INTEGRATED FRESHWATER SOLUTIONS

Mediated Modelling for Integrated Freshwater Solutions: a case study of the Manawatu Catchment

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2014

(Not Reviewed)

ISBN 978-0-9876532-1-5 (Print)

ISBN 978-0-9876532-9-1 (On-line)

Contract number: MAUX1002

<u>Recommended citation:</u>

> van den Belt, M., Forgie, V. E., Singh, R., & Schiele, H. C. (2014). Mediated modelling for integrated freshwater solutions: a case study of the Manawatū catchment. Ecological Economics Research New Zealand, Palmerston North, New Zealand. Technical Report, not reviewed.

Acknowledgements

This project (MAUX1002) was funded by the Ministry of Business, Innovation and Employment (MBIE). Without the dedicated time and effort of the various participants this project would not have been possible. We wish to acknowledge the early efforts of Garry Murfitt, the past Chairman of Horizons Regional Council (HRC), for providing the leadership behind both the Manawatū River Leaders' Forum and the collaboration with the Integrated Freshwater Solutions research project. Our thanks go to Greg Carlyon (ex HRC) and Barry Gilliland (HRC) for their efforts within HRC and original outreach to iwi and other organisations.

Table of Contents

1. EXECUTIVE SUMMARY

The Integrated Freshwater Solutions (IFS) project was funded by the Ministry for Science and Innovation (MSI), thereafter the Ministry of Business, Innovation and Employment (MBIE), to develop and test a new approach and tool for collaborative and adaptive management of freshwater. The case study area was the Manawatū River catchment. New approaches, regulation and tools are imperative to get beyond the current limitations of politics, stakeholder power imbalances and the use of science in a fragmented and often divisive rather than integrated manner.

The start date of the IFS adaptive management project (October 2010) and the stakeholders involved overlapped with the Manawatū River Leaders Forum (MRLF) initiative lead by Horizon's Regional Council (HRC) to develop an Action Plan to clean up the Manawatū River. The IFS research project was directed at finding long-term solutions to the sources of water degradation in the Manawatū River catchment. It was grounded in adaptive management which regards "policy making as an experiment" and emphasises the capacity to iteratively go through the stages of envisioning, assessment, planning, implementation and monitoring with the ability to adjust when new information becomes available or policy implementation underway has unintended consequences while still working towards a shared vision. Since the long term goal (a healthy Manawatū River) and the short term goal (an Action Plan) provided some (but not complete) common ground between IFS and the MRLF, a collaborative approach in the context of adaptive management was applied by the IFS project and efforts were combined rather than run in parallel.

HRC was an early supporter of the IFS project, however, many of the HRC councillors and staff who championed the IFS project were no longer at the HRC by the start of the project. IFS organised and provided the facilities for the workshops and the HRC funded the MRLF's Chairman's involvement as a joint facilitator. The first three workshops were led by IFS researchers based on an integrated, Mediated Modelling (MM) approach; which refers for 'model building with stakeholders' as a means to better understand how issues of concern interlink and how possible solutions could look. MM is intended to function as a mediation tool to assist a group of non-modellers to scope for interlinkages in a complex system. It is not intended as a 'black box' expert model constructed *for* stakeholders. The four subsequent workshops were hosted and supported by IFS, but led by the MRLF Chairman using a 'linear' rather than a 'dynamic' action planning mode aimed at producing an Action Plan in a six month timeframe. After the Action Plan was completed two further workshops were hosted by IFS. The first considered the economics of the various solutions considered as part of the MM modelling, and the second focused on the 'account-ability of collaboration'.

This report presents and reviews the MM and action planning process from an IFS research perspective. We offer a reflection on the context in which the MM approach operated, the process that evolved, and a description of the content of the resulting model. Specifically discussed are: (1) stakeholder analysis and management; (2) what happened during the workshops; (3) participants' feedback based on surveys before, mid-way and after the action planning workshops; (4) the resulting Action Plan, and; (5) the status of the evolving system dynamics model.

The 'scoping model' resulting from the abbreviated MM process simulates some relevant trends (sedimentation, nutrient run off and aquatic habitat) at an aggregated, catchment level. Assumptions include on-going intensification of dairy farming and population growth in the catchment. The model also scopes the potential impact of some actions (fencing, riparian planting, nutrient management, reforestation and wetland restoration), the funding available and the anticipated impact such actions could have on proxy indicators.

