the findings (again?) and those that will contribute the most gains
- Would be useful to brief the CLP Board
- When restructured organisations with the responsibility for these matters are adequately financed and resourced, the strategies need to be re-promoted for implementation

Are you aware of other people, engineers or professional colleagues who are using the results of this project in their work? 2 / 6

If so, how is it being used?

- In terms of AEAM it is being used by Sinclair Knight Mertz (Dr Rowan Barling) and my LWRRDC transfer project (Dr Rob Argent, CEAH, Melbourne Univerity).
- Water authorities, river management authority, major industry.
- I am not in close contact with those managing Latrobe River issues, so I am unaware of specific outcomes

5. Evaluation Assessment

Yes / No

Do you think that the restated objectives in logical framework format (see Appendix at the end of the questionnaire) accurately reflect the perceptions of the project during its course 8 / 1

Comments:

- The goal I believe was not a key determinant. Ongoing monitoring was not addressed and there was no generalised statement re other catchments–amend accordingly.
- The objectives should have included greater community participation as a huge bank of knowledge was available. Ultimately a separate community program provided vital information both directly to local authorities and to the project
- Yes, except that the action plan and monitoring objectives were left to the development and implementation of the Central Gippsland WQMS by EPA, West Gippsland Catchment and Land Protection Board and other parties.
- Yes, although I was not aware of Objective 4

If no, what do you suggest will make them more accurately reflect the situation at the time?

Do you think that the statement of outputs in the Appendix accurately reflect your perceptions of the results of the project 7 / 1

If no, what do you suggest would be a more accurate statement of the outputs?

- They reflect my views, but some members of the community still retain old views.
- Only the first output was achieved at a coarse scale, complementing community-based water quality monitoring–primarily Output 1.
- It is some time since this project finished and I am a little hazy on the details

Did your perceptions of the problem and the possible solutions change in the course of the project 5 / 1

If so, what were the key changes?

- (i) The extent to which the river channel is delivering sediment to Lake Wellington. (ii) The notion of distributed point sources. (iii) The need for management objectives to be clearly articulated and based on a sound understanding of the behaviour of the system. A slightly related issue which became clear in the course of this project–no group or agency should collect data (in the sense, say, of monitoring water quality) unless they have a clear purpose for doing so and that ongoing analysis of the data directed towards that purpose forms an integral part of the process.
- Meant that we did not need to focus on in-stream sources but needed to concentrate our efforts more on other point sources. The problem was not where we thought it was.
- Agree on output 1 and 2, provided community input is better recognised. These comments (Output 3) have the cart before the horse. Surely clearly articulated management priorities are a product of good information, resulting from both community and project results.
    - catchment erosion sources of sediment are greater than stream bed/bank erosion;
    - Macalister irrigation run-off as a dominant phosphorus input for much of the year;
    - sewage treatment plant 'P' inputs confirmed as problems, however, probably lower than irrigation run-off;
    - phosphorus run-off from high rainfall dairy pastures is very significant (a community discovery backed-up by agric research); and
    - ratio of P to sediment is not constant across the catchment.
    - Difficult to answer, not fully aware of the findings and had minimal input through the process.
    - Complexity/diversity of issues involved in management of large catchments and the process needed to implement change.
    - My interaction with this project focused on developing a cooperative and complementary approach vis-à-vis the SEPP/CGWQMS project ie. to encourage Dr Grayson to reform his project–which he largely did. However, there remained a basic tension between producing 'publishable scientific studies' and producing 'management-relevant information'. The SEPP/CGWQMS project did in fact produce management objectives for water quality and
      sediment and nutrient loads, partly assessed by the outputs of Dr Graysons's project.
    - Clearly identified source area. Clearly identified contribution from systemic catchment area.
    - The magnitude of problems, particularly sediment transport not as great as originally thought, plus the sources of sediment greater than originally perceived. The need for 'all' to contribute to improvements (however small) became more evident than originally perceived.

Evaluation No 4. Ref. No: JCU1

Limnology and Classification of Tropical Floodplain Wetlands, with Particular Reference to the Effects of Irrigation Drainage

Contents

List of tables

1 Background

1.1 Rationale

The values of wetlands are becoming widely recognised world-wide. In Australia there is a growing body of information on wetlands in most States and Territories with important work being done in Western Australia, the Northern Territory and in the Murray–Darling Basin. It is considered that there is an urgent need for basic research into the management of water bodies in Australia, especially as it may be inappropriate the results of research done overseas to transfer to Australia. It may also be inappropriate to apply results from the temperate zone to the tropics. Tropical wetlands have received much less attention despite the often much greater climatic problems such as highly seasonal rainfall, a high degree of inter-year rainfall variability, high temperature and evaporation, especially where coupled with shallow storages.

The project addressed problems of water management in a tropical wetland system which is experiencing substantial changes through the development of a major irrigation scheme. The Barrattas wetlands are part of a wetland system which is highly significant for waterfowl and for its nursery role for commercial and recreational fisheries, especially barramundi and penaeid prawns in the Bowling Green Bay area. The lower reaches of the region are an important part of the Cape Bowling Green National Park, which was extended to include the wetlands of the Bowling Green Bay area because of the importance and poor conservation status of tropical wetland environments in Queensland.

These wetlands are part of a natural drainage system that is due to be progressively affected by irrigation inputs as the Burdekin irrigation area is gradually developed. Currently the catchment of Barratta Creek is lightly wooded and devoted to pastoralism. In due course much of this area will be irrigated for agriculture, especially for the production of sugarcane. The development is possible because of the recent completion of the Burdekin Falls Dam and is being monitored by the Queensland Water Resources Commission (QWRC).

There has been concern expressed about the possible effects of irrigation drainage on water quality and on the downstream ecosystems. The QWRC has been supporting a water quality monitoring program as a baseline study before large-scale developments commence. This program has also received some funding from the Australian Water Research Advisory Council (AWRAC) in 1989. The project continued this earlier work.

1.2 Project Arrangements

Implementing agency:
Australian Centre for Tropical Freshwater Research, James Cook University, Townsville, Qld 4811

Principal investigator:
Dr Robert Congdon

Submission date:
April 1990 to the Australian Water Research Advisory Council (AWRAC)

Start/finish dates:
March 1991 to March 1994

Third party:
Queensland Water Resources Commission (now Queensland Department of Primary Industries–Water Resources, QDPI–WR)

1.3 Objectives and Scope

Scope of the project

Few studies have been made of floodplain lakes in Queensland. The project aimed to substantially increase knowledge, especially as it was undertaken at two levels to generate testable predictions. The significance would be wider than a basically descriptive inventory, as the project sought to assess the impacts of agricultural activity in the catchments of some of the wetlands with the aim of providing management recommendations.

The Burdekin River delta and floodplain are the largest in the tropical north-east of Australia. The river has a mean annual discharge of 9 million ML and the greatest instantaneous peak discharge of any river in Australia. The floodplain has an area of 900 $km^{2.}$ It is drained in the centre by Barrattas Creek which, together with numerous lagoons, billabongs and swamps, is part of an intricate mosaic of rich and

diverse wetlands. The fertile alluvial lands of the delta and floodplain have supported the development of one of Australia's most intensive agricultural areas, including one of Australia's main sugar-growing regions.

The establishment of the Burdekin Irrigation Scheme on the floodplain is likely to have a major effect on the hydrological regime of the region. The annual increase in tailwater volume in the Barrattas wetlands is estimated to be 25,000 ML/year, together with a 400% increase in nitrogen concentrations and 100% in organochlorine pesticides. This study aimed to document changes over the first few years of operation of the irrigation scheme. The establishment of new farms had created concern to collect data to distinguish between long-term changes and those caused by seasonal and climate-induced year-to-year variations.

Objectives

1. Describe and characterise the wetlands of the lower Burdekin area in terms of major physical, chemical and biological variables.

2. Assess short- and long-term variation in these variables both in relation to natural events and inputs from irrigated agricultural areas.

3. Assess the impact of irrigation drainage through comparisons among affected and unaffected sites.

4. Provide recommendations for management of the wetlands of the Barrattas area, especially in relation to optimal disposal of drainage water.

1.4 Financing Arrangements

Total budget was estimated to be $166,115. Funding was proposed to be in equal shares between the AWRAC and the QWRC. Details are summarised in Table 1. There was no proposed allocation of project income/intellectual property rights.

1.5 Completion

The project was originally planned to commence in January 1991 and be completed 2.5 years later in June 1993. It actually commenced in March 1991 and was completed three years later in March 1994. The final report was published in December (?) 1994.

1.6 *Ex-Post* Evaluation

This evaluation report focuses on pertinent aspects of the project and presents the findings of the *Ex-Post* Evaluation (EPE). The EPE presents an assessment of the effectiveness of the project in achieving its objectives, the extent to which the outputs generated by the project have been adopted and their sustainability. The EPE is based on documents provided by LWRRDC as listed, detailed discussions with the principal investigators and identified potential users of the project outputs, and on other acknowledged sources of information.

Table 1. Original budget for funding sources and expenditure

Budget Item/Funds Source	1990–91	1991–92	1992–93	Total	Percent
Salaries	13,655	27,723	28,705	70,083	84.4
Operating	1,500	2,000	1,000	4,500	5.4
Capital	700			700	0.8
Travel	1,719	3,314	2,742	7,775	9.4
Adoption				0	
Total	17,574	33,037	32,447	83,058	50.0
Research Org: James Cook University				0	0.0
Third Party: Qld Water Res Comm'n	17,573	33,037	32,447	83,057	50.0
Total funding	**35,147**	**66,074**	**64,894**	**166,115**	**100.0**

Source: Project Application

In preparing the evaluation, the reviewers have had access to the following documents:

1. December 1995—Project schedule

2. April 1990—Original application to the AWRAC

3. January 1992—Milestone report #1.

4. July 1992—LWRRDC first review report

5. March 1993—Milestone report #2.

6. January 1995—Final report

7. August 1995—LWRRDC response to the final report

* * * * * * *

2 Implementation Performance

2.1 Design

The circumstance of a stable wetlands being progressively affected by irrigation over a period of years was seen to offer unparalleled opportunities for basic and strategic research that would not only substantially contribute to proper management, monitoring and prediction in this irrigation scheme, but would also provide vital guidelines for impact assessment and monitoring of wetlands elsewhere in the seasonal tropics.

The research program incorporated two main approaches. There was a broad-scale study of the region's wetlands to set up a classification system to allow predictions about the natural and impacted water bodies to be made and tested. A numerical classification of the wetlands on the basis of readily identifiable biotic components was proposed. The outcome was expected to be testable in water bodies not previously examined and having different levels of disturbance. To calibrate the broad-scale classification, detailed studies on a number of physical and chemical variables were undertaken at selected sites to provide a unique medium-term (several years) data-set against which to assess gradual and long-term changes.

To facilitate an objective review of the project, the original objectives in Section 1.3 are restated in terms of the logical framework approach.

Goals:
To maintain and improve the quality of the environment through the development of strategies for managing the consequences of the downstream impacts of irrigation on natural wetlands.

Purpose:
To generate testable predictions of the impacts of agricultural activity in the catchments of some of the wetlands with the aim of providing management recommendations.

Outputs:

The wetlands of the Lower Burdekin described and characterised in terms of major physical, chemical and biological variables.

Assessment of the of the short and long-term variation in the major physical, chemical and biological variables both in relation to natural events and inputs from irrigated agricultural areas.

Assessment of the impact of irrigation drainage through comparisons among affected and unaffected sites.

Recommendations for management of the wetlands of the Barrattas area, especially in relation to the optimal disposal of irrigation drainage water.

Inputs and activities:
Establish a large number of wetlands sites in Barrattas Creek for the broad-scale survey, selected on features such as size and depth.

Sample sites on a seasonal basis to characterise each in terms of physiognomic, physicochemical and biotic variables.

Analyse data utilising several methods including multivariate statistical analysis, to show complex interrelationships.

Develop and test predictive and path models to represent the likely changes in the wetlands ecosystem.

2.2 Outputs

The project under review was part of an ongoing stream of activity which started with an ecological study of the proposed Burdekin irrigation area by CSIRO in the late 1970s. This early study was reviewed in 1987 and the omission of an analysis of wetland impacts and baseline studies of flora and fauna were identified as major shortfalls of the original work.

The outputs of the project can be seen in two forms. The most immediate output is a series of reports which, together with the output of other studies, give a comprehensive understanding of the terrestrial and aquatic flora and fauna and a review of the surrounding environment.

The second output can be seen as a change in the perception of the environmental issues relating to the development and management of the Burdekin River Irrigation Area (BRIA). While the first output was technical studies, the second output can be described as a much sharper approach to management of the environmental consequences of the irrigation development. By describing and quantifying the situation in the first output, the concepts underlying the project have formed a vital component in developing the environmental management plan for the BRIA.

The project was able to demonstrate that the environmental consequences could be mitigated by a better understanding of the environmental processes. As a consequence, QWRI has continued the research program under its own funding, further developing the concepts first initiated by the project.

2.3 Organisation and Management

The project had no specific comments to make on project management. The interaction with LWRRDC was seen as positive, particularly the mid-term review.

2.4 Contact with Potential Output Adopters

The original project proposal said that regular reports to QWRC and AWRAC would be made and that there would be close liaison with the QWRC. Papers based on the results of the research were to be submitted to appropriate scientific journals and other publications for dissemination to water managers and users. The detailed results were to be written-up as a technical report of the Australian Centre for Tropical Freshwater Research (ACTFR) to place the data on record for interested parties.

In a practical sense, however, the most important local link for this project was with the Burdekin River Irrigation Area Technical Advisory Committee (BRIATAC). Throughout its three-year life, the project worked closely with this committee which is a statutory body responsible for the oversight of the scientific issues arising from the BRIA development. Its membership included all the major scientific organisations with an interest in irrigation and regional development issues: CSIRO, James Cook University (JCU), etc. This broad structure not only provided an important input to the work of the committee, but also gave it access to the resources of a number of scientific bodies with specific or general interests in development activities in the Burdekin region.

It is reported that, for a large part of its active period (1992–94), the work of the project dominated discussion at BRIATAC. The broad scientific base of the committee enabled it to recognise the relevance of results as they were reported by the project and to identify where ongoing work or more detail would be needed. This interaction with other scientific and administrative organisations was a major strength of the project and led to the rapid absorption of its findings into the routine environmental assessment and planning process. It also acted as a trigger for ongoing research to extend the original findings.

2.5 Dissemination of Results

In the first instance, project reports were directed to BRIATAC and LWRRDC. Subsequently, as more formal results were achieved from the project, papers were presented at both national and regional environmental conferences in 1994 and 1995.

An important element of disseminating results was the interaction with potential adopters throughout the life of the project. Within six months of the start of the project, a seminal meeting was held with Water Resources and National Parks. Participants included representatives of JCU, ACTFR, Queensland Department of Environment and Heritage (QDEH) and QDPI–WR. The discussion centred on cooperation between QDEH, ACTFR and QDPI–WR.

Topics included the prioritisation of ecological areas and the design of a multiple-use land-use framework for the irrigation area, including an east–west corridor across the area.

This level of interaction continued with regular consultation with the Burdekin Landcare Group (BLG). Membership of this group included representatives of the local council, the Endeavour Foundation, the local ecological society, the Burdekin River Trust, the Bureau of Sugar Experiment Stations (BSES) and the Burdekin Agricultural College. Other formal and informal meetings were held in both the second and third years of the project with the local sugar industry and with officers of the QDPI–WR responsible for the planning and implementation of the BRIA.

2.6 Actual Cost and Financing

Actual LWRRDC funding was $130,968 which was 79% of the original budget of $166,115. Details of actual funding are given in Table 2.

Intellectual property/project income was agreed to be LWRRDC 50% and the research organisation and third party (QWRC) combined 50%.

Budget variations are analysed in Table 3.

Table 2. Summary of actual funding sources and annual outlays

Actual Item/Funds Source	1990–91	1991–92	1992–93	Total	Percent
Salaries		27,723	28,705	56,428	86.2
Operating		2,000	1,000	3,000	4.6
Capital					
Travel		3,314	2,742	6,056	9.2
Adoption					
Total		33,037	32,447	65,484	50.0
Research Org					
Third Party		33,037	32,447	65,484	50.0
Total funding		**66,074**	**64,894**	**130,968**	**100.0**

Source: Project Schedule

Table 3. Comparison of budget and actual outlay

		1990–91	1991–92	1992–93	1993–94	Total	Percent
LWRRDC	Budget	17,574	33,037	32,447	0	83,058	
	Actual	0	33,037	32,447	0	65,484	
	Difference	−17,574	0	0	0	−17,574	−21.2
Third Party	Budget	17,573	33,037	32,447	0	83,057	
	Actual	0	33,037	32,447	0	65,484	
	Difference	−17,573	0	0	0	−17,573	−21.2
Total	Budget	35,147	66,074	64,894	0	166,115	
	Actual	0	66,074	64,894	0	130,968	
	Difference	−35,147	0	0	0	−35,147	−21.2

3 Adoption of Results

3.1 Survey

A survey was undertaken of 12 persons identified as having had direct or indirect contact with the project during its operation and likely to be interested in the adoption of the project output. The principal source of contact names was from participants in the ACTFR Tropical Floodplain Workshop. The number was reduced by limiting those from the same workplace and by attempting to get a geographic and technical spread of interests. Two farmers who were members of farm inspection committees but did not attend the workshop, were separately identified. The final list comprised 17 names. However, five of these declined to participate as they considered the project or the technical issues under review as being too remote from their area of expertise or current activity to comment.

Questionnaires were sent to two irrigation farmers, five QDPI officers in resource and water management, two researchers (from CSIRO and BSES) and three officers from other Queensland government bodies (National Parks, Land Use and Fisheries and Environment and Heritage). Nine responses were received, covering ten of those surveyed, with two officers in the same department electing to submit a joint return, which has been treated as a single response.

The detailed results of the survey, including respondents' comments, are given in Annex 1. The numbers used in the analysis represent specific responses to options offered, ie. *Yes / No*. In most questions the options were not mutually exclusive, and neither were the respondents required to mark every option. The numbers therefore represent the conscious choice of respondents indicating their attitude on a specific matter. For most questions, respondents were offered space to record a comment to supplement or expand their response. All the respondents' comments are included in the analysis of the questionnaire in Annex 1.

3.2 Findings

Respondents had a range of reasons to be aware of, or interested in, the ecological consequences of the development of the BRIA on the Barrattas and other wetlands. For many (6/9) the interest came through professional work. Two of the other three respondents were local farmers who had specific interests as members of local advisory or representative committees and one came from a farm background and was now a government employee in the environmental area.

In terms of the importance of the ecological consequences on the Barrattas wetlands of the development of the BRIA, five of the nine respondents saw the issue as important and needing specific action to define solutions. One respondent ranked the issue as urgent and needing critical attention, another considered that, while the issue was important, the issue would resolve itself over time. Two were not involved/aware of the issue at the time of the project. The comments covered a range of concerns, including the wider context of environmental impact of irrigation development generally, the clearing and development of coastal areas for sugarcane and the need for measurement to prevent environmentally destructive development.

Only four of the respondents had direct connections to the project. However, all had some connection with the ecological consequences of the BRIA development as professional advisory/regulatory officers (five), through attending project seminars (four) or as farmers/farmer members of advisory committees.

When asked to identify the output of the project, all but one respondent identified as an output a changed approach among those associated with the development of the BRIA towards a greater recognition of the ecological consequences of the irrigation scheme. In recognising the impact of the project in changing attitudes, the comments made showed some differing perspectives as to whether the change had been fully incorporated into the management regime of the irrigation area, or had been too late, or was receiving more token than actual recognition.

Six of the nine respondents considered as an output enhanced water management and farm management practices to limit the effects on the downstream environment. Three identified the direct scientific outputs of published papers and seminars/technical meetings. The 'other' outputs identified were technical data on the current status of the water quality as a benchmark against which to measure impacts and input into the BRIA management plans.

The potential users of the project outputs were seen as covering a wide spectrum. All (9/9) included farmers and irrigation management officers. Eight of the nine respondents included other government and/or statutory authority/local government officers, together with scientists, engineers and/or other researchers, while 7/9 included private professional advisers in agriculture, environmental science or engineering. One suggested that it was in fact the whole community which should be seen as users of the project outputs.

Five of the nine respondents thought that the linkages between the project and others interested in the technical area were not as well developed as they might have been. Only one respondent thought that there had been adequate involvement of the full range of those with a direct interest, while 3/9 said no to this option. Some (2/9) felt that some groups were well represented and others were not, while others (3/9) thought there were inadequate linkages. The number on non-responders to this question related in part to their distance from the project during its operational phase, so they declined to comment.

Six respondents were aware of the project results and three were not, again reflecting the fact that some of the survey group were at a distance from the project. Of the six who knew the results, the majority (4) had access to the milestone and final reports, three had either had formal contact through committees associated with the BRIA or had been to project seminars and two had heard information from professional colleagues.

There were some adverse comments on the accessibility and comprehensibility of the results. Given the structure of the survey group and the particular issue being investigated, it would seem unreasonable to say that this represented an overall critical view. Yet, given the near unanimous view of the wide range of potential users of the project results, there were seen to have been problems in the accessibility to, or awareness of the results among people outside the group immediately associated with the project. This theme reappears in terms of using the results. While 7/9 respondents said they were likely to use the results in their professional work, three of these said that they did not consider they had adequate access to do so. The accompanying comments do not point to any particular conclusion as to what should have been done. Rather, they imply that in tackling issues with broad ‘community’ concerns, there are likely to be benefits from keeping the ‘community’ informed.

This need for information reappears in the comments relating to whether or not the results were ready to be put into practice. Five of the respondents felt that more publicity and more information transfer were needed to achieve implementation. In a similar vein, three respondents were aware of other professional colleagues using the project results, while six were not aware of anyone using them.

All of these comments need to be seen in the context of the project reporting to BRIATAC, which was a committee with statutory powers and responsibilities. It had direct linkages to all the major scientific institutions within the region interested in the development of the BRIA. To that extent, the research team could be justified in thinking that reporting to BRIATAC would have a flow-on effect, at least to others with a scientific interest in the issue. However, that does not appear to have happened, especially in the case of those with a peripheral scientific, or a non-scientific interest.

In the final evaluation, the outputs one–three on the description of the wetlands, the assessment of the effects variations in physical, chemical and biological variables from irrigation and the assessment of the impact of irrigation were accepted as having been achieved. However, views were heavily qualified in relation to output four, on recommendations for management of the wetlands arising from the project results. These were generally seen to have been insufficiently developed. Comments included: too much emphasis on inventory and monitoring and not enough specific management planning; the report is short on recommendations for management, especially in relation to optimal disposal of irrigation water; and the management output needs qualification in relation to optimal disposal of irrigation water (which was considered to have not been delivered on at all).

4 Conclusions

4.1 Overall Assessment

In the first instance, the purpose of this project was technical measurement. It set out to quantify the major physical, chemical and biological variables of the Barrattas wetlands, assess the degree of variation in these variables and the impact of irrigation drainage on the wetlands. This it did successfully. The results were published in milestone reports and in the final report, and they provided a benchmark against which future changes can be measured.

While there were some delays in the results, these would have to be expected in an undertaking that was related to specific events, such as rain, overflow or flooding. The weather is notoriously variable both within and between years in tropical coastal areas.

The outcome of the measuring activities was to lead to recommendations for management of the wetlands of the Barrattas area, especially in relation to optimal disposal of drainage water to minimise any deleterious effects on the wetlands. Because of this, the mid-term review in June 1992 considered that it was essential that there be regular and close consultation between the researchers and the management agencies responsible for the development, regulation and management guidelines for the irrigated farms and other developments in the region. The review identified as a potential problem, that the management agencies did not appear to have reached the stage where they could readily utilise the results being generated by the project. They suggested that the researchers would need to make sure that their results from the later stages of the project were presented in a way that was of direct benefit and use to the management agencies.

The findings of the survey suggest that there is at least a perception that while the project has been instrumental in changing attitudes to the management of the wetlands, it was not successful in effectively translating this change in attitude into a sound management regime. In terms of the facts, this may be unfair, as the implications of the project findings have in fact been incorporated into BRIA management plans. However, the fact that such an attitude exists may provide some learning experiences from this project.

4.2 Lessons Learned

Three issues are considered to arise from his project. These are: what constitutes effective interaction; the role of project steering committees; and how can projects influence management practice. In no case should the comments be considered as criticising the project, rather they attempt to consider whether there might have been different ways of doing things.

Effective interaction

Only one respondent thought there had been adequate involvement by the project of the full range of those with a direct interest in its outcomes, while three specifically said no to this proposition. Five of the nine survey respondents thought that the linkages between the project and others interested in the technical area were not as well developed as they might have been, or were inadequate.

It is concluded that the concerns expressed relate not so much to awareness of the findings *per se*, but to the consequences of the findings. The results of the survey suggest that the results were perceived to have implications for a broad group associated with the BRIA and the Barrattas area and that there could have been more interaction with this broad group, rather than some narrower scientific group. Yet the project did work with a wide group of potential users. From an early stage it was said to have had interaction with a number of key bodies including QDPI–WR, QDEH, BLG, BSES and BRT.

Two elements are seen in this apparent contradiction. One is that there is a wider awareness that research in specific areas is needed and is being done, but that such work is no longer considered to be the exclusive preserve of scientists or professional/technical managers. It is apparent that beyond the immediate group of professional scientists or resource managers, there is a group of people who are capable of dealing with scientific data and how this is interpreted into recommendations or management regimes which affect their professional area, their livelihood and/or their perception of community good.

The other element is that, to be effective, it may be necessary to carry the interaction with potential adopters beyond the life of the project, at least to a point where it can include some interpretation of the results or assessment of the consequences. Most projects run to tight time schedules, so that finishing

the task and publishing the results by the due date becomes the major objective. Going round the communication loop with those who have earlier contributed ideas to the project is an additional burden for which their is usually neither time nor resources. In this project much of the early interaction was to prioritise ecological areas and the design of a multiple-use, land-use framework. An ACTFR flood plain management workshop was held some time after the project finished. The project outputs were discussed at this workshop, but it does not seem to have met the perceived need for involvement expressed in the survey responses.

This conclusion begs the question of how such interaction might have been done, or what it might have achieved it had been done? Several of those who did not know the project results said that they knew where they were and expected that they could get them if they needed them. A number had attended the ACTFR tropical floodplain management workshop. It is therefore not access or involvement in generating the data that is perceived to be lacking. Rather, it could be seen more as a concern at the lack of involvement or awareness of the conclusions drawn and what was being done about the consequences of those conclusions. The concern appeared to be more that things might not be done, or that people may make environmental mistakes, because they were not aware of the findings of the project.

