ECOLOGY AND SOCIETY

Correct format for citing this article:
Gilmour, A., G. Walkerden, and J. Scandol. 1999. Adaptive management of the water cycle on the urban fringe: three Australian case studies. Conservation Ecology **3**(1): 11. [online] URL: http://www.consecol.org/vol3/iss1/art11/

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Research, part of Special Feature on Adaptive Management

Adaptive Management of the Water Cycle on the Urban Fringe: Three Australian Case Studies

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ABSTRACT

Our group at Macquarie University has run three adaptive management projects in New South Wales, Australia. Their objectives were: (1) to evaluate water cycle management strategies to minimize impacts of urban development on water quality in the Hawkesbury-Nepean basin; (2) to evaluate development planning policies

to minimize water quality impacts on a series of coastal lakes; and (3) to carry out a preliminary assessment of the potential impacts of greater recreational use of Sydney water catchments.

These projects are examined to evaluate the contribution of the adaptive management approach to water cycle management on the urban fringe in New South Wales. The role of the adaptive management approach in education, as a negotiation process, and in policy formulation and evaluation, is presented. The importance of community participation, the role of an "institutional champion," and the need to manage the lead-up phase and the postworkshop phase with as much attention to detail as the workshop phase is underlined. Proposed prerequisites for a successful adaptive management project are developed along these lines.

KEY WORDS: adaptive management, conservation biology, ecosystem management, sustainability transition, sustainable development, water quality, watershed management.

Published June 30, 1999.

INTRODUCTION

Many adaptive management projects have been carried out in Australia in recent years (Table 1). This paper evaluates three recent projects carried out by our group in New South Wales (NSW) (http://www.gse.mq.edu.au), with a view to improving our understanding of the adaptive management approach. These projects are presented briefly in the context of the original premises of Adaptive Environmental Assessment and Management (AEAM). In the discussion, we examine the issues raised by the case studies and make suggestions to improve the likelihood of a wider adoption of the adaptive management approach.

Table 1. Adaptive management projects carried out in Australia.

1.	Project	Region	Purpose	Client	Operator	Reference	Start	Finish
2.	fisheries management	Australia	fisheries research and management	various Fisheries departments	Walters	Walters *pers. comm.* 1997	1982	on-going
3.	AEAM training courses	Sydney NSW	training	GSE	Walters		1987	1988
4.	Macquarie Marshes	NSW	water allocation	Dept. of Water Resources	DWR NSW	Gilmour and Geering 1991	1987	1989
5.	Marmion Outfall	WA	impacts of ocean sewage discharge	Dept. of Water	WAWA	Walters *pers. comm.*1997		
6.	South Creek Valley Sector	Sydney NSW	pollution impacts of urban development	Sydney Water Board	GSE	Gilmour and Walkerden 1993, 1994	1991	1994
7.	Latrobe Valley	Victoria	water quality management	EPA Victoria	CEAH and DCNR Victoria	Grayson et al. 1994	1993	1993
8.	Various catchments	Victoria	nutrient management		CEAH and DCNR Victoria	Grayson and Dollan 1995	1994	1994

9.	Johnstone River Catchment	Queensland	research agenda for riparian revegetation	LWRRDC	CEAH and others	Wilson et al. 1996	1994	1994
10.	Tuggerah Lakes	Central Coast NSW	impacts on coastal lagoon system	Wyong LGA	GSE	Gilmour et al. 1996	1995	1996
11.	Great Barrier Reef	Queensland	effects of fishing	GBR Marine Park Authority and others	CRC for Ecologically Sustainable Development of the GBR	Mapstone et al. 1996	1995	on-going
12.	Blackwood catchment	WA	catchment management		CEAH and WAWA	Walters pers. com.	1996	1997
13.	Recreational access to Sydney Water Supply Catchments	Sydney NSW	impacts on water quality and public health	Sydney Water Corp.	GSE	this paper	1997	1997
14.	Recreational use of Prospect Reservoir	Sydney NSW	impacts on water quality and public health	Sydney Water Corp.	GSE	this paper	1997	1997

Notes: CEAH, Centre for Environmental Applied Hydrology, Melbourne University; CRC, Cooperative Research Centre, James Cook University; DWR, Department of Water Resources, New South Wales; DCNR, Department of Conservation and Natural Resources, Victoria; GSE, Graduate School of the Environment, Macquarie University; WAWA, Water Authority of Western Australia.

THE PROMISE OF ADAPTIVE MANAGEMENT

In their seminal book on adaptive management, Holling (1978) and co-authors developed a set of techniques that integrated environmental issues with economic and social understanding. Their main concern was the failure of environmental impact assessment to deliver better environmental outcomes. Their target audience was people carrying out environmental assessment and communicating the results to senior administrators. They argued that environmental assessment should commence when the design process begins. They (Holling1978) set out to develop a set of techniques to: (1)deal with uncertain information; (2)mobilize available data on partially known processes; and (3) assist with the "formation of objectives that are less sensitive to the unexpected."

They emphasised a systems approach and communication as ways to achieve a better shared understanding of the problem. This implied a need to develop simplified models to better understand the behavior of the system. Walters (1975) had emphasised communication between researchers in various disciplines and between researchers and managers. Walters (1986) strengthened the systems tool kit for making judgments about the management implications of uncertainties.

Attempts to implement adaptive management approaches have revealed many challenges. Iles (1996) argues that there are fundamental problems with getting adaptive management translated from theory to practice: the legislative and administrative structures are too "top down" to benefit from an adaptive management approach. Walters' (1997) pessimistic assessment supports this general conclusion. He underlines familiar constraints: uncertainty, self-interest, and conflicting values, and singles out the difficulty of getting large-scale management experiments to happen because of the costs and risks. Holling (1995) highlights a prima facie contradiction between ecosystem management and resilience: managerial control reduces variety, which reduces both ecological and social resilience.

On this canvas of difficulties, this paper focuses on three strands:

- meeting doubts about the wisdom of adaptive management by acknowledging the difficulty of managing ecosystems;
- creating a platform for follow-through by framing workshop-based policy investigations as negotiations; and
- reducing vulnerability to institutional change by developing community ownership of strategies.

THREE CASE STUDIES

South Creek

Project setting

South Creek Valley Sector (SCVS) lies to the south west of Sydney, the capital of the state of New South Wales, Australia. Proposals to provide new housing in the region were restricted in the early 1990s because of community concerns about the level of pollution in the rivers of the Hawkesbury-Nepean catchment. Potential cost of increased environmental management (Paterson et al. 1993) to future buyers was a central challenge.

The then Sydney Water Board had statutory responsibility to supply water, sewerage, and drainage services to urban areas. In 1991, a central policy officer of the Board proposed the use of AEAM to explore new water cycle and environmental management strategies, and regional management adopted the proposal. Participants from the Sydney Water Board, a wide range of government agencies, the land developers, and community organizations were invited to participate. Although community representatives were sought, only one representative of a regional conservation group participated in all of the workshops.

Problem analysis

Participants explored the environmental impacts of urban development and the effects of alternative policies to address those impacts over 12 days during 1993-1994. A simulation model of the policy options, which related land use and water cycle management strategies (Fig. 1), was defined in workshop sessions and in working groups. Indicators of system status (graphs and maps) and policy options (Fig. 2) cover the three major dimensions of the system: water management, land management, and socioeconomic issues.

Fig. 1. South Creek land use map and model interface.