The research methodology of IFS is “Action Research”. Key learning points from this case study are (1) the collaborative learning approach was successfully embraced by the stakeholders involved, albeit for different reasons; (2) scoping for big solutions and model building got the dialogue started and a scoping model resulted; however (3) time pressure and a public accountability for action planning reduced the role of model building to structuring the dialogue and the collaborative process reverted to linear facilitated negotiation (4) the scoping model, which presents broad long term trends, indicates uncertainty that the Action Plans tasks will achieve the desired water quality goals. Absence of measurable targets will make such evaluation difficult to quantify, and (5) the MM scoping model provided a sound base for a consequent spatially explicit dynamic model built as collaborative research exercise among scientists.

This report stands as a reflection of MM as a tool for use for collaborative and adaptive management purposes.

2. RESEARCH OBJECTIVES

This report is one of a number of outputs from the research programme “Integrated Freshwater Solutions (IFS)” funded by the Ministry for Science and Innovation (MAUX1002) which ran from October 2010 to September 2013. The contract holder is Massey University and the contract executer is Ecological Economics Research New Zealand (EERNZ) (www.eernz.ac.nz) in collaboration with three iwi/hapū (Rangitāne o Manawatū, Muaūpoko, Ngāti Kauwhata/Taiao Raukawa) and the Institute for Natural Resources (INR) at Massey University.

Our **hypothesis** is that science and stakeholders’ (especially political) perspectives have to be rooted in a shared level of understanding for effective, adaptive, whole systems management. All the science in the world will not necessarily persuade stakeholders to change behaviour sufficiently to curb current undesirable trends in freshwater quality. Human drivers for change come about through better understanding of the connections between scientific findings and their own personal situation and this is where “science in the right context” can make a positive contribution. This statement sets the research context of IFS which had the following research aims:

1. Building and testing an adaptive management framework to better understand and value the ecosystem services freshwater systems provide.
2. Examining the current negative trends of various indicators and testing the policy/management options and trade-offs required to achieve improvement and broad societal well-being regarding fresh water resources.
3. Testing the usefulness of System Dynamics based Mediated Modelling (MM) and spatially explicit Bayesian Belief Network (BBN) modelling for assessing progress in an adaptive management context.
4. Assessing how effectively these models (MM and BBN) can draw on existing research data, apply an ecosystem service valuation approach and integrate value assessments from various stakeholders with a particular focus on iwi/hapu.

5. The expected outcomes were:
   - *a cohesive pan-iwi/hapū perspective on freshwater that helps communicate iwi/hapū interests to regional decision makers;*
   - *an economic survey of freshwater ecosystem services;*
   - *a system dynamics model to evaluate scenarios for future adaptive management (MM);*
   - *end-user capacity to use and maintain the system dynamics model;*
   - *linked spatially explicit GIS capacity to evaluate probabilities of impact on freshwater systems from land use change (BBN);*
   - *a set of consensus recommendations among various scientists, stakeholders and policy makers as to the way forward; and*
   - *identification of gaps in relevant and pertinent knowledge.*

At the start of the project, we proposed an **Ecosystem Service (ES)** framework for the IFS project. This ES framework (Figure 1) was intended to serve to integrate stakeholder and research perspectives. The "Ecosystem Service" box identifies the services that people receive from "Natural capital" such as freshwater services (following the Millenium Ecosystem Assessment, 2005). The "Economics and stakeholder values" box includes both market and non-market ways to value ecosystems and their services. Mauri[1] and cultural perspective can be incorporated here. The "Policies and Management" box is where we look at governance. Following this cycle, if governance is well executed freshwater as a "Natural capital" asset will be enhanced into the future. To complete a feedback loop between the boxes requires both careful consideration of the problem and potential solutions. This includes analysis of how potential solutions are expected to improve the situation and/or what the unintended consequences of a policy or management regime might be.

