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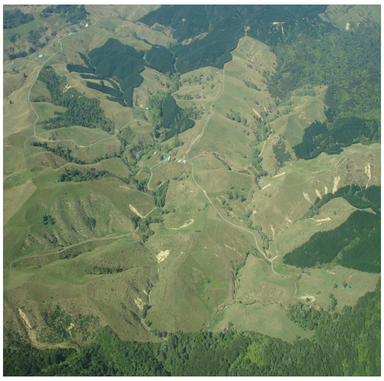
Review of recent rural catchment-based research in New Zealand

Report for MAF Policy

June 2009



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Review of recent rural catchment-based research in New Zealand

AgResearch and NIWA

June 2009

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1 Executive Summary

This report reviews the results, outputs and outcomes of recent rural catchment-based research in New Zealand, for the purpose of deriving key lessons of use to policy developers, policy implementers and researchers seeking to operate within an integrated catchment management (ICM) framework. Fourteen location-specific studies are included, as well as some non-specific studies, but the scope of the report does exclude some related areas (such as catchment management projects with limited research involvement). The compilation of this report relied on analysis of published literature and interviews with senior researchers involved in studies conducted or updated in the last ~20 years. Thus, the report should be considered as an analysis of the role of research in the application of ICM in New Zealand, rather than an analysis of ICM. A draft of the report was discussed at a user workshop and the feedback from that group has contributed to the structure & content of the report.

1.1 General observations

- The projects reviewed vary greatly in their approach to common elements of ICM:
    - Processes of oversight and engagement of non-research stakeholders;
    - Degree to which they address complexity through integration of research;
    - Spatial and temporal scale;
    - Breadth of land use and management comparisons;
    - Variety in communication/education/extension approaches used.
- Under-represented elements include long-term integrated studies and the participation of Maori (including social research on Maori interests).
- All the projects have a strong focus on land use effects on water quality in the broad sense and the use of a geographic (catchment) boundary to examine all the interactions between landuse, water quality and community.
- The projects have provided laboratories – a context for component and integrated research which is dominantly biophysical, relative to the lesser contribution of social and economic research at catchment scales.
- The projects have provided classrooms – a context for extension and learning.
- We now have a burgeoning range of tools (e.g. models, guidelines) to apply to the tasks of forecasting and deliberation. These tools cover the domains of biophysical, social and economic, the integration of these domains and project process aspects.
- We now have a wealth of experience across a range of ICM approaches to draw on for designing projects that are "fit for purpose".

1.2 Key lessons

The following represent the dominant themes arising from the catchment studies reviewed in this report, in the domains of biophysical, social (including process), economic and integrated research.

Environmental management

- Homogenization of stream structure and habitat (e.g. water temperature), leading to reduced aquatic faunal diversity across catchments, is a key degradation process which must be reversed to restore environmental values.
- Variable or critical source areas – sites with impacts disproportionate to their size – can either contribute differentially to contaminant loads (e.g. livestock crossings, flood irrigation) or have key roles in mitigating losses (e.g. headwater and riparian wetlands). Such sites are priorities for cost-effective protection/remedial action.
- Contaminants can take various flow paths (e.g. surface vs. groundwater) which need to be identified to understand and mitigate the associated lag effects on receiving water bodies.
- Stock exclusion from waterways is highly effective at reducing direct inputs of pollutants and thus effecting large proportional reductions in contamination.
- The continuity of riparian vegetation in time and space, interacting with stream order, is critical for mitigating land use effects on habitats and contaminant loads (where they pass through the zone of influence of the plants).
- Extreme weather events have disproportionate effects on soil and water quality in the context of long time scales, and interact with different land cover patterns to produce variable recovery rates.
- Land use has far-reaching effects on downstream and offshore ecosystems.
- The use of information generated by land-use comparisons and associated modelling (as opposed to that derived from actual land use change) for planning land use change has limitations in terms of unanticipated transition effects and their interactions with other dynamic drivers (e.g. climate and economic cycles).
- Variable time lags in environmental responses to management are a feature of catchment-scale processes and must be considered in planning.
- There are a number of factors that drive additional time lags in the on-ground application of environmental management practises by land managers.

Social and cultural processes

- Catchment-scale natural resource issues cannot be resolved within any single property and require landowners to work cooperatively with each other and with the responsible agencies to identify environmental priorities and organise the necessary resources to achieve desired outcomes.

- Two distinct types of communities ("communities-of-place" and "communities of interest") should be recognized in designing participatory approaches to integrated catchment management. Some catchment scale issues may be addressed by only focusing a study upon the local residents (communities of place), and other issues may need everybody with an interest in the waterway to be included (communities of interest).
- Integrated collectives require participation from both "decision-makers" and "decision-takers" for effective buy-in, which will require facilitation competent in conflict management.
- The most effective way to encourage change in landowner behaviour and the adoption of preferred management practices is for agency staff to work one-on-one with the people involved.
- Good relationships are important. This requires time and therefore reliable resourcing (i.e. funding).

Economic benefits and costs

- Restrictions in farmer's ability to intensify production represents a large financial limitation to them, this being the primary means available to them to maintain short-term profitability in the face of continually rising costs and variable product prices.
- Economic drivers are not the only determinant of goals and the adoption of new management practise, factors such as lifestyle, competence, social norms are also important.
- The cost-effectiveness of all BMPs varies greatly with the context in which they are applied – i.e. soil types, existing management systems, sensitivity of the receiving environment, financial drivers and the rigour with which they are applied.
- The costs to catchment communities of encouraging land use change can be considerable, but are seldom fully assessed (e.g. school closures as populations move away).

Research at catchment scales

- One research discipline cannot undertake a catchment research project. Taking a balanced multi-disciplinary approach underpins catchment-scale research.
- Water quality monitoring data sets of at least 5 years are required to make meaningful statements about trends.

- Having a defined structured process for engaging a range of stakeholders (incl. governance, research, education) is a critical part of an integrated approach.
- Non-researcher participants are often unaware of the environment in which science operates, and need to appreciate aspects of this environment to ensure their expectations are realistic. Conversely researcher participants need to appreciate that there are other ways of gaining, and sources of, knowledge.
- Catchment-scale research is better placed to contribute to positive outcomes when it embraces new ways of managing science beyond the traditional hypothesis-testing replicated, controlled experiments and the linear extension processes familiar to biophysical scientists. Key concepts include trans-disciplinary programmes, collaborative learning and adaptive research.

1.3 Recommendations

- A complementary analysis of non-research focused ICM projects should be conducted to gain a more complete picture of key lessons for the application of ICM to sustainable land & water management.
- Policy development must recognize and account for key features of the spatial and temporal dynamics operating at catchment scales, specifically the variability of driving processes in space and time and the existence of spatial and temporal lags. These dynamics imply the need to avoid policies aimed at standards or targets applied everywhere at all times and which address a localized or immediate issue but ignore known remote impacts.
- An ICM initiative needs to incorporate five fundamental tasks in the project design: 1. understand the issues, associated social dynamics and the drivers for change; 2. develop a catchment strategy; 3. precipitate action to bring about solutions; 4. monitor and evaluate implementation; and 5. run an effective program in order to achieve the first four objectives.
- In planning ICM projects, funding time frames should be aligned with realistic time scales for running an effective program to achieve the objectives – for example assessing the impacts of land use change took 10 years after the commencement of the Whatawhata project.
- Future catchment-scale research should address some gaps – filling the long-term research gap and balancing effort across sustainability domains (i.e. more focus on economic, social and cultural).
- Social research within catchment research projects should go beyond the behaviour of individual landowners and their practices to the way those individuals behave when they are interlinked to their communities of geography or interest.

2 Acknowledgements

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3 Introduction

3.1 Project scope

The aim of the project was to produce a comprehensive synthesis of the outputs, outcomes and lessons from New Zealand catchment-scale research projects, deriving a collective understanding that can foster widespread environmental, economic and social gains.

The rationale for this project is that over the last 2 decades a number of research projects have been conducted under the auspices of "integrated catchment management" (ICM). These projects represent an enormous investment in research and extension over a sustained period, but there have been limited opportunities to present users (e.g. policy agencies, land managers and NGOs) with a comprehensive overview of the knowledge gained and lessons learnt. Given that regional authorities, primary industry sectors and MAF have established or are in the process of establishing catchment-scale management leadership groups within the context of sustainable land management initiatives, there is a clear need for a collective wisdom, to guide both the operation and activity of such groups.

This need is not merely limited to a synthesis of knowledge on the technical aspects of catchment management to improve environmental outcomes at landscape scales. The need encompasses an understanding of synergies and tensions between multiple goals for management of the land, water and air resources. Therefore, consideration must be given to the interaction between environmental, economic and social drivers resulting from current land use and potential land use change. A key aspect of applying an ICM framework to research is what additional understanding of catchment-scale systems is generated beyond the results of component research within disciplines and domains.

Furthermore, the process-based aspects of catchment research projects are critical to the achievement of multiple goals – i.e. governance, decision-making and cross-disciplinary interactions. There are important lessons to be garnered from existing studies in terms of ensuring progress in the operation of catchment leadership groups.

Finally, there remains the question of what impact these research studies have had beyond their stated scope, in terms of the relationships between research providers/managers and the wider stakeholder/user community.

3.2 Project limitations

- This document is not a review of integrated catchment management (ICM), but a review of research conducted in the context of catchment-scale projects. Some of the research projects can be considered ICM projects and therefore the results may be applied to non-research ICM contexts.
- For some of the case study catchments covered in this review, it has been difficult to define the boundaries of the "project" and thus to select what component research to include in the review (e.g. Rotorua lakes, Lake Taupo). This is due to the research effort being scattered across different organisations, funding sources and time periods, or being part of larger-scale investigations.
- Not all New Zealand catchment studies are included in this review. For example, we have not considered urban and peri-urban catchment studies (e.g. Pahurehure, Whitford) where the key drivers relate to urbanisation. We have focussed on those rural studies which have included a stakeholder participatory process and/or examined the effects of different land uses on multiple sustainability domains (environmental, economic, social).
- A number of the topics addressed in this review are also the subject of research conducted outside the context of the catchment projects described, which we have not attempted to incorporate (e.g. riparian management, landowner decision-making, cost-effectiveness of BMPs). Such studies may have produced quantitatively differing results, but we have drawn conclusions from the catchment-based research that we believe are broadly consistent with other research we are aware of.
- The literature review drew on information that was publicly available at the time of writing. Some outcome statements will therefore become dated. There is also much knowledge and experience in the area of catchment management that is not yet published, some of which was captured through the interview and workshop processes.
- The scope of the review is limited to catchment studies undertaken or updated in the last ~20 years.

4 Description of catchment research studies

This section summarises the individual catchment research projects included in this review. The locations of the catchments are shown in Figure 1. Table 1 summarises the basic characteristics of each catchment research project. More detailed descriptions of the individual studies can be found in the Appendices (Section 7.1), where sub-sections deal with each studies' background, stated purpose, outputs (e.g. publications, field days, student projects), planning and decision-making processes, major research findings and outcomes (e.g. environmental improvements, policy contributions), based on published literature.

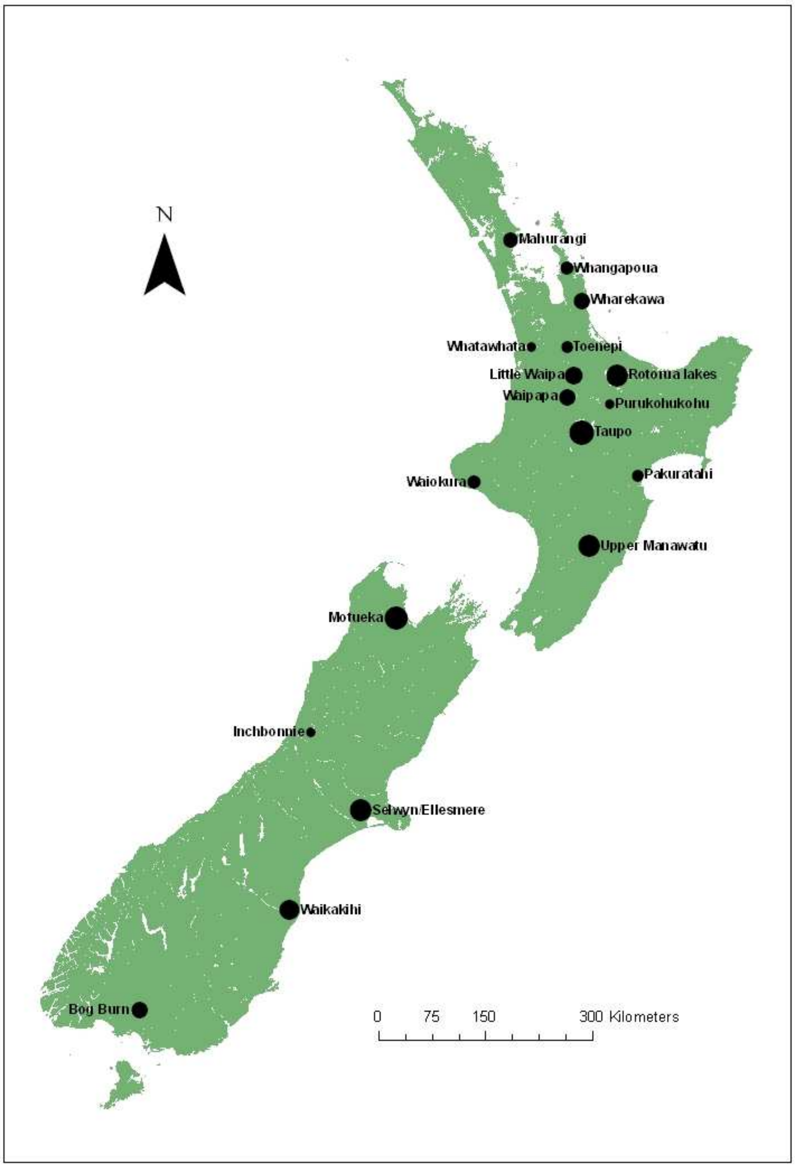

Figure 1. Map of the location of the research catchment projects included in this review, with relative catchment size indicated by the symbol size.

4.1 General observations

These catchment research projects collectively cover a wide range of spatial scales (100s to 100000s of hectares, Figure 2) but in keeping with the relatively recent application of ICM in New Zealand only cover a narrow range in temporal scales, with most being between approx. 5-15 years in duration and only one of multiple decades in duration (notwithstanding the lengthy record of component research in some areas such as the Rotorua lakes). The spatial scale of catchment research is important. Studies seeking to understand specific aspects of land use can be done at smaller scales (e.g. plots and farm paddocks) but to take spatial variability into account (e.g. different soil types, varying proximity to sensitive waterways, human attitudes and behaviours) it is necessary to conduct research at the catchment scale. That is, to a certain extent catchment research is inherently integrative.

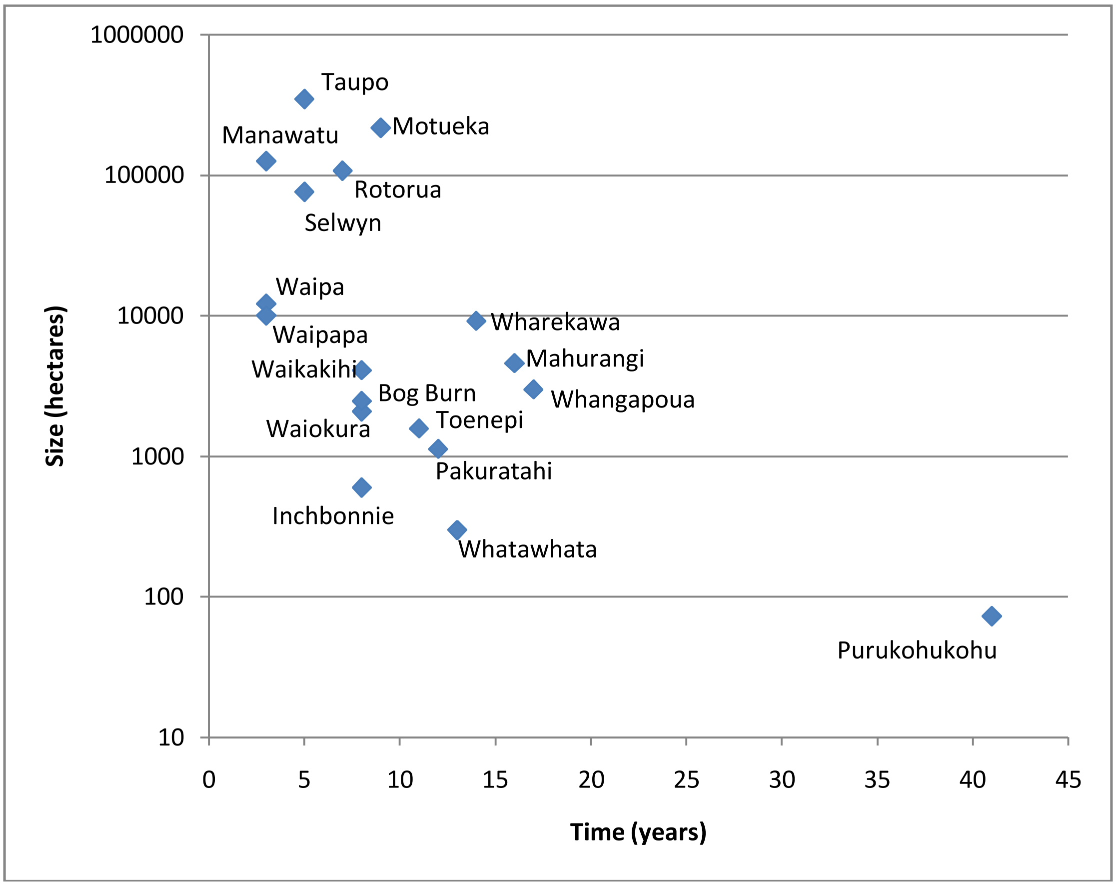

Figure 2: Spatial and temporal scales of New Zealand catchment research projects.

Table 1. Summary characteristics of the catchment research projects included in this review, in order of increasing latitude.

Project name	Participant agencies[1]	Research domains			Driving group	Water body focus
		Biophysical	Social	Economic		
Mahurangi	ARC, NIWA	✓			Local government	Harbour
Whangapoua	EW, NIWA, EOL, MW-LR, SCI	✓			Local government	Harbour
Wharekawa	EW, NIWA	✓			Local government	Estuary
Whatawhata	AgR, NIWA, EW, WDC, DoC, MW-LR	✓	✓	✓	Researchers	River
Toenepi	DRI, AgR, NIWA	✓		✓	Industry	River
Dairy Best Practice (5)	DNZ, AgR NIWA, LV, EW, TRC, WRC, ECan, ES	✓	✓	✓	Industry	River/Lake
Rotorua lakes (12)	EBOP, AgR, NIWA, UOW, LCT	✓		✓	Local government	Lakes
Upper Waikato (2)	EW, AgR	✓		✓	Local government	River/Lakes
Purukohukohu	NIWA, MW-LR, SCI	✓			Researchers	River
Lake Taupo	EW, AgR, NIWA, LV, DNZ	✓		✓	Local government	Lake
Pakuratahi	HBRC, NIWA, MW-LR, SCI, LIRO, MU	✓			Local government	Ocean
Upper Manawatu	HRC, MW-LR, AgR	✓			Local government	River
Motueka	MW-LR, CI, TDC, LCT, FG	✓	✓	✓	Researchers	River/Ocean
Selwyn/Ellesmere	ECan, LV, NIWA, MW-LR	✓			Local government	River/Lake

[1]Agency abbreviations: AgR, AgResearch; ARC, Auckland Regional Council; CI, Cawthron Institute; DoC, Department of Conservation; DNZ, Dairy NZ (formerly Dexcel); DRI, Dairy Research Institute (now Fonterra); EBOP, Environment Bay of Plenty; ECan, Environment Canterbury; EOL, Earnslaw One Ltd; ES, Environment Southland; EW, Environment Waikato; FG, Fish & Game New Zealand; HBRC, Hawkes Bay Regional Council; HRC, Horizons Regional Council; LCT (New Zealand Landcare Trust; LV, Lincoln Ventures; LIRO, (former) Logging Industry Research Organisation; MW-LR, Manaaki Whenua – Landcare Research; MU, Massey University; NIWA, National Institute of Water and Atmospheric Research; SCI, Scion (formerly Forest Research); TDC, Tasman District Council; TRC, Taranaki Regional Council; UOW, University of Waikato; WDC, Waikato District Council; WRC, Westland Regional Council.