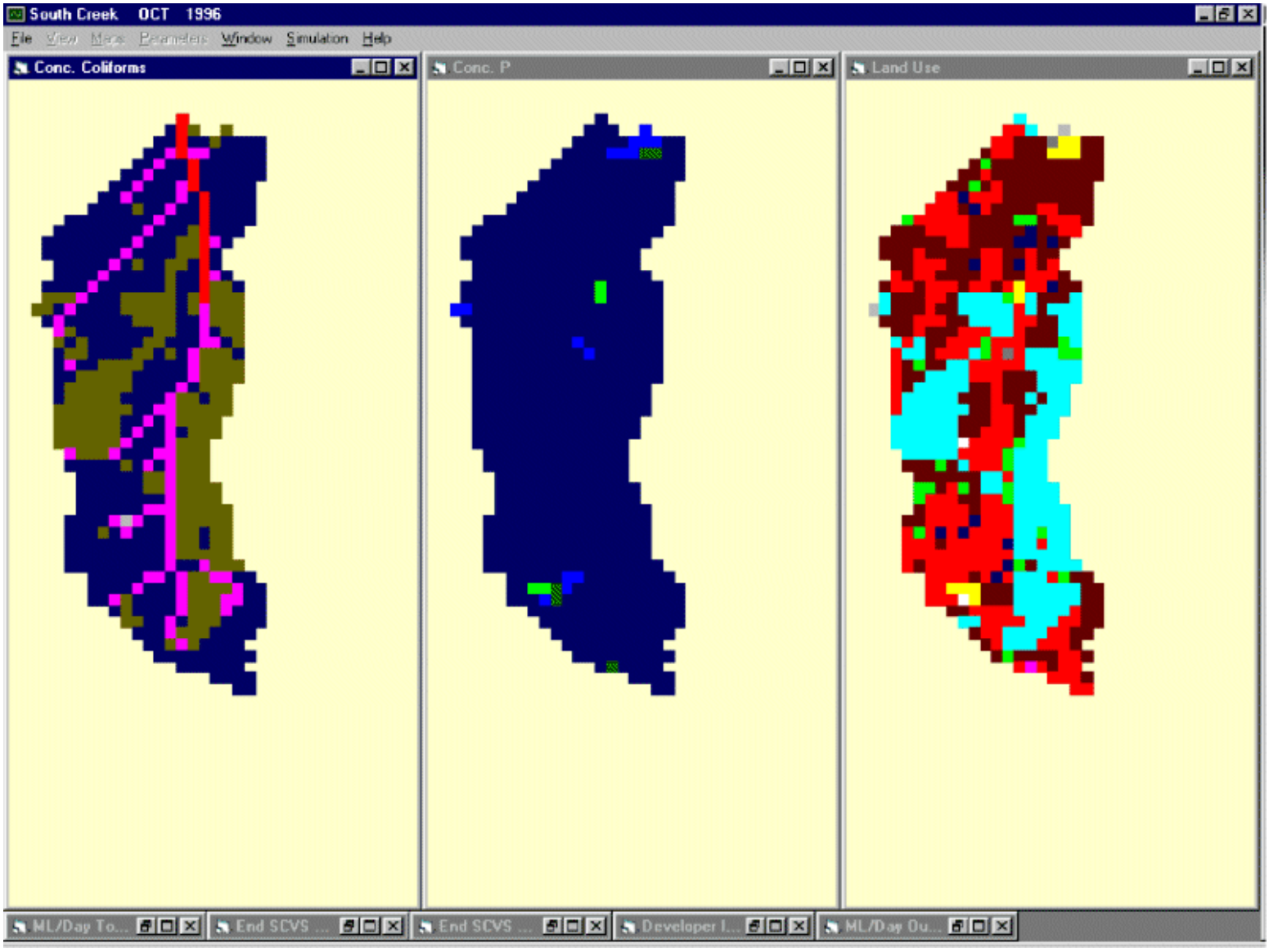
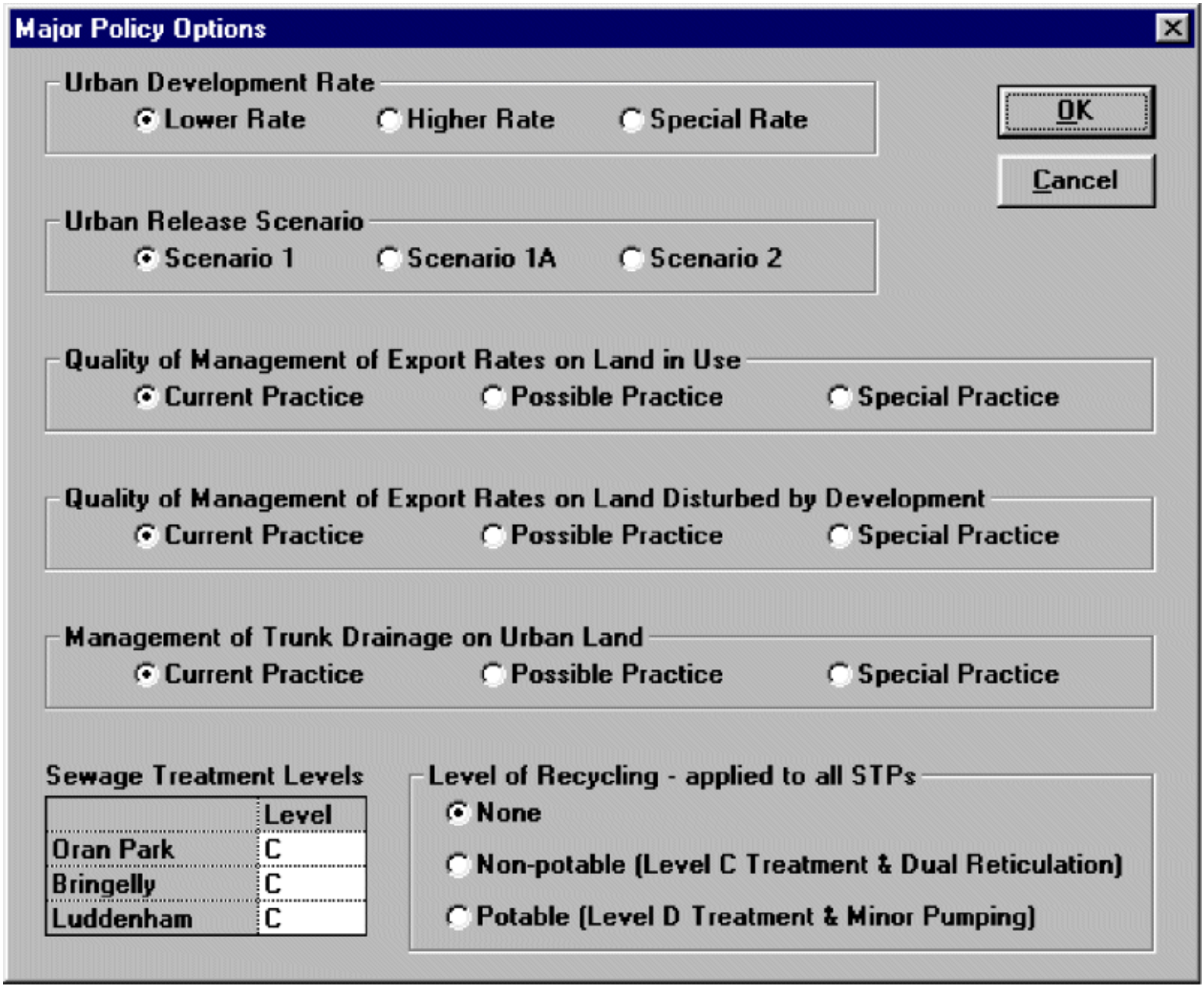


Fig. 2. South Creek policy options menu.