The role of steering committees

Typically a steering committee includes people with specialised knowledge who can provide guidance and back-up to the project and provide linkages to groups with a specific scientific or other interest in its work. In this case the project worked closely with BRIATAC, which was a statutory body and responsible for the oversight of the scientific issues arising from the BRIA development. Its membership included all the major locally-based scientific organisations with an interest in irrigation and regional development issues. This broad structure was considered to have provided access for the project to other scientific resources, to have enabled the committee to recognise the relevance of results as they were reported, and to identify where ongoing work would be needed. This interaction was considered a major strength for the project and is reported to have led to the rapid absorption of its findings into ongoing environmental assessment and planning.

However, we are still left with concerns over interactions having been expressed by farmers and those from other government instrumentalities. One inference which might be made is that while the steering committee may have had strong interactive links with the project, they may have also served to shield the project from looking beyond the immediate scientific/water management group with which it was working. This is no criticism of the project, but rather an attempt to make a generalisation from a specific event. It may be that a steering committee should not be seen as the principal vehicle for communication, other than in a limited technical sense to kindred agencies. Transferring information from the project to the steering committee may mean that the knowledge of project outcomes held by members of the committee constitutes the only addition to institutional memory/capability which has been achieved. The very strength of the position of BRIATAC may have contributed to limiting any wider communications process.

Changing management practices

How do projects which are seen to change attitudes or perceptions turn this output into changes in management practice? In the case of the current project, it is said that the fact that BRIATAC was a statutory committee with specific implementing powers produced direct results. The project outcomes were taken up by the management authority (QDPI–WR) and are said to now be included in the management regimes for the BRIA drainage areas. However, what happens to projects which interact with steering committees that have no specific capacity to influence changes in management practice?

The extent to which projects should see an obligation to ‘push’ their findings on management matters is a debatable issue. Changing management practices may require the balancing of a number of complex issues, of which the particular scientific matter arising from the research may be only part. For this project, the objectives included the intention to provide recommendations for management of the wetlands of the Barrattas area, especially in relation to optimal disposal of drainage water. Recommendations were made. However, in a general sense it may not always be a straightforward matter to make recommendations which are as clear-cut and prescriptive as some would wish. This is particularly so in environmental matters where at least some community expectations may be higher than can be reasonably be answered in a project of fixed funding and duration.

Tackling the matter should start with the project objectives. If it is an objective of the project to influence management practice, then the objective must be accompanied by a statement as to how this will be done. Inputs and activities directed at the adoption of recommendations should be included in

the original, or some revised version, of the project document. As was the case in this project, it should be an issue of concern for discussion at the mid-term review. Once indicative results are available, the project should address what implications might these have for management practice and how could they be effectively presented to decision makers.

4.3 Follow-up Actions

The issue of monitoring and management of the Barrattas wetlands is not closed. It is understood that some further work was commissioned by BRIATAC, especially on water quality. The development of water management plans for the BRIA by QDPI–WR is continuing. The work of farm inspection committees is helping to improve the comprehension of the impacts of irrigation drainage water on the regional wetlands. There is possibly scope for some wider education/participation process in resolving the management consequences of irrigation impacts on the wetlands involving farmers and others concerned with ecological management in the region.

Annex 1. Project Questionnaire and Responses

Questionnaires sent: 12 Responses received: 9

1. Awareness of the Problem

How did you become aware of, or involved in, the problems of the ecological consequences on the Barrattas and other local wetlands of the development of the Burdekin River Irrigation Area?

	Yes / No
– Through media and public discussion	0 / 1
– Technical or scientific journals	0 / 1
– As a farmer or landowner in the region	3 / 1
– Through your professional work	6 / 0
– Other *(please specify)*	2 / 1

Comments:

- As a member of the Farm Inspection and Advisory Committee for the BRIA
- I purchased a BRIA block in October 1991 and again in November 1993.
- Farmer member of Farm Inspection Committee (FIC). As a farmer I pump water from the West Barratta adjacent to the wetlands.
- The importance of the Barrattas was first raised in the CSIRO Review in 1981 of the Burdekin Project Proposal. It has been the subject of investigation since that time as input to planning etc.
- I originally came from the Lower Burdekin region. The study area has been of interest to me since childhood. While working as a campaigner for the North Queensland Conservation Council, I actively sought to raise the profile of the BRIA issues.
- Invited to take part in a workshop on project outputs in Townsville in 1995. Not aware of the project until that time, but not necessarily involved in this type of work.
- My role is to redesign the Clare Weir fish ladder so I am interested in fish movement over the floodplain and up and down the BRIA streams.

If you were aware of the issue prior to 1992 did you see it as being:	*Yes / No*
– Not a serious issue	0 / 0
– An important issue which would resolve itself over time	1 / 0
– An important issue needing specific action to define solutions	5 / 0
– An urgent matter needing critical action	1 / 0

Comments:

- It was apparent that unless some monitoring were conducted, commencing with a baseline, no true impact assessment would be possible.
- I was concerned that this irrigation scheme not become an environmental disaster as had some earlier schemes, particularly regarding salinity and environmental sustainability.
- Not aware of the issue prior to 1992.
- The Barrattas area is a multi-stream one. Not all streams are used for the discharge of the BRIA.
- Minimisation of run-off is the aim of our water pricing and management objectives.
- The original CSIRO Ecological Study was largely a literature review, many of the recommendations were not implemented and development of the BRIA occurred in an environmentally destructive manner.
- Broadly speaking, the issue of drainage and clearing in sugarcane areas along the coast has been an issue for decades and it is not surprising that studies were instigated/funded particularly as population (human) pressures increase.
- Not involved prior to 1995.

2. Connection to the Project

	Yes / No
Were you connected to the project in any way	4 / 3
If yes, how were you connected?	
– Through local land-based/farming activities or Landcare groups	1 / 0
– As a professional adviser or regulatory officer with government or statutory body	5 / 0
– As an attendee at one or more project seminars	4 / 0
– Other *(please specify)*	2 / 0

Comments:

- As a member of the Farm Inspection and Advisory Committee for the BRIA. No direct contact with project management, only through progress reports.
- I served on two DPI committees that have taken account of this issue in various planning functions.
- BRITAC was involved, not the farmers.
- I was involved as both planner/designer and now manager of the areas involved.
- Other, as a conservationist campaigner

What do you see as the output of the project?	
– Some technical papers describing the flora, fauna and ecology of the local wetlands	3 / 0
– Seminars and technical meetings which informed local technical officers, farmers and others associated with the area about the results of the project	3 / 0

- Enhanced water management and farm management practices to limit the effects on the downstream environment 6 / 1
- A changed in approach among those associated with the development of the BRIA towards a greater recognition of the ecological consequences of the irrigation scheme 8 / 0
- Other *(please specify)* 2 / 0

Comments:

- Requires information delivery to extension/advisory personnel to facilitate transfer implementation by growers.
- As time went on more and more attention was paid to this issue until it is now integral to the running of the system.
- There is definitely a changed approach and a greater awareness and effort is being made to accommodate the problems. Drainage water volume is low from the BRIA but is more seen as an income loss and should be minimised.
- Technical data on the current status of the water quality. The output provides a benchmark against which to measure impacts.
- The findings of the project came too late for much of it to be incorporated in development planning. Political will has also been lacking.
- It was apparent at the workshop that water resource engineers/scheme managers were trying to take account of issues raised in the project. I felt it unclear whether they believed in the output or were responding to perceived community pressure.
- Input into the BRIA environmental management plan/operations plans.

Who do you think would be the potential users of the output of the project?

- Farmers or other landowners 9 / 0
- DWR officers associated with irrigation or other development 9 / 0
- Other government/statutory authority/local government officers 8 / 0
- Scientists, engineers and/or other researchers, either locally or outsidethe area 8 / 0
- Private professional advisers in agriculture, environmental science or engineering 7 / 0
- other *(please specify)* 1 / 0

Comments:

- The work being done here should be able to be used by all sectors.
- Other areas of the Burdekin adjacent to the BRIA, the Delta Water Boards, are realising the impact of the environmental problems.
- Information can be interpreted at most levels to aid decision making.
- NGO groups such as the North Queensland Conservation Council could use the output to lobby for more effective management of the irrigation scheme.
- The whole community should be seen as users of the project output.

If you were connected to the project, do you think that there was sufficient involvement of others beyond the research team, such as those listed in the question above, to ensure awareness and information transfer to those who could use, or contribute to, the practical adoption of the research results?

Yes / No

- There was adequate involvement of the full range of those with a direct interest 1 / 3
- Some groups were well represented, but others were not 2 / 1
- There was inadequate linkage between the project and the potential users of the research output 3 / 2

Comments:

- Both developers and users of the BRIA scheme were involved with the results of this work coincidentally.
- I was not sufficiently involved with the project to comment. This work will have impacts on my area of responsibility in the wet tropics coast.
- Do not know.
- Not a lot of interaction between the project and its managers.
- The research results were too late for full incorporation. Also the results were more of an inventory and monitoring nature and were not fully translated into a strategic management plan.
- In general it seemed like the project team had decided that agriculture was the main problem and while that is the general message in the 'Goal' statement in the appendix, this seemed to ensure that the project team did not consider other 'polluters' eg. urban areas.
- The major criticism I have is the apparent inability of these researchers to properly consult/liaise with the general public.

3. Awareness of the Results

Yes / No

Are you aware of the results of the project? 6 / 3

If yes, how did you find out?

- Don't know what the final results were 0 / 2
- From a professional colleague 2 / 1
- Through one of the project seminars/discusion groups 3 / 0
- Through formal contact with the project 3 / 0
- Through access to milestone and final reports 4 / 1
- Other *(please specify)* 1 / 0

Comments:

- Formal contact was through the Farm Inspection Committee and BRIA Technical Advisory Committee with which I am involved. However, I had only seen progress reports of results some time ago.
- The results of this project came through the DPI to the committees on which I serve.
- Draft report not seen yet. Final report just out!
- Other was newspaper articles. The results as provided to the media were, I believe, given in such a way as to heighten concerns about trends while not really saying much about the current health or otherwise of the system.
- I have not sought out the results, or have I been sent any reports.

In becoming aware of the results, do you feel that you were able to:	*Yes / No*
– comprehend them because they were presented in an easily understood manner	2 / 2
– they were understandable because of your professional training in this technical area	3 / 0
– they were not easily understood	2 / 0

Comments:

- I have had no direct exposure to the results at this stage.
- Reports were very difficult to access.
- I am sure I would be able to comprehend the results. I do know the area in question.
- Final interpretation by researchers not very definitive, left it to reader to decide.
- The implications or causes of water quality monitoring results were not elaborated.
- Difficult to answer.
- I attended a JCU workshop on tropical floodplains. I did not realise, even afterwards, that the aim was to present the results of this project. The workshop sessions were aimless. A better approach would have been a set of dot point management recommendations with justifications, followed by a discussion of these.

Do you have any other comments on the presentation of the results of this project?

- Poor publicity.

Do you have any comment on the timeliness of the reporting of results?	0 / 1
– Reports were on time and readily available	0 / 0
– Reports were not on time, or not readily obtainable, which delayed using the results	0 / 0
– Formal reports were late, but results were available through informal contact	1 / 0

Comments:

- I am unaware of the time constraints placed on the delivery of milestones.
- See before. Reports not seen!
- The movement of nutrients is normally event-related which means timetables are not always met.
- Difficult to answer.

4. Adoption of Research Results

Are you likely to utilise the results of the project in your own work?	7 / 1
If yes, do you consider that you have had adequate access to the results to directly use them?	4 / 3

If yes, how did this come about?

- Authors had sent me a copy of the final report (although only very recently).
- Copies of this report are held by the DPI and would be accessible to the farming sector.
- The results have a broader value, however the interaction with the project gives me the sense that they are not looking to use the results in a wider context.
- I am a sugar industry grower elected member, member of the Water Board and FIC and farmer, all of the above give me an interest in the results. I am sure the report and results are available if I ask for them.
- Asked directly for copies of milestone reports and technical reports to be made available to me.
- I suspect that there may be some relevance but my present work is not directly related.

If not, why not?

- Concerns about the inconclusiveness of the information
- I have not sought them. I do not anticipate any trouble if/when I do.

	Yes / No
Do you consider the results of this project are ready to be put into practice?	0 / 1

- Not sure yet.
- Awareness of this issue will be important in consideration as to how we handle the supply and availability of water in the whole of the Burdekin areas and in the future.
- It is hard to determine whether the results have been put into practice or are ready to sometimes mention a small piece of information from these projects to alter decision-makers decisions.

If yes, how?

- Much attention has been given to this issue recently which will force the issue.
- Some are. The results provide sufficient evidence to managers that management measures can, and need to be taken.

If not, what else needs to be done for the findings to be put into practice?

- As indicated earlier, a clear need for technology transfer personnel to become familiar with the results first.
- Not sure yet.
- No, there needs to be a lot more work done with farmers and managers at the BRIA to achieve implementation.
- Publicity and availability of the report and results to see and test how applicable it will be for the future use of irrigation water.

- I believe we need to present the information in a way that will make farmers and irrigation managers will sit up and take note.
- The findings need to be incorporated into strategic management plans which contain explicit recommendati ons limited to a GIS-based catchment plan of the BRIA area.

Are you aware of other professional colleagues who are using the results of this project in their work? 3 / 6

- Comparisons with own nutrient/pesticide studies.
- I would believe that the recent BRIA Environmental Management Plan would have used the draft report. BRITAC was involved.
- I believe elements are being incorporated into the BRIA environmental management plan. I do not know how easy this process has been.

If so, how is it being used?

No comments

5. Evaluation Assessment

Do you think that the restated objectives in logical framework format (see Appendix 1 at end of questionnaire) accurately reflect the perceptions of the project during its course 5 / 1

- Not sufficiently aware of the final result to comment authoritatively.
- No comment
- Probably.
- Not applicable. I was not involved enough.

If no, what do you suggest will make them more accurately reflect the situation at the time?

- Objectives 1–3 are relatively accurate. Objective 4 'provide management recommendations' is the weakness of the project.

Yes / No

Do you think that the statement of outputs in the Appendix accurately reflects your perceptions of the results of the project 6 / 1

- Yes and No. I think that the report is short on 'recommendations for management' of the wetlands, especially in relation to optimal disposal of irrigation water, although it does suggest natural rainfall events have a greater dominant influence.
- The management output needs qualification in relation to optimal disposal of irrigation water. I do not think that this was delivered on at all.
- There is definitely a greater awareness of the environmental effects that the BRIA has had and the local Water Boards. The projected expansion of the Burdekin Dam for more capacity and yield raises the question of the effect this will have on river flows and its environmental effect.
- As above, the management recommendations were not sufficient. Too much emphasis on inventory and monitoring, not enough specific management planning, ie. there was not a single map produced of the wetlands.

If no, what do you suggest would be a more accurate statement of the outputs?

Did your perceptions of the problem and the possible solutions change in the course of the project? 1 / 2

If so, what were the key changes?

- Firstly my understanding of the issue was broadened. Secondly this changed the type of advice I was prepared to give in development issues and thirdly, my own farm management practices have changed to accommodate this issue.
- Not applicable. A greater awareness of the problem is evident now and will increase as we move to secure reliable supplies of water from the Burdekin Dam or its tributary. This will be vital for the future of the district.
- As development continues, there is an increasing need to limit accessions of drainage water. More education in improved water management is required plus development of natural filters prior to entry to the waterways.

Evaluation No 5. Ref. No: UAD1

Phosphate and Pesticide Movement through Soils into Ground and Stream Movement

Contents

List of Tables

1 Background

1.1 Rationale

There are few data from Australian agricultural catchments with respect to pesticide movement into stream waters. Sutherland et al. (1983) and the NSW State Pollution /Control Commission (1980) work in the Namoi showed that organochlorines are likely to be found in waterways downstream of agricultural land uses.

Australian catchments may have a different response to those overseas because of the difference in soil type. The dominant soil type in southern Australia, and especially the Mt Lofty Ranges, is one with a strong texture contrast. Soils with such a marked textural differentiation are not common in other areas where pesticide movement has been monitored. The flow paths of water through the texture contrast soil at the site show an unusually strong seasonal variation. This may be characteristic of other similar soils in southern Australia.

The water supply for metropolitan Adelaide is obtained from several catchments in the high rainfall regions of the Mt Lofty Ranges and is supplemented with water pumped from the River Murray. Favourable climatic conditions and proximity to Adelaide have also led to an intensive agricultural land use within the Mt Lofty Ranges. In the 1970s the Department of Engineering and Water Supply (EWS) became concerned that intensive use of land, particularly for horticulture within metropolitan water supply catchments, could result in a deterioration of water quality.

1.2 Project Arrangements

Implementing agencies:
University of Adelaide and CSIRO Division of Soils

Principal investigator:
Dr D J Chittleborough, Department of Soil Science, Waite Agricultural Research Institute; and
Dr K R J Smettem, CSIRO Division of Soils, Glen Osmond, SA

Submission date:
Originally submitted to the Australian Water Research Advisory Council (AWRAC) in April 1989

Start/finish dates:
April 1990 to July 1993

Third party:
No third party participation was proposed.

1.3 Objectives and Scope

Scope of the project

The use of chemicals for weed, pest and disease control is an essential part of crop production in intensive horticulture. Given the particular topographic and climatic conditions in the Mt Lofty Ranges pesticide losses to waterways could be considerable. Research has already provided some understanding of how catchment hydrology and erosion processes affect pesticide movement, and some of the chemical and physical processes in the system have been identified. In general, losses of applied pesticides average 0.5% or less, but losses can be up to 1% for organochlorine compounds and 5% for powder formulations of herbicides. Highest losses have been detected when rain fell soon after pesticide applications. It has been suggested that the occurrence of pesticide contamination of agricultural run-off has received little attention in Australia. Limited field data from Australian agricultural catchments suggest that the organochlorine insecticides are likely to be found in waterways downstream of agricultural land uses. This may lead to a deterioration of water quality and ultimately affect beneficial use of receiving water, including potable water supply and the protection of aquatic ecosystems.

The problems of pesticides in stream water have been highlighted in recent work by the South Australian Department of Agriculture (DA) and the EWS. Pesticide residues were detected in 83% of water samples and in 100% of sediment samples from streams draining a horticultural catchment in the Mt Lofty Ranges of South Australia. Highest concentrations were detected during the first half of the summer growing season extending from October to December and particularly during run-off events occurring during this period. The organochlorine insecticides DDT, lindane and endosulfan and the organophosphorous insecticide chlorpyrifos were detected in sufficiently high concentrations to adversely affect aquatic environments.

The EWS has also identified phosphate as a major source of pollution in the water supply catchments of the Mt Lofty Ranges. Although there is also increasing environmental concern about the mobility of pesticides within these catchments, there is little understanding of the associated transport processes. Regulatory land use decisions in multiple-use watersheds required information on the sources and

mechanism of phosphate and pesticide transport. These data are currently not available.

Objectives

Objectives:

1. Determine the relative proportions of phosphate and pesticides that are lost by attachment to fine clays and in solution, from an instrumented hillslope in the Mt Lofty Ranges.
2. Evaluate a pesticide root-zone model (PRZM) initially developed by the USDA–EPA, which simulates the vertical movement of pesticides in unsaturated soil, within and below the plant root zone, extending to the watertable with a view to its application throughout the Lofty Ranges watershed.

In the course of the project the original project officer who was to carry out the pesticide work left. As a consequence, the project objectives were revised, eliminating the pesticide work. This change was recognised by the life-of-project evaluation. The final report presented the objectives as:

1. To determine the relative proportions of clay, dissolved organic carbon and phosphate that are lost, by attachment to clays and in solution, from an instrumented hillslope in the Mount Lofty Ranges;
2. To evaluate the effect of land use on the movement of phosphate, dissolved organic carbon and clay within and below the root zone, particularly the effects of cultivation versus pasture;
3. To evaluate the role of organic carbon and silicate clay as carriers of phosphate through soils.

The proposal was for three years commencing in August 1990. The timetable established for the project was:

1989

May–June Installation of logging and sampling systems into two trenches. Preparation of two experimental trips. Commence sampling on a storm event basis.

Jul–Oct Sampling of storms.

Oct–Dec Analysis of water and sediment.

1990

Feb–Mar Installation of logging and sampling equipment on remaining two experimental plots (pasture, with and without pesticide and phosphate).

May–Oct Sampling storms. Begin testing PRZM model with 1989 data.

Oct–Dec Analysis of water and sediment. Controlled irrigation equipment on two strips.

1991

Modelling and further storm-event sampling and analysis.

1.4 Financing Arrangements

The original proposal was to AWRAC for funding of $115,401. The funds were for a research officer to oversee and manage day-to-day sampling and analysis, equipment for sampling, operating costs for sample analysis and travel between the university and the experimental site. Details of the original budget are given in Table 1. Comparison of budget and actual expenditure is given in Tables 2 and 3 in Section 2.6.

1.5 Completion

The project was completed on schedule in August 1993.

1.6 *Ex-Post* Evaluation

This evaluation report focuses on pertinent aspects of the project and presents the findings of the *Ex-Post* Evaluation (EPE). The EPE is based on documents provided by LWRRDC as listed, detailed discussions with the principal investigators and a questionnaire survey of identified potential users of the project outputs and other acknowledged sources of information.

In preparing the evaluation the reviewers have had access to the following documents:

1. December 1995—Project schedule prepared by LWRRDC
2. April 1989—Original application to AWRAC
3. March 1993—Project review report (life-of-project evaluation)
4. Undated—Project final report
5. Undated—Soils Brief No 18, ‘Tackling the Water Quality Issues in the Mt Bold Catchment’, CSIRO Division of Soils.

Table 1. Original budget for funding sources and expenditure

	1989–90	1990–91	1991–92	Total	Percent
Salaries	25,465	27,082	28,914	81,461	70.6
Operating	5,000	5,000	5,000	15,000	13.0
Capital	9,900	4,000		13,900	12.0
Travel	1,680	1,680	1,680	5,040	4.4
Adoption				0	
Total	42,045	37,762	35,594	115,401	100.0
Research organisation				0	0.0
Third party				0	0.0
Total funding	**42,045**	**37,762**	**35,594**	**115,401**	**100.0**

Source: Project Application

2 Implementation Performance

2.1 Design

To facilitate an objective review of the project, the original objectives in Section 1.3 are restated in terms of the logical framework approach.

Goals:
To improve the quality of the environment by a more accurate understanding of the physical process by which phosphate moves through soil and into waterways.

Purpose:
To assist in the improvement of regulatory land-use decisions in multiple-use watersheds.

Outputs:
Description of the method of transport of clay, phosphate and dissolved organic carbon (DOC) in soils with strong texture contrast.

A theoretical methodology for determining the prospect of the translocation of soil phosphorus through the soil profile to downslope streams.

Inputs and activities:
Site preparation undertaken before the start of experimental work. Particle-size distribution, sand, silt, clay mineralogy, chemistry, hydraulic conductivity, sorptivity and moisture characteristic measurements on the soil have been completed.

Seismic survey carried out to define the solum/bedrock interface. Detailed contour mapping of the site by laser theodolite at 50 cm intervals was undertaken.

Four parallel strips with a downslope length of 20 metres, width of 3 metres and 4 metre buffer laid out perpendicular to the contour. These strips will have trenches cut to bedrock at the downslope and troughs and pipes installed at 4 locations; surface, position of abrupt textural discontinuity; position of mottling and solum/weathering rock boundary. The collected run-off will flow into four multi-glass tube, computer-controlled carousels installed on a storm-event basis and including rainfall gauge and ground level piezometers

Pesticide including tracer tags will be applied under controlled conditions. The downslope migration of these tracers will be monitored by coring at selected intervals. Monitoring the movement of the tracers will permit the assessment of water flow direction and velocity within the profile and hence the migration of pesticide and phosphate.

2.2 Outputs

The project demonstrated three important linkages between water quality in streams and land use in the area under investigation:

– throughflow of water in soils with fissured subsoils is important;

– immobile elements in colloidal form are transported in the throughflow; and

– land use, such as cultivation or pasture, can have significant effect on the transport of colloids.

The project showed that while overland flow from cultivated areas could be a significant source of sediment, water could flow through soil more readily than had previously been considered to be the case and could transport colloidal material into streams and waterways. This research provided some specific pointers to land management practices which would mitigate the problems of sediment movement in groundwater and surface run-off.

2.3 Organisation and Management

The original intention of the project to include an investigation of pesticide movement could not be implemented due to loss of a key staff member at the implementing institution. Accordingly, this objective was dropped from the project.

2.4 Contact with Potential Output Adopters

The client for the work was SA Engineering and Water Supply (E&WS). Particular working contact was made with the Mount Lofty Ranges Catchment Resources Centre. Another working contact was the Australian Water Quality Centre (AWQC) which is a business unit of the South Australian Water Corporation and the Cooperative Research Centre for Water Quality and Treatment. Contact was also maintained with Primary Industries South Australia (PISA).

2.5 Dissemination of Results

The life-of-project evaluation reported the following actual/possible activities to disseminate results.

– Work with the Extension Unit of the CRC for Soil and Land Management in Adelaide to develop ways of extending the results of this work to a wider audience

– TV presentation on *Quantum*

– Three papers written and three planned for international and national journals

– Contact with other organisation responsible for water supply catchments throughout Australia interested in the work, eg. Victorian EPA, Melbourne Water, also agriculturalists, soil conservation officers and land managers in water supply catchments.

LWRRDC recommended that researchers work with their communications managers (Margaret Burke, Cathy Sage, Rob Wiseman, Leigh Walters E&WS) to discuss ways of disseminating the results to a wider audience. Some possible vehicles for disseminating the results were the Urban Water Research Association, CSIRO's *ECOS* magazine and other water management magazines.

2.6 Actual Cost and Financing

The actual funds provided were $67,317, against an original budget of $115,401. The reduction was largely due to the elimination of the pesticide part of the work.

Intellectual property/project income was 100% LWRRDC.

Table 2. Summary of actual funding sources and annual outlays

	1989–90	1990–91	1991–92	Total	Percent
Salaries	38,467	14,425	14,425	67,317	100.0
Operating				0	0.0
Capital				0	
Travel				0	0.0
Adoption				0	
Total	38,467	14,425	14,425	67,317	100.0
Research organisation				0	0.0
Third party				0	0.0
Total funding	**38,467**	**14,425**	**14,425**	**67,317**	**100.0**

Source: Project Schedule

Table 3. Comparison of budget and actual outlay

		1989–90	1990–91	1991–92	Total	Percent
LWRRDC	Budget	42,045	37,762	35,594	115,401	
	Actual	38,467	14,425	14,425	67,317	
	Difference	−3,578	−23,337	−21,169	−48,084	−41.7
Third Party	Budget	0	0	0	0	
	Actual	0	0	0	0	
	Difference	0	0	0	0	
Total	Budget	42,045	37,762	35,594	115,401	
	Actual	38,467	14,425	14,425	67,317	
	Difference	−3,578	−23,337	−21,169	−48,084	−41.7

3 Adoption of Results

3.1 Survey

A survey was undertaken of six persons identified by the principal researcher as having had direct or indirect contact with the project during its operation or likely to be interested in the adoption of the project output. As the project involved detailed scientific work in a fairly narrow field, the list of those who could be expected to respond to the questionnaire was necessarily small. The group included three researchers in the field of soil science, a resource manager and two professionals in the field application of land management and/or extension. All were based in or around Adelaide where the work was done.