All the projects have included elements of biophysical research (essentially majoring on the impacts of land management on water quality), consistent with the concept of a drainage catchment being the defining boundary of the studies and the prominence of water quality as an environmental issue over the past 20 years. Some of the studies have included formal social and economic research, with only three (Whatawhata, Dairy Best Practise and Motueka) including all three research domains. Even in these, the output record indicates that the research effort is not equally balanced across the three domains. With regard to the interaction between economic and social domains, the costs to catchment communities of encouraging land use change can be considerable, but are seldom fully assessed (e.g. school closures as populations move away).

The projects collectively also cover a diverse range of participant agencies and driving groups (Table 1). From a research provider perspective, the Crown Research Institutes are much more strongly represented than the universities and private agencies. In terms of local government, 10 of the 16 regional councils/unitary authorities are involved in at least one of the catchments (with Environment Waikato being particularly well represented) and regional councils feature strongly in the list of driving groups. The least represented stakeholder group appears to be Maori organisations.

The projects also display variation in some other dimensions of ICM. For example, the range of land use and management activities covered varies from those studies focussed on management effects within a single enterprise (dairying in the Dairy Best Practise catchments) to multiple land uses and mosaics (pastoral, forestry, indigenous in Taupo) – a feature somewhat correlated with spatial scale. Complexity is another dimension linked to scale, and the need for integration to address this also varies across the projects – contrast the work in Wharekawa on the effects of forestry sediment generation on estuarine ecosystems with the complexity of the terrestrial, freshwater and marine ecosystems connecting multiple stakeholders (agriculture, forestry, tourism, aquaculture) in Motueka. Thus we see a concomitant range in oversight of the projects, from simple contractual arrangements between funder/user and provider, through to multi-stakeholder groups (involving researchers, policy agencies, land managers, consultants, contractors, iwi, etc.) engaged in the whole process of project planning through to implementation and evaluation of on-ground land management changes in an integrated approach (e.g. Whatawhata). Finally, the degree to which these projects have engaged in communication, extension and education varies considerably, with some limited to internal reports while others provide a more comprehensive programme (e.g. Dairy Best Practise, Motueka) including diverse vehicles like scientific papers, client reports, field days, focus groups, workshops, formal teaching, exhibitions, newsletters, websites, training courses etc.

These dimensions that characterise catchment projects can be used to build a typology of ICM (Table 2). Two key dimensions that can be represented by a continuum are the degree of complexity (leading to the degree of integration of disciplines and participant groups) and the degree of outreach (leading to the degree of formalisation of outcomes).

Table 2: Suggested key dimensions of an ICM typology.

Complexity and integration				
Characteristic:	Single-issue →	Disciplinary →	Multi-disciplinary →	Trans-disciplinary
Example:	Sediment	Environment	Environment+social	Science+policy
Case:	Wharekawa	Mahurangi	Dairy best practise	Motueka
Outreach and outcomes				
Characteristic:	Research →	Extension →	Policy development →	Management change
Example:	Science papers	Field days	Regional plan	Land use change
Case:	Purukohukohu	Toenepi	Upper Manawatu	Whatawhata

Many of these projects have provided a knowledge framework that can be thought of in two senses – the catchments provide a "laboratory" for the conduct of component and integrated research by primary learners (e.g. scientists) to generate new knowledge, and provide a "classroom" for the transfer of that knowledge to secondary learners (e.g. land managers) through deliberation and extension.

The picture that this overview of research catchment studies presents is one of a diverse array of contexts and issues that have been addressed, and an equally diverse array of participants, processes and tools that have been employed, to address the goals of sustainable land and water management. While this wealth of knowledge and experience is now available for the design of new projects that can be made "fit for purpose", it does require significant effort by users to access it.

5 Lessons learnt

This section outlines what the authors consider the key lessons from the catchment studies, as gleaned from the literature. These points are not referenced specifically but derived from the analysis of the catchment studies presented in Section 7.1, where the results and conclusions include formal citation of the literature. In general a point has been considered valid for inclusion where it has been noted in the context of at least two independent catchment research projects. In the last sub-section on research at catchment scales the lessons are derived from individual interviews of the senior researchers from the major research projects.

5.1 Environmental Management

5.1.1 Land-water interactions

The relative impacts of the major land uses (pastoral, plantation forestry and native forest) on water quality, stream morphology and aquatic ecology have now been fairly well established, partly as a result of research carried out within these catchment studies. While quantitative effects and differences are site specific, a number of qualitative conclusions can be drawn:

- Pastoral use: Pastoral waterways generally have higher water yields, peak flows, nutrient levels, suspended sediment levels, faecal coliform numbers, water temperature, faunal densities, in-stream productivity and lower faunal diversity relative to forested waterways. These effects can be quantitatively linked to animal stocking rates.
- Forestry use: There is a pattern of reduction in water yield, sediment and nutrient export (the exception being nitrate losses) and improvement in stream biota over a plantation forest growth cycle; with the temporary (3-5 years) increases in these indicators during the logging and early tree regrowth phases still amounting to lower impact on waterways overall, relative to pastoral catchments.
- Wetlands: These have an important role in mediating sediment and nutrient export through physical entrapment and denitrification processes.
- Riparian zones: Tall riparian vegetation has an important role in providing stream shade and mediating water temperatures, thus influencing aquatic ecology. Its continuity in space (along reaches) and time (over harvest cycles) is critical. Riparian vegetation also provides external organic matter inputs, thus influencing the energy base of the stream ecosystem.

- Stream size: The differing dynamics of small vs. large streams are reflected in the former being more rapidly responsive to changes in riparian vegetation (e.g. temperature, biota) and recovering more rapidly after disturbance events.
- Contaminant pathways: The important role of subsurface flow pathways (particularly for inorganic N) creates time lags between land use changes and receiving water impacts – these have been documented at up to ~100 years in lake systems.
- Remote effects: The extensive offshore effects of catchment land use and the associated export of nutrients and sediment on marine systems have been documented at up to 10 km offshore, with nutrient inputs of a similar magnitude to ocean biogeochemical processes.
- Extreme events: Extreme weather events have proportionally large impacts in pastoral catchments, with both the immediate order-of-magnitude increases in erosion, sediment and nutrient export and disturbance to aquatic ecology and stream structure, as well as ongoing discharge of temporarily entrained sediments and slower recovery of fauna.

5.1.2 Best management practices (BMPs)

Best management practises (BMPs) are defined here as modifications to existing enterprises for the purpose of mitigating the negative impacts of those enterprises on key environmental indicators. Thus, they are implemented at scales below the ownership unit. Many BMPs have been proposed and evaluated in the context of catchment studies, though their implementation and evaluation is not predicated on this context. As far as we are aware, there has been no study of the catchment-scale effects of the variable degree of implementation of BMPs other than within modelling exercises (e.g. Upper Manawatu).

- Wetlands: The important mediating role of wetlands noted above emphasises the need to avoid stock/mechanical disturbance of these systems. Wetlands are also a relatively cost-effective mitigation tool for reducing sediment and nutrient inputs to waterways under normal flow conditions. There remains however a recognition that for sediment and P they represent a temporary entrainment solution.
- Stock exclusion: Riparian fencing and bridges have been shown to be highly effective at reducing direct inputs of faecal bacteria (viz. *Escherichia coli*) and thus effecting large proportional reductions in contamination. There is also evidence that the reduction in damage to stream banks has an immediate impact on sediment export.

- Riparian Zones: In both pastoral and forestry contexts planted riparian strips have been shown to reduce stream temperatures and protect aquatic fauna, including through the tree harvest phase. However, the effectiveness of riparian vegetation is limited under conditions of extreme weather events and when contaminant flow paths operate via groundwater (e.g. N-leaching).
- Animals: Reducing animal stocking rates, stocking with lighter/younger cattle and moving from cattle to sheep all have a demonstrable quantitative effect on sediment and nutrient losses and improved water quality. However, since the profitability of farming businesses is highly dependent upon establishing stocking rates that enable them to achieve high levels of pasture utilization, any disruption to that relationship is likely to be a costly strategy for reducing nutrient losses (e.g. Lake Taupo, Dairy Best Practise catchments).

5.1.3 Land-use change

Research on the actual impacts of land use change (within the biophysical, economic or social sustainability domains) in the context of catchment-scale projects is actually quite limited. This is no doubt mainly due to the long time scales and large spatial scales (and attendant costs) involved in planning, implementing and evaluating the effects of land use change in a scientifically robust way. Of the projects covered in this report, only Whatawhata and Purukohukohu have completed this cycle to date, and these are relatively small-scale studies only covering the transition from pastoralism to forestry. The results have been largely in line with expectations, although not necessarily in the time frames expected:

- Reductions in water yields, peak flows, nutrient levels, suspended sediment levels, faecal coliform numbers and water temperature.
- Improvements in per hectare productivity of animal enterprises focussed on better quality land.

Other projects have dealt with questions around the impacts of land use change in two ways:

- Adjacent comparisons of land use (e.g. Pakuratahi), which are limited in that they compare established systems without accounting for the potential effects of transition from one land use to another, or the interactions of land use change and other temporally dynamic drivers such as climatic and economic cycles (e.g. the ongoing effects of implementing vegetation change during a wet period).
- Modelling land use changes (e.g. Rotorua lakes, Lake Taupo, Motueka). The models used are mainly static assessments of effects based on knowledge

generated from the land use comparisons above (e.g. WAM, CLUES, Overseer, NZEEM) rather than dynamic simulations (e.g. AEM, AquiferSim) and thus subject to the same limitations noted above.

Thus, planning and decision-making processes that rely on the predictions of these approaches for the effects of land use change must take such limitations into consideration.

5.1.4 Time scales for uptake and environmental responses

A major understanding that has arisen from catchment-scale research is the appreciation of variable time lags in the responses of environmental indicators to management changes. This is demonstrated in groundwater residence time studies conducted at Whatawhata, Lake Taupo, Rotorua lakes and Motueka where lags of 2 - 110 years have been indicated. It is also indicated by the short-term results of land use and management change at Whatawhata, where differing water quality indicators (sediment, nutrients) did not necessarily conform to expectations based on modelling.

This appreciation must also be set alongside the realisation that the on-ground application of systems and practises targeted at improving sustainable land management also incorporates time lags. This is demonstrated from behavioural research conducted within these catchment research projects (but also from other relevant adoption research) that has identified a number of factors influencing the observed lags:

- Verification of the research results by decision-makers.
- Time required to assess implications of research results.
- Cost effectiveness of new practise (particularly in the short term).
- The role of under-appreciated drivers of decision making (e.g. non-financial).
- Socialized vs. individualized responses.
- Formation of coalitions to resist change.
- Modification of the degree or direction of change to protect core values.
- Integration of new practise into existing systems and associated complexity.

Therefore, understanding differences in the adoption behaviour of decision-makers such as land managers is critical for building realistic expectations of uptake, a process that can be enhanced by segmentation.

Long time-lags in both implementation of mitigation options and the environmental outcomes of implementation have important implications for progress toward sustainable land management:

- Time scales of effects must be recognised when setting goals.
- Monitoring time frames (frequency and duration) must be consistent with the expected time scales of effects.

5.2 Social and Cultural Processes

5.2.1 Establishing the Social and Cultural Dimension

Many of the natural resource issues to be dealt with in a catchment cannot be resolved within any single property. Such issues require a number of landowners and their families to work cooperatively with each other and with the responsible agencies (e.g. primary industry and local authorities) to:

- identify environmental priorities to be addressed at a community scale rather than individual property scale.
- address the priorities and organise people's efforts and any resources that might be needed to achieve their desired outcomes.

While catchments are clearly spatially delineated, the communities associated with those catchments are not as clearly defined. Communities of people that relate to particular geographical centres and have boundaries (structural or physical) separating them from communities with other geographical centres can be considered "communities-of-place". The members within some communities-of-place will relate strongly to each other and easily work together on shared projects, and some will not. In contrast with communities-of-place, some catchment projects involve functional communities or "communities-of-interest", gathered around a single issue or set of issues (such as caring for the waterways in a specific catchment) where some of the members are not resident in the geographic area.

The literature defines integrated catchment management in a number of ways. For some authors it has been defined in terms of the outcome for the natural resources in an area. In this definition the inclusion of the word *integrated* signals the bringing together of *management* practices associated with the sustainable use of water, air, soils and biodiversity for which a *catchment* provides the most effective organising unit. Two such definitions are:

1. Integrated catchment management is the sustainable and balanced use of all land, water and biological resources in a catchment.
2. Integrated catchment management is an approach that recognises the catchment or river basin as the appropriate organising unit for managing natural resources in a context that includes social, economic, and political considerations.

For other authors integrated catchment management has been defined in terms of collective decision making processes. In this definition the inclusion of the word *integration* is more associated with the type of *management* being used within a *catchment*. This management is described as being inclusive and participative and the catchment becomes a way of deciding upon membership to the decision making group, either because of geographical boundaries or else functional interests (communities of place or of function respectively).

5.2.2 Institutional arrangements

In an integrative catchment the planning needs to be done by a collective that combines "decision-makers" (i.e. those whose decisions have an effect on resource quality) and "decision-takers" (i.e. those whose interests depend on resource quality) and not one group or the other. If only one group is involved in a project, the results lack buy-in from the other group and so are not really integrative. This means that the key facilitative skill required in integrative catchment groups is conflict management, i.e. the "socialization" of points of difference by making those differences more explicit in a social context and encouraging groups to resolve environmental issues in ways that respect such differences. The objectivity of science often seems to provide a mechanism for this.

In the literature, there seems to be two different ways of facilitating catchment groups. One way is to introduce processes of collective decision making (e.g. Whatawhata) the other to share technical information about a situation and negotiate an agreed knowledge set for decision making (e.g. Lake Taupo).

Some catchment research projects seem to focus upon a community whereas others focus upon landowners, e.g. farmers. The only projects where the focus is upon communities seem to be researcher-driven projects (e.g. Motueka). The projects that are not researcher-driven (e.g. Upper Waipa) seem to focus upon landowners. This suggests an institutional barrier limiting policy agencies from involving whole communities. If that is the case, perhaps we need to re-examine the way that catchment research is being designed.

There is a dearth of extension capability to champion and guide farmers through planning processes that consider both productive and environmental issues on individual farms. The capability that is available tends to focus on one or other of these domains.

5.2.3 Change strategies

Restrictions in farmer's ability to intensify production through land use change (e.g. forestry to dairy), enterprise change (e.g. sheep to dairy) or increasing stocking rate and inputs represents a large financial limitation for them, these being the primary means available to maintain profitability in the face of continually rising costs and variable product prices.

Financial drivers are important but not overwhelming influences on landowner decision-making and the implementation of land use and management change. Factors such as effects on productivity (as distinct from profitability), ease of implementation, the requirement for significant systemic change have also been identified as important drivers. This has been reinforced by the apparent slowness in uptake of effective mitigation options that are cost-neutral or with small cost-positive benefit and significant mitigation of N loss (e.g. nitrification inhibitors).

The potential to make effective change on farm is dependent on current farm practices. This means that progress and gains in an agricultural catchment requires working with individual farmers for greatest cost- and environmental-effectiveness.

5.3 Economic Benefits and Costs

5.3.1 On-farm

The cost-effectiveness of all BMPs varies greatly with the context in which they are applied – i.e. soil types, existing management systems, financial drivers and the rigour with which they are applied. For example, the use of DCDs was consistently the most cost effective option in the Dairy Best Practise catchments but ranked behind other winter grazing and effluent management options in the Upper Waikato.

Farmers in catchments with nutrient caps (Upper Waikato, Rotorua lakes) were strongly against mitigation options requiring a large capital input (e.g. animal shelter systems) because of uncertainty over whether such actions would be sufficient in the longer term.

Intensification is generally a profitable strategy for farmers in the short-term, and hence reductions in stocking rate are conversely a costly strategy for reducing nutrient losses (e.g. Lake Taupo, Dairy Best Practise catchments).

Conversion of low-productivity land to forestry has been predicted to improve profitability in the long-term, though not necessarily in comparison to pastoral intensification (e.g. Rotorua lakes). For example, the “selective intensification” paradigm (i.e. Whatawhata) that included forestry identified that short-term capital investment and cash flow issues were prohibitive, despite improvements in per hectare profitability after management changes.

5.3.2 At catchment and regional scales

The three catchment-scale economic analyses conducted that relate to the research projects reviewed here have shown:

- There are potentially large losses to the productive value of pastoral agriculture given restrictions on N inputs that curb intensification (e.g. Lake Rotorua).
- The economic value of non-primary sectors in comparison with the primary sectors can be substantial (e.g. Lake Taupo).
- The indirect economic value of ecosystem services is substantial in comparison with catchment gross product (e.g. Motueka).

5.4 Research at catchment scales

Catchments are part of a scale continuum: …plot – paddock – farm – catchment – region – country…; so catchment studies address questions and aggregate effects up to the catchment scale but not beyond. This limitation applies to all scale-dependant questions.

The research experience has demonstrated that water quality monitoring data sets of at least 5 years are required to make meaningful statements about trends, and long-term research is essential to account for and understand the impacts of extreme events in marginal environments.

Integrated research by definition requires the building of relationships and teams across disciplines and outside science, which takes time and commitment. Focus and progress within disciplines may need to be sacrificed to this end, as it can often be held up by the surfacing of unexpected but legitimate issues and definitions. The inevitable turnover of participants means that individuals will be at different stages in their appreciation of the value of integration, and their cognizance of where the project has come from and what it has achieved.

A structured project process helps guide catchment project participants to some tangible outcomes. Key steps include:

- understand the issues, associated social dynamics and the drivers for change;
- define the values associated with a catchment, leading to definition of a set of catchment-specific goals/objectives.
- choose appropriate indicators.
- assess the status of the land and water resource relative to goals.
- understand the key linkages between land management activities and environmental/economic/social outcomes.
- determine the most appropriate land management practices required to deliver to target outcomes.
- develop and implement land management plans of varying complexity.
- monitor and evaluate the outcomes of implementation.

Non-researcher participants are often unaware of the environment in which science operates, and need to appreciate aspects of this environment to ensure their expectations are realistic:

- scientific methods, with attendant strengths and weaknesses and which differ across research domains (e.g. biophysical vs. social).
- funding cycles which affect continuity of researcher involvement.
- inter-agency relationships which affect access to skills and resources.

Researcher participants, who are often inclined to a world view where they are the objective knowledge providers, need to appreciate that there are other ways of gaining knowledge. This includes differing research approaches (e.g. biophysical vs. humanities) and sources (e.g. stakeholder experience).

Identification of a real-life problem, recognised by stakeholders, is critical for moving from a technical/scientific/academic study to achieving change.

6 Recommendations

6.1 For establishing and managing catchment groups and projects

On the basis of our observations, we propose that an ICM initiative faces five fundamental tasks that need to be incorporated in the project design:

- the need to understand the issues, associated social dynamics and the drivers for change.
- the need to develop a catchment strategy.
- the need to precipitate action to bring about solutions.
- the need to have a programme of monitoring and evaluation that encourages learning and adaptation amongst project participants and communicates with other catchment projects.
- the need to run an effective program in order to achieve the first four objectives.