The major outcomes of the study fell into three areas (Gilmour and Walkerden 1994): (1)problem recognition and definition; (2)strategy development; and (3)progress toward consensus.

For new urban developments, the management focus was urban run-off and sewage effluent. Other measures that were explored included improvements to the trunk drainage system and more active management of water demand.

The study concluded that the pollution loads generated under existing land use patterns and under proposed future developments would not meet water quality guidelines. Although considerable uncertainties were identified (Table 2), it was clear from the modeling sessions that managing the new mix of land uses with best management practices could not deliver water quality that was equivalent to, or better than, the water quality resulting from current land use management practice. A commitment to maintaining water quality therefore required improvements in other parts of the catchment.

Table 2. Review of key uncertainties for the South Creek Development.

Uncertainty	Description
Population increase	Subject to national and state policies
Performance and appropriateness of relatively new technologies	Project considered artificial wetlands and reverse osmosis as potential treatment process for sewage effluent, the operating characteristics of both being ill-defined
Degree of success in involving stakeholders in actions to alter water quality impacts	No legislative powers to direct land management practices of farmers and rural residential communities
Effectiveness and costs of Best Management Practices (BMP) in run-off controls	Local government had little experience of improved control mechanisms
Community expectations	Not clear if community is willing to pay for higher environmental standards in housing costs
Community acceptance	Use of recycled water for non-potable purposes untried

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Implementation

Regional staff of the Water Board developed detailed strategy information in the form of a spreadsheet listing control parameters, indicators of change and system state, and commenced to explore the implications of the range of potential strategies. A major internal report was prepared outlining the outcomes of the project. The groundwork for adaptive management of the water cycle in the development area was put in place.

Policy context

The composition of the workshops led to a high level of consensus about the policy outcomes, and the Regional manager, who had become the "institutional champion" for the project, supported the outcomes. A change in the charter of the Water Board occurred that directed the Water Board away from resource management, narrowing its focus to corporate-style service provision. As a result, the project was abandoned.

Tuggerah Lakes

Project setting

Wyong Shire is located some 100 km north of Sydney on the New South Wales coast. The Tuggerah Lakes and their catchment of approximately 720 km^2 constitute the major part of the Shire. The fringes of the Lakes experienced rapid urban development in the 1960s and 1970s. Most of the developing areas relied on septic sewage treatment even though significant portions had soils that were unsuitable for such systems. The largest of the three Lakes is connected to the ocean by a single channel, which in the past was often closed by a sandbar.

Community concern about the health of the lakes led to a State Government Inter-Departmental Committee that reported in 1978. A reticulated sewerage system was constructed during the 1980s. From 1988 to 1992, a program of works intended to restore the lakes was carried out. These included:

- ocean entrance dredging to improve tidal exchange and flushing;
- removal of nearshore anoxic sediments, nutrients, and macroalgae from the lake system via a foreshore reclamation project; and

- construction of mini-wetlands and gross pollutant traps on many stormwater drains discharging to the Lakes.

King and Hodgson (1995) concluded that, despite evidence of degradation by nutrient inputs, the Tuggerah Lakes were only mildly eutrophic. Two main responses to the risks posed by development in the catchment were proposed and discussed in the local press: more point and diffuse source programs to reduce nutrient loads from the catchment, and further enhancing flushing of the lakes by tidal exchange.

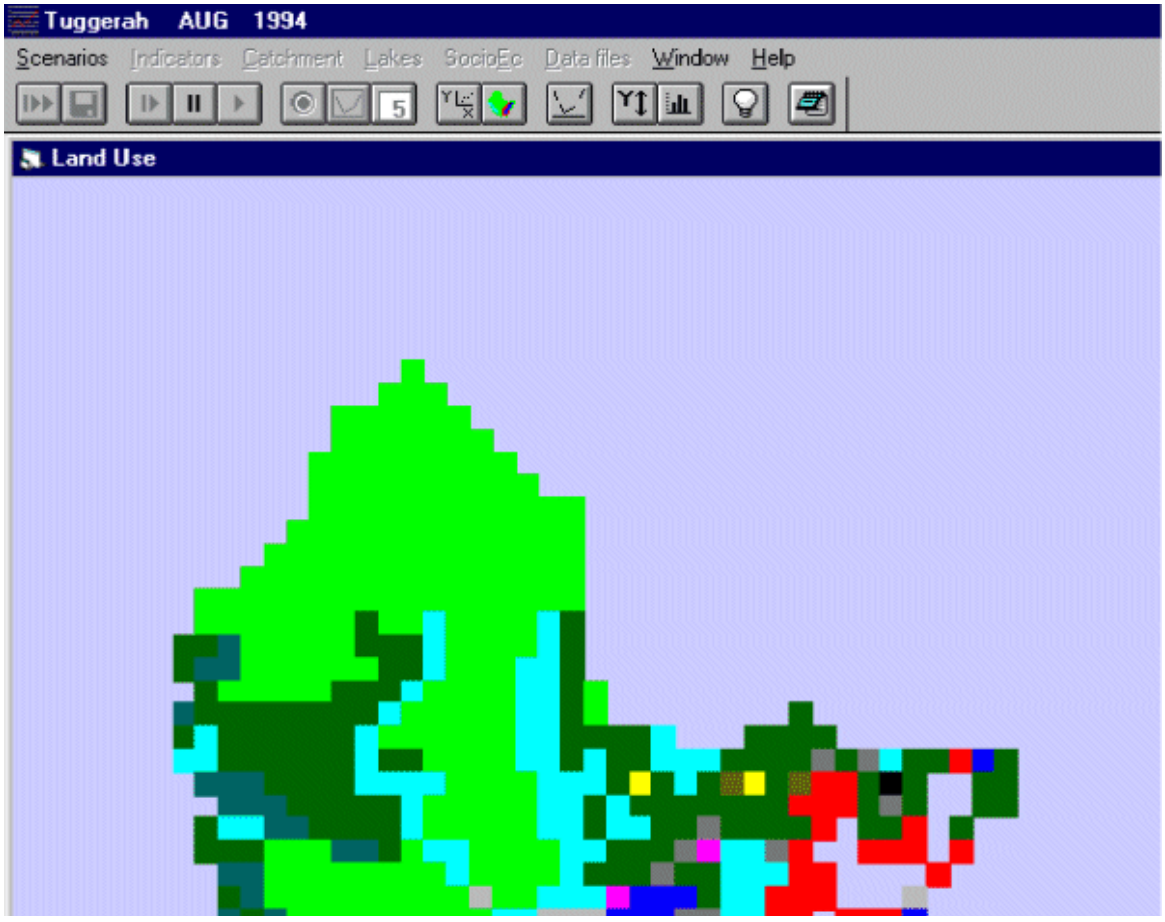
Although many studies had been undertaken into particular aspects of the Tuggerah Lakes, in 1995 there was no integrated, comprehensive data set. The local government authority, Wyong Shire Council, realized that potential solutions would require the understanding and support of the electorate. Some community leaders were arguing that a second entrance to one of the northern lakes should be constructed to increase flushing. In 1994,the then Environmental Systems Manager proposed evaluating management options for the Lakes and their catchment using an AEAM approach. Workshop participants included eight community representatives, two elected Councillors and six Council staff, an officer from each of three government agencies, and four invited technical specialists.