[1] Life giving force in the Maori culture

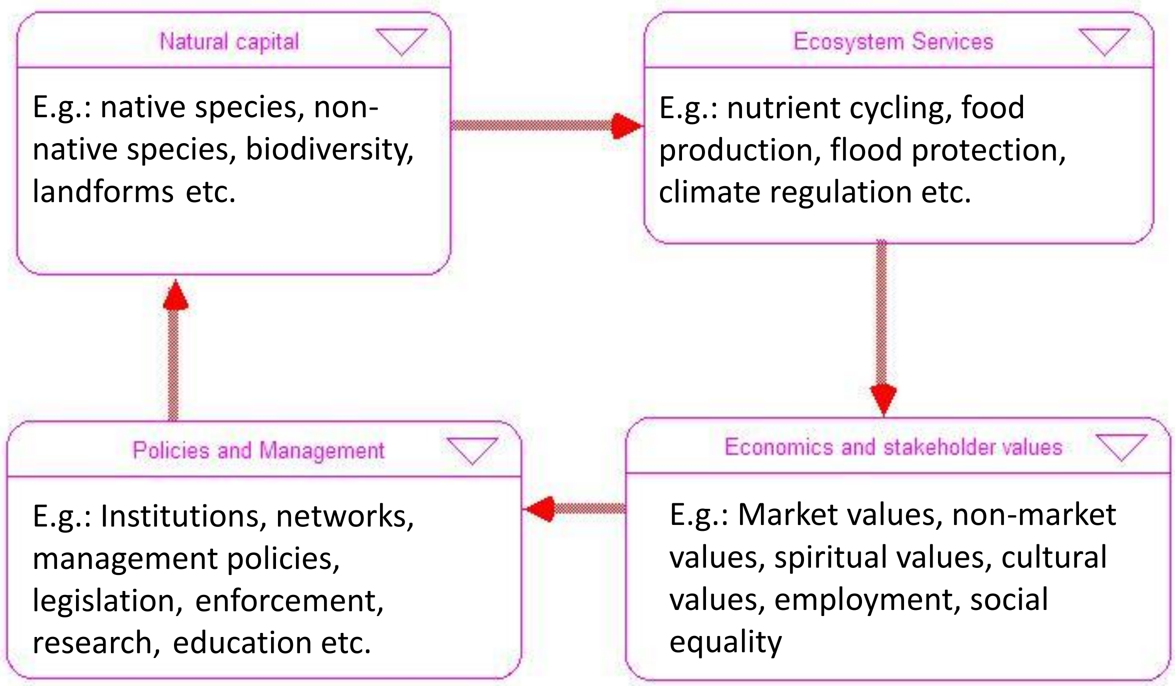

Figure 1: Generic Ecosystem Service Framework

1. Mediated Modelling (MM)

MM is a technique to put science in a context useful to stakeholders. Model building is done with a group of about 20 participants as a tool to build a shared understanding of complex problems and to provide an assessment tool for ongoing adaptive management purposes. During a series of (between 3-10) workshops, spread over a period of four months to one year, key stakeholders often with adversarial perspectives, assess various trend data. This includes information on water usage, biotic indicators, land use changes, level of water tables, storm events, economics, demographics and quality of life indicators. A facilitated dialogue elicits stakeholders' understanding of the underlying system to explain the trends of concern. The dialogue is simultaneously interpreted and reflected onto a projected computer screen for all to see. Participants can, therefore, build on each other's perspectives. Participants are encouraged to be explicit and clear; nobody has the whole picture. Learning happens through the sharing of perspectives and facts, which opens pathways toward common ground and solutions. The modelling approach is system dynamics which looks for interconnections. The model is built to understand why current trends are negative, and to explore 'what-if' scenarios as a testing ground for reality to set up positive reinforcing cycles. The relatively user-friendly model that simulates various what-if scenarios is well understood by the stakeholders as they built it. This model can easily be updated and ideally this is done by end-users. After a few years of monitoring relevant indicators, stakeholders can assess how well the model has done and make necessary adjustments. Surveying the perceptions of the stakeholders before and after the MM process is used to evaluate the value-added capacity of this tool. The MM model produced for the IFS project is discussed in more detail in section 4.

2. Bayesian Belief Network (BBN) Model

A Bayesian Belief Network (BBN) model links spatially explicit GIS maps of climatic, geological, hydrological and land use/landcover to biological functions in the river to present scientific data in an accessible way to stakeholders. BBNs unite current scientific knowledge of the catchment, in terms of climatic, geological, ecological and other scientific data. Required data was to be collated and presented in a way requested by the MM workshop participants to show the probable effects of changes in land uses on water quality and the ability of certain fish species to survive in rivers and streams.