6.2 For policy development and knowledge uptake

One of the key tenets of integrated catchment management is the recognition that knowledge can be derived in a number of ways from a diversity of sources. The science conducted in research-based catchments contained in this report represents one of those sources. It is recommended that further analysis should be conducted, inclusive of the numerous successful non-research focused catchment projects (e.g. Taieri, which has been reported on in detail elsewhere). This will help to gain a more complete picture of the elements for successful application of ICM in terms of on-ground application in a local community context. An obvious starting point for this analysis are the results of the MfE Sustainable Management Fund project “Integrated catchment management: sharing best practice nationally” conducted by the NZ Landcare Trust.

Policy development must recognize and account for key features of the spatial and temporal dynamics operating at catchment scales, specifically variability of driving processes in space and time; and lag effects in space and time. A lag effect is an effect which is observed some distance from, or some period after, the action which caused it. Some observable examples are shown in Table 3. The variability inherent in systems at all scales implies the need to avoid policies which seek to achieve some standard conditions or targets everywhere at all times. Lag effects in systems at all scales implies the need to avoid policies which address a localized or immediate issue but ignore known remote impacts (i.e. further away or in future).

Table 3: Examples of important spatial and temporal considerations.

	Spatial	Temporal
Variability	Critical contaminant source areas Effectiveness of BMPs	Extreme weather events Fluctuating product prices
Lags	Offshore plumes Community of interest links	Groundwater residence times BMP implementation barriers

6.3 For future catchment-scale research

Some existing catchment research projects should receive continuity of funding to work towards addressing the lack of longer-term studies, in light of the strong evidence of temporal lags; the disproportional effects of infrequent extreme climatic events; and the recognition of long-term climate cycles.

There is scope in most existing catchment research projects for redressing the imbalance between biophysical and non-biophysical research, where the latter is a recognised part of the research objectives. A greater focus on economic, social and cultural studies at catchment scales would require consideration of increasing funding or re-prioritizing fixed existing funding.

Because biophysical catchment responses can take a long time to appear, it is important for research planners to develop realistic objectives for studies conducted at these scales. If the objectives include a robust evaluation of biophysical trends and making defensible assessments of key land-water linkages, then funders will need to be prepared to commit to reasonably long project lives (>10 years). If instead the objective is to use the catchment as a focal point for discussions about catchment values and probable farming impacts (i.e. a less technical assessment of things), then shorter project lives may be adequate.

Social research associated with catchment management examines the relationships between community functioning and waterway functioning. Catchment research projects should therefore go beyond the behaviour of individual landowners and their practices (sometimes referred to as human capital) to the way those individuals behave when they are interlinked to their communities of geography or function (also described as social capital).

7 Appendices

7.1 Research project descriptions

This section describes the individual catchment studies, ordered by increasing latitude. For each study, sub-sections deal with the project context and background, stated purpose, outputs (e.g. publications, field days, student projects), planning and decision-making processes (where the stakeholder context makes this relevant), major research findings and outcomes (e.g. environmental improvements, policy contributions). The information in this section is largely based on published literature.

7.1.1 Mahurangi

The Auckland Regional Council, recognising the need to balance ecological and recreational values of the Mahurangi Estuary with reasonable economic use of its surrounding land, commissioned NIWA to conduct a series of studies within the catchment and estuary (ARC 1993).

Purposes:

- Pesticide use and the risk of movement to waterways
- Colour and clarity of estuary waters
- Sediment and nutrient loads to streams and the estuary
- Sediment history in the estuary
- Movement of water and contaminants within the estuary
- Patterns and trends within the ecology of the estuary

Outputs:

Two reports to Auckland Regional Council and a scientific paper on hydrological modelling.

Major research findings:

Use of a computer simulation model (BNZ) showed that the long-term average sediment load to Mahurangi Estuary from its surrounding catchment was 52,270 tonne $year^{-1}$ (448 t km^{-2} $year^{-1}$) and ranged from about 13000 to 136,000 t $year^{-1}$ (Stroud and Cooper 1997). The model predicted that the combination of steep slopes and pastoral land use was the dominant factor behind the high sediment loss from the land surface.

Nutrient loads were typical for catchments with the same mix of land uses but with a higher than usual proportion of particulate forms associated with inputs of fine, nutrient-rich material from the erosion of clays soils within the catchment. The pine sub-catchment had lower nutrient loads than that measured for the pasture and large, mixed land-use sub-catchments.

A recent study (Hume et al. 2009) investigated how using a Knowledge Network Model (KNM) might aid sediment management in the Auckland region by bringing planning and science together when reviewing sediment management and controls. The methodology, utilising Bayesian Belief Networks (BBN) modelling, provides an effects-based approach based on an understanding of the key waterway/catchment values that need protection/restoration and how to manage and mitigate the pressures from land development on these values. The focus was on sediment effects on the harbour and biophysical issues as opposed to wider catchment and social science issues. The process of model development revealed that in general, information on catchment runoff is relatively good and quantitative but information on effects in the estuary is more limited and often relates to specific temporal or spatial scales.

Outcomes:

The Mahurangi Action Plan (MAP), a joint ARC and Rodney District Council project, was established in 2004 in response to long-term environmental monitoring that indicated that the health of Mahurangi Harbour was in decline. The goal of the MAP is to halt, slow or reverse the adverse effects of sedimentation on the harbour. This is being achieved through:

- managing projects in the area, particularly with landowners
- significant fencing and riparian planting
- compliance monitoring for earthworks and forestry
- environmental monitoring
- research and investigation that includes a sediment source assessment project
- extensive environmental education throughout the local community and schools

Further details of the MAP including progress on actions may be found at http://www.arc.govt.nz/environment/coastal-and-marine/mahurangi-action-plan/mahurangi-action-plan_home.cfm

7.1.2 Whangapoua

The Whangapoua catchment drains to a large estuarine harbour (13 km^2) on the north east coast of the Coromandel Peninsula. It has been the site of FRST-funded research (NIWA, Landcare Research, Environment Waikato and Scion) and industry-funded monitoring (Ernslaw One Ltd and Environment Waikato) on the effects of forestry practices on erosion, riparian vegetation and stream habitat and biota and the effects of fine sediment on estuarine fauna. Much of this work has occurred within the 30 km^2 Opitonui sub-catchment.

Purpose:
To monitor the effects of pine forest logging on stream and harbour environments and to understand the processes driving responses.

Outputs:
Several presentations to audiences ranging from community meetings to international science conferences, 10 scientific articles and book chapters, and five technical reports for Environment Waikato.

Major research findings:

- Native forest riparian buffers in pine plantations were shown to substantially reduce the impacts of logging on stream habitat, water temperature, food resources for in-stream biota, macro-invertebrate communities and fish.
- Clear-fell logging of pine plantations to the stream-edge caused marked increases stream temperatures with increases in both daily mean (2.0-3.8 °C) and maximum (4.0-7.3 °C) during summer. Increases were greatest in medium sized streams where harvest slash was removed after logging.
- Stream temperature recovery rates (annual cooling) after clear-fell logging were inversely proportional to stream size as indexed by catchment area, channel width or flow. Summer daily mean and maximum temperatures declined during the riparian vegetation regrowth phase by 0.18 and 0.47 °C /year, respectively, for the largest stream and 1.4 and 1.9 °C/year in the smallest stream. Thermal regimes were restored in small streams (2–4 m wide channels) about 6–8 years after clearfelling. In medium-sized streams (6–12 m wide channels) recovery was predicted to take 12–16 years.
- Pine harvest slash deposited in and over headwater streams at Whangapoua maintains cool water temperatures after logging. Despite high organic loadings

beneath slash, stream dissolved oxygen (DO) is generally > 60% of saturation in the water column (probably due to high atmospheric re-aeration in these shallow, steep streams). Mechanical removal of larger stems, resulted in dense packs of leaf litter over much of the stream bed immediately after logging and "stream-cleaning" and DO was strongly depleted in dense packs in backwaters (minimum recorded 19% of saturation) although DO remained >80% saturated in the thalweg flow.

- The species composition of invertebrate communities was found to overlap strongly between streams in native forest, mature pine, and logged sites with continuous riparian buffers, but clear-fell sites had significantly different composition and patch buffer (i.e., upstream areas clear-fell but buffered along local reaches) sites were intermediate in composition
- Clear-fell logging impacts on small streams may persist for up to seven years where logging removes shade for some distance upstream - water temperature and shade are key factors influencing invertebrate community impacts and recovery.
- Riparian buffers in mature pine plantations contained a mix of native species that was generally similar to, and not significantly reduced in species richness, from reference native forest.
- Radiata pine plantations in Whangapoua Forest can provide suitable conditions for the development of riparian buffer zones that will become dominated by native species, similar in richness and structure to neighbouring native forest. Thus, riparian buffer zones in plantations of exotic forests have the potential to act as a refuge for indigenous species which may be important if such refuges are lacking elsewhere in highly managed landscapes. To maintain the long-term integrity of permanent riparian buffers alongside major streams and rivers, a riparian width from the stream bank of at least 10 m is required.
- Sediment tracing using Compound Specific Isotopes (CSI) indicates that the contributions of different land uses as sources of sediment in Whangapoua Harbour vary considerably between the different arms, with these differences related to the recent pine logging and sediment movement patterns. Native forest and scrub contribute 20-30% on average over all the harbour. At all three eastern estuarine arms, there was a substantial contribution of soil from recent exotic pine forest logging, with proportions ranging from about 54% to 75% at those sites in the harbour.

The integrated long-term research led to the development of two conceptual diagrams published in the forestry chapter of Freshwaters of New Zealand (Figs. 3 & 4).

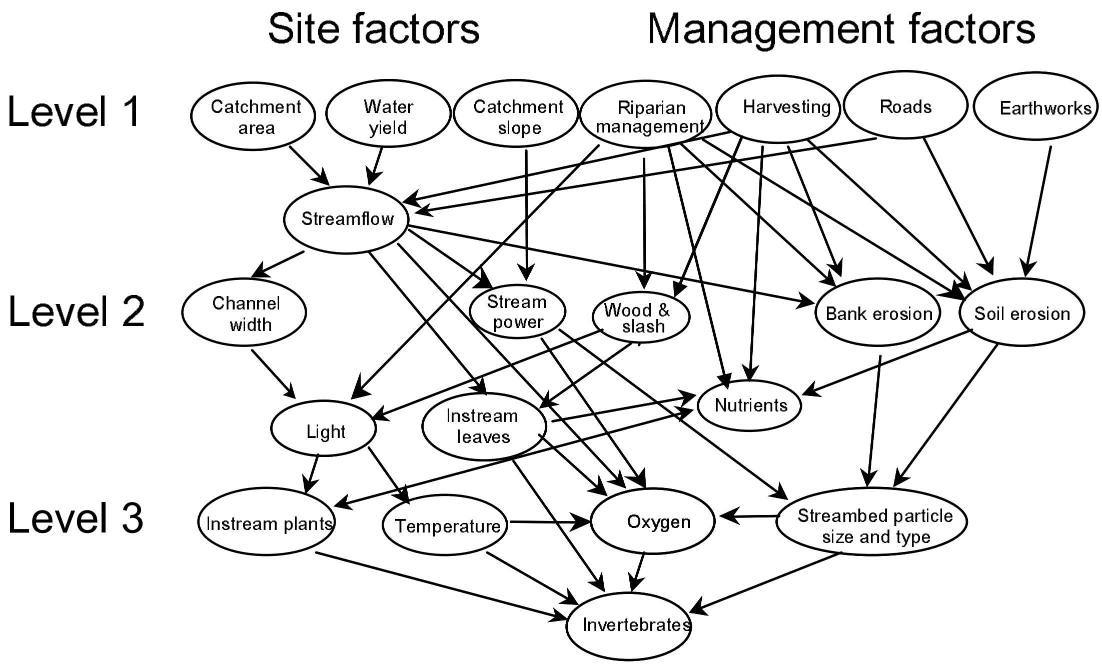

Figure 3: A causal linkage model of site and stream factors influencing the effects of forestry activities on stream invertebrates.

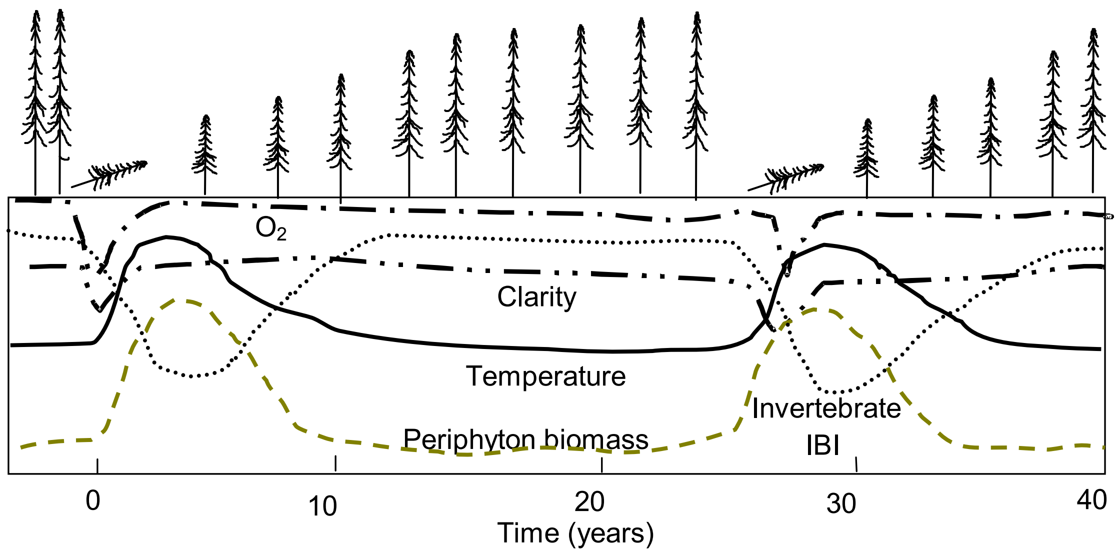

Figure 4: A schematic diagram summarising the magnitude duration of effects of clear-cut on stream habitat, clarity, temperature periphyton and macro-invertebrate Index of Biotic Integrity (IBI) values.

Outcomes:

Study findings have fed into resource consent hearings before Environment Waikato and the Environment Court.

7.1.3 Wharekawa

This study concerned the effects of plantation forestry operations and land use on benthic fauna in Wharekawa Harbour. The location of the study, on the eastern side of the Coromandel Peninsula meant that occasional very heavy rainfall events might exacerbate sediment runoff impacts on the nearshore environment. Sedimentation rates in the Wharekawa Estuary are higher now than prior to human land use changes in the catchment. Monitoring had shown a decline in invertebrate species sensitive to sedimentation at selected sites within the estuary. The source of sediments causing these ecological effects was unknown however.

Purpose:
To identify sources of sediment, to understand their impact on Wharekawa Harbour and to devise remedial actions where possible.

Outputs:
Two technical reports to Environment Waikato and the forestry company.

Major research findings:
A forensic stable isotope technique was used to identify and apportion the sources of soil, by land use and by sub-catchment. Results indicate that terrigenous soil contributions were present at all estuarine sites from pine (1-23%), pasture (<1-10%), native forest (<1-3%) and slip (<1-13%) land use sources. It was found that flood-plain material contributed high proportions (29-95%) of the soil in the sediments across the estuary and further analysis indicated that slip and flood-plain silt made up about a quarter of the soil transported in the Wharekawa River, suggesting that there was a continuing supply of the flood material being washed out of that river. The study results indicated that only the inshore parts of the large pine-slash debris field deposited in the estuary near the Kapakapa Stream mouth during the July 2005 storm were still producing fine silt accumulating along the upper tide level downstream of the Kapakapa Stream. The significance of this was that the sediment load from the Wharekawa River sub-catchment, which has a high proportion of the flood-plain soil, is gradually burying the older sediments and seagrass beds in the mid-to-upper estuary. The study showed the impacts of extreme weather patterns (viz., intense rainfall events), which have been increasing in frequency recently. Land use practices which remove the protective cover of plants on steep land exacerbate the production of sediment during such extreme events. Furthermore, flood material

deposited in the river and stream channels during extreme events may continue to be discharged into the estuary over extended periods as chronic loads long after the extreme event has passed. This chronic sediment load may adversely affect some invertebrate species such as the cockle, *Austrovenus stutchburyi*, and the mud snail *Amphibola crenata*.

Outcomes:

Findings from this work have been incorporated in Environment Waikato resource planning to protect sensitive harbour ecosystems in the Coromandel peninsular from sedimentation arising from catchment activities.

7.1.4 Whatawhata

The Whatawhata project arose out of research collaborations between AgResearch and NIWA in the early 1990s (Smith et al. 1993) and formally commenced in 1996 with the formation of a stakeholder catchment management group (Parminter et al. 1999). This group included representatives from three domains: science (AgResearch, NIWA and later Landcare Research), policy (Environment Waikato, Auckland Regional Council, Waikato District Council, Department of Conservation, Federated Farmers) and landowners (local farmers, foresters and Maori). The aim of the research was to "understand resource management issues from the perspective of community decision-makers and develop planning and decision making tools that could be used to improve their ability to collectively manage such issues". Over the subsequent 10-year period the group went through a process of setting land management goals and objectives; choosing appropriate management indicators; assessing catchment performance based on the 300 ha Mangaotama catchment at the Whatawhata Research Centre; planning land use and management change using forecasting processes based on ongoing research; and implementing land use change and monitoring outcomes (Dodd et al. 2008a,b,c). While the stakeholder group is no longer functioning and the farm management has been integrated back into the research centre, monitoring of water indicators by NIWA and terrestrial biodiversity by Landcare Research is ongoing.

Purposes:

- To improve water quality and biodiversity in hill catchment areas by engaging a multi-stakeholder management group in designing, implementing and monitoring a management scheme for a case study catchment (Mangaotama);

- To understand the processes driving land-use effects on stream flow, water quality and stream biota and the time-scales of responses to ICM and various sub-catchment treatments;
- To study multi-stakeholder processes of learning and decision making as a way of influencing individual behaviour.

Outputs:

To date the project has produced 57 refereed journal publications (including a dedicated special issue of the NZ Journal of Marine and Freshwater Research: 1997, vol 5), 22 unpublished reports, 43 conference/workshop papers and popular articles and 5 postgraduate theses. These outputs encompassed studies on terrestrial and aquatic ecosystem processes, enterprise and farm-scale economic analyses, management group processes and adult learning. Findings formed a key component of the 13 half-day workshops around the country for dry-stock farmers in 2006 on 'Intensifying your farm: what are the effects?' The site has hosted a stream management workshop (Quinn &Thorrold 1998), a NZ Grasslands Association field day (2001), a national ICM workshop field day (2004) and regular training days for Environment Waikato land management officers. It is also used for annual stream evaluation training sessions by Wintec students studying their Ecosystems and Conservation module. Website: http://www.whatawhata.co.nz .

Planning and decision-making processes:

Using concept pyramid approaches the stakeholder group defined a goal ("a well managed rural hill land catchment farm"), objectives (businesses viability, ecosystem health, landscape values, partnerships, demonstrable environmental performance and rural infrastructure) and key performance indicators (Parminter & Perkins 1996).

The life of the project was described as cyclical (Dodd et al. 2008d), working through three phases ("Assessment", "Forecasting" and "Implementation" phases) each comprising a completion of the learning cycle (Planning, Acting, Monitoring, Reflecting). This showed that a facilitated planning process could develop a catchment plan that utilised a diversity of sources of knowledge to address a range of community goals, by integrating complementary land uses.