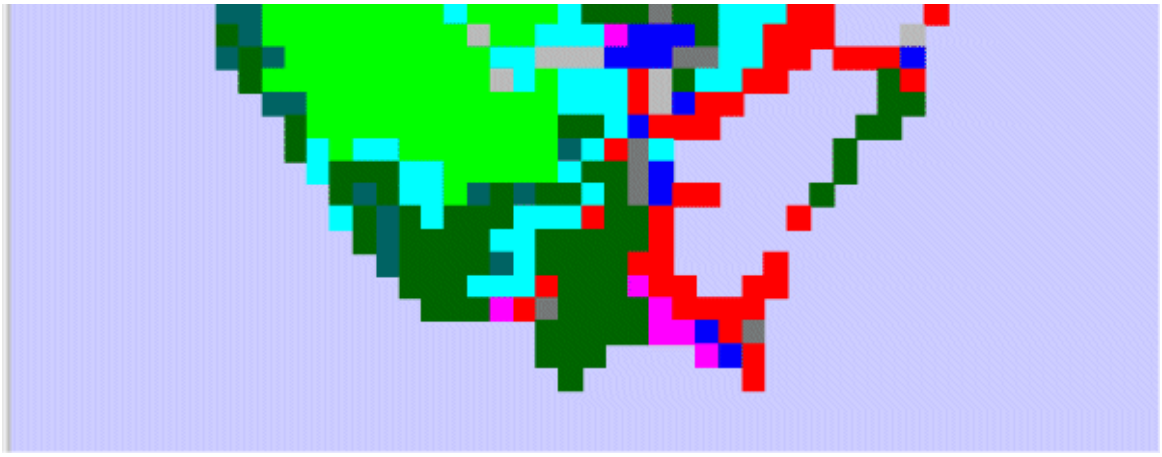
Problem analysis

The project involved 17 workshop days and presentations to seven community meetings. The workshops outlined the structure of a decision support model to assist in the evaluation of management strategies for the Lakes and their drainage catchment (Fig. 3). The main issues identified by the participants in the Wyong AEAM workshops were (Walkerden and Gilmour 1996):

- increasing intensification of human use of the catchment, most notably increasing population;
- changing land uses (Fig. 3), including the advent of turf farms and the demise of dairy farms;
- the influence of land use management practices; and
- improved stormwater management and sewerage systems in urban areas.

Fig. 3. Tuggerah Lakes and catchment land use.





The decision support system that documents the workshop participants' analyses of socioeconomic and biophysical issues focused on three submodels: catchment issues, lake issues, and social and economic issues.

Workshop participants agreed that eutrophication was the main ecological risk confronting the Lakes, so the main focus of the project was the sources, fate, and management of nutrients and sediment in the catchment and the Lakes (Fig. 4). Participants identified a wide range of uncertainties (Table 3). Examples include the ecological consequences of enlarging the existing entrance channel to the ocean or the construction of a second entrance (Fig. 5), effectiveness of stormwater management structures and influence of lake sediments on nutrient dynamics. Policy strategies were identified (Fig. 6) to control nonpoint sources and to improve flushing.

Fig. 4. Tuggerah Lakes issues: community presentation poster.

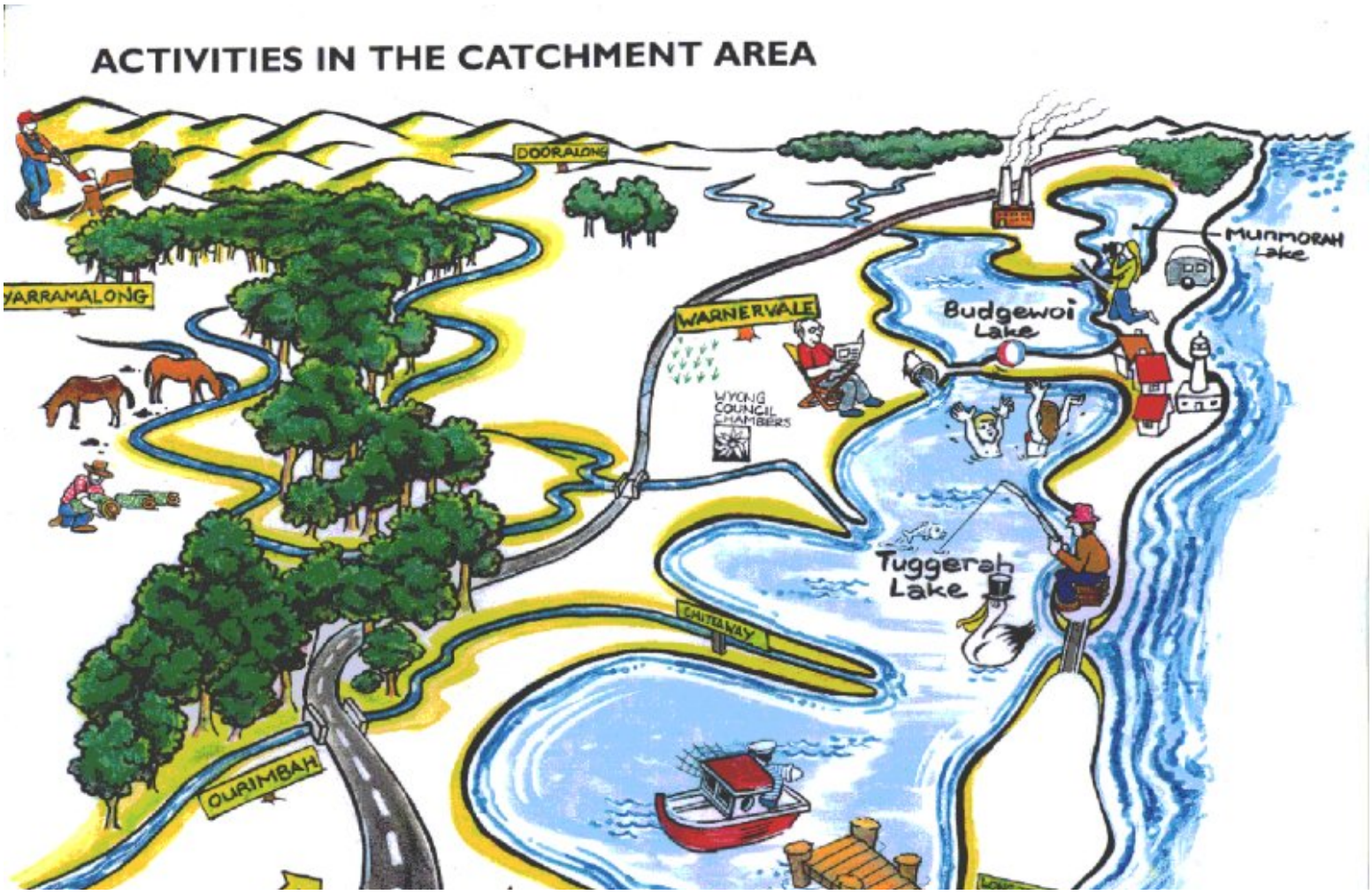


Fig. 5. Tuggerah Lakes water flow policy options.