In assessing the responses to the questionnaire, it should be noted that the survey group is small and closely associated with one or other aspect of soil science. Half the group (3/6) was directly involved in research and half in more practical aspects of soil conservation and land management. While the responses were not consistent at all points, they tended to reflect what could simplistically be described as a ‘scientific view’ and a ‘practical view’. It should also be noted that the survey group offered few comments, which limited the interpretation that could be put on the responses.

The detailed results of the survey, including respondents comments, are given in Annex 1. The

numbers used in the analysis represent specific responses to options offered, ie. *Yes / No*. In most questions the options were not mutually exclusive, and neither were the respondents required to mark every option. The numbers therefore represent the conscious choice of respondents, indicating their attitude on a specific matter. For most questions, respondents were offered space to record a comment to supplement or expand their response. All the respondents comments are included in the analysis of the questionnaire in Annex 1.

3.2 Findings

All six respondents cited their professional work as their source of awareness of the project. In addition, three of the six cited technical and scientific journals as a source of awareness and three identified their role as an agriculturalist, soil conservation officer or land manager as a source of awareness of the problem. A significant majority (5/6) saw the problem as important, needing specific action to define solutions, with only one respondent considering it an urgent matter requiring critical action.

All but one of the respondents had some connection to the project. Two had been involved in collaborative work at some stage and the one respondent who had no connection to the project had been aware of it through the local branch of the Soil Science Society.

The majority of respondents (5/6) saw the output of the project as scientific papers on the movement of water carrying colloids and nutrients through the soil and as detailed technical information which would assist in the development of new techniques or approaches for the mitigation of the movement of sediments and nutrients into waterways (4/6). One respondent considered an additional output as the conduct of seminars and workshops in the professional community changing prior understanding of the process.

Opinions were divided as to who might be potential users of the output of the project. Respondents were unanimous that key users would be resource managers/advisers and scientists, engineers and/or other researchers in water supply and/or land use. A majority considered that users would include private professional advisers in agriculture, environmental science or engineering (5/6) and other government/ statutory authority/local government officers (4/6). Two respondents thought that farmers would be potential users, while two specifically said *No* to this proposition, arguing that while the findings were relevant to farmers, the implementation would be essentially at the resource manager or responsible authority level.

Opinions were again divided over whether there had been adequate involvement of those who had a direct interest in the project. Some thought that there had been adequate involvement (2/6), while others thought that some groups were well represented and others not (1/6), or that there had been inadequate linkage between the project and the potential users (2/ 6). It appears that these views were quite strongly held, as most having indicated *Yes* to one proposition, specifically indicated *No* to an alternative. The division of opinion is not quite along the scientist/ non-scientist divide, but those expressing the view that the linkages were not ideal were all in the non-scientist group and removed from the project.

All respondents were aware of the project results and cited personal and/or professional contacts as the principal source of the information. All considered that they could understand the results because of their professional training, but opinion was divided on whether the results were comprehensible to a wider audience. Not surprisingly, it was the scientists working in the same field (2/6) who considered the results as easily understood and non-scientists (2/6) who thought them difficult to understand. Few respondents offered any views on the timing of outputs.

The adoption of the results generated the most interest and comments. All respondents considered that they would use the results in their own professional work and a majority (4/6) considered that they had adequate access to them, or could get them when needed. It was acknowledged that the project had changed perceptions of the process of nutrient and colloid movement through soils and that the findings pointed to different approaches to controlling movement into waterways. However, most expressed uncertainty how this new knowledge would find its way into improved land management practice. The differences of opinion as to whether the results were ready to be put into practice were more a matter of approach than fact. Some saw them as ready to be put into practice, but by other scientists further developing this topic, while others thought that they were not ready because more work had to be done before the concept could be put into general use.

In terms of the evaluation assessment, five of the six respondents thought that the restated objectives in the logical framework format accurately reflected their perceptions of the project during its course. A slightly smaller majority (4/6) thought that the statement of outputs accurately reflected their perceptions of the

results and a similar number considered that their perceptions of the problem and the possible solutions had changed during the course of the project. In particular, this related to the extent of subsoil/ macropore flow in the movement of nutrients.

* * * * * * *

4 Conclusions

4.1 Overall Assessment

This project had close links with a key network of others in the soil science field including field level practitioners. It has clearly changed perceptions of peer scientists in the matter of colloid and nutrient movement through subsoil. While the project was of a detailed scientific nature, all those associated expressed varying degrees of interest or concern at how to translate the important findings into improved field level practice. However, no one had any particular idea how that would happen.

4.2 Lessons Learned

Two lessons are seen in this project. One relates to communication between scientists and others with an interest in what they do. The other relates to bridging the gap between the emergence of new scientific perceptions and the development of usable field practice based on that new knowledge.

This project was part of a larger group of research activities which are linked together through the Adelaide-based network of soil science related institutions. The questionnaire responses show that there was good communication within the network. This is not entirely surprising, as it was this network which was used to identify people who might be able to the answer the questionnaire. All the respondents were professionals in the field of soil science and/or land or water management. All knew of the project through their professional work and all said that they would use the results in their work. However, the evaluation was not able to get outside this network. It was not possible to determine the extent to which it had external linkages and how effective these were in spreading information. It would seem that the network functioned through a high level of personal contact and through more-formal systems such as workshops and published technical literature. However, among a group from within this network opinions were divided as to whether the project had contact with all the people who were likely to be interested in its outcome. This suggests that it is possible for such a network to become self-feeding, exchanging ideas internally, but lacking broader communication.

The matter which excited the most comment from respondents was what to do with what was agreed to be significant new knowledge. All saw it as potentially changing land-management practices in some way, to better limit the flow of nutrients into waterways. However, some saw it as grist to the mill of further scientific work. Others saw the need to define what field practices could be put in place to bring this better understanding of soil water movement into general use. Both views were equally valid, but neither group had any particular concept of how it would happen.

Concern was expressed by one respondent that restructuring and cost cutting at all levels of government had reduced the capacity to wrestle with new ideas and to find resources to develop better practices and present them to end-users. This is certainly part of the problem. The practice of a research team developing an idea and then having a field and/or extension team available to pick it up and take it to implementation level no longer exists. The withdrawal of resources from State departments of agriculture or similar bodies has weakened this capacity for developmental work taking detailed research to field practice. At the same time, the move to competitive funding for research has potentially shifted the focus away from the usually less glamorous and often time consuming applied research.

4.3 Follow-up Actions

There is more to be done in developing this concept to field level practice. It is understood that other work has followed on from this project. To the extent that LWRRDC is funding any of this work, it may be appropriate to assess the extent to which any ongoing work will lead to the practical application of the findings.

Annex 1. Project Questionnaire and Responses

Questionnaires sent: 6 Responses received: 6

1. Awareness of the Problem

How did you become aware of, or involved in, the problems of nutrient and pesticide movement through soils into groundwater and streams?

	Yes / No
– Through media and public discussion	1 / 1
– Technical or scientific journals	3 / 0
– Through your professional work	6 / 0
– As a farmer or landowner in the region	0 / 1
– As a water supply manager	1 / 1
– As an agriculturalist, soil conservation officer or land manager	3 / 1
– Other *(please specify)*	0 / 0

Comments:

- I work in the South Australian agency (PISA) with responsibilities for land management and became involved that way.
- Not part of CSIRO, but aware through work issues. Potentially a large problem.

If you were aware of the issue prior to 1992 did you see it as being:

– Not a serious issue	0 / 2
– An important issue which would resolve itself over time	0 / 2
– An important issue needing specific action to define solutions	5 / 0
– An urgent matter needing critical action	1 / 2

2. Connection to the Project

	Yes / No
Were you connected to the project in any way?	5 / 1
If yes, how were you connected?	
– As a professional adviser or regulatory officer with government or statutory body	3 / 0
– As a water supply manager	1 / 1
– As an attendee at a seminar where the work of the project was discussed	4 / 1
– Other *(please specify)*	1 / 2

Comments:

- I had some participation in extension of results and development of project.
- I have been collaborating with Prof Oades' research projects since the early 1980s. He was the Head of the Department in which this work was carried out.
- Initially a colleague at the AWQC was collaborating with the researchers. More recently I have become more directly involved in collaboration with the CRC for Soil and Land Management.
- Some indirect knowledge of the project through the local branch of the Soil Science Society.

What do you see as the output of the project?	*Yes / No*
– Some scientific papers publishing results of trials on the movement of water carrying colloids and nutrients through soils	5 / 0
– Detailed technical information which will assist in the development of new techniques or approaches for the mitigation of movement of sediments and nutrients into waterways	4 / 1
– Neither of the above	0 / 1
– Other *(please specify)*	1 / 0

Comments:

- Seminars and workshops in the professional community changing prior understanding of process.

Who do you think would be the potential users of the output of the project?	*Yes / No*
– Farmers or other landowners	2 / 2
– Resource managers/advisers in water supply or land use	6 / 0
– Other government/statutory authority/local government officers	4 / 1
– Scientists, engineers and/or other researchers in water supply and/or land use	6 / 0
– Private professional advisers in agriculture, environmental science or engineering	5 / 0
– Other *(please specify)*	0 / 1

Comments:

- The outcome of this study should be known and understood by those in the above categories involved in some way in land management, where fertilisers and pesticides are applied.
- The output of the project is relevant to farmers, but it is hard to see how they can use it effectively. It is better seen as being used at the resource manager or responsible authority level.

If you were connected to the project, do you think that there was sufficient involvement of others beyond the research team, such as those listed in the question above, to ensure awareness and information transfer to those who could use, or contribute to, the practical adoption of the research results?

	Yes / No
– There was adequate involvement of the full range of those with a direct interest	2 / 2

- Some groups were well represented, but others were not 1 / 1
- There was inadequate linkage between the project and the potential users of the research output 2 / 1

Comments:

- The context of the research and the results were poorly communicated-too single issue and focused to Joe Bloggs's to be able to do much with the information.
- I was not in a position to judge the involvement with possible users of the output.
- Not enough contact or knowledge of the project to comment.

3. Awareness of the Results

Yes / No

Are you aware of the results of the project? 6 / 0

If yes, how did you find out?

- Don't know what the final results were 0 / 2
- From a professional colleague 3 / 1
- Through a workshop 4 / 0
- Through formal contact with the project 4 / 0
- Through access to milestone and final reports 1 / 1
- Other *(please specify)*

Comments:

- I am not completely aware of the project results and have only heard bits of it.
- The work was closely linked to our activities on similar research with NOM transport.

In becoming aware of the results, do you feel that you were able to:

- comprehend them because they were presented in an easily understood manner 2 / 1
- they were understandable because of your professional training in this technical area 6 / 0
- they were not easily understood 2 / 0

Comments:

- The results of this project need people to look at the movement of colloids and phosphorus in a very different manner. The change in mindset will slowly only occur.

Do you have any other comments on the presentation of the results of this project?

- The results were clear enough, but the implications were dramatised and not integrated into other areas of concern and endeavour.
- Not on the presentation of results but, as discussed by phone, the adoption of the results of this type of valuable work by water resource managers has been severely hindered by the vast restructuring of the public service at all levels.

Do you have any other comments on the timeliness of the reporting of results?

- Reports were on time and readily available 1 / 1
- Reports were on not time, or not readily obtainable which delayed using the results 0 / 1
- Formal reports were late, but results were available through informal contact 1 / 0
- Don't know.
- I was not aware of the timetable, so I cannot comment.

4. Adoption of Research Results

Yes / No

Are you likely to utilise that results of the project in your professional work? 6 / 0

If yes, do you consider that you have had adequate access to the results to directly use them? 4 / 1

If yes, how did this come about?

- My personal contact with the program.
- Already have adopted the results through direct links with the project team.
- Through regular contact with the researchers.
- I have been provided with a copy of the report.
- I do not have the results at this stage, but they are accessible if or when I need them.

If not, why not?

- I am not confident I know enough about the project findings and their relevance.

Do you consider the results of this project are ready to be put into practice?

If yes, how?

- The work (and ours on NOM transport) needs further demonstration on a larger catchment scale. This is necessary to demonstrate the concepts are practical for farmers and other managers. However, the concepts have been clearly demonstrated in a scientific sense and should be an important part of the knowledge base of professionals involved in extension, etc.
- The results point to different approaches for controlling nutrient and colloid movement. They can be used in further investigations of amelioration trials.
- Results are of value in water resource and land management planning. However, more detail would be required to develop specific management procedures.
- The output of this project highlights the existence of an intermediate area between front-line research and end-user client. We do not yet fully understand the implications for field practice.

If not, what else needs to be done for the findings to be put into practice?

- Better extension of findings to extension officers, Soil Boards etc.
- Need to know the social, environmental and productivity implications of the work.

- What we have from the project is a better understanding of the particular processes, but no specific way that we can alter end-user practices to gain the benefits of that better knowledge. We need to further understand the implications of the findings, especially how they should be developed to where they can become part of fieldpractice.

Are you aware of other people, engineers or professional colleagues who are using the results of this project in their work? 2 / 3
If so, how is it being used?

- To guide related scientific studies.
- The findings are being used in the way many officers and researchers address issues relating to nutrient and colloid management.

5. Evaluation Assessment

Yes / No

Do you think that the restated objectives in logical framework format (see Appendix 1at the end of the questionnaire) accurately reflect the perceptions of the project during its course 5 /1
If no, what do you suggest will make them more accurately reflect the situation at the time?

Do you think that the statement of outputs in the Appendix accurately reflects your perceptions of the results of the project? 4 / 1
If no, what do you suggest would be a more accurate statement of the outputs?

- I would like more detail, particularly on the land management pointers.

Did your perceptions of the problem and the possible solutions change in the course of the project? 4 / 1
If so, what were the key changes?

- Subsoil/macropore flow considered more important than previously thought. Confusion over management implications of the research.
- The proportion of nutrient contamination moving through the subsoil is significantly higher than previously understood. This has implications for land management, but I am not sure what these implications are.
- My impression is that the extent of through-flow of water and associated nutrients (especially before the soil became significantly wetted) surprised the researchers.
- The importance of fissures in determining flow through soils.

Evaluation No 6. Ref. No: DAW3

Forage Plants for Recharge Control

Contents

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1 Background

1.1 Rationale

Half of the ten million hectares of cleared land in the wheat belt is lateritic upland or sandplain. In this environment, perennial plants have two distinct roles in limiting recharge: minimising wind erosion and increasing the productivity of the soil. This can be achieved by:

– using perennial plants to provide forage in autumn/early winter at a time of annual scarcity; and/or

– as vegetation belts in an 'alley farming' system on areas suited to annual crop and pasture production.

The primary aim of this research project was to select species for the former role. The selection of species suited to direct seeding for the secondary role was seen as a possible spin-off of the project.

1.2 Project Arrangements

The formal project arrangements were:

Implementing agency:
Agriculture WA (AWA)

Principal investigator:
Mr E Lefroy

Submission date:
May 1991

Start/finish dates:
August 1991 to August 1994. (Whole project 28.08.88 to 31.08.94)

Third parties:
Department of Conservation and Land Management WA (CALM)
Land Conservation District Committees (LCDCs)

1.3 Objectives and Scope

Scope of the project

Of the 35 million sheep in the agricultural area of Western Australia, approximately half receive supplementary feeding each autumn at a cost of $2/head. Perennial sources of forage could replace this and improve the establishment and total production of annual pasture through deferred grazing. Vegetation belts integrated with crop and pasture have been shown to increase production by up to 20% in similar environments, and to increase lambing%ages by similar amounts. Increases of this degree would cover the cost of establishing perennial forage belts within five years. In both systems, perennials have also been shown to contribute to landscape stability and nutrient cycling. The lack of autumn feed, lack of recharge control and the damage caused by wind erosion have been recognised as limitations of the present farming system by the Land Conservation District Committees (LCDCs) of Jerramungup, Esperance, and Dowerin and Cunderdin, the Koolanooka/Bowgada Landcare Group, the Land Management Society and the Martindale Research Project.

The project set out to collect germplasm of perennial herbs, grasses and shrubs from areas with a Mediterranean-type climate and evaluate their ability to:

– survive environmental stress at a range of sites in the wheat belt;

– produce forage that is digestible (55%), palatable and of sufficient energy and nutrient content for the maintenance of sheep;

– produce forage free of toxins;

– regrow following autumn grazing;

– resist insects and disease;

– establish easily;

– fix atmospheric nitrogen; and

– have little potential for becoming noxious weeds.

Objectives

The objectives of the original proposal were to:

1. collect and evaluate perennial plants suited to the wheat belt of Western Australia (250–450 mm annual rainfall) that will

    a) intercept the 5–10% of annual rainfall that is presently unused by crops and pastures and causing secondary salinisation, and

b) as an economic incentive to their use, provide feed for sheep in autumn/early winter as a substitute for supplementary feeding and to allow deferred grazing of annual pasture; and

2. produce a short list of species within five years based on survival, dry matter production, nutrient analysis and palatibility for use in later animal production evaluation.

The timetable for the project was:

Date for completion	Description of milestone	Achievement criteria
July 1990	Collection and propagation of material from within Australia.	Establishment of seedlings at five sites.
July 1991	Collection and propagation of material from the Mediterranean basin.	Establishment of seedlings at five sites.
September 1992	Screening on the basis of survival, growth rate and nutrient analysis at 12 months.	Publish description of collection and results of preliminary screening.
May 1993	Screen on basis of growth and palatibility at 18 months old.	Publish results of second screening.
August 1994	Screen for regrowth, palatibility and nutrient analysis at 30 months.	Publish results of third screening.

* * * * * * *

1.4 Financing Arrangements

The project was estimated to cost $338,702 over a three-year period. Funding sources proposed were LWRRDC (56.6%), Agriculture WA (35.4%) and third parties (8%). The original budget and financing sources are summarised in Table 1.

The project was ongoing and had previously received funding of $212,422 over the two years 1989–91. The sources of the funding were the same in the earlier phase and in generally similar proportions to those proposed for the second phase. The third parties in each case were the Department of Conservation and Land Management WA (CALM) and LCDCs. The initial project funding request proposed the intellectual property/project income be shared on the basis of LWRRDC 50% and the research organisation (AWA) 50%.

1.5 Completion

The project was completed on schedule in August 1994.

1.6 *Ex-Post* Evaluation

This evaluation report focuses on pertinent aspects of the project and presents the findings of the *Ex-Post* Evaluation (EPE). The EPE is based on documents provided by LWRRDC as listed, detailed discussions with the principal investigators, a survey of identified potential/actual users of the project outputs and other acknowledged sources of information.

In preparing the evaluation the reviewers have had access to the following documents:

1. December 1995—Project schedule prepared by LWRRDC

2. May 1991—Original application to LWRRDC

3. July 1993—Milestone report

4. Undated—Milestone report. Forage plants for recharge areas

5. Undated report—Ecological indicators for sustainable agriculture

6. Undated final report—Forage shrubs and alley farming

7. March 1996—The place of tagasaste in farming systems (Lefroy *et al*.) in Proceedings of Tagasaste Review Workshop, Yanchep WA.

Table 1. Original budget for funding sources and expenditure

	1991–92	1992–93	1993–94	Total	Percent
Salaries	51,520	55,064	56,618	163,202	85.1
Operating	5,150	5,150	5,150	15,450	8.1
Capital				0	
Travel	4,350	4,350	4,350	13,050	6.8
Adoption				0	
Total LWRRDC	61,020	64,564	66,118	191,702	56.6
Research Org	40,000	40,000	40,000	120,000	35.4
Third Party	9,000	9,000	9,000	27,000	8.0
Total funding	**110,020**	**113,564**	**115,118**	**338,702**	**100.0**

Source: Project application

2 Implementation Performance

2.1 Design

To facilitate an objective review of the project, the original objectives in Section 1.3 are restated in terms of the logical framework approach.

Goal:
To improve the quality of the environment through developing more-sustainable systems of agricultural land-use

Purpose:
To reduce salinity caused by rising watertables in the Western Australian wheatbelt, while improving the autumn feed supply for sheep run in association with grain cropping

Outputs:
A collection of perennial herb, grass and shrub species adapted to the Mediterranean-type climate, evaluated and ranked according to their ability to survive environmental stress at a range of sites in the wheatbelt, produce forage that is digestible (55%), palatable and of sufficient energy and nutrient content for the maintenance of sheep, produce forage free of toxins, regrow following autumn grazing, resist insects and disease, establish easily, fix atmospheric nitrogen and have little potential for becoming noxious weeds.

Inputs and activities:
Collection and propagation of material from within Australia and from the Mediterranean basin

Screening of collected material on the basis of survival, growth rate and nutrient analysis at 12 months.

Screening of collected material on the basis of growth and palatibility at 18 and 30 months of age.

2.2 Outputs

The outputs of the project were:

– An assessment of 188 accessions of woody herbaceous perennial plants ranked according to a range of criteria for their use in providing autumn fodder for livestock and in utilising rainfall.

– A system of ecological analysis providing a basis for determining and ranking possible ecological indicators for sustainable agriculture.

– A strategy for revegatation of the Western Australian wheatbelt in a systematic approach to overcoming land degradation.

– A directly applicable system of agroforestry (alley farming) which is ecologically and commercially sustainable under a range of conditions.

The final outputs of the project were not those envisaged in the initial objectives. It became fairly apparent after 12 months in the field that there were

no new promising species. This assessment was based on the perception that early growth was important for species establishment and such growth was not apparent among any of the accessions in the trials. The view was then taken that if the search for new components was not promising, then a better approach would be to look for alternative systems for existing species. The project was reorientated towards the outputs indicated above, with outputs two and three directed at developing the scientific logic underlying the approach and outputs one and four directed at the farming community as the ultimate implementers.

2.3 Organisation and Management

The principal researcher noted two particularly favourable elements in the support from LWRRDC. One was the project review in August 1992 when a presentation was made looking at comparisons in edible dry matter production between current commercial species and the potential of other systems. It was at this meeting that the Board encouraged a re-ordering of project objectives and led to its successful outcome. The other important element of support was to facilitate an awareness of the work outside Western Australia. It is considered that the work in Western Australia would have gone ahead regardless, but the development of a wider network enabled the researchers to come to the view that the work was less universally applicable than had been thought. There were more questions surrounding pasture competition than had been previously believed.

2.4 Contact with Potential Output Adopters

Field and commercial-scale experiments were conducted on five commercial farms in different districts covering a range of environments. The farming systems analysis was carried out in conjunction with CSIRO, AWA, CALM and Greening Australia (GA) and specifically with the Trees in Agriculture Group of AWA.

2.5 Dissemination of Results

Technology transfer was proposed by annual autumn field days at each of the five sites hosted by relevant LCDCs, commencing in 1992, Other methods proposed were by articles in industry journals, newsletters and newspapers and through the production of a video, which was to be the subject of separate funding through the National Soil Conservation Program (NSCP).

In 1992–93 the principal investigator was a speaker at four field days on fodder shrubs, three organised by catchment or land conservation groups and one by the University of Western Australia's (UWA) animal science group. Two papers were presented at workshops for extension staff and one seminar presented to regional research staff.

The project has been a vigorous publisher of material in a range of journals and magazines. It has also been an active networker among those interested in salinity control and the development of fodder trees. The survey of project cooperators has highlighted to a considerable degree the informal interaction between the principal researcher and other workers in the technical area. It has also highlighted the readability and accessibility of much of the published material from the project.

2.6 Actual Cost and Financing

Actual project expenditure was $318,333, details of which are given in Table 2.

Final outlays were $20,369 (10.6%) less than the original budget. This comprised $16,869 less on salaries, $6,950 less on operating and an increase of $3,450 in travel outlays. The budget/actual comparisons are made in Table 3.

Table 2. Summary of actual funding sources and annual outlays

	1991–92	1992–93	1993–94	1994–95	Total	Percent
Salaries	43,640	47,120	49,440	6,133	146,333	85.4
Operating	4,000	3,000	1,500		8,500	5.0
Capital					0	0.0
Travel	5,500	5,500	5,500		16,500	9.6
Adoption					0	0.0
Total LWRRDC	53,140	55,620	56,440	6,133	171,333	53.8
Research Org	40,000	40,000	40,000		120,000	37.7
Third Party	9,000	9,000	9,000		27,000	8.5
Total funding	**102,140**	**104,620**	**105,440**	**6,133**	**318,333**	**100.0**

Source: Project schedule

Table 3. Comparison of budget and actual outlay

		1991–92	1992–93	1993–94	1994–95	Total	Percent
LWRRDC	Budget	61,020	64,564	66,118	0	191,702	
	Actual	53,140	55,620	56,440	6,133	171,333	
	Difference	−7,880	−8,944	−9,678	6,133	−20,369	−10.6
Third Parties	Budget	49,000	49,000	49,000	0	147,000	
	Actual	49,000	49,000	49,000	0	147,000	
	Difference	0	0	0	0	0	0.0
Total	Budget	110,020	113,564	115,118	0	338,702	
	Actual	102,140	104,620	105,440	6,133	318,333	
	Difference	−7,880	−8,944	−9,678	6,133	−20,369	−6.0

Source: Data in Tables 1 and 2

3 Adoption of Results

3.1 Survey

A survey was undertaken of 14 persons identified by the project as having had direct or indirect contact during its operation and likely to be interested in the adoption of the project output. These included researchers in both Western Australia (2) and other States (3), regional extension managers in Western Australia (2) and South Australia (1), extension workers in Western Australia (2) and farmers who had developed alley farming (4). Ten responses were received and included considerable commentary on current work in the field. The high level of cooperation among those asked to contribute to the survey is in part attributed to the way in which the principal researcher has built-up and supported a network among those interested in the field of dryland salinity and the development of alley farming systems.

The detailed results of the survey, including respondents comments, are given in Annex 1. The numbers used in the analysis represent specific responses to options offered, ie. Yes/No. In most questions the options were not mutually exclusive, nor were the respondents required to mark every option. The numbers therefore represent the conscious choice of respondents indicating their attitude on a specific matter. For most questions,

respondents were offered space to record a comment to supplement or expand their response. All the respondents comments are included in the analysis of the questionnaire in Annex 1.