Decision making by the catchment management group reflected two feedback loops that had to be brought together. One loop was the farmer-farm system-farm production- livelihood process, the other the stakeholder-landscape-ecosystem-lifestyle process. The farm production feedback loop was much faster than the ecological loop and so tended to dominate decision making. Developing and using a suite of diverse indicators helped to link the two feedback loops together and flagged potential unintended ecological consequences from production system changes. "The multiple goal approach may have made it inherently necessary to have a variety of indicators, some immediately responsive to drive uptake and ensure timely intervention by managers, other less responsive but indicative of the fundamental status of the land and water resource. This range of indicators would be critical for helping hill country land managers to align management to achieve the multiple outcomes now expected by the sector stakeholders".

An evaluation of the learning results of the project highlighted that project participants formed new relationships across institutional barriers, establishing trust and sharing experience and knowledge. The learning evaluation identified that greater learning would be encouraged by reducing the amount of challenges to peoples' expressed opinions and increasing the modelling of desired behaviours. The result was that participation in the project was more useful to people as individuals than to their originating organisations (Parminter et al. 2000).

<u>Major research findings:</u>

- Comparisons of the initial status of pastoral vs. forested sub-catchments showed very clear differences: higher suspended solids, N & P levels, sediment and nutrient loads, light levels, stream temperatures, erosion rates, faunal densities, in-stream productivity, faecal coliforms; lower biological diversity, and narrower stream structure in pasture (Davies-Colley 1997, Quinn et al. 1997, Quinn & Stroud 2002, Donnison et al. 2004).
- Riparian deforestation has reduced stream invertebrate biodiversity at the catchment scale by homogenising aspects of stream habitat (Collier et al 2000).
- Koura (freshwater crayfish) are abundant in both pasture and forest streams and act as a keystone species through their effects on bioturbation and roles as omnivores and organic matter processors (Collier et al. 1997). Pasture stream populations are more vulnerable to extreme flow disturbance than those in forest streams where more refuges occur (Collier & Quinn 2003).
- Stream shade/riparian vegetation has profound effects on stream ecology through effects on geomorphology (channel width), water temperature, periphyton biomass, organic matter input and nutrient uptake. Surveys, experimental streams

studies and models have defined the relationships and threshold levels between shade and these attributes (Quinn et al. 1997, Davies-Colley et al. 1998, Rutherford et al. 1999, Rutherford et al. 2001).

- Stream size is the main control on retention of both fine and coarse organic particles (Broekhuizen & Quinn 1998).
- Headwater and riparian wetlands play key roles in influencing in-stream concentrations of sediment, nitrogen and phosphorus (Ngyuen et al. 1999). Cattle are attracted to these and their faecal bacteria inputs result in very high export during high flows (Collins 2004).
- Rainfall simulator experiments demonstrated that soil treading damage and exposure of bare ground from intensive livestock grazing is a key driver of sediment and nutrient input to streams (Ngyuen et al. 1998, Elliott et al. 2002). Impacts of grazing on sediment and nutrient losses were less in summer than winter due to less damage to vegetation and greater soil infiltration rates in summer (Sheath & Carlson 1997).
- Under heavy rainfall on steep pastoral land, overland flow can transport substantial quantities of faecal bacteria to streams within overland flow and it is unlikely that vegetated buffer strips will be particularly effective at attenuating these bacteria under these conditions (Collins & Rutherford 2004).
- The application of watershed, forestry and pastoral management models highlighted a range of land use and management changes with potential to improve environmental and economic performance, centred around paddock restructuring, tree planting and livestock intensification (Collier et al. 2001, Dodd et al. 2008b).
- Time scales for environmental improvements varied depending on the indicator of interest and in the short-term (5 years) were not always as predicted by modelling and stakeholder experience – e.g. sediment loads declined more quickly than expected (Quinn et al. 2006, Dodd et al. 2008c).
- Extreme weather events have a strong influence on sustainability of land use in marginal environments (i.e. drystock agriculture on steep hill land) and impacts of land use on stream ecosystems (Parkyn & Collier 2004, Collier & Quinn 2003, Quinn & Basher 2007). For example, after an intense rainstorm (97 mm in 4 hours) in February 2007, land slips were 13 times more frequent in areas maintained in pasture than in areas (assessed as more erosion prone when in pasture) that were afforested with pines in 2001 (Quinn & Basher 2007).

Outcomes:

Measured improvements (after 5 years) in the following key performance indicators (Dodd et al. 2008c, Quinn et al. in review):

- Increased per-ha lamb productivity by 87% and beef productivity by 170% from new enterprises on a reduced pastoral area (285 ha down to 131 ha).
- A 40% increase in terrestrial native plant diversity on an area basis within fenced and pest controlled forest remnants, which have been increased in area from 5 to 12 ha by native tree planting.
- Mean annual sediment export reduced by 76%.
- Mean annual P export reduced by 62%.
- Mean annual stream temperature differential (forested vs. pastoral) declined from 6.7 to 3.8 ºC.
- A significantly greater increase in the macro-invertebrate community index (MCI) relative to forest streams.
- Afforestation (mostly with pine) of 62% of the catchment reduced annual water yield relative to an adjacent native forest catchment by 6%/year over the first 6 years.
- Habitat and biota responded to riparian restoration more rapidly in small than large streams.

The research project developed and profiled an emerging approach to research management described as "adaptive research", which combined elements of action research and adaptive management to forge a process of research involving stakeholder oversight, transformation of the key research question through the life of the project, and application of the knowledge to the management of a whole farm/catchment system.

The research has contributed to policy development by Environment Waikato (Hill & Blair 2005) and was featured in the Parliamentary Commissioner for the Environment's (2004) "Growing for Good" report.

7.1.5 Toenepi

The original Toenepi study (1995-98) was the forerunner to the Dairy Best Practice catchments (Section 7.1.6) and was initiated by the New Zealand dairy industry to address environmental concerns about dairy farming. The study was carried out on the Toenepi Stream catchment, near Morrinsville in the Waikato and was based on a combination of field measurements and numerical modelling techniques. The study highlighted the need for the dairy industry to provide research on ways of mitigating environmental impacts of dairy farming. It also served as a benchmark study for dairying in the Waikato region and was the first dairy-focused catchment study in New Zealand.

Purposes:

- To characterise stream quality in a typical Waikato dairying catchment;
- To establish linkages between dairy farming practices and water quality impacts;
- To evaluate the efficacy and economic impact of dairy farming practices that minimise water quality impacts.

Outputs:

The study produced 5 scientific papers, 6 technical reports and 9 conference papers, and results were presented to 7 end-user meetings and in 4 popular industry magazine articles.

Major research findings:

Characterisation of poor stream water quality

- Very high total nitrogen concentrations (comprising mostly nitrate) in winter, and high concentrations of total phosphorus during spring and autumn
- Low dissolved oxygen levels and high stream temperatures in summer that were unsuitable for many stream organisms
- Faecal bacteria concentrations that were occasionally very high and nearly always exceed criteria for contact recreation
- Stream life was intermittently disrupted by drain clearance.

Linkages between farming practices and water quality impacts

- Nitrogen export increased with stocking intensity due to increases in N leaching. Modelling indicated that almost all (98%) of the N exported in the pastoral land use scenarios was predicted to be in soluble N forms (mostly nitrate-N).

- Phosphorus export was closely correlated with dairy cow stocking in the pastoral land use scenarios, due to the contribution of P from oxidation pond effluent discharges.
- Base levels of ammonia and faecal bacteria loads to the stream could be attributed to inputs from oxidation ponds.

Evaluation of farming practices that minimise environmental impacts

- Greater utilisation of land application for effluent disposal would reduce stream inputs of phosphorus, faecal organisms, ammonia and suspended solids.
- Effluent irrigation would be a relatively costly method of reducing P losses and a costly method for reducing N where effective oxidation ponds with sufficient storage are operating.
- Fencing stock out of streams and drains would reduce direct inputs of faecal matter.
- Careful timing of P application on soils with high runoff risk, and reducing direct application of P fertiliser to waterways, would reduce exports of P in some situations.
- Increasing the drainage of lowland catchments reduced the nitrate attenuation potential of the catchment.
- Dairy farming regions with significant areas of poorly drained soils or tile drainage would show greater loads of P and sediment than this catchment through the effects of greater surface runoff or flow through tile drains.
- Riparian shading would inhibit weed growth and improve drainage properties of streams, and provide better habitat conditions for stream organisms. Utilisation of wetlands and riparian areas would be less expensive ways of reducing N inputs to streams.
- Reducing stocking rates was an effective but costly way of reducing N exports.

<u>Outcomes:</u>

A key outcome was the public recognition of dairy farming's environmental impacts and a willingness by the industry to adopt measures that supported the 'clean, green' branding for New Zealand dairy products overseas. A number of initiatives followed, including ‘Market Focused’ and ‘The Dairying and Clean Streams accord’.

Over the period 1995-2008, there have been marked reductions in total nitrogen (TN), total phosphorus (TP) and suspended sediment (SS), such that the stream loads in 2007 were 71%, 64% and 24% of their respective 1996 values. The reduced sediment loads are most likely due to improved stock exclusion (fencing) from stream banks, whereas the changes in N and P loads are attributable in part to fewer discharges of dairy shed effluent and more farmers using land irrigation.

7.1.6 Dairy Best Practice catchments

This project began in 2001 as an initiative by the New Zealand dairy industry to integrate environmentally safe practices into dairy farming. It now includes five regional focus catchments where soil and stream monitoring has been undertaken to get baseline information. These catchments are the Toenepi (Waikato), Waiokura (Taranaki), Waikakahi (South Canterbury), Inchbonnie (West Coast), and Bog Burn (Southland). The project was intended to provide a regional focus for innovative new research on cost-effective ways for dairy farmers to reduce adverse environmental impacts (i.e. Best Management Practices, BMPs). While not strictly integrated catchment studies (because they exclude the non-dairy landowners within a catchment), these studies do examine the cumulative effects of dairying within a catchment context.

Purposes:

- To identify key local environmental and productivity issues surrounding dairy farming within the focus catchments
- To identify and develop improved practice (BMPs) to address these key issues and promote extension of these practices widely within each of the regions
- To encourage the adoption of these practices and where possible monitor resulting changes in water quality

Outputs:

Including Toenepi, the project has produced 12 scientific papers, 13 conference presentations, 12 industry reports, one masters student project and a newsletter series (6 to date, accessible at http://www.maf.govt.nz/sff/about-projects/search/03-069/index.htm and http://www.maf.govt.nz/sff/about-projects/search/05-047/farm-management.pdf). A web-based BMP toolbox has been developed, to help identify the most cost-effective and relevant mitigation measures for an individual farm.

Planning and decision-making processes:

Bewsell et al. (2007) interviewed 30 farmers from four catchments: Toenepi, Waiokura, Waikakahi, and Bog Burn. Bewsell and Kaine applied Kaine's framework integrating consumer behaviour theory with farming systems theory to identify the factors influencing the adoption of new farm practices. The results highlighted the benefits of segmenting farmers to understand their adoption behaviour. There were no research results in the paper on the effects of participation in ICM.

Major research findings:

- In Waiokura, key issues identified were, the large number of cattle crossings and stream tributaries, making it challenging to keep stock separate from waterways; and numerous discharges of dairy shed effluent from treatment ponds.
- The key feature of the Waikakahi catchment is that the low rainfall is supplemented by border-dyke irrigation and that excess runoff from the irrigated land has a major influence on the water quality of Waikakahi Stream.
- High runoff loads of sediment and P leaving Inchbonnie, due to high rainfall (5 m/yr) are the major concerns. Recent calculations based on water balances to Lake Brunner suggest that dairy farming in the catchment should have an average specific yield of 50 kg N ha^{-1} yr^{-1}, compared with a value of 23 that was measured at the catchment outlet. A study of groundwater N levels (Zemansky & Horrox 2007) found groundwater losses that tend to confirm the estimates based on water balances.
- Water quality in Bog Burn is influenced by runoff conveyed via the subsurface drainage system, especially interception of irrigated effluent. At Bog Burn the key waterway values identified by the stakeholder group (farmers, Environment Southland, DOC, Fish and Game) were trout (spawning and rearing) in Bog Burn itself, along with the downstream Oreti River values of fishing, contact recreation, and as a major water supply source for Southland. Sediment management was identified as a key issue for enhancing Bog Burn fishery, whereas phosphorus and faecal pollution were the key issues for protecting the Oreti values and farm finances (EBIT) was the key farmer value. The Bog Burn model (Fig. 5) evaluates what practices will be effective and their optimal combinations. The model was used to evaluate the effects of management practices, applied singly and in

combination scenarios, on farm EBIT and waterway values. Of the single management actions, deferred effluent irrigation was predicted to have most benefit for the Oreti values, while riparian fencing and planting had most benefit for trout in Bog Burn. Combining practices that reduce farm pollutant losses produced more benefit and cost less than simply focusing on edge of field controls with riparian management and wetland treatment systems for tile drainage. However, combining the best of these practices had added benefits for relatively low cost.

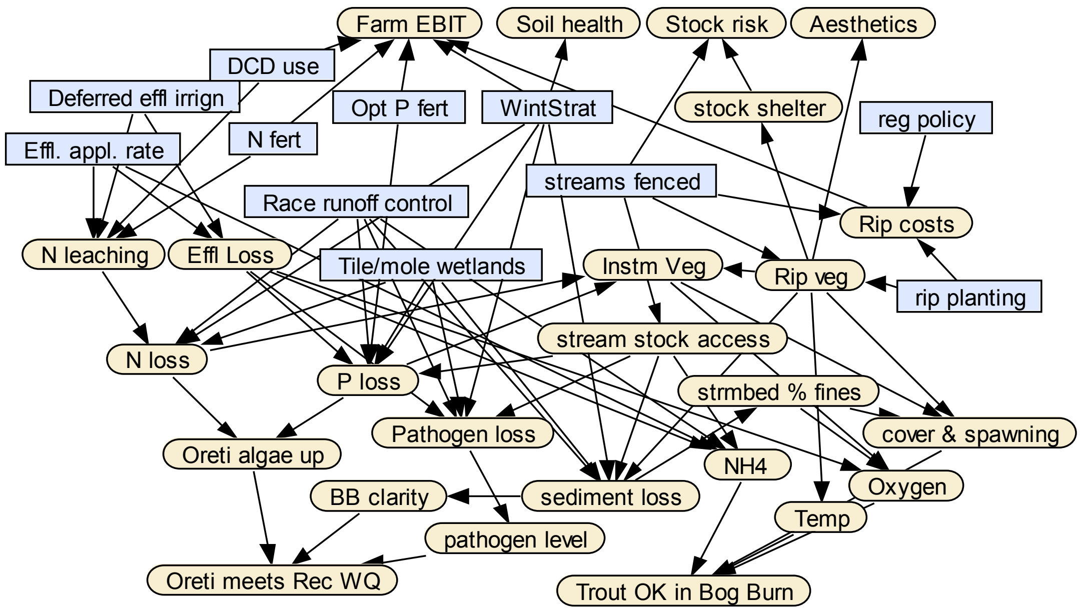

Figure 5. The Bog Burn farm-waterway linkage model.

Outcomes:

Toenepi Stream (Waikato – see previous section)

Waiokura Stream (Taranaki)

Significant improvements have occurred since monitoring began in 2001. Loads of filterable reactive P (FRP), TP and SS have declined by 25-40% as a result of increased riparian protection from 40 to 52% of the total stream length – notably in key reaches where major inputs to the stream were identified from stream surveys, a reduction in dairy shed effluent (DSE) pond discharges from 8 to 6 with conversion to land irrigation, and a 25% reduction in the average application rate of P fertiliser. Median annual *E. coli* concentrations declined at a rate of 116 per 100 ml during

2001-08, as a result of fewer point source discharges and improved riparian management.

Waikakahi Stream (Canterbury)
Concentrations of nutrients, faecal indicators and turbidity were compared for two periods, 7 Sep 1995 – 10 Apr 2000 and 10 Apr 2001 – 9 May 2005, showing that median concentrations were very similar for the two periods. Perhaps the most dramatic change that has occurred over the last 10-12 years has been the 4-fold reduction in sediment loads at Glenavy that resulted from (a) retirement of a sacrifice paddock and (b) improved stock exclusion (fencing) from stream banks and springs

Inchbonnie (Westland)
Because monitoring has only been underway since 2004 there is not yet a long enough record to make meaningful statements about water quality trends. A recent analysis of the Lake Brunner nutrient inflows and trophic status has shown that the lake is P limited and that catchment management should focus on controlling P losses. This was accepted at a farmer meeting and is a significant step forward in focusing future dairy practices for improved receiving water quality.

Bog Burn (Southland)
There is a slight downward trend in N but little change in concentrations of P, *E. coli* and suspended sediments.

7.1.7 Rotorua lakes

Eutrophication has long been a problem in Lake Rotorua with research on this and associated issues dating from the late 1950s. Diversion of sewage effluent inputs and riparian management measures have been adopted over the years to reduce these loadings on the lake. In recent years declining water quality associated with nutrient enrichment has also been observed in other lakes in the Rotorua region, providing renewed impetus for action to limit and reverse eutrophication. The Rotorua Lakes Protection and Restoration Action Programme commenced with the Lakes Strategy in 2002, developed with the aim of halting further degradation of the lakes and restoring water quality to acceptable levels. Each of the12 lakes has a different combination of causes and options for remediation. The programme is a $200m project over 20 years to improve sewage reticulation; intercept and treat nutrient flows to the lakes and promote changes in land use to reduce inherent leaching. To facilitate this, Environment BOP have convened a Technical Advisory Group (TAG) including representatives of Iwi, University of Waikato and Crown Research Institutes (viz. NIWA, GNS and SCION) as well as specialist consultants from other organisations. All parties meet regularly to discuss and debate technical issues, facilitate consultation amongst and between parties and with other stakeholders, and negotiate funding for work to be done. Environment BOP has also established a Land Use Futures Board (LUF) with representatives of Iwi, landowners, and Crown Research Institutes (AgResearch and SCION). Both the TAG and the LUF report to the Rotorua Lakes Strategy Group comprising local body politicians and stakeholders. Motu Economic and Public Policy Research is leading a study, which uses Rotorua as an example, to examine the potential benefits of nutrient trading as a way to help address water quality problems.

Purpose:

To arrest deteriorating water quality in the Rotorua lakes and to restore lake water quality through the implementation of action plans for the various lakes.

Outputs:

Public meetings of the Rotorua Lakes Strategy Group Joint Committee have been convened at regular intervals and agenda and minutes posted on the EBOP website (http://www.ebop.govt.nz/About-us/agendasminutes/Rotorua-Lakes-Strategy-Group.asp). Strategy documents have been produced for public dissemination and there have been numerous research publications produced by university and Crown Research Institute authors, most of which are listed on the website http://www.envbop.govt.nz/Water/Lakes/Technical-Reports.asp .

Planning and decision-making processes:

A local authority imperative was issued in 2001 for farmers to take action on apparent lake water contamination from soil nutrients. In response, the farmers organised their own meetings, workshops, community activities and a research project. Through industry contacts they organised funding for the project and institutional support to provide them with a community problem solving process, give them confidence and positive reinforcement throughout the process of change, and reward their successes. The farmers also contracted science agencies to provide them with a consistent technical resource to draw upon, to challenge their management constructively and to provide positive feedback about the changes they made to the farming practices that they were using.

Parminter et al (2007) interviewed 16 of the ~30 farmers resident in the Lake Rerewhakaaitu catchment to examine the use on-farm of nutrient budgets by farmers and the off-farm factors that had influenced that use over the previous 3-4 years. Although the farmers may be considered a community-based ICM group they did not consider themselves as such and kept no records of the processes of dialogue, negotiation and resolution that they used. The report prepared by Parminter is a retrospective study that attempts to explain the behaviour of individual landowners rather than the group or the community. The report considers a single management practice – nutrient budgeting and so contributed little to an understanding of ICM processes. That is unfortunate given the uniquely community based initiative involved.