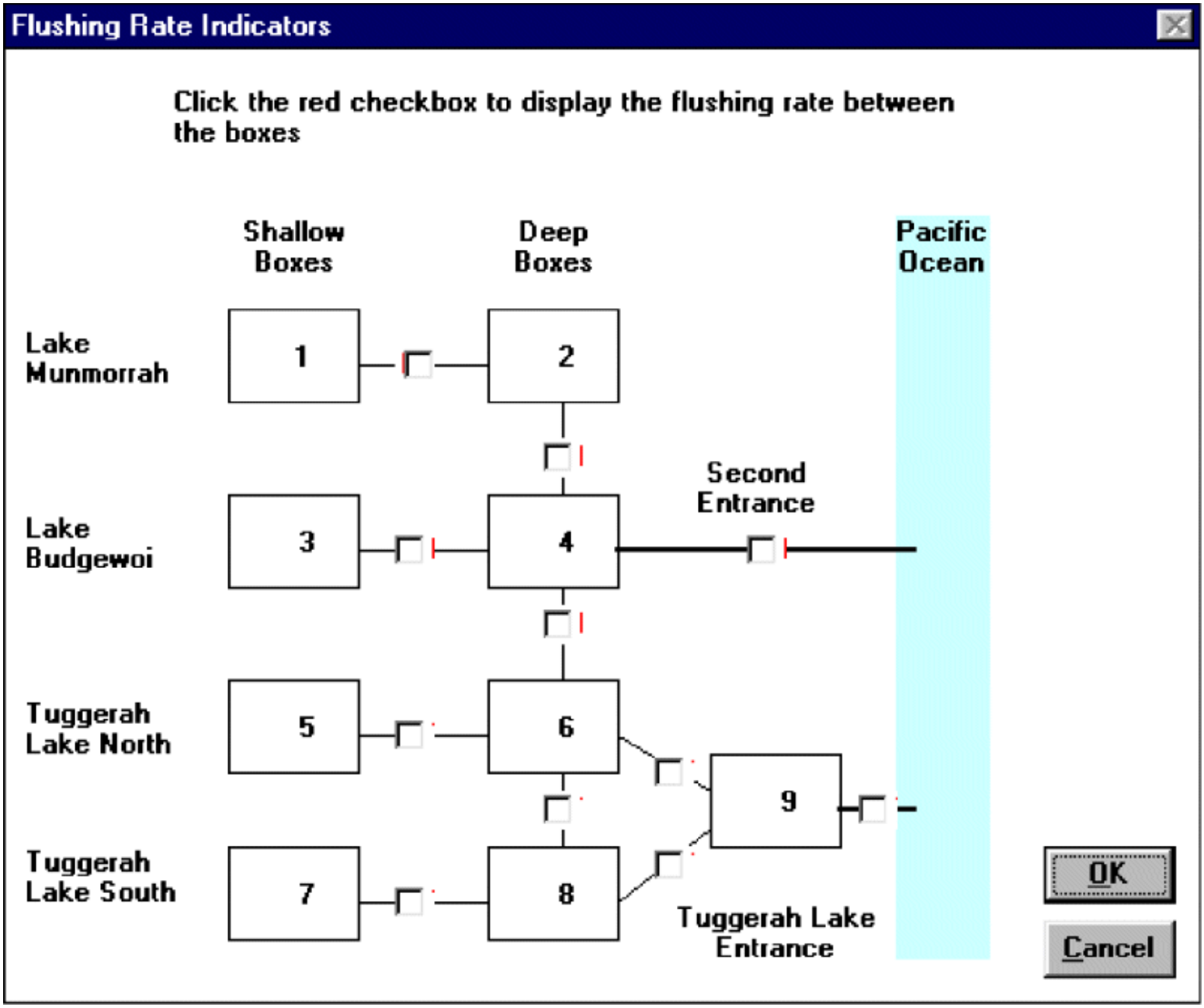


Fig. 6. Tuggerah Lakes policy options menu.

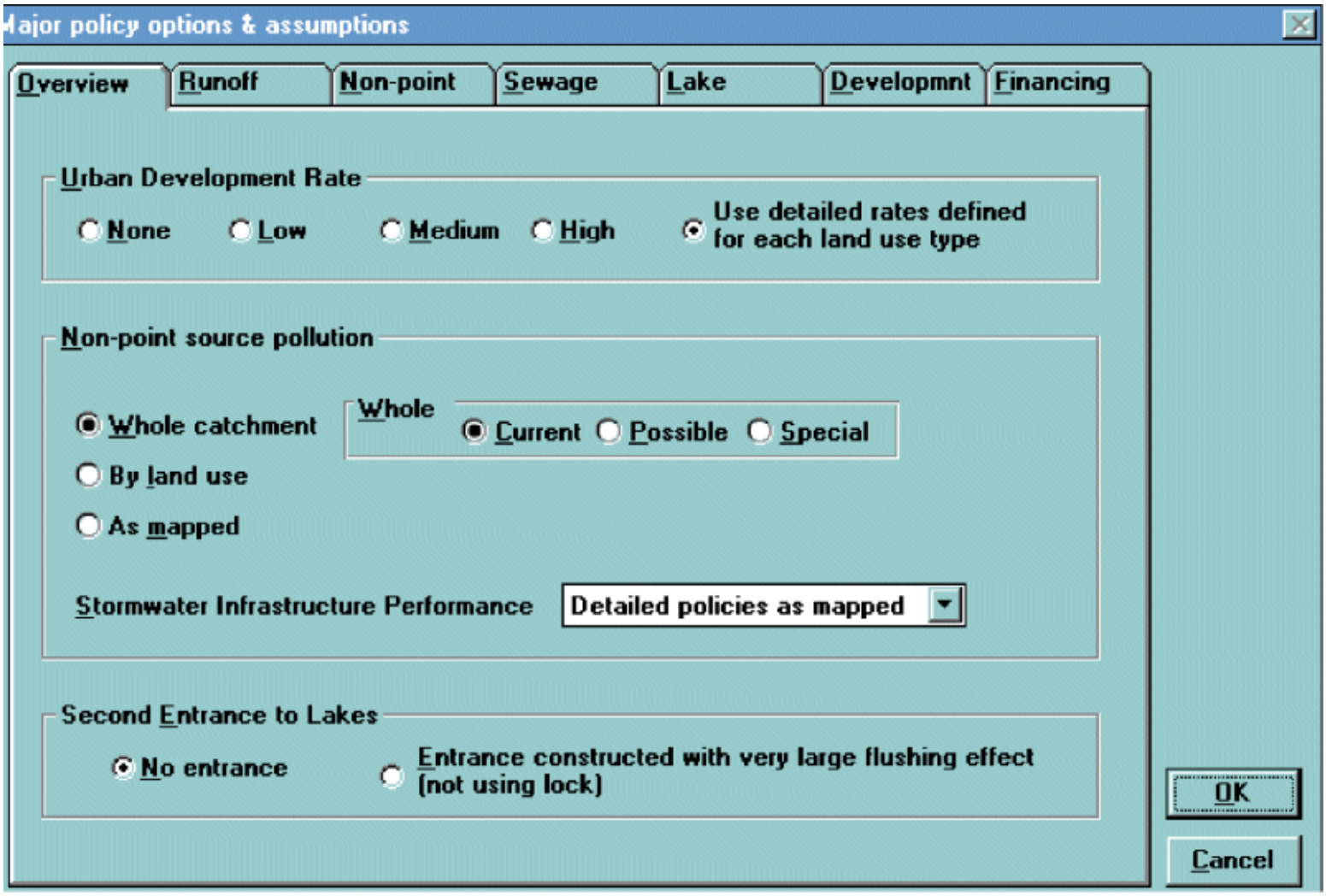


Table 3. Review of key uncertainties for Tuggerah Lakes.