3. Three iwi/hapū local research projects

Three out of the four iwi/hapū participating in the MM workshops were engaged with sub-projects as part of the IFS project. Each iwi/hapū had chosen a research topic that helped make visible an aspect relevant to the Manawatū River. A specific goal of the IFS research project was to enhance the bottom up capacity of iwi/hapū to effectively contribute their perspective to the regional conversation. Ngāti Kauwhata supported by Taiao Raukawa, developed a community based monitoring programme of freshwater macroinvertebrates. Muaūpoko Tribal Authority developed a community based shellfish monitoring programme and Rangitaane O Manawatū focussed on co-management models for the Manawatū River. The outputs from the three IFS iwi/hapū sub-projects are available on www.ifs.org.nz.[2]

[2] Now at: http://www.massey.ac.nz/massey/learning/departments/centres-research/eernz/integrated-freshwater-solutions/integrated-freshwater-solutions_home.cfm

3. CONTEXT

This overview provides a brief contextual background to the governance situation of the IFS project from the view-point of the IFS research team. Such context needs to be noted as understanding why an intervention evolves as it does (in terms of the process and fit of the content) is an important part of Action Research.

3.1 Formation of the Manawatū River Leaders Forum (MRLF)

The IFS research concept was developed and submitted to the Foundation for Research, Science and Technology (FRST)[3] in August 2009. The project was funded to commence in October 2010.

The publication of the report "Temporal variability in ecosystem metabolism of rivers in the Manawatū-Wanganui Region" (Clapcott & Young, 2009) and media labelling the Manawatū River as the "river of shame" drew public attention to the poor water quality and state of the river (Chapman & Jackson, 2009; Morgan & Burns, 2009). This prompted the HRC to invite business, local government and other leaders in the Manawatū catchment to come together to discuss the problem. The outcome of this initiative was the establishment of the MRLF, and the August 2010 signing of an Accord to take action to improve the state of the Manawatū River. The Accord set out a focus, vision[4] and goals[5] for the river and was signed by all parties involved with the exception of Federated Farmers.

The formation of the MRLF resulted in a partial merger or collaboration with the IFS research project. This was brokered as a synergetic way forward as many of the organisations who had committed to participate in the IFS project were also part of the MRLF. Some MRLF members were directly involved in the subsequent workshops but most participants were delegates of the higher level leaders. The IFS research project provided a 'neutral' space for the highly political MRLF process.

The starting point for the combined effort (referred to here as IFS/MRLF) was the Accord Goals of the MRFL.

3.2 National Significance of Freshwater - Land and Water Forum (LWF) and National Policy Statement for Freshwater (NPSF)

The importance of good freshwater management for New Zealand is also recognised as a national issue. In June 2008, the Government announced its new strategy 'New Start for Freshwater'. First, the Sustainable Land Use Forum was established as a forum for multiple stakeholder groups to work collaboratively on recommendations. This forum was renamed 'The Land and Water Forum" in 2009,

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[3] By the time the IFS project was funded, FRST had become the Ministry for Science and Innovation (MSI). MSI morphed to the Ministry for Business Innovation and Employment (MBIE) by the end of the project in 2013.

[4] Vision: Kei te ora te wai, kei te ora te whenua, kei te ora te tangata. If the water is healthy, the land and the people are nourished.

[5] Goals: (1) The Manawatu River becomes a source of regional pride and mana (2) Waterways in the Manawatu Catchment are safe, accessible, swimmable, and provide good recreation and food resources (3) The Manawatu Catchment and waterways are returned to a healthy condition (4) Sustainable use of the land and water resources of the Manawatu Catchment continues to underpin the economic prosperity of the Region.

and the number of collaborating stakeholders increased. The LWF published its first report with 53 recommendations in September 2010. A further report on setting and managing limits was published in April 2011. Following the initial report, a National Policy Statement for Freshwater was developed which came into effect on 1 July 2011. These national level activities promoted regional/local collaboration. Recommendation 15 (Report LWF, page 61) presents 'Collaborative Decision-Making':

"There should be a presumption in statute that a collaborative approach will be used for the development of or change to:

a. freshwater-related national instruments
b. the freshwater-related components of regional policy statements and related regional plans."