Major research findings:

- Nitrate inputs from pastoral farming have increased and largely negated the decline in nitrogen inputs from sewage diversion. Groundwater lags vary from 15-110 years between catchments and have disguised the effects of land use changes since the 1940s.
- As of 2005 Lake Okaro was deemed to be supereutrophic, whereas Lakes Rotorua, Rotoehu and Rotoiti were eutrophic. Lakes Rotomahana, Rerewhakaaitu, Okareka and Rotokakahi were mesotrophic.
- Nutrient load targets for Lake Rotorua have been proposed (Rutherford 2008)
    - ‘target’ P load from streams and rain to not exceed 34 tP/yr with an additional 3 tP/yr from sewage giving a total lake loading of 37 tP/yr.
    - ‘target’ N load from streams and rain to not exceed 405 tN/yr, with an additional allowance of 30 tN/yr from sewage to give a total lake loading of 435 tN/yr.
- An economic evaluation of land-use change options (Bell et al. 2003) has identified that:
    - There is a positive benefit of a shift from low intensity sheep and beef to plantation pine forest of $378 per hectare. This needs to be considered alongside the suitability for the same land to move to moderate or high intensity sheep and beef which may provide a greater gain in value.
    - All other forestry scenarios result in a net cost of land conversion.
    - There will be a significant cost where there are restrictions placed on land currently in low sheep and beef production and capable of sustainable higher production with capital expenditure.

- Preventing a move from moderate intensity sheep and beef to moderate or high intensity dairying where the land has the potential for this change in land use to occur with reasonable levels of capital expenditure will have a significant cost to landowners.
- There will be a considerable loss to landowners where a shift in intensity of dairying is prevented on land that is currently used for dairying and is suited to higher intensity production.

- A follow-up economic evaluation of the loss in the productive value of land in the Rotorua and Rotoiti catchments (Bell et al. 2004) has identified that:
  - Imposition of an N cap could result in a $31-44M loss to Rotorua catchment landowners depending on the degree on intensification that might have occurred without land use restrictions.
  - This loss could rise to $90M under scenarios of increasing reductions in allowable N input to Lake Rotorua.

Other reports include: evaluation of a range of capping materials and flocculants to inhibit phosphorus release from lake beds, assessment of the Ohau channel wall that reduces the mixing of eutrophic waters from Lake Rotorua with those in Lake Rotoiti; other remedial measures for improving lake water quality; and geothermal sources of importance to the lakes

<u>Outcomes:</u>
Measures to reduce undesirable algal blooms have been initiated (e.g. Ohau channel wall, riparian protection schemes) or are under active investigation (e.g. lake sediment capping agents).

Individual ‘report cards’ are available for each lake (see website reference) that show the current and target TLI values.

Action plans have been formulated by EBOP for reducing N and P inputs to lakes. An action plan is activated when the trophic level index (TLI) of a lake exceeds the target TLI by 0.2 for two years in a row, as set out in the EBOP *Proposed Regional Water and Land Plan*.

7.1.8 Upper Waikato

In 2006, Environment Waikato commenced an ICM pilot project in the Upper Waikato sub-region, based in the Little Waipa (12 210 ha) and Waipapa (10 050 ha) sub-catchments which drain into two of the Waikato Hydro lakes. The project was partly in response to a legal challenge to the Regional Plans efficacy at reducing diffuse nutrient loss. Hence, the focus of the project is on-farm nutrient management to minimise losses to waterways, and involved community engagement processes to encourage individual farmers to participate in farm planning using industry-developed tools. AgResearch and EW staff provided a model-based analysis (using OVERSEER, UDDER and CLUES) to predict the outcomes of management changes on nutrient dynamics at farm and catchment scales, and on farm business indicators. This ICM project focussed upon one policy issue and took an adoption-of-technology approach in its design. Hence integration in this project refers to integration of economic and environmental analysis across a number of landowners and integration of all the functions of the regional council through operational staff, rather than integration across a number of natural resource issues.

Purposes (Abercrombie 2008):

- To integrate delivery of Environment Waikato's policies in two sub-catchments;
- To improve nutrient efficiency on farms for better water quality.
- To identify barriers to, and benefits of, the adoption of nutrient management practises.
- To provide information for Environment Waikato's policy review process.

Outputs:

Events have included public meetings, workshops and drop in days, several field days and a focus on on-farm visits bringing about whole farm planning in each catchment. There have also been newsletters, media articles in local and national media, presentations at industry conferences such as NZARM and FLRC and locally in industry forums. The research results have been described in 3 Environment Waikato Technical reports (including an iterative social research evaluation of the project).

Planning and decision-making processes:

Hungerford (2008) describes in her project review the intensive policy implementation methods applied in the Little Waipa and Waipapa catchments. The intervention was focussed upon "working with farmers, to change or improve their agricultural practices which are contributing to rising nitrogen levels within the Upper Waikato River's catchment, specifically by ensuring compliance with consented and permitted activities and by encouraging a suite of identified best practices to mitigate nutrient losses".

Participants reported that they valued the "ICM project" because it worked with individual farmers and their properties. This contrasts with the whole-of-catchment approaches used in research projects. Council staff spent time working with landowners to understand their management processes and build "positive" relationships. This has meant that specific staff members have then become a conduit to other Council services.

This project has taken a deliberate approach to non-participating catchment landowners and appears to have been the only one to have done so. They have been included in the evaluations and the contact and visiting programme. "There has been a positive response to these contacts by those people who had not previously been involved with the ICM project".

An evaluation of the project mentions fertiliser and industry representatives working together and how they have built up trust in each other's work. This was built into the project as a sub aim but has become a vital spin off in extending the message more widely.

Major research findings:

- Farmers are most likely to undertake a suggested action if they perceive it will not take much time to implement, is not costly, and is either cost effective or will not negatively affect production (Hungerford 2008).
- The most effective mitigation strategies were reduction in winter N fertiliser use, winter grazing off, shifting effluent application to land and increasing application areas. Combining such practises can reduce N losses by up to 20%.(Longhurst & Smeaton 2008).
- The most profitable N leaching mitigations were winter grazing off and increasing effluent land application areas, with scenarios more likely to be profitable at higher milk prices (Longhurst & Smeaton 2008).
- While substantial declines in N leaching losses can be achieved on these free draining soils (e.g. from 40 to 30 kgN ha^{-1} y^{-1}, water quality targets (initially set at 26 kgN ha^{-1} y^{-1}) are unlikely to be met in the short term (Abercrombie 2009).

Outcomes (Hungerford 2008):

Of the 120 farms in the catchment 15 farm plans are completed or in progress.

The project has increased the rate of adoption of best practices in the Little Waipa and Waipapa catchments.

Environment Waikato staff have clarified their roles internally and externally and developed internal agreements to manage conflicts between compliance and education.

The ICM process has been well received by farmers and led to more positive relationships between landowners and regional council staff.

7.1.9 Lake Taupo

Farmers living in the Lake Taupo catchment thought they had been doing a good job limiting the impact of their farming systems upon lake water quality. Water quality issues identified in the 1970's had been addressed by extensive provision of stream bank retirement (Thorrold et al. 2001). However, observations of increasing nitrogen concentrations in Lake Taupo through long-term monitoring by Environment Waikato led to widespread community concern during the late 1990s at the potential for deterioration of water quality (most notably, its appearance) in this iconic lake. Taupo residents were already expressing concern about water-weed washing up along beaches as a result of inadequate septic tank treatment. However, historical pasture development in the catchment was identified as the main contributor of N to groundwater sources. Three separate FRST-funded science programmes (led by AgResearch, NIWA and Lincoln Ventures) are providing research into the biophysical dynamics of the catchment and lake, with the AgResearch programme also exploring on-farm mitigation options and conducting social and policy implementation research. Five Sustainable Farming Fund projects have addressed farm production and profitability constraints and opportunities in the context of environmental limitations related to nitrogen and water quality. Alongside these research projects is a range of central and local government policy initiatives, such that the "Taupo project" should be seen as a complex network of research and policy programmes with various objectives and approaches, and not necessarily as a tightly defined Integrated

Catchment Management project. This section focuses on those aspects of the Lake Taupo catchment covered by the research projects noted above.

<u>Purposes:</u>

- To understand the short and long-term dynamics of N in the Lake Taupo catchment;
- To reduce the amount of nitrogen flowing into Lake Taupo in the short and long term;
- To develop rural land use and management options that minimise N losses to the environment;
- To maintain the profitability of rural enterprises in the catchment.

<u>Outputs:</u>

The research has generated 6 scientific papers, 11 conference presentations, 11 technical reports, mainly for Environment Waikato and numerous industry and stakeholder presentations.

<u>Planning and decision-making processes:</u>

The initial response of farmers was both disbelief in the culpability of farming and a feeling that they were being unfairly singled out by the regional council for attention. Many of the non-Crown (both Maori and non-Maori) farmers formed a representative group called Taupo Lake Care (TLC) to hold a series of consultative meetings with Environment Waikato (EW) regional councillors and staff. Two AgResearch staff, with technical backgrounds in farming systems, were invited to attend the meetings as a "neutral third party". The group met approximately every three weeks over a period of a year. The meetings were intended to objectively address and resolve points of conflict between landowners and regional council staff and provide a better outcome for the stakeholders and the Lake. The TLC consultative team has maintained ongoing contact with the wider group of landowners through newsletters and meetings.

The farmers were particularly concerned that they could become unprofitable if they were forced to reduce the intensification of farming. Particular care has been taken to make sure that the implications for farmers at each stage of the process were understood. The consultative team have at all stages measured the joint understandings arrived at during consultation against the probable reaction of the wider group, and have themselves reacted accordingly. AgResearch staff worked with the farmers to examine the impact of possible changed management scenarios on farm performance and nitrate emissions.

TLC and EW gained a greater understanding of each others' points of view and more respect for each other's positions on policy matters. The stronger relationship was expected to create a more positive response to the introduction and implementation to the plan variation. Differences of opinion still existed, but they were identified and the consultation moved on and it was hoped that this approach to consultation would increase the likelihood of timely compliance to any potential regulations (Clark and Lambert 2002).

Vigorous debate occurred at the meetings regarding the scientific "facts". TLC questioned the validity of the scientific explanations for changes in lake water quality, they were not confident that the relatively limited water quality data being used actually demonstrated that a water quality problem existed. Variability in the estimates of various nitrogen pools and fluxes disturbed them. However, over time, acceptance of many of these conclusions was achieved. The group remained sceptical about how it could be possible to create specific rules about land use when the data was so imprecise.

It became obvious through a year of meetings that three major groupings of landowners (and individuals within the groupings) would be affected differently. Any policies and assistance packages being developed would need to accommodate these differences. There was an acceptance by EW that farmers would be severely disadvantaged if the proposed regulations were put in place, and it was acknowledged that there was a need for an assistance package that would involve very substantial sums of money. Local, Regional and Central Government were identified as the three agencies that could establish the package.

Environment Waikato then offered to move the date of the proposed variation back in time, and subsequently to not issue a proposed variation, but rather a draft variation. The draft had no legal status but provided the people in the catchment with a consultative document. The variation was not intended to be finally established until details of an assistance package was finalised.
The consultation process was then widened to include other stakeholders who would be less severely, or indirectly, influenced as the TLC-EW consultation continued.

There has been general agreement that this consultative route was preferable to one of regulation and confrontation. Of course this approval is tempered with caution because of an awareness that as more stakeholders become involved, and the political processes of governmental agencies impact on the process, the outcomes may not be satisfactory for one or both of the parties. Also, there has been an understanding throughout that the goals of TLC and EW differ, because of the different roles they have within the community.

Major research findings:

- Historical pasture development in the catchment was identified as a major contributor of N to groundwater sources, with a key process identified as N leaching from urine patches during the winter (Ledgard et al. 2007).
- Groundwater residence times of 50-100 years occur in some catchments and cause stream nitrogen concentrations to lag land use changes by decades (Morgenstern 2007).
- All forms of intensification (i.e. sheep stocking rate, bull beef and dairy conversion) are profitable and thus restrictions will impact profitability and farm value (Thorrold et al. 2001).
- Mitigation options (i.e. less N fertiliser, bought in feed and wintering off) resulted in 40-60% reductions in N leaching but all led to lower farm surpluses (Ledgard et al. 2001).
- Cropping has the potential generate substantially more N leachate than grazing animals (Betteridge et al. 2007).
- Application of carbon (sugar) in a lysimeter study resulted in a 25-45% reduction in N leaching but also a 12-39% reduction in pasture production (Ledgard et al. 2007).
- Salt supplementation to dairy cows led to increased urination volume and frequency, potentially reducing N leaching by 30% (Ledgard et al. 2007).
- Denitrification potential greater in topsoil and upper vadose compared to deeper soil layers (Collins et al. 2005).
- Removal of 95% of N inflows in the wetlands of the Tutaeuaua sub-catchment was attributed to denitrification (Collins et al. 2005).
- Multiple Criteria Decision Making studies highlighted that non financial drivers can dominate likelihood of adoption of nutrient mitigation options.
- Nutrient mitigation options requiring significant system change are favoured least by farmers (e.g. winter management options utilising a stand-off pad had large

mitigation potential but were the least favoured option, apart from conversion of land to trees, because of the need for significant management changes, staff input, and capital requirements).

- There was surprisingly limited willingness to take up win:win options (Bewsell et al. 2007).
- Investigation of energy crops as a land use change mitigation option identified *Salix viminalis* and *S. purpurea* using 25 cm cuttings, with weed control in year 1 as producing the best biomass growth (McIvor et al. 2007). Projected EBITs were $242/ha (Snowdon et al 2008).
- The contribution of tourism to catchment GDP in Taupo was $90M compared with $88M for forestry and $18M for agriculture in 1998 (Petch et al. 2003).

Outcomes:

Observed increases in stream nitrogen concentrations reflect historic land use changes because of groundwater lags and natural variability.

Following a long and involved public consultation process, Environment Waikato has developed a "Protecting Lake Taupo Strategy and introduced a Variation to the Regional Plan (2005) aimed at reducing manageable nitrogen loads to the lake (i.e. farm leaching losses and urban/peri-urban wastewater treatment).

Environment Waikato is implementing a regulation to 'cap' landowners by allocation of nitrogen discharge allowances.

A Trust has been established through central and local government funding to manage a 20% reduction in N inputs, through purchasing pastoral farms and modifying land use and management, and funding research into alternative land use.

7.1.10 Purukohukohu

Purukohukohu Experimental Basin, between Rotorua and Taupo, was set up as a long-term hydrological site in 1968 as part of the International Hydrological Decade Programme (1965-1974), sponsored by UNESCO (Beets & Brownlie 1987). Studies at the Basin over 40 years have provided a rare long-term record of land use effects on nutrients and hydrology. Three land uses are represented: Purutaka pasture catchment (11 ha, cleared in 1920's, sheep and beef grazing, part of Mangimingi station), the adjacent Puruki pine plantation (34 ha, previously pasture since 1920's, planted in pines 1973, logged in January-July 1997 and replanted in August 1997), and the nearby Puruwai native forest (28 ha, 2000 year old podocarp/mixed hardwood forest). Early results were collated in a special issue of NZ J Forestry Science in 1987 (Beets & Brownlie 1987), but additional information has been published in the last decade and is included here.

Purpose:

To understand the hydrological and water quality effects of pasture development and pine afforestation throughout the forest rotation from establishment to harvesting and replanting.

Outputs:

Two recent scientific papers and a report at the Rotorua Lakes Symposium.

Major research findings:

Hydrology:

- Beets and Oliver (2007) compared paired catchments in native forest and in transition from pasture to pine. They found a reduction in relative yield as the pines grew on previously pastoral land that stabilised at around 250 mm (c. 40%) lower than the native forest from age 5 to 12 years (when simultaneous recording was halted).
- Average water yield from the mature pine forest was 76% of pasture (range 61-88%) over the 7 years before logging (Quinn and Ritter 2003). Water yield increased in the first 3 years after logging to 125-127% of pasture yield, representing a 65-67% increase over pre-logging yield. However the relative yield from the pine and pasture catchments decreased to the pre-logging level between years 3 and 7 after logging and replanting.

Nutrient dynamics:

- Average TP yield from the pine catchment was 4-fold higher than from native forest in the 5 years after logging, but was still 4-fold lower than from pasture (Quinn & Ritter 2003).
- Patterns of nitrate yield and concentration over 30 years provide a longer-term perspective on the effects of pine afforestation from pasture conversion to pine through to the first logging and replanting. Nitrate yield and concentrations showed a gradual decline over the 5 years after conversion from pasture to pine in

1972. Average nitrate yield was almost an order of magnitude lower in the subsequent "young forest" phase (1978-85). Nitrate concentrations and yields were higher from the "mature" pine forest, just before logging, than in the "young forest" phase.

- Yields and concentrations in the year of logging and the first year after logging increased to similar levels to those during the pasture-pine conversion phase, but decreased quickly towards levels seen during the "young forest" phase.

Outcomes:

The long-term information on pine forestry effects on hydrology and nitrogen yields played a key role in expert witness caucusing and evidence presented to the Environment Court in Appeals hearings over Lake Taupo – Variation 5 to the Waikato Regional Plan in 2007-8.

7.1.11 Pakuratahi

This paired catchment study was initiated in 1993 as part of a collaborative venture between the Hawke's Bay Regional Council and the local forest industry. The two adjacent catchments, one in pasture (Tamingimingi, 795 ha), and the other in *Pinus radiata* forest (Pakuratahi, 345 ha, planted in 1970-72) are located in the coastal hill country of Hawke's Bay, north of Napier. Data on water quantity and quality, soil erosion, sediment generation and in-stream values was collected over 12 years (1993–2005) by scientists from the Hawke's Bay Regional Council, Landcare Research, the former Logging Industry Research Organisation, Forest Research Institute (now Ensis), Massey University, and NIWA. The project produced 12 research reports and 3 scientific papers, summarised in Eyles & Fahey (2006)

Purpose:

To compare the effect of pastoral farming and pine forestry on erosion and stream environments through key stages in the forestry rotation.

Outputs:

Eleven technical reports, three scientific papers and a popular article, with the entire project summarised in a Hawke's Bay Regional Council report.

Major research findings:

- Water yield from mature forest was 6% less than pasture, increasing to 22% more than pasture during harvest.
- Peak flows were 15-65% lower from forest compared to pasture, except during harvest.
- Sediment yield from pasture was 4 times higher than mature forest.
- During harvest there was a 6-fold increase in sediment yield, to levels 2.5 times the pasture catchment, but this returned to mature forest levels within 2-3 years.
- During harvest, native fish and macroinvertebrate communites declined to levels similar to those observed in pasture, but recovered within 3-5 years.
- The adoption of prudent management practises minimised environmental impact.
- The main sources of sediment associated with forestry operations were road cutbank and sidecast failure, shallow landslides, and stream bank erosion. In the pastoral catchment they were shallow landslides and stream bank erosion.
- forestry operations in the coastal hill country of Hawke's Bay are unlikely to cause any substantial and long-term changes in water quality.
- Mature pine forests were more effective at moderating storm impacts on stream channels than pasture.

Outcomes:

The study has been used on the East Coast for planners, soil conservators and Council implementing rules for land use, by land advisors and consultants advising clients, by the forestry industry for planning harvest, and by landowners considering farm forestry options (Gisborne District Council 2008).