Uncertainty	Description
Speed of land use change / intensity of development.	Rate of development is hard to predict, e.g., economic cycles, Commonwealth government policy on immigration, etc. If change occurs faster than expected, eutrophication risks will increase.
Timing and effectiveness of catchment management policies.	For most land uses, the current effectiveness of land management practices is not known in any detail. The likely long-term effectiveness of wetlands in stripping nutrients out of flows is still a matter of debate.
Time it will take for rate of release of nutrients from sediment to water column to change.	What is not clear is what buffering role these sediments play. For instance, if we dramatically cut nutrient and sediment inputs now, how long would it take the Lakes system to respond? Understanding the role of exchange of nutrients between the sediments and the water column, which is a natural process, is vital to answering this question. Our understanding of this is poor.

Time it will take for the effects of management decisions to become evident.	Long-term changes in catchment management practices should change water quality in the Lakes. Over the short term, rainfall contributes very large variability to water quality data. Consequently, extensive water quality data are needed before an attempt to identify the "signal" from management (i.e., evidence of its presence) is feasible.
Reducing sediment loads may trigger phytoplankton blooms.	Either light or nutrients may be limiting the growth of aquatic plants and, in particular, the growth of phytoplankton in the main water bodies, as this is where the creeks deliver their loads. If nutrients are limiting, then erosion controls will reduce phytoplankton growth. However, if nutrients are present in abundance, then increasing the availability of light will allow phytoplankton growth to take off.
Potential for sediment under main water bodies to become anoxic.	If this region in the sediments below the main water bodies becomes anoxic or hypoxic, i.e., if the oxygen levels drop to zero or to very low levels, than nutrients could stream out of the sediment into the water column, triggering phytoplankton blooms.
Future rainfall sequences.	Long-term strategy might, for example, be seen by the community as a relatively poor strategy because its benefits are not obvious during a prolonged period of high rainfall.
Impacts of second entrance on hydrodynamics and ecology.	A second-entrance strategy is a very high-cost strategy (financially and ecologically) compared to the alternatives. The ecological impacts are much more difficult to quantify, with precision, than hydrodynamic impacts, although major shifts in abundance of differing species are likely if the Lakes become much more tightly integrated with the ocean.

Implementation

Series of community information seminars discussing the main issues and communicating progress to date (Fig. 4) were also run in local meeting halls throughout the catchment, after the project was largely completed in April 1996. By the end of the workshop series, a general management strategy was clear, but an action plan had not been developed. Shortly after the end of the project, the Environmental Systems Manager, who had been the "institutional champion," resigned to take a promotion elsewhere. Fortunately, one of the members of the consulting team was appointed to this position, so internal support for the project continued and an implementation program was developed and is being actioned.

Policy context

The participation of both elected councillors, a range of council staff, and community representatives was a strong feature of this project. Despite this, the transfer of knowledge gained in the project was low and there was a lack of commitment within the organization. There was lack of support for the outcomes by government agencies that were not fully committed participants.

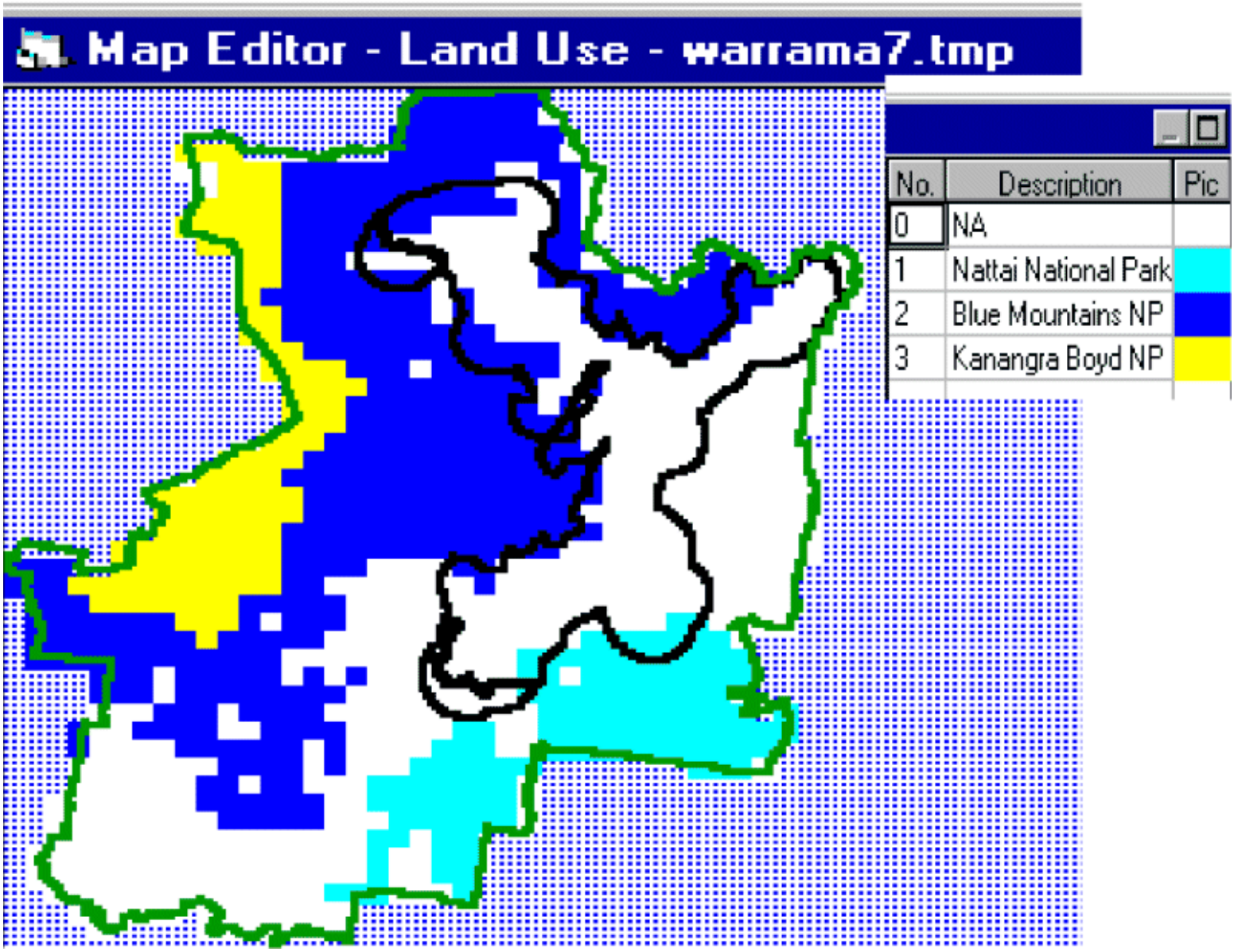
Sydney Water Catchment access

Project setting

The Sydney Water Corporation (the Sydney Water Board after corporatization in 1995) controls access to the immediate catchments of its water supply reservoirs. Increasing political pressure led to an assessment of

the potential impacts of greater recreational use of these catchments. A facilitated workshop approach, with limited AEAM objectives, was used to assist in the development of a management plan for these areas, under the joint sponsorship of the Sydney Water Corporation (SWC) and the NSW National Parks and Wildlife Service (NPWS). Lake Burragorang (Fig. 7) and its catchment, the major storage that supplies most of the potable water to Sydney, was the focus of interest for the main recreational stakeholder groups.