3.2 Findings

All the respondents had a professional interest in the problems of dryland salinity and attempts to resolve the issues associated with this, though not all were directly involved in the field of farm fodder trees/ alley farming. Most of the respondents (8/10) saw the problem as needing urgent action.

Only four of the ten respondents had direct connection to the research project. There was a diversity of other connections, through project field days, seminars, district conservation committees and through work as government advisers or regulatory officers. A number of respondents commented on personal contact with the principal researcher and highlighted the frequency of their informal discussions and/or previous collaboration.

There was strong agreement among the respondents as to the outputs of the project. Three principal outputs were identified: technical papers on the accession trials (8/10), a system of enhanced land management and farm management practices to limit the effects of salinity (9/10) and a changed approach to land management towards a greater recognition of ecological solutions to salinity problems (7/10). This last point drew a more sceptical view from two responders, who felt that the output was preliminary and insufficient to effect a changed approach at this stage.

The lack of success in the initial attempt to identify new or previously unused plants suitable for autumn fodder was not seen as a failure for the project by 8 out of 10 respondents. Rather, they saw the project as having used these findings as a springboard to approach the problem from a different perspective. At the same time the respondents offered a number of provisos to this perception. Some thought that the species identification question was not yet resolved and that more work could be done, either with the best of those species rejected in the earlier work, or in more focused work on other species.

There was a unanimous view that the potential users of the project output were community-wide. Those included were farmers, land management officers, officers in government and statutory authorities, scientists and land-use planners and private professional advisers. All were seen as important stakeholders, though there was some uncertainty as to how many would use the technology.

Fewer respondents felt qualified to comment on whether there was sufficient involvement in the project of all those who had a direct interest in the outcome. However, most respondents commented on the excellent level of communication established by the principal researcher and pointed to the existence of a good network among those involved in the technical field.

The good communication and networking skills of the project were also highlighted by the responses to a question on the source of information on project results. Of the eight options offered, two each were ranked by five, four, three and two respondents as sources of information, which indicates the wide spread of information about the project. Again, a number of comments highlight the personal nature of the direct contact with the principal supervisor. One interstate respondent highlighted the role of the video on the work as stimulating him to contact the project and leading to ongoing interaction.

The information available was seen as readily understandable. Some of the comments, however, highlight the fine line between making scientific results accessible and understandable and meeting scientific rigour. One comment was that dryland salinity was a complex issue and that it was easy to oversimplify the answers. Some though the success of the project could be rated higher in terms of extension/development than as science.

Respondents were largely non-committal when asked if the reports were on time and readily available. The majority said they did not know if they had been on time and highlighted that fact that the high level of informal information flow had kept them abreast of the work.

Virtually all the respondents (9/10) said that they would use the results of the project in their own professional work. Their comments suggested that they saw the output as providing background to similar work they were undertaking in other locations and in aiding the design and refining of ideas for ongoing work in this technical area. Most saw the results of the project as being ready to put into practice, though almost all had some proviso, which suggested that there was more work to be done before the system was fully understood. More work was suggested on shrub/pasture competition, species selection for the wheatbelt or other States and on the financial benefits of alley farming. Seven of the ten

respondents were aware of related work being done by other colleagues, which again attests to the significant network which has been encouraged by the project.

Six of the ten respondents said that their perceptions of the problem and possible solutions had changed in the course of the project. There is no doubt that the project contributed to these changing perceptions At the same time this has been a rapidly evolving area with both generic and location specific work being done in a number of different places. It would seem that the principal contributions of the project have been in conceptual development and as a catalyst through the information network built-up by the principal researcher.

* * * * * * *

4 Conclusions

4.1 Overall Assessment

This project has been successful in three ways. It has used failure of its initial hypothesis as the springboard to approach the underlying problem from a different perspective. The success of this approach has been generally acknowledged by others working in the same field. Secondly, it has developed a conceptual framework for planting trees/perennial shrubs on farms which provides the opportunity for a wide range of adaptive work in other regions and soil/ watertable conditions. That is, it can be seen to have taken an idea and given it an intellectual rigour which will encourage a considerable amount of ongoing scientific and on-farm development. Thirdly, it has had significant success in building an information network around its own publications and the willingness and enthusiasm of the principal researcher to contribute and exchange information with others in the same field.

4.2 Lessons Learned

It is considered that there are two lessons to be learned from this project. The first relates to the role of the review process in stimulating and assisting researchers to find the right path to follow. In this case the principal researcher was faced with his initial approach to resolving the combined problems of dryland salinity in a region with an autumn feed deficit as being likely to produce no usable result. He put forward an alternative approach to the review panel and was sufficiently able to justify it that the Corporation was willing to allow a significant change in the direction of the project. In this case it worked. In others it might be harder to provide the necessary intellectual rigour or guidance to reorientate a project which is heading up a blind alley.

The experience of this project offers no specific formula of what to do when this problem is encountered. Here the principal researcher evolved his own solution and was able to justify it and it led to a strong result. It would be harder to know what to do when the same situation is encountered, but with alternative proposals that are less-robust intellectually. Perhaps the real lesson is how important the mid-term review process is to the ultimate success of projects. If this is correct, then the review process must attract a sufficient proportion of the Corporation’s resources to ensure that the overall investment in research is successful.

The other lesson is the extent to which a principal researcher who is an active and willing communicator can stimulate intellectual exchange. In this project the principal researcher was an active and enthusiastic communicator, responding promptly to requests for information. Phone queries were returned quickly and requests for publications brought a copy in the next mail. The success of this approach is reflected in the high level of response to the questionnaires and the fact that most respondents commented at least once on their personal interaction with the principal researcher.

There are two sides to this coin. One is that you have to be willing to communicate and to do something about it. This is partly a matter of personality. Some are obviously better than others and get stimulation from the communication process. Others may be less enthusiastic or see the time taken in communication as a misallocation of their scarce resources. The other element is that there has to be something to communicate and/or a willing audience with whom to communicate. This project focused on a topic of great

concern to many, including scientists, farmers and the community generally. In putting forward an intellectual concept such as alley farming, there were a range of people ready to respond to project ideas. This would not necessarily be so with all the projects sponsored by the Corporation.

LWRRDC is credited with assisting the development of this project's communications network outside Western Australia. This highlights an important role for the Corporation in identifying those projects which would benefit from wider networking and stimulating them to do something about it. Here there was a willing and able communicator who needed little more than some help to identify who was doing similar work and where they were doing it. Others may need more help. Again, it is a matter of balancing resource allocation between the competing ends of sponsoring as much research as possible and spending funds on developing better interaction among the projects in train.

4.3 Follow-up Actions

This project is part of a continuing stream of work which will attract support on the merits of the proposals put forward for funding. However, one element that may warrant further attention is to look more closely at the networking among those involved in the dryland salinity work to see what elements of it may have a wider application in furthering the information process from within LWRRDC.

Annex 1. Project Questionnaire and Responses

Questionnaires sent: 14 Responses received 10

1. Awareness of the Problem

How did you become aware of, or involved in, the problems of the dryland salinity and attempts to resolve the issues?

	Yes / No
– Through media and public discussion	4 / 2
– Technical or scientific journals	5 / 1
– As a farmer or landowner in the region	2 / 3
– Through your professional work	10 / 0
– Other *(please specify)*	1 / 0

Comments:

- I work in rural revegetation research.
- Received partial copy of results in progress from Ted Lefroy.
- I was involved in initiating this project and preparing the submission to LWRRDC and have been involved in salinity R&D work for around 20 years.
- Other connection with problem. During the project period I was in charge of the Catchment Hydrology Group within the Department. Ted (Lefroy) was not part of this group.
- Landcare technician consulting to landholders on salinity and revegetation issues.
- Soil conservation and landcare adviser, then Program Manager.
- I am a CSIRO scientist working is the area of sustainable farming systems.
- Involved in research into land degradation/nature conservation issues.
- I was particularly interested in the dryland salinity problems of the Upper South East of South Australia.
- Studied geology, worked in consultancy addressing salinity and groundwater extraction.
- Observation over a period of years, the gradual decline of water quality in Lake Hindmarsh, part of the Wimmera River system, has been important in raising my awareness of the regional problem in the Wimmera.

If you were aware of the issue prior to 1989 did you see it as being:

– Not a serious issue	0 / 2
– An important issue which would resolve itself over time	0 / 2
– An important issue needing specific action to define solutions	4 / 0
– An urgent matter needing critical action	8 / 0

Comments:

- I have come into this field since 1989.
- There was an urgent need to identify woody or other perennials for non-saline areas in the WA wheatbelt.
- As coordinator of the salinity program in the Goulburn/Broken River catchment in Victoria in the 1980s.
- The issue was often portrayed as insurmountable and beyond repair.
- I support the development of catchment-wide strategy plans, with targets for implementation.

2. Connection to the Projec

	Yes / No
Were you connected to the project in any way	4 / 4
If yes, how were you connected?	
– Through local land-based/farming activities or Land Conservation District Committees	2 / 0
– As a professional adviser or regulatory officer with Government or Statutory body	3 / 0
– As an attendee at one or more project fodder shrub field days	2 / 0
– As an attendee at one or more project seminars	2 / 0
– Other *(please specify)*	3 / 0

Comments:

- I had frequent discussions with Ted Lefroy in a supervisory/consultative capacity.
- I was aware of the work in the wheatbelt because it extended previous work that Ted had done in the higher rainfall South Coast where I was working.
- A tenuous connection through local landcare activities
- Program Manager in the Avon River Basin for Agriculture WA.
- Collaborated with Ted Lefroy in developing revegatation guidelines, sustainability indicators.
- Connection was as a researcher in related field. I heard Ted Lefroy talk on the work of this project in 1993.
- No direct connection, but we have had lengthy discussions with Ted Lefroy and others who were involved.

3. Project Outputs

What do you see as the output of the project?

– Some technical papers describing usefulness of selected plants for autumn grazing and utilising rainfall	8 / 1
– Seminars and technical meetings which informed local technical officers, farmers and others associated with the area about the results of the project	5 / 1
– A system of enhanced land management and farm management practices to limit the effects of salinity on the environment	9 / 1

- A changed approach among those associated with land management systems in WA and other dryland farming areas towards a greater recognition of ecological solutions to salinity problems 7 / 2
- Other *(please specify)* 2 / 0

Comments:

- The most significant outcome for me was the development of the thinking on different land management systems. However, the species evaluation and methodology thereof are extremely valuable.
- Helped me design my own research on alley farming and tree-crop interface.
- Results from the project were given a reasonably high profile by Ted Lefroy.
- The original aim of finding 'new' species suited to the low rainfall wheatbelt was not met as far as I am aware. However there was progress made on better integration of know species into alleys and on re-introducing native species for nature conservation purposes.
- Tagasaste system has been reasonably well refined. Other options very limiting.
- Output not sufficient to effect a changed approach.
- This project is one of the few that, if successfully adopted, could genuinely turn around dryland salinity in WA.
- Both the enhanced land management system and the changed approach were preliminary in nature.
- The project has looked at farming systems in a new and exciting way.
- There is awareness of, and interest in, the system of 'Alley Farming' in the Victorian Wimmera, most likely attributable to the results of this project.

The initial thrust of the project was to identify new or previously unutilised plants suitable for autumn fodder for livestock and utilising rainfall. No new or unutilised plants were identified.

Yes / No

Do you consider that because of this outcome the research project:

- Was a failure 1 / 8
- Used these findings as a springboard to approach the problem from a different perspective 8 / 0
- Other *(please specify)?* 1 / 0

Comments:

- I still believe that the top five species have potential in mixed plantings and certain management techniques.
- At least we now know that some 180 accessions which were thought to have potential apparently don't.
- A failure as a research project, but a success as an extension/development project.
- New systems will be complex and require a great deal of research and development.
- Communication of the project findings was insufficient to use.
- Tagasaste still shows great promise and its use is not fully exploited.
- The project began to investigate how to use these species and provided information on a range of other species.
- Whilst not identifying new species, it did illustrate which species we should not waste time with. The project has prompted a wider search for species. A more focused effort has resulted on the more promising species.
- Development of the integration of known plants into farming systems was an important outcome.

Who do you think would be the potential users of the output of the project?

- Farmers or other landowners 10 / 0
- DAWA officers associated with land management 10 / 0
- Other government/statutory authority/local government officers 9 / 1
- Scientists, land-use planners and/or other researchers, either locally or outside the State 10 / 0
- Private professional advisers in agriculture or environmental science 10 / 0
- other *(please specify)* 0 / 0

Comments:

- The concepts developed during the project are receiving widespread attention in the WA wheatbelt.
- All are important stakeholders.
- All could use it, not sure if they actually would!
- The work has created much interest among farmers, extension officers and researchers. It has added to the mix of solutions available to the community in regards to dryland salinity.
- Information from this WA project has been useful to many Wimmera landholders, particularly those on light sandy soils in the west of the region.

If you were connected to the project, do you think that there was sufficient involvement of others beyond the research team, such as those listed in the question above, to ensure awareness and information transfer to those who could use, or contribute to the practical adoption of the research results? *Yes/No*

- There was adequate involvement of the full range of those with a direct interest 4 / 0
- Some groups were well represented, but others were not 2 / 1
- There was inadequate linkage between the project and the potential users of the research output 2 / 0

Comments:

- Not involved closely enough with the project to comment, but I think Ted Lefroy is well connected.
- I was not directly connected to the project.
- Ted Lefroy is an excellent communicator and involved a range of people from other agencies and universities as well as farmers.
- I don't know enough about all those involved. I was aware of school children involved in evaluating species. While this was a great extension method I believe it failed because of poor supervision.
- A good network exists. Strong linkages to farmers/landholders were somewhat unnecessary at this early stage in R&D.
- Not applicable (no direct contact with project)

- It is difficult to say from so far away. I do believe that there was some good involvement of others beyond the research team. We certainly had excellent cooperation provided when asked. I have met many farmers who have benefited from the work.
- I think all groups were represented in some form or another.
- Cannot comment

4. Awareness of Project Results

Yes / No

Are you aware of the results of the project? 8 / 1

If yes, how did you find out?

- Don't know what the final results were 2 / 3
- From rural media/farmers newsletters 3 / 2
- From Department of Agriculture publications 5 / 1
- From another farmer or a professional colleague 5 / 2
- Through one of the project seminars/discusion groups 3 / 2
- Through formal contact with the project 4 / 2
- Through access to milestone and final reports 4 / 2
- Other *(please specify)* 3 / 0

Comments:

- Direct from Ted Lefroy informally.
- Have not seen assessment of 188 accessions. Ted published a chapter in 'Reintegrating Fragmented Landscapes' which is widely copied and distributed. Also with Guide to Revegetation in the wheatbelt went to all farmers and has been influential.
- I have not read the results/conclusions of the project, although I am aware of the general thinking is this area.
- Direct discussion and site visits with project manager.
- Subsequent to this project being completed, I have worked with the author. The project has formed a good foundation for future work.
- Do not know all the results. Maintained informal direct contact with Ted Lefroy. Most knowledge via direct personal contact.
- I have probably looked into this work in more detail than many people. However, some enthusiastic farmers have begun to explore the work on their own farms.
- As a Agriculture WA employee with a strong interest in the project, I was sent a copy of the final report.
- A television documentary screened on the ABC Four Corners program stimulated interest in the Wimmera.

In becoming aware of the results, do you feel that you were able to:

- comprehend them because they were presented in an easily understood manner 6 / 0
- they were understandable because of your professional training in this technical area 8 / 0
- they were not easily understood 0 / 3

Comments:

- Very balanced, combining practical approach with hard data to back it up.
- They were pretty straightforward.
- Ted is a very good communicator, both orally and in writing.
- Dryland salinity is complicated. It is all too easy to over-simplify the answers.
- There was a combination of well presented extension material and more in-depth technical material.
- I had no difficulty in understanding the information I had access to.

Do you have any other comments on the presentation of the results of this project?

- I actually have not seen the final formal report as far as I know. Could you send me a copy please.
- Final report to LWRRDC very good. Also publications in WA Journal of Agriculture were easy to read and understand.
- The final report was quite good. The results were not rigorous statistically, however the subject was too broad to be constricted by white peg agronomy.

Do you have any comment on the timeliness of the reporting of results?

- Reports were on time and readily available 1 / 0
- Reports were not on time, or not readily obtainable, which delayed using the results 0 / 0
- Formal reports were late, but results were available through informal contact 1 / 0

Comments:

- Don't know.
- No comment.
- Don't know. Am only aware of the chapter, booklet and journal of Agriculture publications, not the formal report results.
- Do not know.
- I have had good cooperation and information from the project. Note that I am waiting on Ted's alley farming literature review.
- Any information required by me was more easily gained through informal contact.
- Cannot comment.

5. Adoption of Research Results

Yes / No

Are you likely to utilise that results of the project in your own work? 9 / 0

If so, in what technical area:

- As a farmer/landowner 2 / 2
- As an extension officer or land management professional officer 5 / 1
- As a research worker in the land management field 5 / 2

Comments:

- The project provides invaluable background for the same sort of farming systems under evaluation in South Australia.
- Helps me develop and refine my ideas on developing agroforestry systems on farms, use and extending ideas to other landholders.
- Able to rule these species selections out as useful in the farming system.
- The information in the report is central to my current research.
- We have used the report to aid in the design of our current work.
- The integration of shelter belts into our farming system is planned. Professionally I have passed on information to interested landholders.

If yes, do you consider that you have had adequate access to the results to directly use them? 9 / 1

If yes, how did this come about?

- Copy of final report from LWRRDC. Direct contact with Ted Lefroy.
- By reading the articles mentioned previously. Am unaware of the plant ranking results.
- Discussed with Ted Lefroy directly.
- Direct contact with the researcher.
- Through the author (principal researcher).
- I have read the milestone reports and I have visited farmers who cooperated with the project.
- Results were sent to me. I attended seminars and field days where results were presented.
- Phone conversations with people concerned.

If not, why not?

- No notification of their availability.

Do you consider the results of this project are ready to be put into practice?

If yes, how?

- Some results, eg. role of tagasaste.
- Yes. Increased interest in alley farming by raising knowledge of Dean Melvin's alleys. Provided very useful information on revegetation options using native species. Created a vision of what the wheatbelt might look like if revegetated.
- Not sure. Not sufficiently aware of the results to comment.
- Yes, but some uncertainties remain, especially as to the best place to plant shrubs/trees. However, adoption should be encouraged even as research continues.
- The fodder shrub aspects are not. The revegetation guidelines are.
- Alley farming systems should be taken up by farmers in a gradual way to fine tune the management needs.
- Yes. Some adaptation will be required to fit different agricultural areas, demonstrations of species etc.

If not, what else needs to be done for the findings to be put into practice?

- Hard data are needed on species and designs for regions where tagasaste is not suitable.
- More work on the financial benefits of alley farming with fodder and shrubs. More work on shrub/pasture-crop competition.
- Am unconvinced that there are not economic species suited to wheatbelt. More work in his area need to be done in he future.
- The results need extension and development in South Australia. Research on the actual benefits is also necessary.
- The performance of some plants in Victorian conditions is unknown. Research into locally indigenous acacias is a priority. (Acacia saligna is an environmental weed in Victoria).

Are you aware of other professional colleagues who are using the results of this project in their work? 7 / 1

If so, how is it being used?

- Ian Nubert, Adelaide University, teaching and developing research program.
- In design of Murray–Darling Basin Commission funded project on low rainfall alley farming systems.
- Given a high profile to alley farming in wheatbelt. Other extension workers have taken up the cause.
- Information is well disseminated through the WA Agroforestry Working group. Chairperson Peter Eckersley, Ag WA Bunbury and Secretary Brett Ward, Ag WA Katanning.
- The use of perennials in agriculture has wide-ranging appeal. Work in this area will increase.
- Roger Lawes has read the final report and is using the information to set up a major alley farming trial.
- I would think most development officers in Agriculture WA have used the results in one form or another as part of their extension program.
- Several Alley Farming layouts are being developed in Western Victoria. Greg Dalton, PISA Murray Bridge is leading a new research project in SA and Northern Victoria.

6. Evaluation Assessment

Yes / No

Do you think that the restated objectives in logical framework format (see summary on page 2) accurately reflect the perceptions of the project during its course? 7 / 1

Comments:

- Am unsure whether the evaluation and ranking of species was comprehensive or thoroughly carried out and that this area is not still a research need.
- Yes, in part. Missed out the work on alley cropping which was an important part of the project.
- Objectives were in a logical framework, but outputs were optimistic.

If no, what do you suggest will make them more accurately reflect the situation at the time?

No comments

Do you think that the statement of outputs in the summary accurately reflects your perceptions of the results of the project 8 / 1

Comments:

- Outputs 3–4 reflect results that most people are familiar with–these do not relate well to the original proposed objectives (which is not a major deficiency).

If no, what do you suggest would be a more accurate statement of the outputs?

Comments:

- Not yet demonstrated that Alley Farming model is ecologically and commercially sustainable in Victorian conditions. Hence need for further investigation.

Did your perceptions of the problem and the possible solutions change in the course of the project? 6 / 1

If so, what were the key changes?

- Over the course of the project my own thinking has been developing along a similar line–whether originally or through exposure to this sort of project information I cannot tell. I agree with the integrated alley approach.
- Become more pessimistic about finding high-value fodder shrubs for low rainfall areas.
- Like saltbush, the best species for revegetation are probably of local origin because they are best adapted to the environment. They also bring associated nature conservation benefits. We need to spend more time looking at our local species rather than look for some magical species from overseas.
- Changed through greater understanding of the ecological factors. More aware of the difficulty involved in devel oping sustainable agroforestry systems.
- I only got involved after the project was completed.
- They constantly change as new perspectives on the problems/solutions become apparent.
- The concepts were what interested me. Incorporating perennial shrubs and trees into a viable broadacre farming system could vastly improve the farming systems likelihood of long-term success. The concept was attractive and the project began to show a pathway for a better farming system. This is difficult stuff. We are working with very complex living systems. This project helped me find an approach to tackle the major land degradation issues. I don't agree with all of the conclusions, but the work has shown some significant new directions.
- They changed in the sense of a broadening of the problem to increase the problems of wind erosion, maintaining ecological balance, practical implementation (how do we get it on the ground?). The solutions need to meet a much broader set of criteria than salinity and forage.

Evaluation No 7. Ref. No: QPI1

Herbicide Management and Herbicide Residues in Conservation Cropping

Contents

List of tables

1 Background

1.1 Rationale

Soil erosion is the biggest single danger to continued crop production in Queensland farming areas. The maintenance of a protective stubble cover, together with structural works such as contour banks on sloping country, can reduce erosion to an acceptable level. The use of herbicides rather than cultivation for fallow weed control helps to maintain a stubble cover and decrease the vulnerability to soil erosion, and to reduce the loss of fallow moisture normally associated with cultivation.

In order to gain confidence in the use of herbicides, more information is required on the persistence and breakdown of residues and their limitations on subsequent cropping options. Residual herbicides such as atrazine and chlorsulfuron are being used more widely in conservation tillage because of their cost effectiveness in medium to long-term weed control. However, because of soil residues, the use of these herbicides limits the options currently available to farmers for follow-up crops.

1.2 Project Arrangements

The formal project arrangements were:

Implementing agency:
Queensland Department of Primary Industries (QDPI)

Principal investigators:
Mr S R Walker, Queensland Wheat Research Institute
Mr P Hargreaves, Agricultural Chemistry Branch, Agricultural Research Laboratories

Submission date:
The original application (undated) was to the National Soil Conservation Program (NSCP)

Start/finish dates:
1 January 1991 to 30 June 1994

1.3 Objectives and Scope

Scope of the project

The project was to address several problems. Firstly, the high cost and potential residue problems of using herbicides (and mixtures of herbicides) for fallow weed control discouraged many farmers from using them. Secondly, neither a simple tool nor precise guidelines were available, that indicated how soon after herbicide application residue-sensitive crops could be sown. Thirdly, the environmental fate of herbicides important in the major broad-acre cropping lands of sub-tropical, sub-humid Queensland was largely unknown.

The project included research on the application, rates of degradation and environmental fate of herbicides at six existing conservation tillage sites in central Queensland, Dawson/Callide, Wide Bay/Burnett and the Darling Downs region. Interrelations among soil animals, microbiology and fertility were being studied by others at these sites with major funding assistance from NSCP, and the herbicide data would augment those projects.

The project was to provide valuable information to agronomists by establishing no observable effect levels (NOELs) for major summer and winter crops grown in southern and central Queensland. This was to enable agronomists to recommend on the likelihood of success of planting residue-susceptible crops into soils containing various concentrations of residues. A better understanding of the risks involved in using residual herbicides would generate greater confidence in their use and hence more rapid adoption of conservation management strategies. The multi-site nature of this project was to ensure that the effect of variation in climate on herbicide breakdown was accounted for in the final recommendations across a range of cropping options.

The project was to evaluate potentially useful herbicide-residue test kits under development in Victoria. It was considered that, if suited to Queensland conditions, such kits could give an on-the-spot assessment of the risk of planting a residue-sensitive crop.

Objectives

The objectives of the original proposal were:

i. Through glasshouse and field trials, find no observable effect levels (NOELs) of atrazine on wheat, barley and chickpeas and NOELs of chlorsulfuron on sorghum, maize and sunflower.

ii. Evaluate herbicide-residue test kits in the laboratory and subsequently extend to field applications.

iii. Find more economical mixtures for fallow weed control that minimise possible herbicide-residue carryover problems.

iv. To determine residue levels and thus define persistence of herbicides in soils and waters for sites with a well-documented history of herbicide usage in conservation tillage agriculture.

v. To ascertain the presence and extent of detectable residues of herbicides in earthworms.

vi. To disseminate the information by extension activities.

The objective concerning earthworms was subsequently deleted with the approval of LWRRDC.

The timetable set for the project was:

1990–91

– Commence glasshouse NOELs experiments

– Commence field NOELs experiments with atrazine, atrazine+2,4-D, chlorsulfuron, diuron, metsulfuron-methyl and other herbicide mixtures

– Commence examination of herbicide mixtures

– Develop/confirm relevant laboratory methods for priority herbicide-residues.

1991–92

– Continue glass and field experiments to establish NOELs for central and southern Queensland.

– Continue experimentation on cost-effective herbicide mixtures on selected crops.

– Analyse herbicide-residues in soils and waters of established reduced tillage sites for major cropping areas of central Queensland, Dawson–Callide, South Burnett and Darling Downs. Also analyse samples from the NOELs and cost-effective herbicide experiments.

1992–93

– Commence field and laboratory testing of residue test kits.

– Continue with glass and field experiments for NOELs and cost-effective herbicide mixtures.