7.1.12 Upper Manawatu

Horizons Regional Council contracted SLURI (The multi-CRI Sustainable Land Use Research Initiative) to determine the potential for water quality improvement arising from the initiatives outlined in its regional plan ("One Plan"). These initiatives include the Sustainable Land Use Initiative (SLUI) addressing erosion on farms and Farmer Applied Resource Management strategy (FARM) addressing nutrient losses from intensive land use in priority catchments. Regional Council monitoring data for the Upper Manawatu Water Management Zones was combined with erosion (NZEEM, SedNet) and nutrient budget (OVERSEER) models to estimate amounts and sources of sediment and nutrient export to the Manawatu River, and the impact of mitigation measures (BMPs and Whole farm plans).

Purpose

To determine the potential for water quality improvement at the catchment scale resulting from on-farm implementation of BMPs.

Outputs

Two conference presentations and two reports for Horizons Regional Council.

Major research findings:

- Most P losses in the catchment result from erosion of steeper land under pasture during major storms, but these can be reduced by ~45% with targeted tree planting (Parfitt et al. 2004);
- Dissolved P losses can be reduced by ~30% on drystock farms by targeted tree planting, by ~45% on dairy farms by improved effluent management, limiting soil P to the optimum agronomic range and excluding livestock from streams, and by ~70% from point sources by improved effluent management (Parfitt et al. 2004).
- Implementation of whole farm plans can potentially reduce sediment loads in the Manawatu River by 8% (random implementation) to 47% (implementation targeted at farms identified with the highest erosion potential) (Schierlitz et al. 2006).

Outcomes:

The results were incorporated into submissions for the Horizons Regional Council "One Plan".

7.1.13 Motueka

The Motueka project began in 2000, having originated in 1998 from a multi-disciplinary science workshop in Nelson looking into the effects of land use on freshwater, coastal and marine ecosystems (Basher 2003). The ICM research project that developed out of this is a FRST-funded partnership between Landcare Research, the Cawthron Institute and Tasman District Council, with significant involvement of iwi group Tiakina Te Taiao, the NZ Landcare Trust and Fish & Game NZ (Nelson-Marlborough Region). The case study resource includes the 2180 km^2 land area of the Motueka and Riwaka catchments, as well as the majority of Tasman Bay into which the catchments flow. Research components are based on stakeholder analysis of issues, with two primary audiences: (1) regional council policy, and (2) subcatchment or sector groups.

The activities of the Motueka project include historical research, biophysical experimentation, simulation modelling and social learning (Table 4) – all aimed at improving the communities' understanding and management of land, freshwater and coastal resources in catchments with multiple interacting and potentially conflicting resource uses. The Motueka is one of the inaugural demonstration basins in the UNESCO/WMO global HELP project (Hydrology for the Environment, Life and Policy), and contributes to a Sustainable Farming Fund project (Improving Water Quality through Farm Environment Planning across the Sherry Catchment, Project 07/113).

Table 4: ICM research components by theme in the Motueka ICM research programme (Fenemor et al. 2008).

Theme	Research components
Fresh Water	Modelling effects of land uses on river water quality and habitat
	Trout migration in response to low flows and floods
	Links between Māori cultural and scientific indicators of river health
	Fish-friendly floodgate design and management
Land	Faecal bacteria and on-farm actions to minimize stream contamination
	River-aquifer modelling for sustainable water allocation
	Land use effects on streamflows and nutrient loads
	Riparian restoration methods using native plants
	River gravel transport, monitoring and management
	Sediment sources, yields and modelling of its river and coastal impacts
Coastal	River plume effects on offshore benthos and water column
	Modelling catchment effects offshore for ecosystem function and aquaculture space allocation
Collaborative Learning	Collaborative learning approaches for ICM
	Building iwi (Māori tribal) capacity and collaboration for ICM
	Enhancing institutional learning by the Council for ICM
	Science responsiveness to community needs
Integration	Knowledge management and delivery for ICM

Purposes:

Develop and demonstrate approaches which guide sustainable management of land and water resources at small to large catchment scales, including the adjacent coast, and based on four 'big picture' issues:

- Building Human Capital and Opportunities for Community Participation
- Allocation of Scarce Water Resources among Competing Land Uses
- Managing Land Uses in Harmony with Freshwater Resources
- Managing Land and Freshwater Resources to Protect Marine Values

Outputs:

To date the project has produced over 40 refereed journal publications, 75 unpublished reports and 95 conference papers and popular articles. The Motueka Catchment Toolbook, an interactive CD-ROM synthesizing science knowledge for the Motueka catchment and its international context was produced in 2005. Since 2001, community reference group meetings have been held approx. quarterly and an annual stakeholder AGM has been held, with the 2008 meeting combined with the NZ Association of Resource Management Conference. A newsletter "Catchment connections" is produced quarterly. Project staff have provided teaching to Lincoln and Canterbury University students since 2005; in 2007-8 the project was supporting 5 MSc and PhD students, 3 interns, 2 international students and a Royal Society Teacher Fellow. Collaborative ICM approaches were promoted in a *Country Calendar* television programme about the Motueka ICM project in June 2008. Website: http://icm.landcareresearch.co.nz

Planning and decision-making processes:

The research into water allocation drew upon the results of an interaction matrix of systems and linkages in the Motueka catchment to track chains of effects that might be caused by the introduction of different policy measures. These were included in a pre-workshop discussion paper (Sinner et al. 2006). "In the workshop, many people shared a willingness to listen and understand the issues as other stakeholders described them. Collectively they supported some of the policy options presented. The level of agreement at the workshop was in contrast to the responses to the post-workshop survey, which showed a more diverse range of views and less apparent consensus. So, although in a social situation stakeholders seemed able to acknowledge and accommodate competing views with their own, when they had to consider their own individual position they became less flexible. Whether the degree of consensus apparent in the workshop would be maintained in a discussion with more direct policy implications, i.e. if stakeholders believed that decisions were likely to lead directly to policy changes by the council, remains a question for further investigation".

It was also unclear as to how much the participants would be willing to make behaviour changes for their own properties as a result of workshop decision making relative to their own individual positions on the same practices. The comparison between socialised and individual responses shows that this study has started to examine the differences that might become apparent in landowner behaviour developed through ICM decision making compared to individualistic decision making.

The research studied four social spaces of engagement in the Motueka ICM programme (Kilvington & Allen 2007). These were:

- The central science collaboration space
- The space where science became involved in problem-solving research (the learning space)
- The information exchange space
- The external space where an individual ICM project interacts with the wider national and international catchment research and management community.

In the Motueka ICM project scientists in the collaboration space needed more un-programmed time to meet with each other and develop collaborative relationships as the basis of integrated research, rather than attempting to do integrative research by focussing upon tasks.

The interactions between community and scientists through a Community Reference Group can be valuable for information exchange and this requires quite standard facilitation approaches however these need to be deliberately designed for that purpose, if active learning is to be encouraged.

The information exchange space requires the least amount of interactive development in expressed ideas of any of the spaces. This was the most successfully developed of the spaces in the Motueka ICM study, and received the most widespread support from people outside of those directly engaged in the project.

The external space was the easiest space to develop and built upon a shared scientific and research understanding of the issues involved in ICM. However, the project does not appear to have provided similar opportunities to the non-science members that have been involved.

<u>Major research findings:</u>

- The direct impact of cows crossing a waterway to & from milking was documented and showed sharp spikes in faecal indicator bacteria (50 000 cfu/100ml), suspended solids and total nitrogen. On the return journey, contamination was less elevated but over a longer period. The cows defecated ~50 times more per metre in the stream vs. the race (Davies-Colley et al. 2004).

- Cross scale assessment of river works data showed no strong link between the amount of bed level degradation and the amount of river works (rock works, willow planting tree felling (Henker & Basher 2006).
- Rates of organic matter breakdown and ecosystem metabolism in streams are suggested as useful indicators of the functional aspects of river ecosystem health, augmenting more conventional structural measures such as water quality and aquatic community composition (Young et al. 2008).
- Isotope studies showed that groundwater is predominantly river-derived, with mean residence times of 2-14 months (Stewart et al. 2006).
- Economic input/output modelling showed that the catchment contributed $219M dollars in gross product towards the 2001 Tasman gross regional product of $933M. Using benefit-transfer, non-market valuation methods it was shown that natural ecosystem services annually contribute non-market (indirect) goods and services of $163M, more than half annual catchment gross product (Cole, see Toolbook).
- A comparison between Maori cultural monitoring, community based water quality monitoring and objective scientific monitoring of waterway health showed that the different approaches "successfully capture [similar] aspects of river and stream health" (Young et al. 2008).
- ICM must take a proactive rather than reactive approach, as "effects based" ecosystem management can lead to "too late" identification of problems with remedial action becoming too difficult or costly (Bowden et al. 2005). The existence of cause-effect time lags suggest a precautionary approach to land use change (Fenemor et al. 2008).
- The human dimensions of ICM present the greatest challenge, requiring significant effort in building social capital, but this is essential to a proactive approach where the questions are not clear and the technologies are not yet available. Critical factors for successful ICM include communication, education and enlightened leadership (Bowden et al. 2005), a clear understanding of property rights in relation to water use, technical understanding and it limits, and acceptance of common objectives (Fenemor et al. 2008).
- Economic factors are not the only influence on community goals (Davie et al. 2004) and key social questions often cross catchment boundaries (Fenemor et al. 2008).

- An integrative Triple-Bottom-Line modelling approach was trialled using a participatory process (Influence Matrix) with a group of scientists and catchment residents without specialist scientific knowledge (Cole at al 2007). The Influence Matrix brings together the perceptions and knowledge of multiple stakeholders. The process identified these critical factors likely to affect future sustainability of the catchment:
    - Nature and extent of primary industries,
    - Measures of water quality and supply, and
    - Available mix of policy-plans-rules-legislation.
- In a review of local government implementation of ICM, Daly & Fenemor (2007) note that:
    - many local authorities still approach issues on an individual basis but do recognise the need for more integrated approaches;
    - considering the scale (spatial and temporal) and complexity (biophysical and social) of ICM, funding projects adequately is a problem;
    - local authority role as regulator hinders the type of relationships required for a successful ICM approach;
    - there is a continual need for accessible science and best practise guidelines, particularly in terms of social dynamics and economic benefits.
- There exist a number of defensive mechanisms used to avoid meaningful behavioural change in collaborative learning groups (Allen & Kilvington 2005), such as:
    - modifying the degree and direction of change required to protect the core values and beliefs of participants by avoiding the underlying causes and drivers of unsustainability;
    - Minimising the change required so that it becomes a marginal shift in behaviour rather than a radical change in values;
    - forming coalitions with like-minded confederates to resist the need for change
- Strong linkage between the land and near-coastal environments and the profound effects that large storm events have on sediment dynamics were demonstrated by analysis of sediment yield from the catchment and sediment composition in Tasman Bay. The impacts of a “50-year” storm localised in the headwaters of the catchment in March 2005 extended all the way out to Tasman Bay and continue to

be expressed 3 years after the event (Hicks and Basher 2008). This paper highlights the problems of using short-term data collection to characterise catchment sediment yield. Normally a stationary relationship is assumed between flow and suspended sediment concentration. The Motueka study clearly demonstrated non-stationarity as a result of the impact of large storm events, and showed that storms affect for some years the relationship between flow and suspended sediment concentration. This finding changes how sediment yields should be calculated and will have implications for sediment control.

- Catchment export can have impacts on the marine environment up to at least 10 km offshore on seasonal/annual time scales (Davie et al. 2004). Under non-flood conditions, multiple physico-chemical and biological indicators demonstrated a localised (6 km offshore) effect of the river plume on subtidal sediments and associated faunal assemblages (Forrest et al. 2007). On an annual basis, 60% - 70% of the input of "new" inorganic nitrogen to Tasman Bay from freshwater tributaries is contributed by the Motueka River. By comparison, accumulation of inorganic nitrogen via endogenous re-mineralisation is of a similar order of magnitude to the annual input from freshwater sources (Mackenzie et al. 2004);
- The loss of inorganic nitrogen from Tasman Bay via denitrification appears to be ~four times greater than the delivery rate via river inflows, suggesting that the presently existing land use characteristics of contributing catchments do not represent a serious threat in terms of potential over-enrichment of the Tasman Bay ecosystem (Mackenzie et al. 2004). However, approximately 50 sq. km of seabed off the Motueka River mouth in Tasman Bay has a terrestrial signature arising from the river outwelling plume. This research demonstrated that management of coastal ecosystems and fish and shellfish resources must take account of the activities on the entire land/sea continuum. This is a major deviation from current coastal management practice with implications for the rapidly growing aquaculture and continuing marine farming businesses.

<u>Outcomes:</u>

Using a collaborative negotiated approach, the Motueka water conservation order was gazetted in September 2004, allowing (among other constraints) for 12% of the river flow to be abstracted.

Through support for the Sherry River Catchment Group, the project has resulted in bridging of all four dairy cow crossings of the Sherry River, leading to declines of over 50% in bacterial loads.

The Sherry River catchment group comprising dairy, sheep & beef, lifestyle farmers and forestry has taken steps through completion of some 20 Landowner Environmental Plans to further improve water quality to swimming standards.
Based on information on the extent of catchment influences on Tasman Bay the Ministry of Fisheries was able to relax its requirements for exhaustive dredging to avoid overpopulation of shellfish beneath mussel farms.

A whole catchment nutrient budget has been produced through working with farmers in Golden Bay's Motupipi catchment.

A process for evaluating Integrated Catchment management Plans (ICMPs) using an Orders of Outcome approach involving multiple timescales for planning outcomes was developed by this project in conjunction with Auckland Regional Council.

Calibration of one of NZ's most detailed integrated river-aquifer models which integrates effects of flow depletion on aquatic ecology has allowed Tasman District Council to develop evidence-based water allocation and environmental flow limits in its Resource Management Plan.

The project has demonstrated the value of in-situ river plume monitoring buoys for coastal management by regional councils and aquaculture interests.

The project applied an emerging trans-disciplinary approach to ICM research which is not simply integrative in a multi-disciplinary sense but combines the "pillars" of biophysical knowledge and social process, to achieve collaborative learning, i.e. building knowledge and commitment for sustainable land management.

7.1.14 Selwyn/Ellesmere

The Selwyn catchment encompasses most of the Selwyn District and includes the water that could discharge off the coast between the northern tip of Lake Ellesmere (Te Waihora) and the northern edge of the Rakaia catchment (http://www.selwyninfo.org). The Selwyn River/Waikirikiri rises in the eastern ranges and foothills of New Zealand's Southern Alps, flows southeast for 35 km through foothills, then east for 58 km across and under the alluvial Central Plains of the Canterbury Region. The catchment of the Selwyn River encompasses the steep talus slopes of the Big Ben range, the pine plantations and pastureland of the Malvern and Wyndale Hills and Wainiwaniwa Valley, the intensively-farmed Central Plains, and Lake Ellesmere/Te Waihora. A characteristic of the Selwyn River is that over much of its course the river flows through wide shingle channels and can dry up completely during drought years. This can happen within 20 km of its outflow to Lake Ellesmere.

In 2004, the Canterbury Regional Council determined that the Selwyn catchment was "over-allocated", indicating that permitted groundwater takes exceeded the sustainable limit. In the near-future, economic growth may be constrained by water availability, and users may be competing with aquatic ecosystems for water allocations. The research being carried out comprises environmental monitoring of river flows, precipitation and weather forecasting; river ecosystem research and groundwater ecosystem research. An important framework used in the study is IRAP (Integrated Research for Aquifer Protection) involving several research agencies working to solve key questions relating to surface water–groundwater interactions in the Canterbury Plains.

Purposes:

- Quantify biological, chemical and geological responses to changing river flows and groundwater levels.
- Explore new frontiers and new technologies in hydrology, ecology and geomorphology.
- Determine the impact land use changes will have on the quality of groundwater available in the future.
- Determine how nutrients move through the soil to the aquifer and then through the aquifer system.
- Determine whether using best practice farm management techniques will be enough to maintain acceptable groundwater quality.

Outputs:

- Eleven scientific papers focussed on low and intermittent flows and the impact on aquatic fauna.

- Two linked nitrogen transport models at farm and aquifer scales, presented at conferences and to end-users.

Major research findings:

- The differences in water values between farmers and anglers, taken in aggregate, were less marked than differences between different farmers and between different anglers. This enhances prospects for consensus across user groups.
- Longitudinal patterns of increasing fish and invertebrate density and species richness with flow permanence are interpreted as the product of species-specific responses to drying events and the spatial position of refugia within the riverscape.
- Fish and invertebrate communities in intermittent reaches are nested subsets of the communities in perennial reaches.

Outcomes:

As part of the Sustainable Groundwater Allocation Research (SuGAR) project, Lincoln University have developed a method to help stakeholders in groundwater management to visualize and then weigh the landscape consequences of different water allocation regimes (Kerr & Swaffield 2007). It focused specifically upon improving understanding of the way people trade off different amenity outcomes of allocation decisions.

For the first time in New Zealand quantitative predictions have been made of key cumulative effects at the catchment scale, of both water abstraction and the use of water for irrigation. The predictions were integrated and used to achieve a balance between the needs of conflicting water values (agriculture, energy generation and recreational uses).

7.2 Non-specific catchment research

There have been a number of research publications that have addressed the operational aspects of ICM projects in general, without being aligned with any particular catchment project. Some key results are outlined in this section.

<u>Morrissey (2004)</u>

This postgraduate study noted that “specific research into ICM groups, why they form and how they operate have been limited” and reports on a study including interviews and surveys of participants from four ICM groups. The author found that overall ICM groups were influential in improving the sustainability of member’s behaviour; however the results were highly variable and difficult to predict.

The author considered that successful ICM groups needed clear goals and objectives and participatory decision making. Most of the participants in ICM groups appeared to be responding to egotistical values when considering changes to their behaviour. If there were perceived to be individual benefits then altruistic drivers were additionally influential.

“The creation of a community group within a catchment has the ability to develop new social norms. If a group can generate significant community support and be seen to be making changes to the way they manage the environment and properties with added benefits the strength of the new social norm will increase to a level where it affects people’s intentions to carry out behaviour”.

Although not always found in overseas research, the author considered that monitoring of key objectives is important in terms of behaviour theory, as people need to be able to see that the environment is improving as a result of work completed. Such an outcome will increase people’s perceived behavioural control, thus increasing their strength of intention to carry out specific behaviours.

When participants were asked what the main roles of the ICM group were three, key roles emerged from all [4] groups. These roles were: providing leadership, motivation and liaising between farmers and councils and research agencies. The ICM group was seen to create an informal forum for discussion of ideas that allowed for groups to focus on the overall goal of improving water quality without creating a new level of bureaucracy. This was a key theme from all ICM groups in this study regardless of their progress and achievements.

Feeney & Allen (2007)

A project established by the Auckland Regional Council's ICM Planning Team and reported in Feeney and Allen (2007) set out to develop for the ARC Stormwater Action Team a framework for the ICMP team to "monitor and evaluate what they have been doing and what they plan to do in the future". A review of 51 catchment plans showed them to "have met their flooding and water quantity objectives very well", with an "increasing awareness of water quality issues and social amenity …" However, the review found that the ICMP team lacked the expertise to develop ICMP to 'the same high standard as the old catchment management plans". There was also a shortage of capacity in the industry to support the development of plans to the required standard. A framework was developed in the report to guide the evaluation of ICMP.

Forsyth (2002)

This graduate study was an evaluation of the extent to which the key characteristics of ICM (geographic focus, data & policy integration, multidisciplinary cooperation, participative processes) were being incorporated into catchment management as practised by regional councils. The analysis was based on interviews with agencies, iwi and resource users within three case studies: Oreti (Southland), Wairau (Marlborough) and Ruamahanga (Wairarapa).

The key conclusions were that:

- The pace of land use change has overrun the planning process and reliable data on land use change is difficult to obtain.
- Variation between agencies in their willingness/motivation to share data was a hindrance to integration.
- A lack of iwi resources (human capability and financial) hindered their involvement in resource management processes.
- There was a divergence of views on the role of central government in catchment management (non-local government actors wanted a greater role of central government in providing guidance on recurring issues of national relevance and monitoring performance).