Fig. 7. Lake Burragorang and catchment, showing land tenures.



Some 30 stakeholders, managers, and scientists were selected by the sponsoring organizations in discussions with the consultants. The workshop participants were selected on the basis of their knowledge of the geographic area, experience and awareness of current and prospective activities, and expertise in technical disciplines relevant to the issues discussed.

The project was a reaction to intense lobbying by some stakeholder groups, particularly those seeking increased access. These groups ranged from conservation and bushwalking clubs with controlled access to the catchments, to the peak body of four-wheel-drive clubs, barred from access, and a lobby group supporting unlimited access to public lands in New South Wales. Many of these groups had a long history of mutual antagonism.

Problem analysis

Six workshops were held to evaluate the issues, explore management options, and make recommendations. Workshops provided a process in which participants, some of whom were barely on speaking terms, could exchange information. They were structured to gradually move from general to specific issues. Participants were encouraged to distance themselves from the detail of their stakeholder positions to arrive at a consensus on underlying technical and social issues presented in the workshops. A series of technical meetings was held during the workshop process to provide the opportunity for focused discussion on technical issues.

After documenting the issues, boundaries of the concerns, and proposed recreational activities, the workshop participants attempted to identify the relationships between recreational activities and their impacts on the catchments. Catchment values included the quality of stored water and ecological and cultural integrity. Indicators for tracking these impacts were identified based on the published literature. It became clear at an early stage, however, that important relationships between activity impacts in the catchments and the health consequences of consuming treated water were undefined and unreported in the literature. Two approaches were identified for making progress in the debate: (1) collecting and interpreting additional information to reduce the uncertainty of activity-impact relationships; and (2) community consultation on the risks, costs, and benefits of recreational access decisions.

Implementation

The workshops recommended studies and strategies supporting these approaches. The workshop report also recommended that, until these studies produce credible information indicating that it is safe and socially acceptable to do otherwise, the current regulations for the protected areas around the water reservoirs should be retained. The SWC has yet to consider the practicability of implementing these recommendations, which include an adaptive catchment management strategy.

Policy context

The water supply and sewerage authority had been recently corporatized and a political decision to hand management responsibilities for the protected catchments to the National Parks and Wildlife Service had recently been taken. The Park Service saw the project as external to their normal plans of management development process. In these circumstances, there was no "institutional champion."

DISCUSSION

Ownership of the process and acquisition of knowledge

The three projects all had water quality issues in a catchment as their primary focus. All had broad directions, provided by the sponsoring agency, that allowed participants a degree of flexibility in determining the agendas for each workshop series. The nature of the participation ranged from minimal community involvement in South Creek, to a preponderance of community representatives in the project regarding access to water supply catchments. A high level of technically skilled participants made systems analysis in workshops considerably easier and quicker. At this end of the spectrum, however, we were concerned that, because few participants had broad community support, the political strength of the workshops' judgments was modest. At the other end of the spectrum, in the Sydney Water Access project, the participants were largely selected on the basis of their stakeholder group representation. Thus, there were too few specialists to ensure a balanced discussion at all times.

The selection of participants would appear to require more attention if the goal of community ownership of the adaptive management strategy is to be achieved. A more public selection process with a series of community meetings could proceed the workshops, in an effort to build community support. The Tuggerah Lakes project community should have been interspersed with the workshop sessions to allow more immediate feedback.

We have asked participants to complete evaluation forms at the end of each workshop to provide feedback on the progress and effectiveness of the workshop series (Table 4). In each of the three projects, workshops participants' concerns about the AEAM process have fallen into three main areas: (1) weaknesses in the collective understanding of the system (Tables 2 and 3); (2) the approximations involved in modeling; and (3) the impacts of wider political processes of institutional and local, state and federal politics.

Table 4. Evaluation issues in workshops.

- performance of the facilitators;
- success of the process in facilitating the analysis of the environmental system;
- understanding of other people's points of view;
- use of working groups;
- value of a field trip;
- workshop notes; and
- effectiveness of the model notes in documenting participants' understanding of the management issues.

Concerns about the political process, raised as potential problems early in each of the projects, reflected a cynicism about what influence studies such as these might have on decision making. In seeming contradiction, there were fears that overenthusiastic use of the modeling tool might occur. Later in the workshop series, concerns were raised about the model in relation to the uncertainty of the data, the identification of key data, and the sensitivity of the process relationships. In the case of South Creek, the more technical participants accepted these limitations, whereas in both the Tuggerah Lakes and the water catchment access projects, further investigations were indicated. The latter project was the most constrained in its recommendations, as a consequence of being sharply focused on human health issues.

These three concerns will typically arise in adaptive management projects, because they reflect fundamental difficulties in environmental management. They are similar to those raised in other projects in Australia (Grayson et al. 1994, Grayson and Doolan 1995). Our approach to these three concerns was to discuss these, and other, difficulties of the exercise we were undertaking collectively. The themes that we stressed to workshop participants were:

- we were seeking ways to manage amidst uncertainty; uncertainty itself is unavoidable;
- some simplification is involved in all efforts to understand ecosystems: the goal is to use simplified models to assist decision making, not to substitute models for judgment; and
- all policy development processes run the risk of being derailed by external factors; our goal in the workshops is to provide better resources for policy implementation, acknowledging the risks.

We framed these difficulties by stressing that, collectively, we have the opportunity to invent new management approaches. Feedback from participants indicates that, for the most part, we successfully addressed these concerns.

Most respondents indicated that the adaptive management process was very successful in facilitating their analysis of the environmental system. The adaptive management process, notably the submodel development and review, contributed significantly to the participants' understanding of management issues. Most participants felt that they had achieved a clearer understanding of the structure and dynamics of the systems being investigated. Technical participants also acknowledged an increase in their breadth of understanding of the issues during the course of the workshops. Thus, all three projects demonstrated a rapid acquisition of knowledge by participants. The workshops provided an effective information flow and clearly provided a process for creating shared understandings, as required for a successful adaptive management project (McLain and Lee 1996). The shared understanding of the uncertainties noted in the first two workshops (Tables 3 and 4) was not considered to be a barrier to implementation. The community group in the Tuggerah project gained sufficient understanding of the issues to see the second entrance as a high-risk option, and were able to identify specific, high-priority investigations. The more technically focused group in the first case study was more used to dealing with the uncertainties identified, and the shared understanding gained of the system-wide issues was a good grounding for further cooperative work. The third case study helped the community stakeholders to gain a better understanding of the implications of a lack of knowledge about biophysical processes and allowed them all to sign off on a consensus report recommending no further access at

this time.