– Continue monitoring of conservation tillage sites with positive herbicide-residue findings. Analyse earthworms at these sites.

– Use herbicide-residue data to this stage with input from other agronomists to set priorities for further investigations on the degradation of priority herbicides.

1993–94

– Complete field and laboratory evaluation of the herbicide-residue test kits.

– Complete sample and herbicide analyses from all field experiments.

– Collate data from degradation studies, field monitorings, soil characterisations and climatic recordings. Address any problem situations that may have been suggested by the studies and recommend ameliorative or preventive activities.

– Disseminate the information widely by way of field days, press releases and formal publications. Integrate the results with data from other projects researching the interaction of conservation tillage with soil fauna and flora.

1.4 Financing Arrangements

The original project budget was $1,232,070 over four year. Proposed funding was the NSCP $341,150 (27.7%) and QDPI $890,920 (72.3%). The original budget and funding sources are shown in Table 1.

There was no statement on the proposed apportionment of intellectual property or project income in the original submission.

1.5 Completion

The project was completed on schedule in June 1994.

1.6 *Ex-Post* Evaluation

This evaluation report focuses on pertinent aspects of the project and presents the findings of the *Ex-Post* Evaluation (EPE). The EPE is based on documents provided by LWRRDC as listed, detailed discussions with the principal investigators, a survey of identified

potential users of the project outputs and other acknowledged sources of information.

In preparing the evaluation the reviewers have had access to the following documents:

1. December 1995—Project schedule prepared by LWRRDC

2. Undated—Original application to NSCP

3. Undated—Progress report 1992

4. July 1993—Project review report, LWRRDC

5. December 1993—Milestone report No 3.

6. 1994 Final report—Herbicide management of herbicide-residues in conservation cropping

7. June 1995—Comments from principal researchers on response to final report from LWRRDC.

8. Various dates—Articles from Australian Grain, Dec '91–Jan '92, Feb '92 and June–July 1992 and Australian Farm Journal, April 1994.

9. 1996 Brochure—'Herbicides: an important part of sustainable agriculture'.

Table 1. Original budget for funding sources and expenditure

	1990–91	1991–92	1992–93	1993–94	Total	Percent
Salaries	36,100	77,880	86,080	48,280	200,060	58.6
Operating	10,700	21,800	25,100	8,200	65,800	19.3
Capital	19,000	21,000			40,000	11.7
Travel	6,200	11,470	12,310	5,310	35,290	10.3
Adoption					0	0.0
Total LWRRDC	72,000	132,150	123,490	61,790	341,150	27.7
Research 0rganisation	319,626	367,806	203,488		890,920	72.3
Third party					0	0.0
Total funding	**391,626**	**499,956**	**326,978**	**61,790**	**1,232,070**	**100.0**

Source: Project application

2 Implementation Performance

2.1 Design

To facilitate an objective review of the project, the original objectives in Section 1.3 are restated in terms of the logical framework approach.

Goal:
To improve the quality of the environment in subtropical areas through a reduction in soil erosion resulting from crop production.

Purpose:
To increase the confidence of farmers and extension advisers in the use of conservation tillage practices by a more accurate specification of the persistence, breakdown and ongoing effects of residual herbicides used in crop production.

Outputs:
Specification of no observable levels (NOELs) of atrazine on wheat, barley and chickpeas, and NOELs of chlorsulfuron on sorghum, maize and sunflower in both glasshouse and field trials.

Evaluation of herbicide-residue test kits in both laboratory and field applications.

Specification of more economical mixtures for fallow weed control that minimise possible herbicide-residue carryover problems.

Determination of residue levels and definition of persistence of herbicides in soils and waters for sites with a well-documented history of herbicide usage in conservation tillage agriculture.

Definition of the presence and extent of detectable residues of herbicides in soil fauna, using earthworms as an indicator animal.

Dissemination of the project results to potential users by extension activities.

Inputs and activities:
Glasshouse and field NOELs experiments undertaken with atrazine, atrazine + 2,4-D, chlorsulfuron, diuron, metsulfuron-methyl and other herbicide mixtures.

Examination of herbicide mixtures undertaken, leading to the development and confirmation of laboratory methods for priority herbicide-residues.

Analysis of herbicide-residues in soils and waters of established reduced tillage sites for major cropping areas of central Queensland, Dawson–Callide, South Burnett and Darling Downs, together with samples from the NOELs and cost-effective herbicide experiments.

Field and laboratory testing of residue test kits.

Set priorities for further investigations on the degradation of priority herbicides using herbicide-residue data from experimental work with input from other agronomists.

Collation into usable form, of the data from degradation studies, field monitoring, soil characterisations and climatic recordings, including addressing any problem situations that may have been suggested by the studies and making recommendations for ameliorative or preventive activities.

Wide dissemination of project information and results by way of field days, press releases and formal publications, including the integration of the results with data from other projects researching the interaction of conservation tillage with soil fauna and flora.

2.2 Outputs

The actual outputs of the project were:

1. Recommendations of mixtures of herbicides which are cost-effective in controlling broadleaf and grass weeds, including quantified statements as to the:
   - degrees of sensitivity of specific crops to carryover residues;
   - conditions under which crop responses in the field might occur; and
   - safe levels for recropping intervals.
2. An appraisal of the accuracy and usefulness of commercially-available immunoassay kits in determining the presence of herbicide-residues in soil and water.
3. Information on the environmental impact of chemical residues.

2.3 Organisation and Management

The perception of the project implementers is that LWRRDC was relatively remote from the work of the project. There was a mid-term review at which the project situation was discussed in detail. After the review, the principal investigator was hoping for some feedback on how to promote adoption, but this was not discussed.

2.4 Contact with Potential Output Adopters

The project attempted to develop working contacts with people involved in the use of agrochemicals on dryland crops in either government or private industry employment. These included the agrochemical industry, private and government consultants/advisers, farmer advisory bodies, regional advisory committees and the Grains Research and Development Corporation (GRDC). Building stable contacts was in part frustrated by a series of employment changes among key contact persons who either changed roles within the industry or who moved to other geographic or technical areas. Another consequence of this

situation was the limited number of people who could be approached with the evaluation survey with some prior knowledge of the project and its work.

2.5 Dissemination of Results

The original submission proposed the following activities in the dissemination of results:

- Annual reports were to be produced in March of each year which will be made freely available to extension agronomists in QDPI and the officer-in-charge of the Conservation Farming Centre.
- Farm walks, field days and meetings were to be held with local growers groups as useful results become available from field trials.
- A final report was to be produced
- Technical reports were to be prepared for publication in the Biennial Report of the Queensland Wheat Research Institute, Agriculture Branch Annual Report, Agricultural Chemistry Branch Annual Technical Report and for scientific journals.
- Papers were to be given at conferences at state and national level.
- Results from the regional programs were to be incorporated into existing or developing farm advisory packages. For central Queensland, they were to be incorporated into the Fallow Management Decision Aid Support program being run by DPI Rockhampton (Allan Jamieson) and for southern Queensland they were to be incorporated into the fallow management guidelines being developed at Goondiwindi (Dave Blackett).
- Mixture trial results were to be incorporated into the 'Weedsearch' computer database, which is available to all QDPI officers in the State.
- Results from the herbicide-residue and NOEL work were to be incorporated into the CALF herbicide persistence model and the decision-support computer program, 'Herbicide Adviser', both of which are being developed at Tamworth.

Actual project publications:

Articles

- 'Drought may hamper atrazine breakdown', *Queensland Graingrower* 09.06.93
- 'Testing for soil herbicide-residues', *Queensland Graingrower* 08.09.93
- 'CQ research on herbicide effect on planting', *Queensland Graingrower* 15.12.93
- 'Waging war on weeds', QWRI Research Report 1992.

Papers and Posters at 10th Australian Weeds Conference and 14th Asian-Pacific Weed Science Society Conference, Brisbane September 1993

- 'Towards safer and more efficient use of residual herbicides in the north-eastern grain region of Australia'
- 'Crop sensitivity to residues of atrazine and chlorsulfuron in a soil-free system'
- 'Crop tolerance to residual herbicides in central Queensland'
- 'Evaluation of atrazine immunoassay kit'

2.6 Actual Cost and Financing

Actual project funding was $1,208,351 against a budget of $1,280,350, a reduction of $71,999 or 5.6%. All the reduction was in LWRRDC contribution which was down by 18.5%. The final payment of $15,884 was held back due to the delay in completing the project final report. Details of the actual funding are given in Table 2.

The final agreed apportionment of intellectual property/project income was LWRRDC 30% and research organisation (QDPI) 70%, which was broadly in line with funding contributions.

The budget/actual variation are given in Table 3.

Table 2. Summary of actual funding sources and annual outlays

Actual	1991–92	1992–93	1993–94	1994–95	Total	Percent
Salaries	77,880	86,080	32,833	15,448	212,241	66.9
Operating	21,800	25,100	8,200		55,100	17.4
Capital	21,000				21,000	6.6
Travel	11,470	12,310	5,310		29,090	9.2
Adoption					0	0.0
Total LWRRDC	132,150	123,490	46,343	15,448	317,431	26.3
Research organisation	319,626	367,806	203,488		890,920	73.7
Third party	nil	nil	nil	nil	nil	0.0
Total funding	**451,776**	**491,296**	**249,831**	**15,448**	**1,208,351**	**100.0**

Source: Project schedule

Table 3. Comparison of budget and actual outlays

		1990–91	1991–92	1992–93	1993–94	1994–95	Total	Percent
Lwrrdc	Budget	72,000	132,150	123,490	61,790		389,430	
	Actual	0	132,150	123,490	46,343	15,448	317,430	
	Difference	−72,000	0	0	−15,447	15,448	−72,000	−18.5
Res org	Budget	0	319,626	367,806	203,488		890,920	
	Actual	0	319,626	367,806	203,488	0	890,920	
	Difference	0	0	0	0	0	0	
Total	Budget	72,000	451,776	491,296	265,278	0	1,280,350	
	Actual	0	451,776	491,296	249,831	15,448	1,208,350	
	Difference	−72,000	0	0	−15,447	15,448	−72,000	−5.6

Source: Data in Tables 1 and 2

3 Adoption of Results

3.1 Survey

A survey was undertaken of 13 persons identified as having had direct or indirect contact with the project during or since its operation, and who were likely to be interested in the adoption of the project output. These included three employees of chemical companies, four local chemical suppliers, four grain growers and two consultants. Six responses were received, two from chemical company researchers and four from local chemical suppliers/advisers.

The detailed results of the survey, including respondents comments, are given in Annex 1. The numbers used in the analysis represent specific responses to options offered, ie. *Yes/No*. In most questions the options were not mutually exclusive, and neither were the respondents required to mark every option. The numbers therefore represent the conscious choice of respondents indicating their attitude on a specific matter. In this survey, a number of respondents had obviously marked a *No* answer in order to highlight their selection of *Yes* for one or more of the other options. Not all respondents answered every question. For most questions, respondents were offered space to record a comment to supplement or expand their response. All the respondents comments are included in the analysis of the questionnaire in Annex 1.

3.2 Findings

The 13 persons to whom questionnaires were sent were all involved professionally the use of chemicals on crops, including researchers, advisers and grain growers. However, only 6 responses were received, all of which were from a narrower subgroup of chemical researchers and advisers for chemical companies. All indicated an awareness of the problem through their professional work, with 2/5 indicating awareness through media and public discussion and 1/5 through technical or scientific journals.

Respondents were asked to indicate their perception of the seriousness of the issue before 1991. Almost all answered *Yes* to more than one option, in every case selecting an adjacent pair of options, suggesting some uncertainty about the responses. The greatest number (4/6) indicated that they saw it as an important issue needing specific action to define solutions. Only 1/6 saw it as an urgent matter needing critical action, while 2/6 specifically said *No* to this option. Interestingly, there were five *Yes* responses to the less serious options, with 2/6 saying that they had not seen it as a serious issue before 1991 and 3/5 having seen it as an important issue which would resolve itself over time. The accompanying comments supported the diversity of opinions. One respondent had arrived in Europe at that time, where the issue of atrazine in groundwater was taken very seriously. Another said that while the residual nature of herbicides had been established, the overseas data suggested low risk.

Three respondents had some connection to the project, while two had no specific knowledge of it. With one exception, the connections of those who knew about the project were relatively tenuous. These limited linkages reappear in the next question, where half the respondents (3/6) thought that there had been inadequate linkage between the project and the potential users of the research output. Only 1/6 thought there had been adequate involvement of the full range of those with a direct interest while 4/6 specifically said *No* to this proposition. One respondent felt that there could have been closer involvement of the agribusiness service sector agronomists, while another doubted that there had been good contact with the development managers of the agricultural chemical companies.

Opinions were divided as to the outputs of the project. The most widely recognised output (4/6) was information on the environmental impact of chemical residues Half (3/6) considered that other outputs were recommendations of mixtures of herbicides which would effectively and cheaply control broadleaf and grass weeds and an appraisal of the accuracy and usefulness of commercially available immunoassay kits for determining the presence of herbicide-residues in soil and water. Two respondents specifically answered *No* to these three options, one to the first option and one to the next two. One respondent did not select any *Yes/No* options, indicating that the perceived output was residue levels and crop tolerances.

Only half (3/6) the respondents thought that the results included degrees of sensitivity of specific crops to carryover residues and 2/6 thought that they included conditions under which crop responses in the field might occur or safe levels for recropping intervals.

Only one respondent used commercially available immunoassay kits to determine the presence of herbicide-residues in soil and water, while the other five specifically said they did not. No respondent was aware of the information published by the project on the accuracy and usefulness of such kits.

Respondents were unanimous in nominating a wide range of potential users of project outputs. These included farmers, QDPI agronomists and extension officers, the agricultural chemical industry, scientists and crop production advisers both locally and interstate and private professional advisers in agricultural chemicals and crop agronomy. Four of the six respondents also included officers from other government bodies such as the Environmental Protection Authority.

Respondents were divided in their awareness of the project results. Three were aware of the results through formal contact with the project. A fourth respondent indicated contact with the project as the source of awareness of project results but felt that he had only partial knowledge of project outcomes. Individuals indicated a fairly wide range of other sources of information about the project, such as published material in the *Queensland Graingrower*, papers and posters at the 14th Asian–Pacific Weed Science Conference, from professional colleagues and through access to milestone and final reports. This diversity of information sources suggests that information on project results was available over a fairly wide range of sources.

Four of the six respondents felt that they could understand the project results because of their professional training in the technical area. One felt that the results were presented in an easily comprehensible manner, while one felt that they were not easily understood, commenting the information had not been presented in an effective manner for use as an extension tool. One comment on the presentation of the results highlighted the fact that most graingrowers were astute professionals who would be keen to use this information to their

advantage, while another suggested that the results were not widely known and could be usefully developed into farm advisory notes or to better educate agronomists and advisers. Only two respondents commented on the timeliness of reporting, both indicating that they thought the reports were on time and readily available. One other suggested that in this sort of work, timeliness of reporting was not the issue, rather that content and quality were the paramount issues.

Five of the six respondents considered that they would use the project results in their professional work, though only three indicated that they felt they had had sufficient access to the results to directly use them. A smaller number felt that the results were ready to be put into practice. The most positive response was to the information on the environmental impact of herbicides where half the respondents (3/6) said the information was ready to be implemented. There was more scepticism on herbicide mixtures, with only two respondents suggesting that the recommendations were ready to be used, while three specifically said *No* to this option. Only one indicated that the appraisal of immunoassay kits was ready for adoption, though the response to this option may be influenced by the fact that the majority of respondents said that they did not use these kits.

Three respondents suggested that more extension activity was needed to get the findings put into practice. Two were aware of other professional colleagues who were using project results in their work, while another thought there was an interstate group who should be aware of the work.

In the overall evaluation of the project, half (3/6) the respondents felt that the logical framework statement of objectives accurately reflected their perceptions of the project. The doubts expressed related mainly to the NOEL work. Four of the six indicated that the statement of outputs accurately reflected their perceptions of the results of the project, while the other two felt they did not know enough to comment. Two respondents felt that the project had influenced their views of herbicide problems, citing a better understanding of residue levels and crop tolerances and better definition of the system.

* * * * * * *

4 Conclusions

4.1 Overall Assessment

This has been a technically competent project which has met both its scientific and time targets. Because it was dealing with strictly scientific issues, it did not need any specific interaction with potential adopters. It did have an extension objective to disseminate its results which it met through publication of articles in the *Queensland Graingrower* and the presentation of posters and papers at the 14th Asian–Pacific Weeds Conference.

To the extent that all these sources of information were cited by survey respondents in noting their awareness of project outputs, it can be said that this objective was met. However, comments from the survey on the readiness of project results for adoption suggest that an information/understanding gap remains, which must be dealt with to achieve an adequate uptake of project findings.

4.2 Lessons Learned

Two lessons are seen in this project, both of which relate to the extension flow-on from scientific research. One is that it may not be possible to develop extension outputs while the research is in progress. The other is that developing usable extension messages does not automatically flow from scientific research.

There is a simple logic which says that, at best, usable material for extension emerges in the later stages of a research project. Prudent scientific method requires results to be confirmed before recommendations can be made. Thus, even if preliminary information is available as a project progresses, it is not likely that extending this to a wider field of potential adopters will take place until the later stages of a project, or as a post-research project activity.

Coupled with this time sequence, is the fact that extension objectives can often be interpreted more flexibly than scientific objectives. It is generally clear whether a scientific objective has been met or not. However, there are fewer objective criteria for measuring the achievement of extension objectives such as 'disseminate the information'. As these objectives are much more open-ended, so long as some attempt is made, it can be said that objective was at least addressed.

In this project, the extension activities were listed last in the work plan as taking place in the fourth and final year. The plan called for the wide dissemination of the project information by way of field days, press releases and formal publications. Results were to be integrated with data from other projects researching the interaction of conservation tillage with soil fauna and flora. In the end, the project timetable became very tight and although the scientific objectives were met, it is arguable that less was done by way of extension than had been envisaged when the project was planned, because the researchers ran out of time.

These comments should not be interpreted as criticism of the principal researchers. All but one of the respondents to the survey reported some knowledge of the project and its findings and they cited a variety of sources of this information: press articles, conference proceedings, other colleagues and personal contact. The researchers therefore fulfilled their obligations to disseminate the findings and the people to whom these messages were directed received them. Yet the majority of the survey respondents also expressed degrees of doubt or uncertainty as to project outputs and their immediate usability, which suggests that an information gap still remains.

This leads directly to the second lesson, which is that extension/information flow cannot be expected to automatically appear from a research project. It is a specific activity and if it is a project objective, suitable resources and time should be provided at the project planning stage to ensure that it happens.

There were no special plans for dealing with the adoption process in this project. At the planning stage the budget allowance for promotion of adoption was zero, notwithstanding that there was a general adoption objective. It must be assumed that the expectation was that the scientists would find time to develop the extension messages as part of their scientific work. This they did and these were seen and reported on by those at whom they were directed. However, more was needed. This was identified after the project was completed and a well presented technical brochure was prepared by QDPI in 1996. It should also be noted that plans to have project outputs extended through other organisations such as the Conservation Tillage Information Centre were limited by staff changes in those organisations which were beyond the influence of the project.

The lesson of this project is the need to think through the extension process at the beginning and then to keep reassessing the needs and achievements as the project progresses. It must be decided who is responsible, who will actually do the work, when it should be done and what resources will be needed to achieve the desired result. It may not always be possible to answer these question unequivocally at the outset, so they should be revisited during the life of the project. This should happen at least at the mid-term review stage, or with a checklist at each milestone report, including the final report. The prospect of additional funds at the end of the project, specifically for extending the project outputs, should always be a possibility. This is currently done by LWRRDC as the need is perceived. However, it may be that a more formal approach to identifying extension needs and implementing extension action is warranted.

4.3 Follow-up Actions

The action of QDPI in producing a technical brochure based on project findings addresses the most obvious information gap. As this project was part of a wider network of related projects funded from several sources and which are still continuing, it would seem best if any further extension activity were planned in the wider context of the spectrum of related projects, than strictly in terms of this project alone.

Annex 1. Project Questionnaire and Responses

Questionnaires sent: 13 Responses received: 6

1. Awareness of the Problem

How did you become aware of, or involved in, the issues of potential residue problems and the environmental fate of herbicides used for fallow weed control in dryland crop production?

	Yes/No
– Through media and public discussion	2/0
– Technical or scientific journals	1/1
– As a farmer or landowner in the region	0/1
– As a government adviser or extension officer	0/1
– As a worker or professional adviser in the agricultural chemicals industry	6/0
– Through your professional work *(please specify)*	3/0
– Other *(please specify)*	0/0

Comments:

- As a post-doc at the University of Illinois, atrazine carryover and leaching was an important issue in the early '80s. In Europe, working for Ciba–Geigy (85–90). In Australia, immediately upon arrival in 1990, as I was sensitised to the issue.
- As a Dupont researcher, the issue of herbicide-residue was addressed in trial work
- Agronomist at many locations throughout south–east Queensland and saw problems with situations.

If you were aware of the issue prior to 1991 did you see it as being:

	Yes / No
– Not a serious issue	2 / 0
– An important issue which would resolve itself over time	3 / 0
– An important issue needing specific action to define solutions	4 / 1
– An urgent matter needing critical action	1 / 2

Comments:

- Having arrived from Europe, where atrazine in groundwater was a very serious issue, this was obviously important, and would not be restricted to atrazine, but to other herbicides as well.
- The residual nature of herbicides was established. Overseas data suggested low risk

2. Connection to the Project

	Yes / No
Were you connected to the herbicide-residue project in any way?	3 / 2
If yes, how were you connected?	
– Through local land-based/farming activities	0 / 1
– As a professional adviser or regulatory officer with Government or Statutory body	0 / 1
– As an attendee at a conference where the project results were discussed	1 / 1
– Other *(please specify)*	4 / 0

Comments:

- Liaising with John Marley and Steve Walker as a matter of my job duties
- As project officer for Conservation farmers
- As a research officer with Dupont, the manufacturer of herbicides. The local development rep at Toowoomba advised me in Nov '95
- By everyday activities and walking through countless numbers of paddocks. Probably attended technical meeting where project results were discussed.

If you were connected to the project, do you think that there was sufficient involvement of others beyond the research team, to ensure awareness and information transfer to those who could use, or contribute to the practical adoption of the research results?

	Yes / No
– There was adequate involvement of the full range of those with a direct interest	1 / 4
– Some groups were well represented, but others were not	2 / 0
– There was inadequate linkage between the project and the potential users of the research output	3 / 0

Comments:

- Could have seen closer involvement of agribusiness service sector agronomists-not just Seed and Grain Sales staff (although S&GS did pursue an interest)
- Probably more contact with herbicide manufacturers who are responsible for label statements and have access to overseas data. I doubt whether development managers of ag chemical companies had good contact on this project

3. Project Output

What do you see as the output of the project?	*Yes / No*
– Recommendations of mixtures of herbicides which will effectively and cheaply control broadleaf and grass weeds	3 / 1
– An appraisal of the accuracy and usefulness of commercially-available immunoassay kits in determining the presence of herbicide-residues in soil and water	3 / 1
– Information on the environmental impact of chemical residues	4 / 1

- Other *(please specify)* 1 / 0
- None of the above 0 / 0

Comments:

- Residue levels and crop tolerances
- Guidelines for plant-back periods which are not as over-restrictive as the current labels
- Used as a guide for recropping and plant back estimates. As fallow herbicide use guide.
- Recommendations maybe restricted by product labels that would need to be altered to accommodate the new recommendations

If you see the results as having included recommendations of mixtures of herbicides which will effectively and cheaply control broadleaf and grass weeds, do you consider that this information includes: *Yes / No*

- information on the degrees of sensitivity of specific crops to carryover residues? 3 / 0
- conditions under which crop responsesin the field might occur? 2 / 1
- safe levels for recropping intervals? 2 / 1
- other *(please specify)* 0 / 0

Comments:

- Although valid, the research may not cover the worst case scenario for recropping ie. drought crop varieties.

Label changes make companies liable for damage compensation *Yes / No*

- Do you use commercially available immunoassay kits to determine the presence of herbicide-residues in soil and water? 1 / 5
- If yes, are you aware of the information published by the project on the accuracy and usefulness of such kits? 0 / 1
- If yes, has this information changed your view of such kits and the opinions or advice which you might give based on the results from such kits? 0 / 0

Comments:

- Ciba uses immunoassay in the lab, but personally I do not currently use them in the field. Soil samples usually interfere with the ELISA unspecifically
- Not aware of immunoassay results from project

Who do you think would be the potential users of the output of the project? *Yes / No*

- Farmers or other landowners 6 / 0
- QDPI agronomists or extension officers associated with dryland cropping 6 / 0
- Other government bodies/authorities *(Environmental Protection Authority, etc)* 4 / 0
- The agricultural chemical industry 6 / 0
- Scientists, crop production advisers, either locally or outside the State 6 / 0
- Private professional advisers in agricultural chemicals or crop agronomy 6 / 0
- other *(please specify)* 0 / 0

4. Awareness of the Results

Yes / No

Are you aware of the results of the project? 3 / 2

If yes, how did you find out?

- Don't know what the final results were 2 / 0
- From a professional colleague 1 / 0
- Through published material in the *Queensland Graingrower* 2 / 0
- Through project papers/posters at the 14th Asian–Pacific Weed Science Conference 1 / 0
- Through formal contact with the project 4 / 0
- Through access to milestone and final reports 2 / 0
- Other *(please specify)* 1 / 0

Comments:

- Personal enquiries because of personal and work-related interest, also because Ciba is contributing funding (atrazine analysis)
- Partially aware of results
- Through attending some field presentation
- From telephone and face-to-face discussions with researchers

In becoming aware of the results, do you feel that you were able to *Yes / No*

- comprehend them because they were presented in an easily understood manner 1 / 1
- they were understandable because of your professional training in this technical area 4 / 0
- they were not easily understood 1 / 0

Comments:

- As a scientist it is obvious to me, however I cannot judge whether the results are understood by lay-people
- The QWRI have not been effective in presenting this information as an effective extension tool
- Not clear on the results or the overall project objectives

Do you have any other comments on the presentation of the results of this project?

- Most graingrowers I know are rather astute professionals and are keen to use this information to their advantage
- I believe the results are not widely known and could be further developed into useful farm advisory notes/ or educate agronomists and advisers better
- No
- Did not see a full report of research, however heard about at different field days.

Do you have any comment on the timeliness of the reporting of results

	Yes / No
– Reports were on time and readily available	2 / 0
– Reports were not on time, or not readily obtainable, which delayed using the results	0 / 0
– Formal reports were late, but results were available through informal contact	0 / 0

Comments:

- Unsure as to the timetable. Lateness is of no concern, content and quality are paramount
- A couple of papers were obtained by request

5. Adoption of Research Results

	Yes / No
Are you likely to utilise that results of the project in your own work?	5 / 0
If yes, do you consider that you have had adequate access to the results to directly use them?	3 / 2

If yes, how did this come about?