3.3 Regional Council Politics

Council affairs such as the 'One Plan', annual plans and reports, the 10 year long-term planning cycle, and negotiating contentious consents all influenced the context in which the IFS project emerged. Often the same organizations (sometimes the same people) were involved in all activities.

The HRC One Plan effort to integrate land, air, and water management had been underway for two years prior to the start of the IFS project. The One Plan was highly controversial and went from the Public Hearing phase before Commissioners, to the Environment Court during the IFS/MRLF workshop phase. Because of the requirement to set enforceable policies and regulations the One Plan was science driven. The hearing process, as set out under the RMA, allows submissions to be made and the associated science provided by vested interests is frequently used in an adversarial manner. This is an expensive exercise. The IFS project proposed a way of using science differently. Instead of adversarial positioning the MM workshops instead used dialoguing as a complementary pathway to the statutory approach.

The IFS project commenced 1 October 2010. Local body elections were held during October and resulted in changes to the elected representatives on the HRC. HRC was required to adjust governing procedures to align with the newly elected body.

4. PROCESS - MEDIATED MODELLING (MM) AND BAYESIAN BELIEF NETWORKS (BBN)

As has been discussed, the IFS project was accelerated to fit with the MRLF and changes had to be made to accommodate this. This section sets how the structure for the three-year IFS project was initially proposed.

Step 1 Stakeholder engagement: During the preparation stage the research team suggested a stakeholder network analysis to guide a transparent stakeholder management system with regard to selection and engagement with MM participants. The ideal MM participants should be located in the quadrant with High Interest/ High Power.

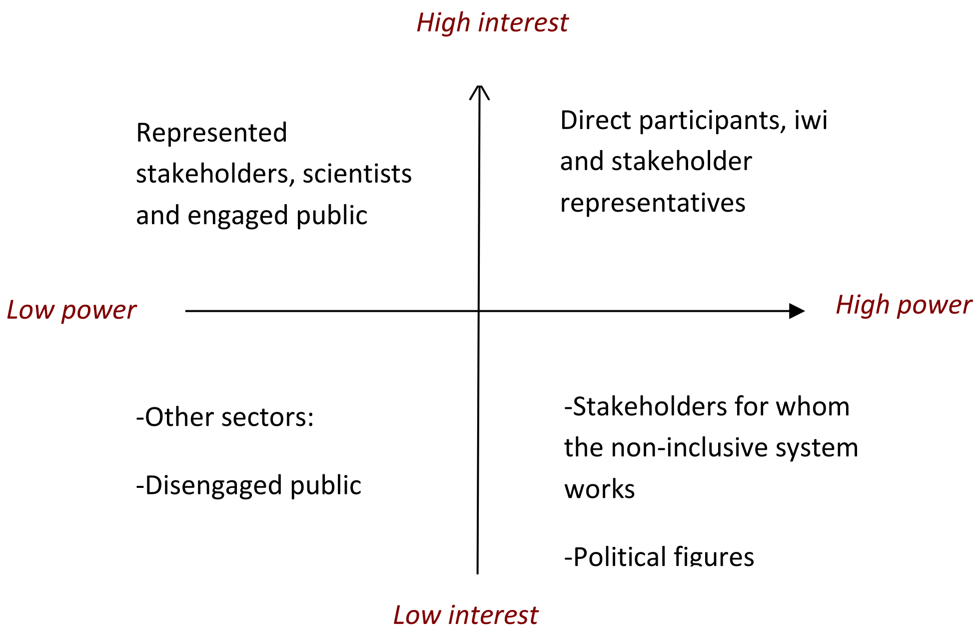


Figure 2: Proposed Stakeholder Engagement

Also as part of Step 1 was the construction of the BBN model for the catchment to be used in the workshops to help stakeholders understand the pressures on the freshwater system.

Step 2 Workshops: By the end of 2012, key stakeholders would be required to have participated in 50 hours of MM modelling and dialogue (utilising BBNs) to examine the implications of trade-offs and alternative solutions to freshwater ecosystem problems.