The participants' answers also indicated that, for the most part, they felt that the workshop series succeeded in reducing conflicts over both value-based issues and technical issues. Most felt that their concerns were adequately reflected in the joint analysis. All participants recorded improved levels of understanding of other people's points of view. Participants enjoyed the opportunity to exchange views, and a number commented on their sharpened insight into the issues. Thus, the workshops developed the common ground for joint resolution of policy problems. The process of these projects conformed broadly to Fisher and Ury's (1981) criteria for principled negotiation: focusing on the problem and not the person; focusing on underlying interests, not just policy positions; developing options for mutual gain; and using objective criteria to decide what is fair. The AEAM workshops worked as mediums for "provention" (Burton 1990).

Project implementation

The issue of getting agencies to implement AEAM recommendations is more complex than is suggested by the questions of self-interest and self-protection raised by Walters (1997). In all three cases, the agencies were struggling with the political overtones of environmental management problems. They were all seeking a technical solution with broad community support, and chose the AEAM approach as a potentially successful path. None of the sponsors appeared to have thought through the issues involved in implementing the workshop outcomes. On the other hand, Iles' (1996) assertion that our political and legal framework is inappropriate for adaptive management is not borne out by our case studies. An adaptive management strategy is being implemented for the Tuggerah Lakes and is an option for making progress in the management of Sydney's water supply catchment.

Getting follow-through on adaptive management workshop projects presents large challenges. We relied on the client to provide the ongoing structure and processes. With hindsight, we would place a much stronger emphasis on getting commitment, at the start of the process, that a key outcome will be that stakeholders will sign off on an implementation strategy, if something approaching consensus can be reached. We would put more emphasis on the role of adaptive management workshops as forums for negotiation.

Managing the wider political arena is a problem often neglected by project managers. The South Creek project exemplifies derailment by the wider political process. The corporatization of the Sydney Water Board occurred as Sydney Water shifted its institutional goals away from general water resource management and toward a narrower focus on provision of service. This precluded the development of coordinated implementation strategies based on the AEAM project.

In the Tuggerah Lakes case, an adaptive management strategy has been developed in which the lead role in implementation is being taken by the local government authority. The role of the "institutional champion" has been critical in gaining acceptance of the AEAM approach by both council and community participants. In this case, however, the resident "institutional champion" left; in the event that one of the authors (G. Walkerden) had not been appointed to the position, there would have been little or no follow-up from the project, either within or outside the sponsoring Council.

The sponsor in the Sydney Water Access project is currently considering follow-up actions based on the recommendations of the first workshop series, so it is too early to draw general conclusions about follow-through from this case study. The absence of an "institutional champion" suggests that follow-up on the proposed adaptive management project is unlikely.

It is clear from the South Creek and Tuggerah Lakes projects that there are important long-term benefits to be gained from developing community support for adaptive management strategies. Ecosystem management is a long-term process. In both cases, a single agency has had the lead role in driving follow-through, even though there were multiple organizations involved in the workshops. Events in the lead agencies in both projects demonstrate the vulnerability of adaptive management strategies to organizational change. Clearly, when designing long-term ecosystem management strategies, it is sensible to provide as broad a base of active support as possible. In communities with democratic governance, local community support can play a key role. The local community lives with long-term ecological outcomes and can maintain relationships in which agencies are held accountable. This emphasis on the value of community involvement is echoed in the experiences in the Pacific Salmon Fishery (Hilborn and Luedke 1987), the Columbia River (Lee 1993), and in the Grand Canyon (Wieringa and Morton 1996, Collier et al. 1997). Grayson and Doolan (1995) have covered many of these concerns, but did not develop the issue of the community's role.

In all three of our projects, political pressures to create broadly acceptable solutions made a participatory process attractive to the lead institutions. Yet, having achieved a degree of consensus, with a resulting reduction in political pressure, each lead institution scaled back the level of community involvement. There is a tendency to revert to familiar, less inclusive processes, and this works against the long-term needs of ecosystem management. We argue that, as adaptive management demands a more open approach to uncertainty, and a more inclusive approach to decision making, it creates a need for a person within the lead agency to act as a change agent: the "institutional champion." This person needs to be sufficiently influential in the lead agency

decision-making processes to be able to keep the project focused on the experiment-review-feedback cycle essential to the implementation of an adaptive management strategy. To be successful, the "institutional champion" should be an excellent communicator at multiple levels within and outside the organization. From a long-term perspective, we need to be working to strengthen the community's ability to hold agencies accountable. Community development of this kind can be driven from the inside (e.g., by an institutional champion) or from the outside (e.g., by community members). When running adaptive management workshops, we should be looking for stakeholders who can maintain a pressure for long-term ecosystem management.

This analysis suggests a series of issues (Table 5) that prospective adaptive management projects should consider. These include the need for a phase of the project to focus on laying the ground for the workshops, the workshops themselves, and a more formalized implementation phase. The education and co-option of a senior manager in the sponsoring organization to fulfil the role of institutional champion appears crucial. The cultivation of the community and the evolution of stakeholder participants are more important tasks than previously identified. The development of a clear strategy of continuation of the adaptive management process is essential. The pressures against such a solution are hugh. Budgets, human resources, and time are all constrained, and political pressure is applied by all of the players in the political landscape.

Table 5. Prerequisites to success.

1. A transparent, community-based process for the selection of stakeholder participants in the workshops of the project.
2. A hypothesis in the form of a conceptual systems model, sometimes expressed as a computer-based simulation model, that represents the understanding (agreed to by the stakeholders) of the system elements, structure, and processes.
3. A set of strategies that represent management policies or actions that recognize the uncertainties inherent in the system, designed to test assumptions about the data and the processes incorporated in, and the responses of, the modeled system.
4. A set of criteria for judging the success of the implementation of management actions and policies tested in the model and to be implemented in the real system.
5. A process and preferred set of management responses to be implemented at defined stages as the post-workshop project progresses.
6. A clearly defined suite of responsibilities for implementing management actions and policies with an explicit, public reporting procedure.

CONCLUSIONS

Environmental management problems commonly involve large numbers of stakeholders. Adaptive management recognizes this as both a central constraint on, and an opportunity for, effective environmental management. The large number of stakeholders is a constraint because management strategies that are not broadly supported are unlikely to be effectively implemented. It is an opportunity because the diversity of perspectives provides a resource from which a rich characterization of the environmental problem can be built. Adaptive management takes advantage of the opportunity by involving diverse stakeholders in a joint analysis of the environmental management issues. It deals with the constraint by using the analytical workshops as a context for building mutual understanding, increasing the chances of achieving a consensus among the stakeholders. The approach has a clear role in educating both community representatives and narrowly focused specialists, and it provides a setting for principled negotiation.

To increase the effectiveness of adaptive management workshop processes, we recommend:

- exploring the difficulties and uncertainties of ecosystem management, while at the same time exciting participants with the potential for inventing new ways of managing;
- emphasizing the role of workshops as forums for negotiation from the start, with the intention of signing off on a management strategy, if a consensus emerges; and
- making a self-conscious commitment to community development as an aspect of projects, with a view to developing skills in holding key stakeholders accountable in an assertive way.

RESPONSES TO THIS ARTICLE

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Acknowledgments:

We would like to acknowledge the role of Ian Armstrong (then of Sydney Water), together with Chris Glynn and Ray Abe (of Sydney Water), and Brian Bell (then Manager of Environmental Systems, Wyong Shire Council), for their vision and support for the adaptive management approach and for their faith that we could deliver useful outcomes. We would also like to thank Carl Walters for his enthusiastic support over the years since the early 1980s, and we thank our reviewers for their constructive advice.

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