- In conjunction with my own professional work
- Personal contact, literature
- Possibly if I asked they would be available, but not in a user-friendly form readily usable by farmers

If not, why not?

- Only have notes taken at seminar
- I am vaguely aware of the results, but lack specific details, especially the immunoassay work

Do you consider the results of this project are ready to be put into practice?	*Yes / No*
– Recommendations for mixtures of herbicides	2 / 3
– Appraisal of the accuracy of commercially available immunoassay kits	1 / 0
– Information on the environmental impacts of herbicides used in dryland cropping	3 / 0

If yes, how?

- Usable information on residue levels. Herbicide mixture information too broad.
- Reassessment of label recommendations re plant-back periods. Improved immunoassay are still being developed and will be more useful than the currently available ones.
- *Chemistry and use restrictions need constantly updating. QWRI staff do not seem to be altogether* au fait *with the spectrum of activity/field performance of some mixes to make the recommendations. Need to work on this with practitioners*
- Not enough information on the above

If not, what else needs to be done for the findings to be put into practice?

- Know nothing about the assay kits. Am doubtful that QDPI extension staff could reasonably solve problems based on what they know of this project's outcomes either
- Steve Walker has acquired an excellent working knowledge of residual herbicides in the field. Though a researcher, he could additionally undertake an excellent role in extension of these findings to the wider industry. This knowledge needs to be linked to practical weed control recommendations from practitioners/chemical companies
- Circulation of the results. Organise a meeting for relevant groups

	Yes / No
Are you aware of other professional colleagues who are using the results of this project in their work?	2 / 4

If so, how is it being used? *(if possible, please give a contact name which we could use for follow-up)*

- Reassessment of recropping intervals (Geoff Cornwell, Du Pont, Brad Wells, Cyanamid, both in Toowoomba)
- Currently getting limited use and know of no one contemplating using assay kits although the demand would be there
- I am aware of other researchers in related fields who 'should be' aware of the results eg. the GRDC funded SV project on the alkaline soils of SA/Vic

6. Evaluation Assessment

	Yes / No
Do you think that the restated objectives in logical framework format (see Appendix at end of questionnaire) accurately reflect the perceptions of the project during its course	3 / 2

If no, what do you suggest will make them more accurately reflect the situation at the time?

- Could do better with NOELs. Little suggestion as I see it of the value of earthworm monitoring
- Not enough information on the project to comment. I would have been very interested to communicate on this project had I known of the objectives. Dupont has an immunoassay group in the USA and will set up a lab in Sydney soon
- Chemical residue in soil for NOEL is very difficult to determine. I feel uncomfortable using a test kit to see of any NOEL are possible.

	Yes / No
Do you think that the statement of outputs in the Appendix accurately reflects your perceptions of the results of the project?	4 / 0

- These facets have been reported in a fact sheet? I haven't seen them. Have had only bits and pieces

If no, what do you suggest would be a more accurate statement of the outputs?

- Soil and related buildings and contamination are what I would like research into. Commercial chemical solutions are a dime a dozen. So is the question from farmers, "Can I put sorghum into what was Glean country 12 months ago?"

	Yes / No
Did your perceptions of the problem and the possible solutions change in the course of the project?	0 / 4

If so, what were the key changes?

- Greater awareness of ability to manage residual herbicides
- Unaware of the project until Nov '95.
- We have labels on chemicals and that is the only 'legal' buffer on crop damage. The residue test kit certainly won't pay a cent to compensation. Also, with Glean (as an example) being so generic, there will be no more company research into it. There should be some more protection given to chemical companies with products out of patent to assist with all sorts of research. Why would Dupont allocate any money for further Glean research?

If yes, was the work of the project influential in changing your perceptions of the problems and the possible solutions?	2 / 0

If so, in what way?

- Better understanding of residue levels and crop tolerances
- Awareness of problems, not solutions
- Not the problem, but did define the system better

Evaluation No 8. Ref. No: UNE2

Pneumatic Application of Lime to Agricultural Subsoils

Contents

List of Tables

1 Background

1.1 Rationale

Many Australian soils are naturally acidic, particularly in the upper horizon. With a high percent age of plant roots in this layer, growth of both crops and pastures is reduced by the soil acidity and the associated toxicity of mineral elements such as aluminium and manganese.

Soils are either naturally acidic, or they slowly become increasingly acidic over time. One estimate is that soil acidification increases (ie. the soil pH[*] falls) at a rate of one unit of pH every 20–25 years. Agricultural management practices of pastures and cropping are given as reasons for increasing acidification. Pastures are claimed to decrease the soil pH by increasing the organic matter, which produces weak acids, and hence raises soil acidic level. The continued removal of plant nutrients from the soil through cropping is another agricultural practice that increases soil acidity. It is estimated that 55–65 kg of lime would have to be added to the soil to account for each tonne of lucerne and clover hay removed from a field.

It is possible to lower the surface acidic level through the surface application of lime. The major problems are that lime is low in solubility and is slow to mobilise. When lime is applied to the soil surface using mechanical spreaders, it is slow to move into the soil and it may take up to a year for any pasture response to be observed. Mixing the lime with the top 75 mm by tillage disperses it and reduces the crop response time to a few months.

Where only the soil surface layer has been treated with lime, deep-rooting crops which are intolerant of acidity, such as lucerne, have serious problems as their root systems will not penetrate into the more acidic subsoils. If the subsoil is acidic, the roots will be confined to the surface soil layers, reducing the amounts of moisture and nutrients potentially available to the plants. Acidic subsoils pose a greater challenge, as both spreading and surface tillage do not offer any corrective action. Deep tillage which can mix the lime to depth is slow and energy demanding and must follow surface applications. Due to the slow mobilisation of lime in the topsoil and the dispersal through tillage, the full benefits of lime application will not occur if the subsoil is left acidic.

Application of lime to the subsoil can be achieved through mixing lime and additives to a slurry, which is then pumped to spray outlets on the trailing edges of deep ripper tillage tynes. This technique can apply lime in bands at depths below the normal tillage layer and can reduce the total amount of lime which has to be applied. The major limitation of this system is the physical size and weight of the machinery needed. Large quantities of water have to be used, requiring frequent refilling which slows the application rate and can require more labour and support vehicles. Most of the machinery which can apply lime to depth is expensive to purchase and operate and is dedicated to a single task.

A system where the slurry medium is removed and only the lime powder has to be transported would increase the efficiency of the operation. The purpose of this project was to develop a lime applicator which would apply powdered lime to depth using, for the most part, existing farm machinery.

1.2 Project Arrangements

The formal project arrangements were:

Implementing agency:
University of New England, Armidale, NSW, 2351

Principal investigator:
Dr Simon Murray, Resource Engineering Department, UNE,

Start/finish dates:
1 March 1991 to 31 August 1993

Third party:
There was no third party

1.3 Objectives and Scope

Scope of the project

Acidity is a recognised problem in the surface soil layer. The area over which acidification affects pasture growth in New South Wales has been

[*] The pH scale runs from 1 to 14. A neutral pH is 7; values below 7 are increasingly acid, and above 7 increasingly alkaline.

estimated to be more than 1 million ha. More recent estimates of the acidity have put the problem at over 7.5 million ha in New South Wales where pH values are less than 5.0. A proportion of soils also displays a natural increase in acidity with depth. The area of such soils is thought to be 5 million ha in New South Wales and 200,000 ha in Victoria.

A field trial based on red earth soils at Wagga Wagga estimated that 8.8 tonnes/ha of lime would be required to raise the pH of the subsoil from 4.5 to 6.0 to a depth of 300 mm. Assuming the top 100 mm could be limed from the surface, the bottom 200 mm would need to be subsoil limed. An economic analysis of crop rotation data suggested that a cost of $553/ha for liming would lead to a negative return of $350 over a ten-year period for a sub-clover rotation, but if higher-value lucerne could be grown, the return would be $207/ha. The data suggested that the initial investment could be recovered in five years. If liming benefits last for 8–20 years, the farmer will gain at least three years added benefit for the liming.

Objectives

The objectives of the original proposal were:

– to devise a system which would meter a pre-selected rate of lime and place it directly into the subsoil in a manner which would enhance the movement of the lime to soil particles.

– to design, build and test and demonstrate a pneumatic lime injection system which will transport lime from a hopper and disperse it into the soil at selected rates and depths.

The objectives were refined during the course of the project. As a consequence of the mid-term review, the objectives were extended to include an economic analysis of the pneumatic lime-injection system. In the final report of the project the objectives were stated as:

i) Design and construct a prototype pneumatic conveying system, capable of injecting agricultural limestone at a rate of between 1 and 10 tonnes per hectare, using a deep ripping implement.

ii) To investigate theoretical and empirical design methods for pneumatic conveying.

iii) To determine through experimentation, the lean phase and dense phase conveying behaviour of a particular agricultural lime product.

iv) To investigate the distribution patterns in the subsoil using the pneumatic lime injection system.

v) To perform an economic analysis of the pneumatic lime-injection system.

The timetable established for the project was:

1991 Design and testing of suitable metering and pneumatic distribution system. Field testing of a small deep-ripping tillage unit. Construction and testing of the field prototype should take approximately six to twelve months.

1992 In the second year, equipment design and modification would be undertaken. Effectiveness of the project should be known after 18 months from the commencement.

1.4 Financing Arrangements

The project was funded by LWRRDC for a total sum of $19,956. There were no research organisation or third party inputs proposed. The comparison of budget and actual is given in Table 2.

1.5 Completion

The project was planned for 2.5 years from March 1991 to the end of August 1993. It was completed by the due date.

1.6 *Ex-Post* Evaluation

This evaluation report focuses on pertinent aspects of the project and presents the findings of the *Ex-Post* Evaluation (EPE). The EPE is based on documents provided by LWRRDC as listed, detailed discussions with the principal investigators, a survey of persons interested in soil acidity problems and other acknowledged sources of information.

In preparing the evaluation the reviewers had access to the following documents:

1. Project schedule—December 1995
2. Original application—National Soils Conservation Program (NSCP)—(undated)
3. Project review report—October 1992
4. Final report—(undated)

Table 1. Original budget for funding sources and expenditure

	1991–92	1992–93	Total	Percent
Salaries		700	700	0.4
Operating	7,100	3,450	10,550	5.5
Capital	8,000		8,000	4.2
Travel		706	706	0.4
Adoption			0	0.0
Total LWRRDC	15,100	4,856	19,956	5.9
Research organisation			0	
Third party			0	0.0
Total funding	**15,100**	**4,856**	**19,956**	**5.9**

Source: Initial application

2 Implementation Performance

2.1 Design

To facilitate an objective review of the project, the original objectives in Section 1.3 are restated in terms of the logical framework approach.

Goal:
To improve the quality of the environment through mitigating the impact of increasing soil acidity.

Purpose:
To develop a technique to directly apply controlled quantities of lime to the subsoil.

Outputs:
A system to place lime in the subsoil in metered quantities at a pre-selected rate in a manner to enhance the movement of lime to the soil particles.

Inputs and activities:
Based on the original project application, the inputs and activities were to be:

– A pneumatic lime injection system designed and built to transport lime from a hopper and disperse it into the soil at selected rates and depths.

– Field testing of the pneumatic lime-injection system for accuracy of the dispersal into the soil at selected rates and depths.

Based on the revised project objectives, the inputs and activities were to be:

– An analysis of theoretical and empirical design methods for pneumatic conveyancing of lime.

– The determination through experimentation, the lean and dense phase conveying behaviour of a particular lime product.

– The design and construction of a prototype pneumatic conveying system capable of injecting lime at a rate of between 1 and 10 tonnes per hectare using a deep ripping implement.

– Investigation of distribution patterns of lime in the subsoil using the pneumatic lime injection system.

– An analysis of the economic benefits of pneumatically injecting lime.

2.2 Outputs

The outputs of the project were:
– an analysis of the theoretical and empirical design methods for pneumatic conveyancing of powdered lime;

– air and mass-flow rates for reliable conveying of lime were defined, including both lean and dense phases, and an operating range of velocities for the stable conveyance of air/solids mixtures, including lime, set;

– the range of operating airflow rates and mass-flow rates was tested at the preliminary level only for pneumatic lime injection equipment;

– an analysis of the distribution patterns of injected lime in soil, from a range of distribution devices which ejected lime in different directions and from a differing number of outlets; and

– an economic analysis of pneumatically injecting lime, using the 'Lime-it' software program, which indicated that, on the assumptions used, the pneumatic injection of lime consistently gave a higher internal rate of return than the alternative methods of topdressing or incorporation of lime in the topsoil.

2.3 Organisation and Management

The level of feedback from LWRRDC was considered satisfactory. Because the project was a small one there was not a high level of interaction with the Corporation, but all queries were dealt with promptly and succinctly.

2.4 Contact with Potential Output Adopters

There was little contact between the project and potential adopters. Following the publication of a photograph of the pneumatic injection prototype in the rural press, some interest was shown by two lime suppliers in having their product tested by UNE. No contact was made with industry, though discussions were held with a lime company when designing the unit.

2.5 Dissemination of Results

Results were advised to LWRRDC through the project final report.

2.6 Actual Cost and Financing

The final outlay on the project was $9,856, which comprised $4,856 from LWRRDC and $5,000 contributed by UNE. Actual funding is shown in Table 2 and budget/actual variation in Table 3.

Table 2. Summary of actual funding sources and annual outlays

	1991–92	1992–93	1993–94	Total	Percent
Salaries	–514		1,214	700	14.4
Operating	3,450			3,450	71.0
Capital				0	0.0
Travel	706			706	14.5
Adoption				0	0.0
Total	3,642	0	1,214	4,856	49.3
Research organisation	5,000			5,000	50.7
Third party				0	0.0
Total funding	**8,642**	**0**	**1,214**	**9,856**	**100.0**

Source: Project schedule

Table 3. Comparison of budget and actual outlays

		1991–92	1992–93	1993–94	Total
LWRRDC	Budget	15,100	4,856	0	19,956
	Actual	3,642	0	1,214	4,856
	Difference	−11,458	−4,856	1,214	−15,100
Third Party	Budget	5,000			5,000
	Actual	5,000			5,000
	Difference	0	0	0	0
Total	Budget	15,100	4,856	0	19,956
	Actual	8,642	0	1,214	9,856
	Difference	−6,458	−4,856	1,214	−10,100

Source: Data in Tables 1 and 2

3 Adoption of Results

3.1 Survey

In planning a survey to assess the transfer of technology from this project, it was difficult to make a representative list of people involved with soil acidity issues who were also likely to be aware of the work on mechanical application of lime to subsoils. The Soil Acidity Network list prepared by LWRRDC Ameliorating Soil Acidity project was used as the starting point. However, many of those contacted felt that they had insufficient knowledge of, or contact with, the particular issue to complete a questionnaire. Eventually, nine questionnaires were sent out and four responses were received, plus a fifth from a PhD student colleague of one of the responders. Four of the five respondents were researchers in the field of soil acidity and one was a private consultant.

The detailed results of the survey, including respondents comments, are given in Annex 1. The numbers used in the analysis represent specific responses to options offered, ie. *Yes/No*. In most questions the options were not mutually exclusive, and neither were the respondents required to mark every option. The numbers therefore represent the conscious choice of respondents indicating their attitude on a specific matter. Not all respondents answered every question. For most questions, respondents were offered space to record a comment to supplement or expand their response. All the respondents comments are included in the analysis of the questionnaire in Annex 1.

3.2 Findings

The respondents were all aware of, and involved in, the issue of ameliorating soil acidity, mostly (4/5) as researchers and with one crop agronomy consultant. All saw the matter of dealing with subsoil acidity as being an important issue needing specific attention and one added a further *Yes* to it being a matter needing urgent action.

Only one respondent was connected to the project in any way and that was a relatively tenuous connection which had not been actively pursued. After the project, two respondents also working in the field of mechanical application of lime had made contact with the project and had specifically made use of its findings in their current work.

There was some degree of uncertainty about the project outputs. In part this reflected the lack of contact and awareness of the detail of what had been undertaken. It also represented a degree of scepticism about the potential for success in mechanically applying lime to subsoils. One respondent suggested that this was just the latest in a long line of attempts to develop such a mechanical process. Two others commented on the need for ‘practicality’ at the producer level in either the mechanical or economic sense, for such technology to be adopted.

Three of the five respondents considered that the project had made an analysis of the distribution

patterns of lime injected into soil which would enable some predictions to be made on the placement of lime using the technique. Two respondents considered that it had made an analysis of the theoretical and empirical design methods for pneumatic conveyancing of powdered lime. They considered it had provided a set of technical specifications for pneumatic equipment to inject lime into the subsoil, sufficient to enable a working implement to be constructed, while 1/5 did not consider that these outputs had been achieved. One respondent considered that an economic analysis of pneumatically injecting lime had been made, while 2/5 thought this had not been achieved.

There were differing views as to who might be the potential users of the outputs. All (5/5) were agreed that they would be used by scientists and researchers in the field of soil acidity. Most (4/5) considered they would be used by the agricultural chemicals/fertiliser industry and by farmers. The one respondent who had actually built and demonstrated a working machine reported genuine interest from farmers and lime spreaders. This same respondent later reported that some horticultural producers had expressed interest in using the technique, even though the economics of doing so were not proven. Another commented that it will be interest from landholders which will drive private enterprise involvement in developing the technology.

Only 2/5 respondents were aware of project results. Sources of information had been from professional colleagues, the Acid Soil Amelioration Review and from access to project reports. There is undoubtedly a network among those interested in soil acidification, but the mechanised injection of lime does not seem to be a high priority issue.

There was a much higher level of interest in the adoption of the results, with 4/5 respondents saying that they would be likely to utilise the results of the project in their own work. Only one respondent was aware of a professional colleague who was using the results of the project. Three out of five said that they had insufficient access to the results to directly use them, though respondents were aware that if they wanted the results they knew where to get them. The general view of the wider adoption scene is that any technique would need to demonstrate economic benefits. One opinion was that the technique would not be viable under present commodity prices.

Only one respondent had changed views on the injection of lime as an appropriate method of ameliorating soil acidity since 1991. Importantly, however, this respondent was working directly in the field of mechanical injection and had changed views because of the results of the project. The respondent was also involved in developing mechanical soil injection and had adapted the equipment being developed in the light of the project findings.

* * * * * * *

4 Conclusions

4.1 Overall Assessment

The project set out to provide an analysis of theoretical and empirical design methods for the pneumatic conveyancing of powdered lime. It did not set out to develop lime injection equipment suitable for general adoption. As the outputs of the project have been taken up by other researchers working in the same field, the project can be considered to have achieved its goal and to have made a specific contribution to the development of techniques of injecting lime into subsoils. The opinions of the respondents suggest that it is an area in which much more work needs to be done before technically and economically robust equipment becomes available for general use.

4.2 Lessons Learned

The results of this project highlight three issues. The first is the difficulty in setting a time span for what, in some terms, can be seen as a straightforward technical development. The second is the potential for a disparity between economic potential and the development of technically workable solutions. The third is the fact that networking and the transmission of ideas are not automatic.

This project set out to analyse design methods for the pneumatic conveyancing of powdered lime. It achieved its objective and provided the results in a form usable by others. However, it is quite clear from the comments of the survey respondents that this is but one step in a process of indeterminate length, to develop a technique of applying lime to subsoils which achieves economically beneficial outcomes and which is directly implementable at the farm level. One respondent commented that this was but the latest in a long line of attempts to develop such a system. Comments such as this do not negate the value of such research. However, they do highlight the need to periodically put developmental research into some time frame to see what progress is being made. The objective of such a review would not necessarily be to require time-related outputs, but rather to ensure that current or proposed work was not going back over old ground and that progress was being made.

The difficulties associated with developmental research can be seen when looking at the history of the development of mechanical harvesting of sugarcane. Attempts to develop mechanical harvesters were spread over almost 20 years with various techniques being tried, such as full cane or chopped cane and cane burnt or unburnt before cutting. The ultimate stimulus to achieve workable mechanical harvesting came when the disappearance of cane cutters created the economic pressure to get the job done. The same situation may well apply with the application of lime to subsoils, where the real impetus may come when farmer demand for a solution applies sufficient pressure.

An objective of the research was to perform an economic analysis of the pneumatic lime-injection system. Several survey respondents made the point that adoption would be dependent on the process being economically as well as technically practical at farm level. One respondent considered that liming of soils was generally uneconomic at current commodity prices This view is disputable in the light of the current southern Riverina experience in the application of lime to soils. It is also disputable from the experience of the Queensland prototype subsoil liming machine which is being actively sought by some horticultural producers, regardless of any immediately apparent economic benefits.

What is not disputable is that farmers will adopt this technology only if they feel that it will in their best interests to do so. This does not necessarily mean that any additional income has to exceed the costs, but it does mean that at least the perceived benefits, direct or indirect, must be believed to outweigh the costs and effort. This suggests that, faced with the problems from indeterminate time scales for developmental research, research managers could use economic analysis techniques to test what economic pressures might exist to drive the adoption process. That is, rather than set out to prove whether or not a particular process is economic, work could be done to assess the potential payoff to achieving particular technical benefits. This in turn could be set against the recent or long-term history of the developmental process and provide some weighting as to the resources which might be applied to competing research proposals and the pace of progress which might be required.

Such studies can be used to identify the benefits which farmers (or any group of potential adopters) see as relevant. Results can then assist in better research project design. That is, projects could be designed to produce outputs in a form which potential adopters could better recognise as having potential benefits, rather than being solely driven by the scientific or technical imperatives. Like so many other elements in research management, this is an imperfect process, but it represents another technique to provide objectivity in selecting between competing opportunities for research, or in assisting in the design projects with perceived merit to better ensure that the desired outcomes are achieved.

The recent national review of the ‘Social and Economic Feasibility of Ameliorating Soil Acidification’* was such a study. This examined farmers attitudes to soil acidification, their priorities for dealing with the problem and some of the economic pressures for solutions to the soil acidification problem. This took social and attitudinal factors into account as well as economic factors. It identified the various barriers to adoption of measures for ameliorating soil acidity. For instance, the economic barriers were lower for intensive producers such as horticulture, than for extensive rainfed farming systems. This fits with the indicated response in the survey, where some better-off horticultural producers are actively seeking to use the Queensland prototype machine.

The Ameliorating Soil Acidification study also highlighted adoption problems arising from lack of information. In this case the project appears to have been undertaken in relative isolation. This fact is shown by the degree of difficulty in finding anyone who was aware of the work for the purpose of the adoption survey. It is arguable that basic work of this

* AACM International Pty Limited (1995). Social and Economic Feasibility of Ameliorating Soil Acidification—a National Review. Canberra, LWRRDC. ISBN 0 642 20604 X

type does not need, or is necessarily helped by, public exposure to long-term adopters such as the farming community. Yet, in this case the one adopter of the project output heard about it informally and tracked it down, with the result that another version has been built which takes the concept further towards a generally implementable solution.

Given the wide diversity of projects undertaken by LWRRDC, forcing some form of external communication process on researchers may be difficult, or in some cases counter-productive. At the same time, to leave the communication process entirely to individual projects may be to miss adoption opportunities through lack of knowledge of what is being developed. One possible way to deal with this would be to introduce some form of monitoring of the networking process with each milestone report. It could be a simple checklist to test the interaction of the project with potential contributors and/or adopters which could alert research managers to the possibility that they may need to prompt some more action on communications by particular projects.

4.3 Follow-up Actions

Work is under way in Queensland on a field-scale machine for applying lime to subsoils. Interest is being shown in the machine by some contractors and farmers. The principal researcher retains an interest in some of the analytical aspects of the work. There may be scope for ongoing interaction between the principal researcher and those developing the Queensland prototype in tackling some of the more theoretical problems which may emerge through greater field experience. The prototype machine may also provide better field level data on costs, which could assist in more accurate assessment of costs and benefits of the application of lime to subsoils.

Annex 1. Project Questionnaire and Responses

Questionnaires sent: 10 Responses received: 5

1. Awareness of the Problem

How did you become aware of, or involved in, the issue of ameliorating soil acidity?	*Yes / No*
– Through media and public discussion	1 / 1
– Technical or scientific journals	3 / 0
– As a farmer or landowner in the region	0 / 1
– As a government adviser or extension officer	4 / 0
– As a researcher in the field of soil acidity	5 / 0
– As a private consultant/adviser	2 / 1
– As an supplier/adviser in the field of agricultural chemicals and/or fertilisers	1 / 1
– Other *(please specify)*	0 / 1

Comments:

- In South Australia, projects on lime have been going on for 25 years in the Department of Agriculture. Also I was approached to be in this project.
- On commencing duties in the DPI, I was directed to undertake research on soil acidity issues. This has also involved extension of results to farmer/Landcare groups
- Our research into effects of cropping on soil fertility on Oxisol soils showed acidification (particularly in subsoils) to be increasingly important
- I was interested in doing further study in soil science in the South Burnett region and was enlightened about the importance of soil acidity to yields in the area, particularly in the subsoil. I had already a basic knowledge of soil acidity issues from a degree in agriculture and a position as an extension officer in land management

If you were aware of the issue prior to 1991 did you see it as being:

	Yes / No
– Not a serious issue	0 / 0
– An important issue which would resolveitself over time	0 / 1
– An important issue needing specific action to define solutions	5 / 0
– An urgent matter needing critical action	1 / 0

Comments:

- Surface lime application methods available. The problem of subsoil acidification difficult to address, especially under rainfed cropping
- As an undergraduate I felt "on the ground" activity to find practical workable solutions was the way to go when addressing soil management issues

2. Connection to the Project

	Yes / No
Were you connected to the lime subsoil application project in any way?	1 / 4
If yes, how were you connected?	
– Through local land-based/farming activities	0/0
– As a professional adviser or regulatory officer with government or statutory body	1/0
– Through research in a related field	1/0
– Other *(please specify)*	0/0

Comments:

- Our Soils Branch in SA Department of Ag conducted trials, surveys etc. Knew about this project and was interested
- It was only after the project was finished that I heard about it. I then requested a copy of the final report from LWRRDC and subsequently contacted Simon Murray
- Not connected with the project at the time

3. Project Output

What do you see as the output of the project?	*Yes / No*
– An analysis of the theoretical and empirical design methods for pneumatic conveyancing of powdered lime;	2 / 1
– A set of technical specifications for pneumatic equipment to inject lime into the subsoil, sufficient to enable a working implement to be constructed;	2 / 1
– An analysis of the distribution patterns of injected lime in soil which would enable some predictions to be made on the placement of lime using the technique	3 / 0
– An economic analysis of pneumatically injecting lime which compared this technique with the alternate methods of top-dressing or incorporation of lime in the topsoil.	1 / 2
– Other *(please specify)*	1 / 1
– None of the above	1 / 1

Comments:

- Yet another machine/process for the application of limestone to subsurface soils
- I have lost contact with this project, so am not familiar with its final output

- I had some difficulty with the 'economic analysis' since the technology was apparently not tested in the field trial(s) where crop/pasture growth could be measured at a site where acidity was limiting production
- My main contact has been with design of a machine to inject lime into subsoil and specifying distribution patterns
- I have come into contact with a pneumatic lime applicator which was built, I assume, with reference to the results of this project. While it did work, I'm not sure I would call it practical (in a producer's sense of the word) and will definitely require improvement

Who do you think would be the potential users of the output of the project?	*Yes / No*
– Farmers or other landowners	4 / 1
– Government advisory or extension officers	3 / 0
– Persons associated with the agricultural chemicals and/or fertiliser industry	4 / 0
– Scientists and researchers in the field of soils and soil acidity	5 / 0
– Private professional advisers in agriculture or environmental science	3 / 0
– Other *(please specify)*	1 / 0

Comments:

- Many trials have been done over the last 15 years on liming subsurface soils
- Since building a pneumatic lime injecter in Queensland, using it to establish a number of field trials and presenting it at talks and field days, it has generated interest from farmers and lime spreaders
- Before farmers/commercial operators adopt this, the machinery needs to be further developed and responses quantified under different cropping systems
- If landowners show interest, or begin to adopt the technology, this will drive the involvement of private enterprise

4. Awareness of the Results

	Yes / No
Are you aware of the results of the project?	2 / 3

If yes, how did you find out?