Step 3 Uptake: By 2013, the participation of three local iwi would provide an exemplar for future, multi-iwi engagement in scenario planning. By 2013, HRC would have access to a tool, documentation, evaluation and skills to enable freshwater to be better managed in the region. Documentation and the model would be available for other territorial authorities to carry out a similar process if desired.

Figure 3 shows the sequence of workshops and modelling stages as originally proposed.

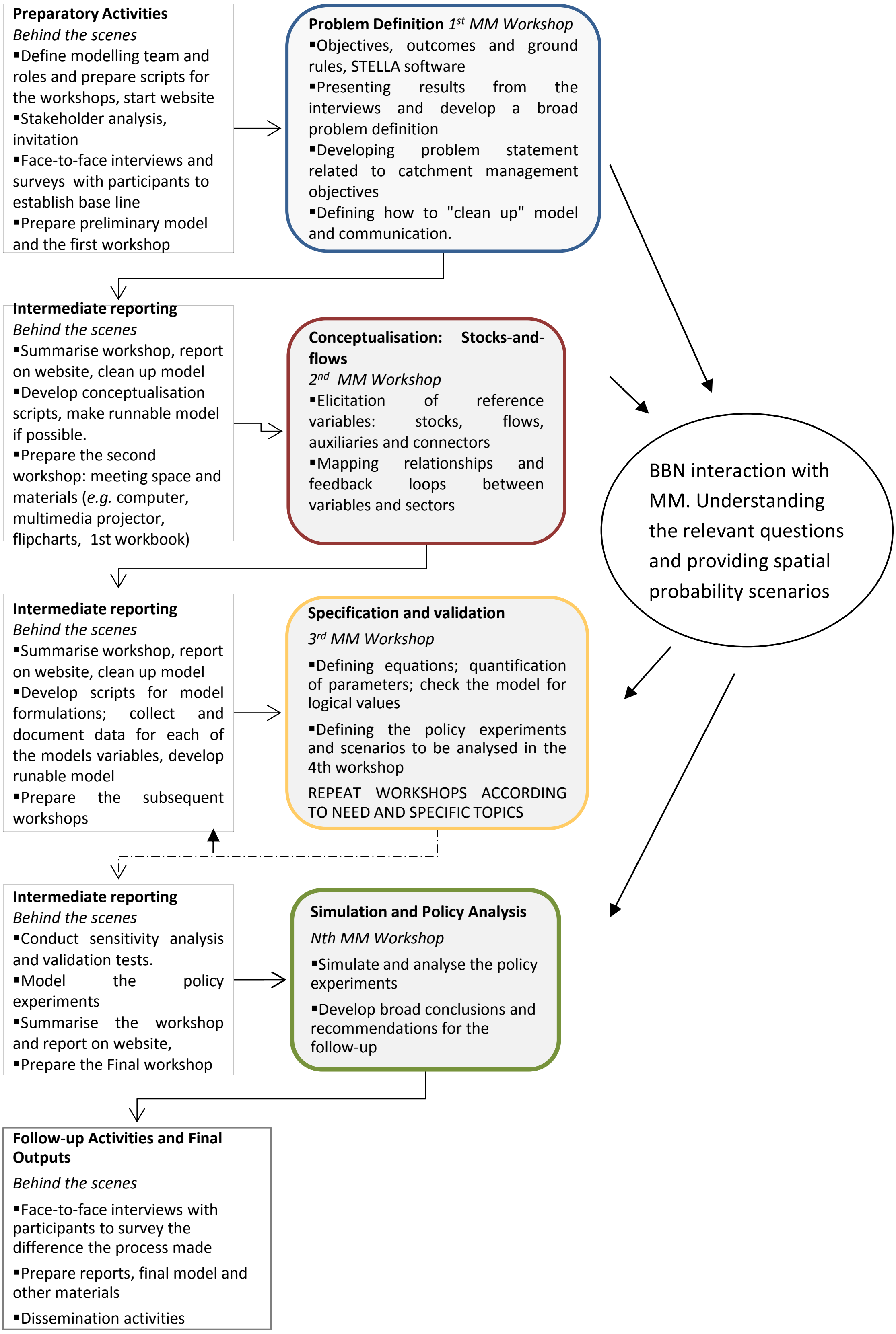


Figure 3: Workshop design and expected outcomes

The summaries of six action planning workshops are available on the website and included in Appendix B. An additional Workshop 7 was mainly concerned with agreeing wording for the final Action Plan.