Edgar (2006, 2007)

These papers provide a summary of the success factors and innovations derived from the two-year MfE project aimed at sharing community best practise in integrated catchment management, based on case study analyses. The author draws the following conclusions:

- The concept of ICM is readily accepted but implementation has been hesitant and unsystematic. Participation has been cautious and progress incremental, in the absence of a clear guiding model.
- A major motivating factor has been the opportunities for groups to learn about the successful experiences of real people making a difference on the ground.
- Success factors included strategic planning to clearly articulate vision and goals, use of a range of communication tools, partnerships with government and research agencies, localised restoration activities, and development of environmental education programmes. However, the outstanding projects went beyond the above factors to implement innovative initiatives.
- Evaluation of the effectiveness of different approaches has been limited to process or socio-economic outcomes, rather than environmental outcomes. There is a need to support communities in implementing structured evaluative frameworks.

7.3 Tools in NZ catchment-based research

The following section list tools developed and/or applied within the context of the catchment projects included in this report. Thus, the list is not exhaustive and other tools have been used in related contexts, for example see Elliott et al. (2006) with reference to sediment models. The list includes mainly models, but also evaluation schemes, guides and research methods. They are listed in alphabetical order, with reference to their use in catchment contexts (rather than their source reference) and a brief description of their function and application.

AEM (Agroforestry Estate Model – Way 1999)

A decision-support simulation model developed by Forest Research to examine the economic (net present value, cashflow), environmental (soil erosion) and social (employment) impacts of plantation forestry in the context of a pastoral farm system. Used to forecast outcomes for land use change in the Whatawhata project.

Aquifer-Sim (Wang et al. 2003)

A regional -scale model of nitrate transport in groundwater developed by Lincoln Ventures, linked to a GIS user interface developed by Landcare Research. Developed and used in the context of the Selwyn/Ellesmere project.

BMP Toolbox (Monaghan et al. 2007)

Identifies nutrient loss mitigation options for farms based on OVERSEER output and/or a farm description. A web-based prototype has been developed by AgResearch http://www.agresearch.co.nz/bmptoolbox/, with the intent of eventually incorporating the toolbox into the OVERSEER model. Developed and used in the context of the Dairy Best Practise catchments project.

BNZ (Basin New Zealand – Cooper & Bottcher 1993)

A spatially distributed catchment model modified from CREAMS for New Zealand conditions by inclusion of nutrient cycling in intensively grazed systems. Used to predict sediment and nutrient losses in the Ngongotaha and Toenepi catchments.

CLUES (Catchment Land Use for Environmental Sustainability – McBride et al. 2008)

GIS-based framework for a suite of models: SPARROW; SPASMO; OVERSEER; EnSus. Available as a toolbar within ArcGIS. Predicts average annual N & P loads and yields, GDP, FTEs and Cash farm surplus for landscapes and farms.

Concept Pyramid (Parminter & Perkins 1996)

A workshop method for setting collective goals and objectives within a catchment. The Concept Pyramid was developed and applied within the Whatawhata catchment programme.

FarmSim (Good & Bright 2005)

A computer software framework for farm-scale simulation of nitrate leaching from agricultural land uses, developed by Lincoln Ventures in the context of the Selwyn project.

FIO (Faecal Indicator Organism – Wilkinson 2007)

Simulates the dynamics of faecal organisms in rivers. Developed in the UK and applied to the Motueka catchment.

GLEAMSHELL (Groundwater Loading Effects of Agricultural Management Systems – Rutherford et al. 2003)

GIS-based biophysical model. Uses the USDA model GLEAMS to calculate nutrient load for a grid of cells and route these down a stream network.

Groundwater Flow model (Hong et al. 2005)

A generalized 3-D adaptive finite element steady-state groundwater flow model to simulate the interaction between shallow aquifer and surface water systems in the Upper Motueka river catchment.

IDEAS (Integrated Dynamic Environmental Assessment System – Dymond et al. 2006)

A set of linked models for assisting stakeholders in planning catchment futures: Land Use Common database, including Catchment Futures Model (input-output economic model) and Evoland. Assesses spatially explicit environmental and socio-economic impact of a stakeholder- articulated vision, at local to regional scales. Developed and used in the context of the Motueka project.

Influence matrix (Cole et al. 2006)

A mathematical model used in the participatory context of the Motueka Community Reference Group to calculate whole-of-system sustainability values.

Motueka Catchment Toolbook

An interactive multi-media CD-ROM synthesizing science knowledge for the Motueka catchment and its international context. Developed by the Motueka ICM team and the Institute of Resources, Environment and Sustainability, University of British Columbia.

NPLAS (Nitrogen and Phosphorus Loading Assessment System – Rutherford et al. 2003)

A web-based planning tool developed by NIWA for Environment Bay of Plenty. Designed to show how changing land use at the property scale will affect annual N & P export.

NZEEM (New Zealand Empirical Erosion Model – Parfitt et al. 2008)

A model for predicting mean annual soil loss from annual rainfall, type of terrain, and percentage of woody cover. Used in conjunction with OVERSEER for estimating suspended sediment loads in the context of the Upper Manawatu.

ROTAN (Rotorua and Taupo Nitrogen Model – Rucinski et al. 2006)

An intermediate complexity, GIS-based model developed by NIWA, incorporating a previous model RULES (Riparian Use of Land Use and its Effects on Streams). ROTAN has been calibrated and tested at Rotorua where it is being used to help land use planning. It has also been applied in one sub-catchment at Lake Taupo.

SCALES (Simplified Catchment Load Estimation System – Rutherford et al. 2003)

A web-based education tool developed by NIWA in the context of a SFF project led by Environment Waikato. Designed to show how changing land-use in a catchment will affect N entering a lake.

SedNet (Schierlitz et al. 2006)

A spatial sediment and nutrient budget model for regional scale river networks, developed in Australia. Measurements of river discharge and land use/cover scenarios are combined with a physical catchment configuration to construct material budgets for each stream section. A simplified version has been applied to the Upper Manawatu catchment.

SHETRAN (Systeme Hydrologique Europeen TRANsport – Adams & Elliott 2006)

A 3 dimensional physically based hydrological model to predict runoff and sediment transport. Developed in Europe and used in the Whatawhata project to reproduce the results of rainfall simulator experiments.

SPARROW (Spatially Referenced Regression on Watershed Attributes – Alexander et al. 2002)

A surface water quality model developed in the US and applied to the Waikato River basin to simulate water yield, nitrogen and phosphorus export.

STOCKPOL (Dodd et al. 2008b)

A decision-support simulation model developed by AgResearch (and now developed further into FarmMax Pro) to predict the feasibility and production and economic results of drystock pastoral systems. Used to forecast outcomes for livestock enterprise change in the Whatawhata and Lake Taupo projects.

SWAT (Soil Water and Analysis Tools – Cao et al 2006)

Physically-based distributed hydrological model, calibrated and validated for the Motueka catchment.

TOPMODEL (Rodda et al. 1998)

A spatially explicit topographic hydrological model based on a digital elevation model, developed to include nutrient losses. Used to predict flowpaths and runoff in the Whatawhata and Mahurangi projects.

WAM (Watershed Assessment Model – Collins 2001)

An upgraded version of the BNZ model with 3 components – the GLEAMS hydrological model, a surface runoff transport model incorporating the impact of riparian zones and a reach network routing model. Used to project sediment and nutrient export following land use changes in the context of the Whatawhata project.

Water Quality BMPs (Fenemor 2008)

A summary of water quality best management practises for farming and forestry, with other resource links, targeted at the Motueka project but widely applicable. Online: http://icm.landcareresearch.co.nz/knowledgebase/publications/public/BMP_final_version.pdf

7.4 Research provider interviews

7.4.1 Researcher interview questionnaire

What was/is the title of the project being focussed on?
What was being researched or studied in the project, i.e. what was its purpose?

SECTION 1: The main research results of the project
Scientific
Economic/social
Ecological

SECTION 2: The results in terms of project management
Who were the research providers?
Who funded the work? For how long?
Was there a reference/steering/advisory group?
Which groups were represented?
If yes, how did this group respond to the project (initially, over time, and when the project was completed)?
How did the scientists become involved in the project and at what stage?
How did local government personnel become involved in the project and at what stage?
How did industry and others become involved in the project and at what stage?
How did the reference/steering/advisory group become involved in the project and at what stage?
How did Regional Council personnel involved respond?
How did industry respond?
How did farmers respond (those in the catchment)?
How did farmers out of the catchment respond?
How did scientists, Regional Council, reference industry and others respond, i.e. what changed in their attitudes, knowledge, behaviour and/or relationships?
If the project had received more funding, what additional research would have had priority?

SECTION 3: Project outcomes
What changes were measured in the catchment during the project (as a result of the project)?
Did the environmental/ economic/social or cultural indicators improve?
What changed beyond the catchment? Did the results influence others? (E.g. policy, farm practice)

SECTION 4: Key lessons learnt
What were/are the key lessons for you from being part of the ICM research project – personally?
What were the key lessons from the research for the catchment project team?
What do you think were the key lessons from the research for NZ (e.g. for stakeholders or governance)?
ICM research can require quite a different approach to research that studies issues to do with individual landowner's behaviour. When you think of the projects that

we have been discussing, what do you think ICM has added to the state of knowledge? Could we have obtained this information any other way?

SECTION 5: Additional literature – any to chase up?

7.4.2 Researcher interview responses

SECTIONS 1-3 &5 were used to confirm the information presented in Section 7.1 of this report.

SECTION 4: Key lessons
(NB: some individual/group identity information erased with XXX)

Interviewee #1

Broadened my mind about integration, learnt a lot about people and processes, basic project management, dialogue and looking for integration links. It changed my mind-set. It has a lot to do with how you see the idea and not having a preconceived idea.

Building up "teamship" takes time. However once you have that base you are much more prepared to think about links to others work, so there are no silos, and now work in an integrative manner across the organisation.

Need to be pursuing the collaborative model for catchment work on an on-going basis so not covering same ground. Need to be connected.

The approach depends on the scale. Some things are quite prescribed (e.g. biophysical) but others (e.g. social) benefit from innovative methods. A lot depends on the local context (including the culture and amount of conflict). To a certain extent this will dictate process. Need to realise it's more than just about farmers…

Interviewee #2

Enthusiasm for process, realisation that this is the way forward. That it is about building relationships. But you have to be part of it to realise this! A good experience! Downside for younger scientists is that doing integrative research can be a real barrier for your career. It's hard to get papers out of it in the same way that other science does. Also it's hard to park individual interests (e.g. didn't get to work on erosion for 3 years!).

Learnt that we don't do evaluations of projects even though we should! Need to have a group of people that are adequately resourced and with the right kind of people skills to do projects like this well. How to do that nationally is a challenge though.

Had a whole bunch of people working together, building relationships for 10 years, which means there is a strong foundation for future work. There is a level of meaning behind it all which can go both ways. Information needs to come from credible sources, which means translating science into useful stuff!

Have to work in this way (ICM) to 'get' it. So I don't believe you can understand the process unless you go through the experience. Need to know that it takes time! The value of getting people together (including end users) cannot be underestimated. The gap is figuring out how to 'chunk this up' and get it working elsewhere… Need to talk through what is a catchment (above farm, but below region). Need multiple communities and connections with all aspects covered.

Interviewee #3

Given us a lot of learning about how integration works and how an integrated team works. Probably only 2 – 3 projects within the group that have really tried to be inter disciplinary and inclusive.

Learnt about working with iwi, councils etc. Highlights (the process makes it really obvious) that councils are all at different stages with different capacity. The lessons from this work are tailored to one council. Note that the process is community based NOT place based (an important distinction of catchment management is that it needs to be community not place based).

Governance needs to be looked at. Need to distinguish between engineering solution and integrative approaches. Much like bringing up children – each child is different so the same approach may not work, and so different approaches can be taken, in the context of the family. Expertise helps but is not sufficient. Need to have a relationship first and foremost! Need to define governance and problem, but it's not always about solving problems. It's about getting communities to be more thoughtful and caring.

Everything needs to be set into scale and community – to make sure that they are involved and aware of scale. This brings a richer landscape to a site problem, and no one conversation is a fix. The relationship thing for dealing with complex problems is about the quality of the process and participation. You should not get hung up on tools!

For our project it was tense for 2 – 3 years, but it changed the way in which scientists see the world. But it takes time! Relationships were built and that is the basis for the work, not the destination.

Interviewee #4

The experience reinforced my view that involving local community members in a local environmental issue can be very productive and achieve things that would be unlikely to be achieved otherwise. As an academic, I offered my experience to answer the questions of XXX members, but tried not to lecture them or to strongly propound my personal views. Nevertheless, 'education' was a key to success - whether formal (work with schools in the catchment, production of a video etc) or informal 'self-directed' learning (field days, workshops, symposium, talking together at meetings).

The only formal research element was that done by XXX (social science), which resulted in setting up the community/university alliance. Much ecological research has been done in the catchment, but not formally as part of the XXX activities, although they provided a pathway for disseminating new knowledge.

At the beginning there was strong antipathy among the community towards the agencies (XXX). The involvement of senior University people seems to have helped break down the barriers, providing confidence to deal with agencies (perhaps without the fear of being bamboozled).

Interviewee #5

The value of the 5 catchments work has been their function as a laboratory or forum around how good/bad/ugly things are and whether people want to do anything about it. They are important barometers of industry impact on the environment. There are not many other catchments where impacts and farmer practices are measured. They weren't about trialling BMPs, not really an objective. However there have been changes. The monitoring says that the water quality has stabilised, even though there are more cows in the catchments. That is success, even though the water is not at the guideline levels (these levels are for water from pristine native bush). Some things are attributable to change within the catchment e.g. the riparian work in the Waikakahi has decreased the sediment in that catchment.

The process followed has been key to the catchments work. This process is: monitoring – defining linkages – establishing values – farm planning (to get to values). This has been a crucial part of the success of the work. Other catchment work has fallen over because there has not been a process like this.

Key lessons are re-emphasising the process and the participants in the process, i.e. having a forum for discussion around values. Unless problems are blindingly obvious then need researchers to figure out what is going on. Having a multi-disciplinary team is important for that. The forum refers both to the mix of people and the process. Key participant are councils as they tend be the arbitrators of community view (they have to do something about what people might be unhappy with). There are valuable lessons for the wider industry as farmers in the catchments tend to be typical of farmer behaviour nationwide.

Not quite sure about the term ICM, as you don't manage catchment, you manage farms within catchments to change things at a catchment level. But the generic process (outlined above) is applicable to other places, but it still comes back to farm planning and response whether it is dairy farmers or forestry.

The next step for the 5 catchments is an exit strategy for researchers, but the catchments are a good thing to continue from a council point of view. Some researchers are more optimistic about the catchments work than others. They are great value but there is only so far group processes can take you before you need regulatory processes as well. Need to ask whether it is about changing things or not, because if it is about change then you come back to farm behaviour.

Interviewee #6

First key lesson is that you need a real problem if you want to get change. You really only do an ICM project if something isn't right and stakeholders often need to agree that something isn't right. If it is a scientific question people are interested but you won't see any real change until people buy into the problem. If people admit the problem they also need to buy into the solution and that if they do something about it that it will make a difference. In Taupo farmers did accept that there was a problem and that what they could do would change things. In Rotorua farmers did accept the problem but did not accept that what they could do would make a difference; too much sacrifice with no real difference. Scientific studies can be fascinating but they are only technical studies until people buy in. ICM depends on the objective. Learning about the connections is a technical study. Engaging stakeholders is change. The five dairy catchments was not set up with the aim of making people change but about learning what was going on. The thought was that maybe once people learnt about it then they would change. In the Toenepi there wasn't really a problem there, it was swimming in one of the downstream rivers that was really critical. Waikakahi was more visible with the impacts on the trout etc. It's too obvious to say that all that's required is information – wrong! Lesson is what sort of teams do you need to construct to achieve objectives? Taupo had breakthroughs because the policy people got involved and they were the ones who had to enforce the rules. There was one interesting meeting there where the participants divided into science/policy and farmers/enforcement. Scientists/policy had a complex view and farmers/enforcement had a practice view! Farmers and enforcement people were on the same wavelength, i.e. focussed on the solution!

Once you get people engaged you often get a lot of stuff you don't expect. This is an issue with ICM. For example in Taupo a lot of residents there felt that the power diversion was wrecking the bays but the council didn't think so. It took a lot of technical debate and discussion to agree that while it was OK for the lake as a whole, it was a problem for the bays, so both sides were right! Illustrates that people wanted to debate other issues. Have to do both. Listen and get issues on the table, then maybe put some outside the scope. Put them through a sieve. Need time to explore not just the perceptions but the links. Be prepared for lots of conversations about stuff you didn't want to talk about! Takes longer than you think, but things can change faster than you think too, e.g. in Whatwhata the catchment changed relatively quickly, in terms of stream temperature and clarity. So lesson here is that we know more than we think we know. Get scientists to answer a question on what they do know, then let them focus on what they don't know. Scientists are amazed at what they do know when those things are integrated. All three studies mentioned used existing knowledge, pulled together models etc. Can't wait for certainty, have to be willing to make leaps. But good news is that people can do it. Some things don't always respond the way you thought though.

There are questions about process, engagement, leadership. You have to have the right people involved. After the event it's obvious! Need people who have interest in a team. Have the technical knowledge and ability to integrate this. Also respect (genuine respect) for other stakeholders – this isn't sympathy, because with sympathy you lose the ability to drive stuff. Often you are searching for the 'least inequitable solution'! The process involves reflection and adaptability. You need experts, translators/interpreters (not really facilitators because you need to be part of the process, not just driving the process, but willing to explain others; maybe a supporting facilitator?) and generalists. 'Like a good loose forward'!

Catchment stuff has drawn on knowledge from elsewhere. Started with 'tell me what you know'. Then you can go to the place and apply the knowledge you have. You need a question or an issue to base it around. ICM suggests catchment. But the scale will need to be appropriate to the question being asked.

Three key things: need a real problem for real change (engaging people), technical experts know more than they think they know (landscapes and systems do behave in certain ways, there is hysteresis and memory, some things will be faster, others slower), managing people's expectations (e.g. when you engage with people they will bring out other issues and you need to accommodate this, making sure you have clarity on the problem. You also need to step back and not assume that your definition is the same as others, e.g. lake quality means different things to different people, weeds, lead shot, power diversion).

7.5 Workshop results

7.5.1 Workshop programme

Date: 1 May 2009
Venue: Miramar Golf Club, Wellington

9:30 am Welcome and introductions (Terry Parminter)
9.45 am Practise groups I

Scientists:	Mike, Bob, Chris, Andrew
Policy Advisers:	Michelle, Piotr, Mary-Anne, Gerald
Policy Implementers:	Ross, Ciaran, Susie, Simon, Julia, Judith, Jon
Industry Developers:	Johanna, Gwyn, Hugh, Gretchen, Jessie, Ian

Record:
1. Who we are
2. Expectations of ICM
3. Expectations of this workshop

10:30 am Report back
11.00 am Morning Tea
11.30 am Report Summary & discussion (Mike Dodd)
12:30 pm Lunch
1:00 pm Mixed groups I

A:	Bob, Gretchen, Michelle, Ian, Susie
B:	Andrew, Gwyn, Mary-Anne, Simon
C:	Mike, Jessie, Hugh, Gerald, Julia, Judith
D:	Chris, Johanna, Ian, Piotr, Ross, Jon

Record report feedback:
1. What are the strengths of the report?
2. What are the weaknesses of the report?

Considering the needs of: Policy advisors, Policy implementers, Industry developers, Scientists

1:45 pm Mixed groups II
Record recommendations:
1. What are the issues to be dealt with in a report revision?
2. What is missing from the report and where can it be found
3. What needs to be developed further and how?
4. What should MAF do with the report?
5. What should happen next, after the report?