– Don't know what the final results were	0 / 1
– From a professional colleague	2 / 0
– Through the Acid Soil Amelioration Review	1 / 1
– Through formal contact with the project	0 / 1
– Through access to milestone and final reports	1 / 0
– Other *(please specify)*	0 / 0

Comments:

- I haven't seen any published results yet
- I haven't followed it up. Many of our clients in SA do not have acid subsoils, so it is not top priority for us
- Richard Merry (CSIRO Adelaide) mentioned that LWRRDC had funded a project looking at pneumatic injection of lime. I subsequently obtained and read the final report
- Main contact through DPI Indooroopilly (Bob Aitken/Phil Moody) Acidification Project and construction of machine using project outcomes
- Would certainly like to know the results of the project

5. Adoption of Research Results

	Yes / No
Are you likely to utilise that results of the project in your own work?	4 / 1
If yes, do you consider that you have had adequate access to the results to directly use them?	1 / 3

If yes, how did this come about?

- After reading the report I contacted Simon Murray. On deciding to build a modified pneumatic injecter, DPI Agricultural Engineering staff visited Simon at Armidale to inspect and discuss his injecter
- Have not had sufficient access to the results to use them at this stage

If not, why not?

- None of the trials on subsurface lime application have ever given economic responses
- It is up to me to follow them up if the results are needed
- Have not yet seen final copy of project report

Do you consider the results of this project are ready to be put into practice?

- Don't know

If yes, how?

If not, what else needs to be done for the findings to be put into practice?

- The value of agricultural produce needs to increase in order to make such technology cost effective
- Benefits of subsurface placement and economics have to be demonstrated. Also, I believe we need to be able to identify situations where subsurface acidity is limiting, so that it is economic for farmers to use this technology. Despite this, there are a number of farmers who have seen our pneumatic injecter and want to use it irrespective of economics. These are horticultural producers who might be 'better off' economically and know they have subsoil acidity
- Machinery design perfected for broadacre cropping/agriculture. Benefits need to be quantified under different cropping systems

	Yes / No
Are you aware of other professional colleagues who are using the results of this project in their work?	1 / 4

If so, how is it being used? *(if possible, please give a contact name which we could use for follow-up)*

- Bob Aitken (QDPI Indooroopilly) and Graham Kingston (BSES Bundaberg) evaluating subsoil lime injection under cane. This is in addition to our work in the inland Burnett with J Clarke's PhD project

Have you views on the injection of lime as an appropriate method of ameliorating soil acidity changed since 1991?	1 / 3
If yes, has the work of this project had any influence on your views?	1 / 1

If so, in what way did it influence you views?

- In Queensland, I had see one or two failed attempts by individual farmers to build equipment for direct placement of lime into subsurface soil. The project and final report indicated that it was possible. This convinced me that we should trial similar technology in Queensland, where we knew we had acidic subsoils. Although the injecter we built is quite different from that of Simon Murray, his work provided the impetus for our work. Based on Simon Murray's project and our trial work here in Queensland, I believe that pneumatic injection is an appropriate method. I had previously looked at slurry injection and did not think it would readily be adopted by farmers.
- I have yet to be convinced we can get product deep enough to make a big impact in rainfed cropping systems in dryland areas

Other comments:

- Given that wheat prices are climbing steadily and world's food reserves are declining, it may be simply a matter of time before Murray's machine becomes a viable proposition for commercial farmers

Evaluation No 9. Ref. No: NDW1

Use and Management of Native Vegetation for River Bank Stabilisation and Ecological Sustainability

Contents

List of Tables

1 Background

1.1 Rationale

Various issues of concern in riverine management are amply demonstrated by the present condition of the rivers of the north coast of New South Wales. In brief these are:

– Loss of riparian vegetation, where the riverine corridor often contains the only significant remnant lowland rainforest vegetation in many coastal valleys;

– Major land degradation through the loss of productive floodplain lands through streambank erosion and floodplain stripping;

– Loss of ecological sustainability and habitat diversity of the riparian corridor through the destruction of vegetation, and the effects of erosion and estuarine sedimentation leading to a loss in aesthetic value, water quality, aquatic habitat and genetic diversity of the riparian corridor and potentially to the loss of a major economic and environmental resource.

It is considered that these issues highlight the gains which could accrue from greater public awareness in the benefits and value of riverine vegetation and riverine corridor management.

1.2 Project Arrangements

The formal project arrangements were:

Implementing agency:
NSW Department of Water Resources (DWR) (now Department of Land and Water Conservation DLWC)

Principal investigators:
Mr John Gardiner, Muswellbrook
Mr Allan Raine, Grafton

Submission date:
August 1991

Start/finish dates:
1 October 1991 to 28 February 1994

Third parties:
Greening Australia (GA)
NSW Forests (NSWF)
Department of Conservation and Land Management (CALM)
Hunter Valley Catchment Trust (HVCT)

1.3 Objectives and Scope

Scope of the project

The project poposed that greater public awareness of the benefits and value of riverine vegetation and riverine corridor management would lead to significant benefits in overcoming issues of environmental loss and degradation. Key elements of any program to achieve such gains were considered to be:

– Increased knowledge of the diversity and condition of the riparian vegetation on the north coast;

– The suitability of particular plant species for solving specific erosion problems;

– Identification of those rare and endangered species in need of protection;

– Assessment of the potential of riverine vegetation in agroforestry; and

– Freely available information on species, planting methods and erosion control techniques for use by all those interested in, or associated with, riverbank erosion, agroforestry and ecological management.

It was proposed that improved skills and ability to manage riverine areas could flow only from increased knowledge and awareness of the value of riverine vegetation, which in turn would lead to improved ecological sustainability of the riverine corridors.

Objectives

The objectives of the original proposal were:

1. Provide resource managers/community with:

   a. a list of species suitable for replanting for bank stabilisation and ecological sustainability of riparian corridors along each catchment;

b. a photographic record and easy key for plant identification in the field to be used in assessing various channel management activities such as tree destruction, channel modification and water abstraction;

c. a guide to planting, maintenance techniques and suitability of species to certain situations and locations; and

d. a list of species potentially suitable for agroforestry.

2. To increase knowledge about riparian vegetation along the north coast.

3. To provide information/education to landholders, schools, TCM committees, Landcare groups, TAFE colleges etc, by;

a. the production of a video outlining problems and presenting possible solutions;

b. the production of a valley-specific kit and complementary documentation; and

c. organising field days.

The timetable proposed for the project in the original submission was as follows:

Date for completion	Description of milestone	Achievement criteria
October 1992	− industry consultation	− liaison and summary reports of industry discussions
	− literature review	− summary reports of relevant literature
	− field investigations of five of nine major north coast river valleys	− site map produced from examination of aerial photography and topographic maps
	− identification of representative sites to be used in video	− preliminary plant list (including species and site descriptions)
	− scripting and initial production of video	− production of rough-cut of video
October 1993	− completion of field investigations of the remaining four river valleys	− preliminary plant list (including species and site descriptions) for the remaining four river valleys
	− completion of documentation and site specific erosion kit	− preparation of draft valley specific kits (600 to be produced)
	− completion of video; scripting, editing and final production	− production of 100 final video copies
	− dissemination of video and site specific kits	− outline of individuals/bodies/groups to which videos/kits are sent
October 1993	Final report	Acceptance of the report by LWRRDC

1.4 Financing Arrangements

Proposed project funding was $207,124 to be divided between four parties. LWRRDC was to provide $119,091 (57.5%), the research organisation, NSW Department of Water Resources (DWR) $59,533 (28.7%) and the third parties a combined $28,500 (13.8%), being $19,500 from GA and $9,000 jointly from the NSWF, CALM and HVCT. Details are given in Table 1.

The original submission made no proposals on the sharing of intellectual property and project income.

1.5 Completion

The project was completed at the end of September 1994, three months after the scheduled completion date. The final report was published as an occasional paper by LWRRDC in 1995.

1.6 *Ex-Post* Evaluation

This evaluation report focuses on pertinent aspects of the project and presents the findings of the *Ex-Post* Evaluation (EPE). The EPE is based on documents provided by LWRRDC as listed, detailed discussions with the principal investigators and a survey of identified potential users of the project outputs and other acknowledged sources of information.

In preparing the evaluation the reviewers have had access to the following documents:

1. December 1995—Project schedule prepared by LWRRDC

2. August 1991—Original submission to LWRRDC

3. February 1993—Letter from LWRRDC following up on first milestone report

4. Undated—Second milestone report

5. August 1994—Letter from LWRRDC following-up first draft final report

6. September 1994—Draft final report

7. December 1994—Letter from project coordinator to LWRRDC

8. 1995—*Rivercare—Guidelines for Ecologically Sustainable Management of Rivers and Riparian Vegetation*. LWRRDC Occasional Paper Series No. 03/95

Table 1. Original budget for funding sources and expenditure

	1991–92	1992–93	1993–94	Total	Percent
Salaries	20,622	18,718	9,129	48,469	40.7
Operating	720	1,400	9,400	11,520	9.7
Capital	22,538	22,538		45,076	37.9
Travel	7,080	5,163	1,783	14,026	11.8
Adoption					
Total LWRRDC	50,960	47,819	20,312	119,091	57.5
Research organisation	21,158	28,585	9,790	59,533	28.7
Third Parties	9,500	9,500	9,500	28,500	13.8
Total funding	**81,618**	**85,904**	**39,602**	**207,124**	**100.0**

Source: Application

2 Implementation Performance

2.1 Design

To facilitate an objective review of the project, the original objectives in Section 1.3 are restated in terms of the logical framework approach.

Goal:
To improve the quality of the environment through developing more sustainable approaches to riverine vegetation management.

Purpose:
To reduce the loss of ecological sustainability of riparian corridors.

Outputs:
A systems approach to the management of riparian corridor vegetation for ecological sustainability.

A list of species suitable for bank revegetation and techniques for their planting and management.

Specific communications packages to heighten community awareness of the consequences of poor riverine vegetation management practices and the techniques available for improved river management.

Inputs and activities:
Preparation of an inventory of existing native/riparian vegetation of north coast river valleys.

Investigation of different approaches to riverine corridor vegetation management through observation, literature review, review of existing revegetation works and planting trials.

Development of a photographic record and easy key for selected species.

Preparation of management and information kits for specific river valleys and/or erosion problems.

Production of community awareness material, particularly a video, illustrating riverine corridor management problems and demonstrating methods of managing erosion problems, suitable vegetation and ecological benefits of revegetating river banks.

2.2 Outputs

The final form of the project outputs evolved during its life. The initial intentions were to produce some form of guide or handbook for riparian landholders and others with an interest in riverine corridor management. The focus was on the use of riverine vegetation as a means of river bank stabilisation and creating ecologically sustainable conditions in riparian corridors. The principal researchers say that during the project a series of interactions with their own government department, with the steering committee and other landholders, with LWRRDC and with the producers of the video, led them increasingly to see that underlying their specific approach was a set of management principles that had general application. The final effect is that the key output of the project is a conceptual approach to riverine corridor management, supported by specific outputs on planning techniques, educational material on the planning concepts and a series of river management plans in varying stages of implementation.

The actual outputs of the project were:

- A systems approach to riverine corridor management based on vegetation management.
- A specific program,—*'RIVERCARE'*—a users guide to effective and inexpensive river maintenance practices, community programs and channel stabilisation techniques, together with an accompanying explanatory video.
- The production of three *'RIVERCARE'* plans embodying the methodology, with another 17 plans in various stages of production, covering about 600 km of badly degraded sections of rivers in New South Wales.
- A video, *'The State of the Rivers'*, presenting an overview of acute problems facing rural communities as a result of poor river management practices.
- A list of species suitable for planting for riverine bank stabilisation in individual catchments, with brief morphological descriptions, post-planting management requirements, indication of other uses and role as wildlife habitat to assist in species selection and management.

2.3 Organisation and Management

The principal researchers report an effective interaction with LWRRDC from the outset. The

project originated as two separate proposals, one for a guide to river training and engineering works, the other for a manual to identify vegetation which could be used for riverbank stabilisation. At the suggestion of LWRRDC the two proposals were merged into a single project with emphasis on producing usable information for riparian vegetation management and the transfer of this information at the community level.

The evolution of the project from emphasis on hard facts towards the development of a riverine vegetation management model was strongly supported by LWRRDC. This support was emphasised by the publication of the project final report as a LWRRDC occasional paper after the project completion.

The project operated with community involvement and was able to make effective use of some non-project related community funding programs for drought relief and labour-market development to undertake some of the implementation work. This served to stretch the funding base and provide more direct implementation capacity than was available from the project budget.

2.4 Contact with Potential Output Adopters

The project worked with a steering committee which was a subcommittee of the Manning River Catchment Management Committee. The membership was predominantly local landholders whose interest was focused on the river management process and how it was controlled. The principal researchers report the interaction as very much a bottom-up process. The landholders were able to directly provide their perceptions of how they thought the river management process should operate and what they saw as the limitations imposed on the process by the requirements of the various government agencies involved. The principal researchers were able to exchange their ideas with riparian landholders directly involved in the problem and to test concepts face-to-face.

The principal researchers report two additional consequences of their close involvement with landholders. One was that the landholders took the initiative in flow-on activities from the project. The same committee went on to establish a water monitoring process involving the collection of samples according to strict protocols at points along the river and sending these for analysis. The other was that the interaction amongst landholders, especially visits to other farms upstream or downstream, provided a form of conflict resolution process with enabled the working out of some non-project related problems associated with the use and management of the river.

2.5 Dissemination of Results

The principal researchers both had a professional background in extension activities and in working with landholders in land planning activities in farm water supplies and soil conservation. They were therefore well equipped to handle the communication process with potential users of the project outputs and were sensitive to the landowner/community perceptions of the problem, as distinct from the research perspective.

The project made effective use of existing landholder/land management structures, particularly Landcare groups. The original research was conducted within one group (Mt George) and, with the assistance of the regional Landcare coordinator, was extended to a number of other groups within the Manning River catchment and beyond.

At the completion of the project, groups which had started to adopt the results included Pappinbarra, Ellenborough and Kangaroo Creek Landcare Groups, the Upper Taylor's Arm Catchment Protection Group, the Paddy's Line Rivercare Group and the South Creek (Nambucca Valley), and Plain Station (Clarence River) Landcare Groups.

The project final report listed the communication and technology adoption activities as:

- Videos
- Promotion—cross country
- Development of a promotional display
- Attendance and participation in conferences as well as presentation and reports
- Rivercare plans currently in production
- Distribution of videos, promotional material and 'How to' booklets to:
    - catchment management committees
    - numerous Landcare groups
    - other government agencies
    - appropriate libraries
    - schools and other educational institutions
    - individual landowners

2.6 Actual Cost and Financing

Table 2 summarises the actual funding sources and outlays, while Table 3 compares budget and actual expenditure. In the final event, expenditure and sources of funds were almost exactly on target, though the final payment from LWRRDC extended into the 1994–95 year, reflecting the fact that the project was three months late in finishing.

There was a minor discrepancy between budget and actual, where outlays were $1,026 greater than budget.

Final agreed apportionment of intellectual property/ project income was 60% to LWRRDC and 40% to the research organisation (DWR) and the third parties, GA, NSWFC, HVCT and CALM.

Table 2. Summary of actual funding sources and annual outlays

	1991–92	1992–93	1993–94	1994–95	Total	Percent
Salaries	20,622	18,717		10,156	49,495	41.2
Operating	720	1,400	9,400		11,520	9.6
Capital	22,538	22,538			45,076	37.5
Travel	7,080	5,163	1,783		14,026	11.7
Adoption					0	0.0
Total	50,960	47,818	11,183	10,156	120,117	57.7
Research organisation	21,158	28,585	9,790		59,533	28.6
Third parties	9,500	9,500	9,500		28,500	13.7
Total funding	**81,618**	**85,903**	**30,473**	**10,156**	**208,150**	**100.0**

Source: Project schedule

Table 3. Comparison of budget and actual outlays #NDW1

		1991–92	1992–93	1993–94	1994–95	Total	Percent
LWRRDC	Budget	50,960	47,819	20,312	0	119,091	
	Actual	50,960	47,818	11,183	10,156	120,117	
	Difference	0	−1	−9,129	10,156	1,026	0.9
Third Parties	Budget	9,500	9,500	9,500	9,500	38,000	
	Actual	9,500	9,500	9,500	9,500	38,000	
	Difference	0	0	0	0	0	0.0
Total	Budget	81,618	85,904	39,602	0	207,124	
	Actual	81,618	85,903	30,473	10,156	208,150	
	Difference	0	−1	−9,129	10,156	1,026	0.5

Source: Data in Tables 1 and 2

3 Adoption of Results

3.1 Survey

A survey was undertaken of 24 persons identified as having had direct or indirect contact with the project during or since its operation, who were likely to be interested in the adoption of the project output. These included a number of landowners who had been associated with the project at the outset, members of Landcare groups and professionals in the field of environmental and river management. A total of 18 responses was received which covered the full range of interest groups contacted. Respondents included seven government officers in the field of environment, river management and forestry, five from Landcare or total catchment management (TCM) groups, four farmers/landowners, one privately employed environmentalist and one professional cinematographer who made the project video.

The detailed results of the survey, including respondents comments, are given in Annex 1. The numbers used in the analysis represent specific responses to options offered, ie. *Yes/No*. In most questions the options were not mutually exclusive, and neither were the respondents required to mark every option. The numbers therefore represent the conscious choice of respondents indicating their attitude on a specific matter. In this survey, a number of respondents had obviously marked a *no* answer in order to highlight their selection of *yes* for one or more of the other options. Not all respondents answered every question. For most questions, respondents were offered space to record a comment to supplement or expand their response. All the respondents comments are included in the analysis of the questionnaire in Annex 1.

3.2 Findings

There was a high level of awareness of the issue of riverbank erosion among the survey group. Most respondents were involved in some aspect of the issue of riverine management. Four of the respondents had been directly involved at one time or another as technical assistants in the project. All of them remain involved in river management work and implementation of project results.

Half (9/18) were landowners, all of whom had come looking for assistance to deal with the problem of riverbank erosion. Some had been involved in the project field work and the project had in fact grown out of attempts to deal with their initial problems. Others had found out about the project outputs through involvement in Landcare or TCM groups which were actively addressing riverbank erosion issues.

The level of involvement of respondents in these issues is highlighted by the relatively small number of respondents (4/18) who identified media, public discussion or publications as their source of information about the project. Most knew about the project because they were directly involved.

Several respondents gave no indication of their perception of the level of seriousness of the issue before 1991, on the basis that they were not involved at that time. Those who were involved, ranked the issue as either important needing specific action (10/18), or an urgent matter needing critical action (9/18). Several respondents answered *Yes* to both propositions. Those who gave *No* answers to one or more of the options, did so to highlight their *Yes* answers to other options.

Thirteen respondents had some connection to the project, though in diverse ways. Six were employed by government departments or agencies directly involved in river management or environmental issues. Most of these were involved in parallel work and were associated with the principal investigators through shared interest in the technical area. Four owned land on which project activities were undertaken. Three were Landcare coordinators who sought out the principal investigators to see how project findings could be implemented through their own activities. One was involved professionally in making the project video.

Respondents were divided on their attitude to whether there was sufficient involvement of interested parties beyond the project, while it was in progress. Just over half (9/18) considered that there has been adequate involvement of the full range of those with a direct interest. The remainder were virtually equally divided (5 and 4/18 for each) on the view that some groups were well represented and others not, or that there had been inadequate linkage between the project and potential users.

This finding needs to be interpreted with care. This is a project that had a very high degree of community-level interaction. It is therefore surprising that there were any *Yes* answers to the second or third options,

that there had been uneven or inadequate involvement of interested parties. It seems to be a matter of interpretation of the question. When the *Yes* answers are linked to the associated comments, it seems that these respondents are expressing a *post*-project view of the level of community involvement. They are saying that there is *now* an inadequate linkage between the project (really the project outputs) and the potential users. The comments indicated a view that the community is not taking the problem seriously enough, or that government was not providing the level of resources to get adequate adoption of the results.

There was a high degree of recognition of the project outputs. Two outputs; the list of species for riverbank stabilisation and the specific methodology for river maintenance practices, were recognised by 16 and 17 of the 18 respondents. Three-quarters of respondents (14/18) recognised all the other outputs (video, 'RIVERCARE' plans, better informed management agencies and a systems approach to riverine corridor management). The somewhat smaller number recognising the second group of outputs reflected the respondents degree of contact or involvement with the 'RIVERCARE' approach. The *No* answer to the video outputs was because the respondent had not seen the video. The other two *No* answers indicated that the respondents did not believe that output had been achieved.

A wide spectrum of users of project outputs was recognised. Respondents were unanimous (18/18) that farmers/landowners were potential users of the project outputs and nearly so (17/18) for government agencies and local councils. A slightly smaller number (14/18) thought that environmental scientists would use the results and (12/18) thought the same for private professional advisers in agriculture and environmental science. In addition, a number pointed to its usefulness for environmental education is schools and community awareness and that 'RIVERCARE' activities had been used in employment generation schemes. One respondent put the view that the planning process developed in 'RIVERCARE' had the potential to be used by anyone in the resource management field.

There was a high level of awareness (15/18) of the project results, with many respondents indicating more than one source of the information of project outcomes. The main source was through formal contact with the project (10/18), through involvement in developing 'RIVERCARE' plans (9/18), from professional colleagues (7/18), through seeing the project video (8/18) and access to project reports (6/18). The three respondents who indicated that they were unaware, interpreted the question more narrowly—that they were unaware of all the results, or of the formal results.

There was wide acceptance of the manner in which the results were presented. Most (14/18) considered that they were presented in an easily understandable manner, while an obviously smaller group (8/18) considered that their professional training assisted in their understanding. The invitation to comment on the presentation of results produced several specific comments. One was that many of the farmers learn from talking and that the 'RIVERCARE' forums were very informative in getting the message across. The brochure of species lists was considered to be the most readily useful part for community groups.

There was a division of opinion as to whether the results were available in a timely manner or not. A number of respondents indicated that they simply did not know whether this was so, or that in their context, it did not particularly matter.

Virtually all respondents (17/18) considered that they would use the results of the project in their professional work. This is not entirely surprising given the self-select nature of the survey group. A number pointed to personal contact with one or other of the principal researchers in the course of their professional work. The general comment from the four respondents who indicated that they had insufficient access to the results to use them, was that the reports were not readily available or that their existence was not widely known.

There was a virtually unanimous view that the results of the project were ready to be put into practice. Most respondents pointed to 'RIVERCARE' activities already under way. There were some reservations, though these were largely in terms of the implementation rather than the methodology. Some pointed to the need for, or difficulty of getting, community support. However, more respondents emphasised the fact that 'RIVERCARE' could be implemented at community level as a strength of the system. Some thought that, to get the findings put into practice, more could be done in the area of extension and localising technical information and developing community awareness of the availability of information.

Eleven respondents were able to point to instances where professional colleagues were using project outputs. This group was not just confined to the government officers, but included some involved in Landcare and TCM activities, and farmers.

In the final evaluation, the restated objectives and the description of outputs were accepted by three-

quarters of the respondents (14/18 and 13/18). With the exception of one *No* for each alternative, the remainder did not offer a view. The two *NO* responses were both on technical grounds and represented differences of degree rather than fact. One thought that a 'systems approach' had been initiated but needed more DLWC funding to be implemented adequately. The other opinion was that the proposed output of specific communications packages to heighten community awareness needed more work.

Fourteen respondents considered that their views on riparian management had changed since 1991, while two thought they had not. Both of these latter respondents said, however, that the project had served to confirm views they had held before it started. Both indicated that they felt that the work had raised the awareness and enthusiasm of the community towards the problems of rivers. Some important points were highlighted by respondents. These included the need to listen to farmers and negotiate solutions rather than telling people what to do. Also, the view was put that streambank management could be undertaken by landowners with minimal government agency control. Respondents also confirmed that the 'RIVERCARE' approach had heightened the awareness of the riverbank erosion as part of a system and not a problem in isolation.

* * * * * * *

4 Conclusions

4.1 Overall Assessment

This has been a particularly successful project, both in terms of the acceptance of the outputs and the level of adoption. There is a broad group of those associated with the issue of streambank erosion, including landholders, professional environmental planners and advisers and senior government administrators, who clearly understand what are the outputs of the project and how they can be used. Many of these consider that the output of the project has changed their perception of how to approach the problem. In the space of less than three years since the project was completed, there are over 30 groups involved in the development and implementation of 'RIVERCARE' plans in river valleys from the Hawkesbury to the Queensland border.

Despite this success, there appears to be a sense of frustration among many who are associated with the implementation of the 'RIVERCARE' approach. This stems from the feeling that insufficient resources are committed to supporting the implementation. It also relates to the perception that, at an official level, the implementation process is no longer following the principles and procedures developed by the project.

4.2 Lessons Learned

Both the positive and negative outcomes of this project suggest some general lessons for the broader issue of the adoption of research outcomes.