4.1 Stakeholder Evaluation of the Mediated Modelling Process

This section focuses on the evaluation of the MM process through the three surveys carried out. Regular feedback was sought to monitor how the workshops were meeting participants' needs. Only the nominated participants in workshops were asked to do the surveys and they did not all answer every survey, or question. Back-up participants for nominated participants were not included due to their irregular participation. These surveys do not have statistical validity due to the low sample size. However, the results provide a basis for understanding the group and the progression of the collaborative process.

As is standard procedure with Action Research the IFS/MRLF project participants were surveyed prior to the first workshop. Participants were also surveyed mid-way after workshop 3 and after the final action planning workshop. Participants represented the following organisations and sectors: Local Government, Business, Farming and Industry, Iwi/hapū, Environmental groups and HRC (see Appendix A). To establish a balance of interests a maximum of four delegates were able to sit at the table from each of the five sub-groups represented. There was some change in representatives over the course of the workshops.

Rather than reporting on survey results only, we have inserted some *reflections in italics* in this chapter, as a lead-in to chapter 6, Reflections.

4.1.1 Pre-Survey

The pre-survey was done either in person or by phone with 16 of the 17 confirmed participants to: (1) understand the individual concerns; (2) answer any questions participants had about the workshop format; and (3) establish base-line perceptions. The results presented at the first workshop were as follows:

Q1 asked participants to rank the relative importance of Economic, Environmental, Social and Cultural factors of wellbeing for the Mediated Modelling workshops in order of priority for their stakeholder group (4 highest – 1 lowest). The question was answered by 15 of the 16 participants. Figure 4 shows that the Environment was considered most important (scores shown in blue). Within the responses there were two identifiable clusters: (1) an 'Economic cluster' of 10 participants, that ranked the Economy on average at least as high as the Environment and (2) a 'Cultural cluster' of 5 participants that ranked cultural issues on average as high as others ranked the Economy. Figure 5 depicts the average weighting of responses as well as the two identified clusters.