2.00 pm Report back the 3 most important recommendations.
2.30 pm Chris' catchment continuum
2.45 pm Concluding ideas from all individuals
3:30 pm Thanks and depart

7.5.2 Notes from practise groups I

SCIENTISTS

1. *Who we are?*

Knowledge providers
- Answers for questions (set method)
- Data/info generation – biophysical

– economic
– social
– cross domain

- Big picture conceptualisers (not all scientist)
- How things work
- How knowledge is used
- Consider ourselves neutral/objective

2. *Expectation of ICM*
   - Opportunity to integrate, connect science discipline/edge
   - Opportunity to integrate with users
   - New research opportunities
   - Reality check – simple → complicated → complex
   - Overarching framework
   - Provides examples of science in practice
   - Opportunity for science – to work in a new way, to learn
   - Integrative science (different from disciplinary science) – a shared understanding.
3. *Expectation of Workshop*
   - Good lunch
   - Meet some new people
   - Heads up for bidding, direction, ICM?
   - This group will think what we've done is useful (project)
   - Share among other research projects progress
   - <u>Project</u> – report balance, endorsed – recommendations useful to others
   - Consensus on value of ICM approach → if it's not, why?
   - MAF (and other agencies), uses this to lever action
     - funding
     - investment
     - implement

POLICY IMPLEMENTERS

1. *Who we are?*
   - Promoters of best practice
   - Land/catchment managers
   - Protectors of resources (env & ec)
   - Facilitators and collaborators between landowners, council and industry
   - Statutory responsibility – guiders
   - Interpreters/communicators of policy
   - Maker of decisions (one of many) at catchment level – catchment oversight
2. *Expectations of ICM*
   - Collaborative process to achieve above
   - Policy tool to link land and water and people
   - Conflict resolution
   - Multi-stakeholder decision making process
   - Positive environmental outcomes > change on the ground
   - Setting agreed outcomes/visions
   - Engaged communities with each other and with land managers
   - Feed community expectations back to policy
   - Catchment outcomes at various scales

3. *Expectations for ICM Workshop*

- How to fit ICM without regulation?
- Learning breadth/scope of ICM throughout the country and how to use it more effectively
- Building capacity – taking personal knowledge and turning into corporate knowledge
- National recognition that ICM is happening throughout the country – not just research focused
- ICM is not catchment wide research
- Identify gaps
- Definition of ICM – incorporates research and social recognition.

INDUSTRY DEVELOPERS

1. *Who we are?*

- Practitioners of ICM
- Representing sectors and people on the land
- Taking information and repackaging for farmers and industry groups etc
- Evaluating information in order to determine outcomes, e.g. economic/social/environmental
- Provide policy with feedback to provide practical solutions
- Link between science/practical implementation
- Role developing over time with pressures from community etc
- Accountability without big stick (perception of accountability)

2. *Expectations of ICM*

- Helps practical implementation
- Communities (everyone in catchment)
- Target – identify issues – buy in on process – pathway forward – monitor to show progress
- Need to be real – not the answer to everything
- Bringing communities together to explore perceptions and misconceptions – reducing finger pointing
- Getting everyone on the same page
- Targets are set by the ICM community vs the wider community
- Everyone is given an "expert" status so everyone on level playing field → all views are valid.
- What are the drivers for catchment work ICM
- Catchment based work vs ICM

2. *ICM Workshop*

- Strong links between four groups
- Hope it demonstrates that each group can work together to achieve good outcomes
- Ground truth where are we at with ICM in NZ - *feeding into the draft document
- What factors are required to make an ICM successful – best options
- Take it beyond theory to practice – highlight what it can achieve
- "Catchment-based research" vs ICM differ – define

POLICY DEVELOPERS

1. *Who we are?*

- Partnership catalyst
- Strategic
- Policy works in land/water space moving forward at local and national level

2. *Expectations of ICM*

- Provides blueprint for resolving identified issues
- Integration
- Multiple objectives being met
- Aggregative effects/actions
- Catchments not necessarily limited to water/hydrology (biodiversity)
  - s/w management
  - air
  - spatially defined
- Diverse stakeholders – consensus over outcomes and methods (Co-operation)
- Effective tool? For land use/water interactions
- Considers all dimensions – enviro, social, economic, governance

3. *ICM Workshop*

- What are are the collective learnings from existing ICM's
- Not just science outcomes
- Comparison with other approaches, e.g. direct landowner contact
- Governance structures/outcomes
- Common lessons to be transferred

7.5.3 Notes from mixed groups I

STRENGTHS
Collation: - Pulls all info on ICM together - Stock take of organisations involved - Having all the information in one place, esp given more communities looking at catchment scale projects. - Has reviewed a range of studies/catchments with different outcome **Lessons Learned** - Highlights the considerable findings of the CRI science around ICM - Are there catchment research projects with Regional Councils or other agencies that could be included? - Good lessons on how to undertake catchment scale research. - Recognise that it is a very time consuming process to carry out. **Section Content** - Section on lessons learned (most important section) - Summaries are an appropriate length - Good map of spread of projects **Process** - dialogue and discussion, feedback before finalised - Inclusion of workshop important - Pleased they interviewed researchers involved in the project - ID similarities and differences (latter in brief) ______________________________ - It's a starting point and has the potential to be able to provide some 'guidance" - Good to capture research from catchment studies in one spot - Highlighted the attitude of landowners to change – successes and failures. - Does evaluate science-based funding (at this point in its evolution) - Potential to identify key areas that need addressing and gap/barriers to

success, i.e. people with skills to work with farmers etc.

- Identifying key learnings and sharing with others → sampling/monitoring timeframes etc.
- New catchment Res or ICM can start from different place and build on.
- A really useful compilation of current catchment studies
- Identifies where catchment issues have been in NZ
- Projects aimed at science – success assessment should stay about research (not adoption)
- Recognition that catchment research processes has benefits beyond the "sum of the individual parts" → collaboration
- Workshop good idea
- Community involvement - education
- References listed
- Inter-institutional collaboration
- Some useful BMP information
- Useful source book literature list
- Good descriptions of the projects
- Research leading to highly relevant issues/problem solving
- Provided a summary of ICM activities in NZ – one place
- Good to see spread of catchments across the country
- Scope identified – boundaries identified
- The report seeks to identify learnings and common themes for successful ICMs
- Tools outcome useful
- Good to see acknowledgement of the need to think carefully about what is wanted from these studies (pg 57 last para)
- Structure of individual studies okay
- Good that all factors are assessed – not just environmental gains, social also assessed
- Role of objectivity of science in ICM important and should be emphasised
- Good review source to start from
- Does identify key factors needed to run a successful ICM
- Try and learn to make ICM work better
- Good balance of studies included
- Good writing style – understandable
- It does pick up on key issues for forms as businesses and financial ???
- It does show that time frames can be long. Temper expectation of stakeholders before starting
- Easy to read, not too scientific for all stakeholders

- Good concept to do this stocktake
- Good review of literature and technical summary
- Recognition that ICM is a process not just development and application of tools (In fact the process is a tool)
- Will help guide situations where ICM a valid/viable approach
- CRI integration is desirable and important
- Will refocus ICM scoping in future
- Initiated this workshop
- Projects like this get communication going between projects, to break down "comparative secrecy"

WEAKNESSES
Report scope - Needs more clarify around the scope and bounds about what this report covers as wider things, e.g. non research CCM - Research focussed, not implementation project focussed, breadth of focus. - Scope – a shorter more concise scope section with very clear aims or goals would be useful. **Content - Feedback** - Report appears to be just a review of interface rather than talking to people on the ground - This is not really a review of ICM it is a review of a number of research projects - Report of limited value from an industry developers perspective **Details of missing areas** - There are a number of ICM programmes that have not been covered in the review - Leaves out community projects eg Whangaparoa harbour care in Waikato (Raglan) which has merits - Need summary and analysis of "lessons learned" - What are the crucial elements common to all projects that are necessary kernels for ICM to happen? - Understanding that project has been carried out as briefed. This workshop has recognised that the "people" perspective may not have been covered to come up with lessons learned - SEDNET is a tool which with NZEEM can produce information for catchments. Please add it to tools section. - Research report identifies need for funding of implementing the desired outcomes? **Further topics to cover** - Can we have recommendations how to set up an ICM e.g. baseline environmental, social & economic data - Lack of analysis and comment on what it would take to make ICM widespread – cost, policy constraints? - Teasing out governance structures – what they were, their diversity, what works generally, what inhibits? - ICM requires integrated catchment monitoring. CRIs and RCFs have made significant improvements around this. Perhaps a short guide to lessons on monitoring would be useful. - Could add to outcomes section a final bullet point on current status of the project (or a separate heading) e.g. Project status - * completed, *community group closed down. - Needs a concise set of bullet points of lessons learned. - Missing some policy approaches to integrated catchment management, e.g. not full ICM processes but aspects have been incorporated in Horizons One Plan. - Need a greater focus on social research and evaluation and how projects are set up for community engagement. - Applicability to other spatially "confined" projects e.g. altitudinal; multi water catchments, relevant to biodiversity → want discussion on limits of ICM. **ICM Definitions** - Bit confused about the difference or definitions of ICM vs. catchment projects. ________________________ - Interviewed only senior researchers, not stakeholders

- Did not do an objective stakeholder survey/evaluation of outcomes/values
- Water quality review only, how about all the water resources (quantity) work which is very advanced?
- What is an ICM study? Better definition
- Need to summarise the key findings.
- Not clear about quality of benchmarking and evaluation/monitoring (as each programme progresses) and then on finishing.
- Research phase might be phase 1, can't expect success on everything – portray this.
- The underlying assumption that catchment research is somehow equal to ICM, instead of a spectrum of 'science' to engagement/commenting process & knowledge.
- Report needs analysis and recommendations to do with funding streams, roles and functions and institutional framework – can any inferences be drawn as to whether these have more benefit than other water quality approaches from a cost/time/benefits perspective?
- What happened after the project stopped, and who funded this bit?
- Long dull report may not communicate messages to end users effectively, other ways too
- Does not recognise RC research and ICM work
- How many of these initiatives have continued past the project phase?
- A lack of Maori focus.
- What are alternatives? international setting? Evaluation and outcomes of ICM
- ICM – confused with catchment based research.
- Needs to identify the long-term aspects of ICM planning – action continuity
- If an intent was to develop a summary of ICM tools/technology and learnings for others to use, I am not sure this can be achieved given the sample of 'catchment based research' not ICM with an ??? and engagement process.

Other research
- Water quantity
- Vegetation
- Air
- Identify end users (readers) please
- Need to better define criteria for 'stakeholder engagement process' and on what basis the cases were selected.
- ICM is evolving, captures research at this point.
- (see diagram)
- Report needs analysis that precedes, and justifies the "lessons learned".
- No focus – findings on what stakeholders got out of involvement in a "knowledge" sense
- Report does not detail how and who projects funded, how much they cost
- Excludes second phase projects which implement science with good results (still govt funded and involve scientists) e.g. Aorere Catchment in Golden Bay.
- Needed more science people, less practitioners at workshop
- Too big
- Economic issues addressed qualitatively only
- Research focus at odds with adoption criticism.

People are not included in the definition of ICM

- Landowners and community are not necessarily two different groups and should avoid describing as such – maybe define community?

- Limited comment from community individuals involved in ICM – would be valuable to have their input
- Terms of reference/requirements of MAF not clearly articulated – scope of report not clear.
- Time scales are very important factors – needs to be discussed more.
- Missing key economic analysis
- It is unclear whether the report is specifically addressing ICM research projects or ICM initiatives in general.
- Needs peer review
- Not enough discussion on economic costs and benefits
- Needs further discussion around drivers other than economic, e.g. confidence in science for mitigation – stewards of land, farm progression/succession inter-generational issues
- Non science derived lessons open to debate – is that always true?
- No mention of iwi role
- How will it help each of the stakeholder groups?
- Not enough focus on need to gain by-ion and how to facilitate behaviour change for successful ICM
- Not enough discussion about the need to clearly identify issues and specific catchment goals
- Does it use all ICM projects to learn about what works or doesn't?
- Needs good summary
- Needs a god succinct summary for general audience dissemination
- Tools for NZ catchment based research – could be more descriptive (I was left wanting more)
- Report covers not only concept of ICM but common finding. Structure of report might be better by putting all social issues in one org etc.
- Need more focus on timeframes
- Qualities of good facilitation – section that outlines this
- Too long
- Incomplete at this stage
- Use of terms "polluters" and "users" not helpful
- Lots of reporting results, little concluding analysis
- Too much of a focus on integrating disciplines – need to acknowledge people more
- Doesn't reflect that participant attitude esp RCs can have a huge impact on results

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- Where there are links to policy being made in the research, identify these (and benefits)
- Some conclusions not well proven
- Could report (say) the 6+ main points from research in setting up a most effective ICM project or groups
- If setting up successful catchment is the outcome then science is only one part of the review
- Recommendation – needs a similar review project for community ICM projects (not just research-based ICM)
- Did each project deliver on expectations (not for ICM necessarily, but its research outcomes)
- ICM needs to be compared to alternative approaches (cost benefit analysis) = recommendation
- Project brief aims to inform MAF action on SLM groups – note that some ICM projects are broader in scope
- This workshop could have occurred earlier to better inform the final report

- Should better explore similarities and differences between the different projects - Acknowledge need for realistic expectations of outcomes – water quality improvement, capacity building etc, take lots of time to be seen. - Evaluate the cost of the science in ICM projects, cost benefit analysis - Upper Manawatu section is missing, best practice phosphorus project (Parfitt 2008), Manawatu Catchment Scenarios – Schlitz, Dymond and others 2007, also how these projects fitted into an integrated catchment management framework

7.5.4 Notes from mixed groups II

RECOMMENDATIONS
- Clearly define scope of the report; What is in scope; What is out of scope - Analyse – fill in lessons learned - Defining what is the use of report after completion - Economic analysis and catchment scale – Ross to follow up Alex Seenstra and Sarah Mackay work. - Recommendations for further investigations – further topics to cover → after scope investigation - Report needs to be considered in context of bigger issues i.e. limitations to going forward. 1. Drivers of change 2. Capacity 3. $ etc - Paint the continuum of participatory (new way) research through to pure science ICM research "old way" as a background. - Fill in "learnings" from the 20+ projects → what common to all? → what critical factor is necessary to make ICM happen? = further analyses - MAF – could boost $ to do social research evaluating success of ICM and define what else would boost effectiveness e.g. ??? or regulations. - MAF Report use? Assist in policy mix debate regionally (would also be useful to commission work on other policy tools & what pros/cons are) e.g. compliance/regulation education etc - Missing from report - Sednet is a tool that can be used in ICM (see John Dymond, Landcare), IFIM instream flow incremental methodology is a method for setting minimum flows - Upper Manawatu section is missing some projects – best practice phosphorus projects Parfitt (2008), Manawatu Catchment Scenarios (Scherlik 2007), Upper Manawatu Water Resource assessment (Jon Roygard at Horizons can provide these), and how these project were then used in an integrated catchment management framework - Having completed this report, MAF could look at ICM processes that have been done in policy frameworks not CRI research projects and on the ground such as with Landcare Trust - Happen next…. Gain use of the report with influencing councils around the country. EW keen on ICM approach more widely as starter. - MAF should indicate what they have used report for and tell this group - Having captured the research findings, where to from here? - Where is the need for future funding, is it research, perhaps it's in implementing the research recommendations to achieve outcomes

What MAF should do with the report:

- Identify where ICM is appropriate and where it will add value, and communicate this.

- Greater consideration of the social or collaborative outcomes associated with ICM process – skill in collaborative research, building understanding and awareness, link to policy and output
- How does MAF deal/respond to the recognition in section 5 (pg 50) that "there is a need to support communities in implementing structured evaluate frameworks" Plus expanded to funds to implementing ICM objectives/goals

Defining Drivers

- To develop - expectations of the ICM projects documented
- Clarify the leadership for each example and reason for its initiation.
- Define this is research focussed and other lessons would also be useful (but not aim of this)
- After the report we need to evaluate the phase ICM work too
- Good idea to document catchment research, leave out adoption
- MAF should take this report as an element of ICM not a definitive
- This report should focus as an outcome that ICM has changed science philosophy for the better (working together, practical, applied etc) this was a totally new concept not long ago.

Report layout/presentation

- Executive summary: – key findings, diagrams, distinguish between ICM and catchment; need to get sexier in presentation of report, good exec summary, diagrams
- The 'scope' section should include a good definition of the brief which is science based. Take out review elements from this section.
- Good section on key lessons for future studies.
- What is a successful catchment study?
- MAF should post the report on their website and advertise it widely.
- Recognise the aims of catchment research (it is a success thus far for what it aimed at. Will not achieve all of ICM aims
- Scientists are critics by nature - comes across as negative.

- Summary section focusing more on key success factors for ICM projects
- Expand discussions on economic analysis and include other ICM information. Reports for Taupo & Rotorua, talk to Landcare Research, Opua Dam study by MAF
- Incorporate findings/learnings from some non-research based ICM projects. Talk to RCs and Landcare Trust
- Solutions to get extension capabilities and resources required for successful ICM projects. Inter governmental agency issue MAF/FRST etc
- Develop a resource for groups running ICM programmes
- MAF direct resource into developing extension capability
- Investigate idea of remedial technology
- More emphasis on stakeholder engagement
- Make recommendation for future research required.
- Include tools section as appendix

- Limited scope of this review – recommend completing a community ICM review as a Phase 2 and start with an audit of existing catchment groups
- Insert a scope section at the start, based on the brief and MAF's

expectations - ICM is about understanding all the trade-offs and consequences of decisions about natural resources (as opposed to disciplinary or single issue decisions) - Include recommendation(s) about further integrative research being needed e.g. link to end user needs, policy, partnerships…. - Identify common features of a successful ICM project or ICM research project - Founded upon a clear brief and not trying to answer more than a review of science research and its successes or failures. - Better define what is an ICM process in 8.1 and define ICM - Note difference between ICM research and science needs of ICM processes of groups - Include cost-benefit analysis commentary

7.5.4 Emergent issues

Scope of ICM – Scale?
Process – policy or a tool?
Difference between discussing – research requirements for ICM vs. ICM
Whether ICM approaches to research are useful.
Stakeholder vs. community.
Management vs. Governance
Socially defined catchments OR policy, biophysical science.
Ecosystem approach?
Needs a catalyst, e.g. water quality.
Policy Mechanisms
Implementation tools to support ICM?
Are there other more meaningful frames e.g. ecosystem landscapes
We lack national priorities and context to go forward.

Collective wisdom on ICM
Translation of results
Forward looking not historical?
Needs of ICM project outcomes?

ICM Lessons and E & E & S and process

7.5.5 Concluding remarks

ICM is about trade-offs.
Need to understand multi dimensions of trade-offs going beyond single problem – solution resolutions.
Parked questions dealt with
Flexibility is the real world – capacity a critical issue to make this work going forward.
What involvement do we want from this group going forward?
Beyond research, how are we going to make it work, $ to go on it get it being applied
Good to see this investment from MAF but keep on collecting success stories (learning) from the field.

More focus on economic outcomes/impacts
See other draft.
Model – write report and submit
Workshop and embrace complexity
ICM is a big cost, is there a benefit at scale to enthuse councillors?
ICM is a process – a thing that you do
Don't come up with what makes it an effective ICM, but rather an effective research ICM.
Taieri project published papers don't reflect comprehensively the nature of the work.
Fuzzy may be used to cover inadequate strategy.
Balance between being reactive and being proactive.

7.6 Bibliography of recent NZ catchment-based research

(References grouped by relevant catchment, ordered by increasing latitude)

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