The first lesson relates to the rapid rate of adoption of the project outputs. It is considered that there were two elements which enabled this result to be achieved. Most importantly, at the time the project was undertaken the problem addressed was widespread and many landholders and other concerned individuals were looking for solutions. What enabled the results to be translated into action so promptly, however, was that the pressure for outcomes which existed was adroitly managed by the principal researchers. It worked because the pressure for adoption came from the bottom-up as well as from the top down. The research was carried out with the active involvement of those who would be most likely to use the outputs. Accordingly, the outputs were largely presented in a form which the adopters could most readily understand.

The project originated with some landholders seeking departmental advice on how to proceed with a riverbank stabilisation program. At the time, concepts of using riparian vegetation to provide an 'ecological' approach to riverbank management were being developed in the DWR. In this particular case, the officer who provided the advice to the landholders recognised that there were more-general principles of stream bank and bed management which could be developed by combining the traditional engineering approach with the vegetation management approach. The merging of these concepts was then developed into a research proposal which became the project under review.

The approach was also successful because the two principal researchers both came from an extension

background. They were familiar with techniques of expressing ideas and with managing group dynamics. With their professional experience they found developing a high level of interaction with potential adopters a relatively straightforward matter. When allied with a group who were actively seeking solutions, it was a powerful synergy of experience and need. In a more general sense, these circumstances would not often be available. However, the concept of the researchers building their approach to problem solving by starting with the potential adopters and developing solutions in tandem with them is one which could be seen as having more general application.

The second lesson is considered to be that a high level of involvement of actual or potential adopters in the research activities does not guarantee a flow-on of adoption. The 'RIVERCARE' concept works best with group action. While each landholder can apply the principles to their own section of river, results are best gained when these actions are coordinated into an overall plan for a length of river.

Many Landcare and TCM groups have taken the initiative in seeking out information on 'RIVERCARE' to implement in their local area. However, they need professional assistance in preparing the plans needed. The DLWC, as the responsible government agency, employs specialist officers to provide this professional assistance to landholder groups. The rate of actual implementation of the 'RIVERCARE' principles is therefore dependent as much on the availability of these resources to prepare and supervise plans, as on the willingness of landowners to take action.

In a general sense, there is always a hazard for the adoption process where the implementation of research outcomes is dependent on third party actions. In such a situation, the process can become captive to events or objectives which are beyond the scope or influence of the particular research project or agency. In the case of 'RIVERCARE', the availability of resources for implementation has been influenced by general government budgetary constraints where priority has been allocated to other areas. They have also been influenced by a restructuring of government departments which has seen administrative responsibilities moved around, with the flow-on consequences being felt at the local office level where services are provided to landholders. There is also the prospect that in formalising the adoption process, the third party changes the nature of what is being implemented to suit its own priorities. This appears to be the case with 'RIVERCARE' in the DLWC.

4.3 Follow-up Actions

The evaluation survey identified several areas where more work could be done. More localised list of appropriate species to be used for riverbank planting was one. Another was the development of more material in 'RIVERCARE' concepts for use in environmental education in schools. Both of these would seem to be more within the sphere of an implementing agency than a research agency.

Annex 1. Project Questionnaire and Responses

Questionnaires sent: 24. Responses received 18.

1. Awareness of the Problem

How did you become aware of, or involved in, the issues of riverine management, such as land degradation, loss of flood plain lands and the loss of ecological sustainability through streambank erosion and the loss of riparian vegetation?	*Yes / No*
– Through media and public discussion	2 / 4
– Technical or scientific journals	2 / 3
– As a farmer or landowner in the region	9 / 3
– As a government adviser or extension officer	6 / 1
– As a scientist/researcher in a related field *(please specify)*	5 / 3
– As a private consultant/adviser	2 / 3
– Other *(please specify)*	3/1

Comments:

- I carried out a survey of riverbank vegetation in the Hunter Valley in 1987 and had worked with John Gardiner at that time
- DLWC Rivercare Officer. Honours student doing research on riparian habitat requirements.
- As an environmentalist
- Through Brunswick Catchment Management Committee
- It was a continuation of a 25-year river erosion project we had at 'Tiri' with the NSW Water Resources Department.
- Had worked on specific problems with the former Department of Water Resources.
- The lack of water for irrigation due to erosion and build-up of gravel in waterholes highlighted the need to do something. We went to Landcare for help and gained awareness of 'RIVERCARE' through that.
- I became aware of problems with the river through a landowner friend in an affected area.
- I assisted John Gardiner in the development of the first 'RIVERCARE' plans. I have worked with John for 16 years in river management.
- My background is hydrology and bush vegetation.
- Forest ecologist (SFNSW), restoration ecologist. Flora and fauna research – habitat assessments (including riparian habitats).
- I worked for six years as a Landcare coordinator. The main issue Landcare Groups are dealing with here is streambank erosion.
- I was employed as a Technical Assistant on the project, working with Allan Raine on Brunswick catchment and later by myself (and with work experience students) on the Tweed catchment.
- As a landowner on the Namoi River, with degenerating river banks and a non-functioning river, silted and blocked with logs.

If you were aware of the issue prior to 1991 did you see it as being:	*Yes / No*
– Not a serious issue	0 / 5
– An important issue which would resolve itself over time	1 / 5
– An important issue needing specific action to define solutions	10 / 1
– An urgent matter needing critical action	9 / 1

Comments:

- In the Hunter Valley, funds were available through the Hunter Trust for streambank stabilisation, however, greater use of native plants was an aim of my study
- Often the urgency is in the instigation of the planning and application. Neither will be realised without the background such a report provides.
- Mainly through personal observation of our local degraded watercourse.
- Not aware of the issue pre-1991.
- An urgent matter needing attention, but cost being a limiting factor.
- We were Government with engineering ideas. Landowners saw us as "Big Brother"
- Prior to 1992 I was unaware of the broad scale implications of vegetation management in the riparian zone.
- I have been working for the past 20 years to heighten community awareness of these problems.
- Major problem with 50+ Landcare groups involved. No knowledge existed re native vegetation.
- Property bought in 1991.
- I saw the issue as paramount in maintaining life support systems (for humans in the planetary biosphere) and decided to invest my life energies in rectifying the situation through positive action.
- Formed a Landcare Group covering about 22 km of the Namoi River

2. Connection to the Project

	Yes / No
Were you connected to the riverbank stabilisation and sustainability project in any way? If yes, how were you connected?	13 / 2
– Through local land-based/farming activities	5 / 3
– As a professional adviser or regulatory officer with government or statutory body	6 / 1
– Through research in a related field	2 / 3
– Other *(please specify)*	6 / 1

Comments:

- I acted as a referee to the project, providing comment on research design and draft publications.
- As a Landcare group 'leader' I discussed various projects and techniques with Allan Raine. Our group is participating in direct seeding and long stem tubestock trials.
- We owned the land and riverbank involved in work.
- Worked with Allan Raine for the Dept of Water Resources. We were very understaffed, covered the north coast region and had to cope with wide range of water-related issues. This meant we discussed many observations and problems together. Was often consulted on my thoughts of eg. developing a brochure identifying relevant species for specific catchments.
- I am a Landcare Coordinator and TCM committee member.
- Landcare member.
- Writer/director of video
- Saw problem through friend's property and helped in work.
- I have worked in the field of river management since April 1980, surveying, drafting, designing.
- I aided Allan Raine in some basic field work and paper preparation.
- Provided planting advice and species identification to project.
- I was on the research team with Allan Raine. We surveyed the Brunswick catchment together and co-authored the Brunswick report. Also as a private adviser in rainforest rehabilitation.
- Tarriaro Landcare ('RIVERCARE').

If you were connected to the project, do you think that there was sufficient involvement of others beyond the research team to ensure awareness and information transfer to those who could use, or contribute to the practical adoption of the research results?

	Yes / No
– There was adequate involvement of the full range of those with a direct interest	9 / 2
– Some groups were well represented, but others were not	5 / 3
– There was inadequate linkage between the project and the potential users of the research output	4 / 3

Comments:

- To my knowledge, a broad range of community and agency input was sought
- Attention was given, not just to those involved in government departments. It is the job of the extension officer to relay this information to the landowner, community groups, councils etc. It is also beneficial to have the various legislative requirements outlined.
- DLWC are critically under-resourced to provide adequate support, information transfer and overseeing of riparian activities.
- *Some excellent work. High community demand for this information, but we haven't marketed the products* or *made products readily available for those who seek them.*
- The community-at-large was not behind the concept of vegetated river banks or stock control at watering points.
- Difficult to convince others than the owners of land along the river of the broader impact of river degradation.
- Adequate involvement of all involved, but lack of ground staff is limiting factor.
- Essentially those on the land saw and supported the project. It took the bureaucrats a long time to get the message.
- Met water resources people at sites and field days.
- Too many people in the initial stage would have slowed the project down. Our own Head Office was against the project in the beginning. They have now taken credit for it.
- Both Allan and John have a background of community/landholder advice. Thus they had constant contact, which by the way, delayed the completion of the project.
- This project has suffered from some political interference, however the community remains eager to get the information, (particularly 'local' information).
- I believe Landcare Groups could have been more actively involved in this project.
- Both Allan and I addressed the Tweed TCM Committee on separate occasions, but no action followed. The Brunswick TCMC has been very positive in its approach to riparian issues and has conducted field days with good community response and positive results.
- Only some members of our Landcare Group were actively involved. Not all river landowners joined Rivercare.

3. Project Output

What do you see as the output of the project?

	Yes / No
– A video, presenting an overview of problems facing rural communities as a result of poor river management practices.	14 / 1
– A list of species suitable for planting for riverine bank stabilisation in individual catchments to assist in species selection and management.	16 / 0
– A specific methodology to guide users to effective and river maintenance practices, community programs and channel stabilisation techniques.	17 / 0
– The production of actual and draft 'RIVERCARE' plans based on the methodology.	14 / 0
– Better informed government/river management agencies and therefore better extension advice on river management issues	13 / 1
– A systems approach (integrated management) to riverine corridor management.	13 / 1
– Other *(please specify)*	2 / 0
– None of the above	0 / 0

Comments:

- Whilst concentrating on north coast streams and hence providing examples specific to these in some instances, the generic 'RIVERCARE' assessment process and planning methodology has been eagerly adopted in the Hunter and other catchments.
- Gave a holistic approach to stabilising riverbanks and promotes management for the long-term enhancement of Australian rivers. Too often, river engineering has neglected to investigate natural stream characteristics and the role of vegetation. This report is an excellent exception.
- I have not seen/I am unaware of a video as yet. I am unsure re the 'RIVERCARE' plans. I have a set of 'Riverwise' off information sheets detailing various methods of erosion control on riverbanks which have been most helpful, but I don't know if they are 'RIVERCARE' plans.
- Apart from those listed above, the work of John Gardiner and Allan Raine brought the problems of rivers to the wider community, especially the video 'State of the Rivers' and the launch of 'RIVERCARE'.
- We also need to shift people's attitudes by marketing through high profile media. If people don't 'think it' they certainly won't 'will it' or do anything about it.
- A commitment from the agencies, local government, Landcare groups, TCM program to value our natural resources and uphold Landcare ethics across-the-board at all levels.
- We believe a riverine corridor management plan to be a high priority and the information is now available to successfully implement this. Funding is the only question.
- All of the above became available to Landcare groups and community groups.
- A clear logical order must be maintained otherwise there is confusion and the development of 'RIVERCARE' plans slows to a snail's pace.
- I use this 'RIVERCARE' system to assist Landcare community groups to better manage their riparian land. The 'RIVERCARE' system is also useful in training non-riparian Departmental staff to have a better appreciation of the complexities of river management issues.
- Outputs are fine, but useless if not picked up, or not in usable form. My opinion is that this project's outputs will be utilised.
- All of the above have relevance. In 'other' employment in riverbank rehabilitation schemes. In the Tweed I have worked as an adviser for LEAP projects employing youth in riverbank rehabilitation, which has been a very positive output. I have also undertaken private riparian consultancy with local landholders and have used the Tweed and Brunswick riparian survey reports to educate them re riparian issues.
- Riverine bank stabilisation will NEVER occur until stock are fenced off from river bank. Fenced off areas are essential and this should be stressed.

Who do you think would be the potential users of the output of the project?	*Yes / No*
– Farmers or other landowners	18 / 0
– Government advisory or extension officers	16 / 0
– Local councils or others with land management responsibilities	17 / 0
– Scientists and researchers in the field environmental management	14 / 0
– Private professional advisers in agriculture or environmental science	12 / 1
– other *(please specify)*	6 / 0

Comments:

- Government advisory officers in conjunction with groups of landowners (Landcare) appear to be the main users.
- Landcare groups, conservationists, schools–if they are aware of its presence.
- Catchment management committees
- All Australians need a higher awareness of the value of their riparian land. To know the benefits and to desire to keep and look after it. To be proud of and have a reverence for our streams.
- All stakeholders can learn from this very important study
- The information is now there and the only limitation is the encouragement to make people use it.
- Farmers have the most to lose by poor river management, so any help to the river is a benefit to the farm.
- Anyone in the resource management field could use the planning process.
- This process suits NSW Government plans towards self-regulation by the use of management plans and integration with TCM plans as well.
- Environmental education component, schools curriculum, general community awareness.
- Landcare groups and TCM committees.
- Employment and education of unemployed youth in riparian rehabilitation projects. Also schools–environmental educational projects in riverbank rehabilitation. Other community groups such as Landcare, Lions etc.
- Rivercare groups and local councils and Rural Lands Protection (stock routes watering).

4. Awareness of the Results

	Yes / No
Are you aware of the results of the project? If yes, how did you find out?	15 / 0
– Don't know what the final results were	3 / 3
– Through seeing the project video	8 / 1
– Through involvement in the preparation 'RIVERCARE' plans	9 / 1
– From a professional colleague	7 / 1
– Through formal contact with the project	10 / 0
– Through access to milestone and final reports	6 / 0
– Other *(please specify)*	3 / 0

Comments:

- Also previous research
- Don't know all results eg. video. The only 'RIVERCARE' plans I am aware of were prepared by DLWC with funding provided by Nambucca Valley Coordinating Committee.
- Bought book after field day organised by Brunswick CMC on riverine vegetation.
- Not aware of the full spectrum of outcomes.
- I have been involved with the project and had input at the planning level and investigation into suitable species for planting.
- The plan has yet to be proven in practice.
- Saw results through photographs and field days.
- I drafted the first four plans through to completion.
- I read and reviewed an early draft of the project report and assisted with plant identification and report layout. Have not seen all outputs.
- The final report is not widely available.
- I was involved in all stages from planning to completion of the tree clearing and spraying.
- *Though formally involved, I am not fully* au fait *with the project's overall results beyond my own work and reading Raine and Gardiner 'Rivercare'*
- We cannot remember receiving any written reports on other Rivercare work in 1991.

In becoming aware of the results, do you feel that you were able to	*Yes / No*
– comprehend them because they were presented in an easily understood manner	14 / 1
– they were understandable because of your professional training in this technical area	8 / 3
– they were not easily understood	1 / 5

Comments:

- Diagrams made the understanding better for a wider range of individuals
- I feel a glossary of terms would have been helpful for newcomers to the 'lingo'.
- The final reports were very wordy. The guts of the findings need to be technical documents.
- The results though feasible have yet to be confirmed in practice.
- The program was intentionally designed to appeal to laymen–keep it simple.
- Easy to see the benefits of the results
- They were drawn so that they were user friendly. It's what the client wanted. It was nothing fancy.
- Community group people who have seen the video and book, like the format and presentation because of its logical step-by-step format.
- A brochure could be developed to complement the report.
- I am aware of the results because I live and work here and see the results as they happen.
- I know the results of the Brunswick catchment survey as co-author of the report. I have no other results to refer to other than Raine and Gardiner's book.

Do you have any other comments on the presentation of the results of this project?

- Presentation as LWRRDC Occasional Paper 03/95 provides an excellent reference document—clearly written, well illustrated and comprehensive.
- Photo quality inferior.
- Brochure of species lists for specific catchments currently being compiled will be the most readily useful part for community groups.
- Both John Gardiner and Allan Raine are excellent men in their field.
- Most people I am involved with learn from talking and the RIVERCARE forums were very informative in getting results across.
- The use of long-term unemployed (New Work Opportunities–NWO) to assist the landowners was well received. They worked well together. Good positive results for all concerned.
- I would like to have seen some public presentation of the results in the Tweed, such as a field day with TCMC, Landcare and LWC representation for landholders in the Tweed, such as was the case in the Brunswick.

Do you have any comment on the timeliness of the reporting of results?	*Yes/No*
– Reports were on time and readily available	4 / 3
– Reports were not on time, or not readily obtainable, which delayed using the results	4 / 0
– Formal reports were late, but results were available through informal contact	5 / 0

Comments:

- I am not sufficiently well aware of the intended time frame to comment here.
- I was not involved in this process
- Took quite a while to get Brunswick River survey out of Department.
- I am unaware of a timetable.
- I am unaware of the time of the reports were supposed to be available but for our own use they were on time.
- No comment.
- Seed money to some groups was slow. Other groups have had fantastic results.
- Direct contact with Allan allowed informal use of results prior to formal documentation was finalised.
- Don't know.
- There are a few loose ends, such as the Tweed report which need attention.

5. Adoption of Research Results

Yes / No

Are you likely to utilise that results of the project in your own work? 17 / 1

If yes, do you consider that you have had adequate access to the results to directly use them? 12 / 4

If yes, how did this come about?

- 'RIVERCARE' planning is being undertaken by a number of groups. I have seen the results of the process and discussed it with John Gardiner and other Departmental officers.
- There is a copy in our work library. I have also utilised the outputs by adopting the river management procedures outlined in my actual work with community groups on river restoration.
- Personal contact with Allan Raine.
- It was all part of the work we were doing on bank stabilisation
- I only had access to the reports because I sat next to Allan Raine.
- I have attended workshops and made myself available to learn
- As a participant in the project, the specific plan for our group's section of the river was given into our care after approval by the CMC.
- There is adequate access to results in the written form.
- I will use the results in my work as a contractor
- I am employed to implement the management options on the plans.
- Purchasing the book and using the video.
- My own inputs into rehabilitation, etc. and floristics of various streams, etc.
- By owning a farm affected by land degradation.
- Because I did the research and have all data for two catchments.
- There has been controversy about the planting of willows from some people. Willows are essential for a 'quick fix' in eroding cliff banks and areas of watering toes of banks.

If not, why not?

- Haven't seen any videos yet. Phoning Grafton from Nambucca for info, etc. is expensive, ie. costly to access and/or make contact with technical help and information.
- Their availability/existence is not widely made known.
- Adequate access to qualified personal to help understand the variations due to natural change.
- Haven't seen final reports, but suspect they are consistent with earlier drafts.
- Report is not readily available

Do you consider the results of this project are ready to be put into practice?

If yes, how?

- They are already in practice and greatly assisting landowners take control of their streambank management.
- These results are already being put into practice through the 'RIVERCARE' Planning Process. There are approximately 30 different community groups on the north coast undertaking river planning. Many of these plans cover in excess of 5 km of river length. Some plans extend for over 20 km.
- We use the report as a reference document for project planning and to increase knowledge and understanding, but I don't know if all Landcare groups have received it.
- Maybe. I am concerned that the farming community's hostility to riverine fencing has not been addressed. Issue is stock control and costs of fencing. No economic incentives.
- Through Landcare, landholders awareness, school students involvement.
- Some of it! 'RIVERCARE' program. General extension advice. Support for various riparian/land management strategies/policies for CMCs/State Agency/LEPs/Councils. To be effective in the local government planning process, we need standard statements for inclusion into LEPs, REPs, DCPs etc.
- They already have.
- Work has begun on the implementation of the 'RIVERCARE' plan by our group with the help of NLC funding.
- Some results are ready to use but there are still many results which are still questionable because of the time needed to get accurate results.
- Though community appreciation and action needed. Absolutely yes.
- Show other Landcare groups our results and help them implement them in their river.
- They have been put into practice in the Manning Catchment, with positive results. NWO work crews have completed a number of projects.
- Yes, there are approximately 30 'RIVERCARE' plans in various stages of preparation in he North Coast Region (Qld border to Port Macquarie).
- Yes. Integrate into TCM, Landcare, community forestry and rehabilitation activities. Empower individual landowners.
- Through Landcare river restoration projects.
- By continuing on with other Landcare work in need of doing.
- Through Tweed River TCMC, Landcare and Dept LWC driving a campaign of riparian rehabilitation through public field days, plus pamphlets outlining basic methods and species appropriate to sites. Plus any broader public education enterprises possible (funding permitting), such as TV ads. I would like to see schools involved with a Riparian Zone Environmental Education Kit produced for teachers and presentations within the schools combined with hands-on riparian rehabilitation projects.
- Our Landcare group has used them with success.

If not, what else needs to be done for the findings to be put into practice?

- More awareness by extension officers of the need to research existing information.
- Local shires and other government agencies need to be brought up to steam.
- Field communication and servicing.

- Very specific local information for landowners (supplementary publications). Community awareness of information availability.
- Public relations exercises, field days for instance.

Yes / No

Are you aware of other professional colleagues who are using the results of this project in their work? 11 / 3

If so, how is it being used? *(if possible, please give a contact name which we could use for follow-up)*

- The 'RIVERCARE' concept is being used widely within the DLWC. David Russell is Rivercare Planner based at Muswellbrook.
- Colleagues within the DLWC involved in river management.
- A major part of the river systems of the Manning Valley have been covered by specific 'RIVERCARE' plans. John Gardiner would have all the contact names.
- The results are being used to create a management plan which covers our whole river (Pappinbarra) then systematically correct problems, fence-off the riverine corridor and plant with correct species to create a sustainable recourse for nature and agriculture.
- To my knowledge only one person outside the Hunter region is using us as a contact for 'RIVERCARE' planning. He is Glen Adamson from the Department of Land & Water Conservation, Sydney/South Coast. He is doing work on the Hawkesbury/Nepean Catchment. John Gardiner is developing RC plans on the North Coast.
- David Outhet, 02-98956211
- Try Bruce Hungerford (Soil Conservationist) LAWC, Murwillumbah office. TCM Brunswick River, contact Ros Elliott.
- By other river-based professional, eg. geomorphologists.
- Other Landcare groups.
- David Berg, coordinator of LEAP Scheme for Tweed Training and Enterprise Company (066-722485) is using species lists and planting advice from Tweed riparian survey in consultancy with myself to rehabilitate selected riverbank sites along the riverbank with unemployed youth labour. Also Grant Periott (075-5242170) who assisted with the Tweed survey fieldwork, has since found work as scientific adviser on a similar DEETYA scheme in Queensland and has been able to bring his experience to bear on riparian rehabilitation of some of the sites within his jurisdiction.
- Rivercare planners, Tamworth, Sally Boon and Peter Boyd.

6. Evaluation Assessment

Yes / No

Do you think that the restated objectives in logical framework format (see Appendix at end of questionnaire) accurately reflect the perceptions of the project during its course? 14 / 1

If no, what do you suggest will make them more accurately reflect the situation at the time?

- Third para of restated outputs re communications packages-I believe more emphasis is needed in this area.
- I think that Objective 3 ended up as pie in the sky for the Tweed.
- There is greater emphasis on species to plant, but nothing on protection from destruction by cattle and/or sheep ie. fencing-off.

Do you think that the statement of outputs in the Appendix accurately reflects your perceptions of the results of the project? 13 / 1?

Comments:

- 1). A 'systems approach' has been initiated but needs more DLWC funding to implement adequately. 2). Haven't seen any videos yet! 3). Species lists are great, but a local flora expert told me that with more time they could have been more comprehensive.
- A photographic record has not been presented to date.

If no, what do you suggest would be a more accurate statement of the outputs?

Comments:

- I have to say that these outputs are largely accurate, except I still maintain they have not met the mark in the Tweed, where the report has still to be done on my survey results. To my knowledge no species list is yet available, except that which I have prepared myself.

Have you views on riparian vegetation and land management changed since 1991? *Yes / No*
14 / 2

If yes, has the work of this project had any influence on your views? 15 / 1

If so, in what way did it influence you views?

- Project demonstrated that streambank management could be undertaken by landowners with minimal government agency control. This provides hope of achieving greater ownership of streambanks by landowners in the Hunter than previously existed.
- A better understanding of river characteristics, restoration work options, the role of vegetation in fluvial geomorphology and the characteristics of different types of native vegetation.
- Made me realise not only the critical importance of riparian vegetation and protection of riverbanks from stock, but also the very much underestimated importance of using local indigenous riparian species to maximise success, maintain genetic integrity and recreate healthy biodiverse ecosystems.
- Showed magnitude of the problem and very constructively addressed most issues except livestock management.
- The reason we say 'no' is that we were part of all the outputs of the project and much of the work we did prior to this research led up to John's and Allan's research, so we were already familiar with the problems of the river. There is no doubt this work has raised the awareness and enthusiasm of the community towards the problems of the rivers.
- *Increased knowledge of 1) specific species function/role in streams eg.* Lomandra *– toe/groundcover. 2) Assemblage of species that create the riparian corridor – habit of plants eg. titree/bottlebrush, springy and*

flexible; Waterhousia floribunda – *root system for bank and bed control. 3) Value of utilisation of appropriate native species for riparian restoration.*

- I have a greater understanding of river dynamics, this helps me in my endeavour to arrest streambank and bed degradation.
- The work has shown us problems we didn't know were problems, but in a few years we would have had big problems. Now we have identified the problems we can stop them from becoming big ones thanks to the work of this project.
- 1) Appreciate the problems associated with river care in a local environment. 2) Understand the difficulties facing local farmers and councils.
- I saw through my work contact with the river, its problems, and how to overcome them for a better river.
- It taught me to listen to farmers and to negotiate solutions rather than telling them what they have to do. Unemployed people do develop a positive attitude to work if they can see the outcome.
- Provided i) specific species to advise people and to use. ii) A methodology for groups to plan river management. iii) Resource material to assist community education on river management.
- It has influenced my views only to a limited extent. My views change on these 'areas' of concern only so much as my (or other) research reveals more about the ecology and environmental processes at work and the techniques to assist rehabilitation and restoration (of stream processes and vegetation).
- By giving me a better understanding of land management.
- I now have a better grasp of what needs to be done and how it can be done. The ignorance (and arrogance) of some older landholders, especially cattle graziers, is a big problem. Their perception of a healthy riparian zone as being treeless, with grass to the water's edge and open access to stock all along the watercourse, needs serious revision. Also, despite public education and laws, many still believe in the use of poisons to control weeds, even along waterways.
- How to stabilise eroded banks with 'Toe' planting and bank revegetation by fencing off. Native species soon (within 2 years) revegetate if allowed to grow ie. no animals/stock.