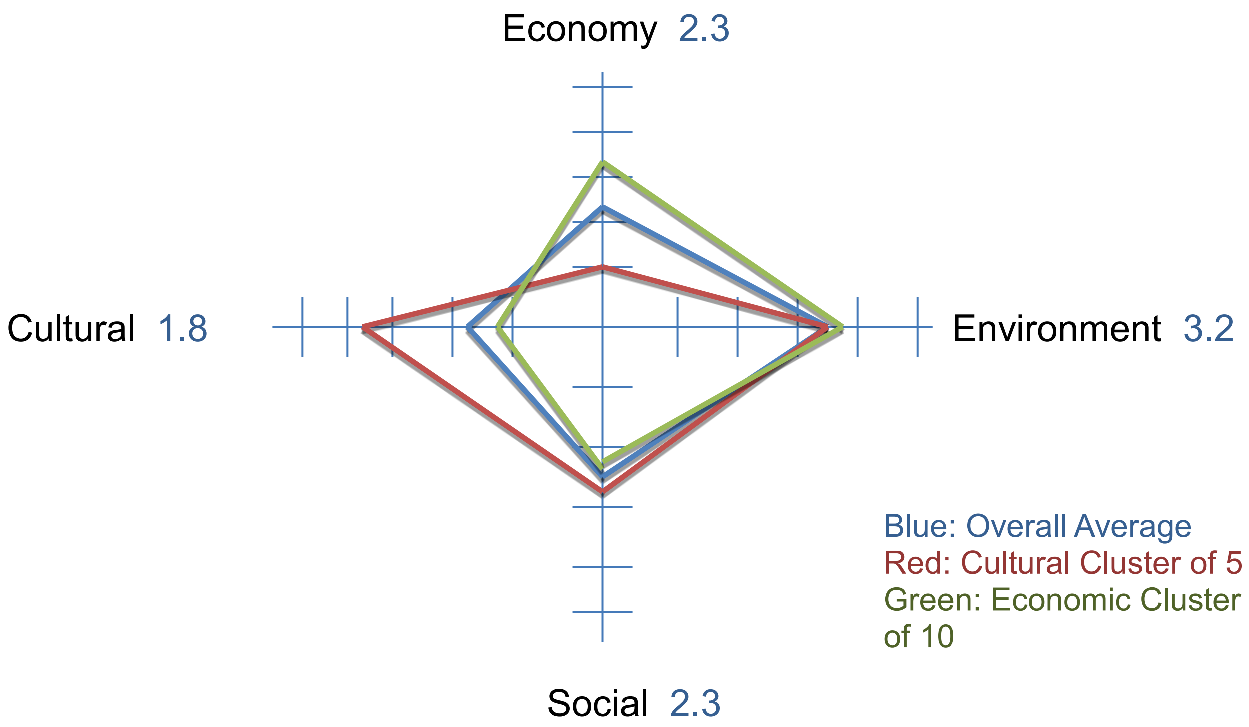


Figure 4: Relative importance of four aspects of well-being

Q2 aimed to establish how stakeholders perceived the water quality of the Manawatū River on a scale from 1 to 10 (1 being very bad and 10 being very good). Results are shown in Figure 3. Participants were asked 'How good or bad is the water quality of the Manawatū River now?' The average result of 3.1 reflects a rather dim perception of the current river water quality. The second part of the question was about the vision for the Manawatū River and asked 'Where would you like to see the rating of the water quality to be by 2030?' The average response of 8.2 signifies a strong ambition to see improvement. Participants were then asked 'Where do you fear the water quality might rate by 2030 if nothing is done?' Average responses of 2.3 signified a concern that water quality would deterioration marginally from the current situation. Finally and in order to provide a realistic point of reference, we asked 'Where do you think water quality could realistically rate by 2030 if action is being taken?' The average response of 7.2 optimistically signalled that significant improvement was considered a possibility.

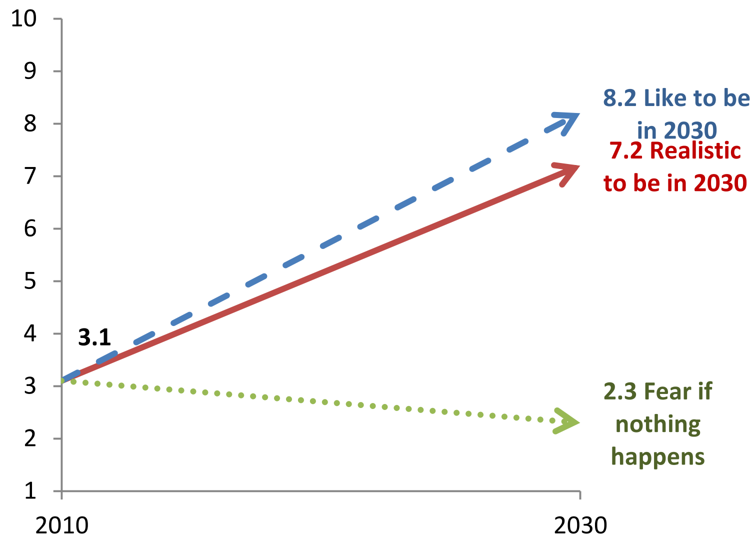


Figure 5: Current, envisioned, feared and realistic levels of water quality

Q3 asked participants about their sense of 'how concerned the wider community is about water quality?' On average, community concern was rated at 6 out of 10 with a broad range of perceptions ranging from 1 to 9. This spread illustrates the difference of opinion and uncertainty as to how the wider community perceives the water quality of the Manawatū River. Opinions varied from the general public having grave concerns, to not being concerned at all.

Q4 asked the participants with whom they had a working relationship prior to the formation of the MRLF and in what field. This question did not require detailed analysis as almost nobody had any previous connections. At first glance this appeared strange given the MRLF had developed the Accord as the starting point for an Action Plan. However, the people involved were not necessarily the same, but often delegates from a sub-set of MRLF partners.

Q5 aimed to establish how the participant group viewed itself in terms of the four criteria of 'a) inclusiveness, b) time preference, c) leadership and d) creativity. Possible responses to this question were 1 to 5, with 1 being very low, 3 being neutral and 5 very high. For both the level of inclusiveness (i.e. the level of inclusiveness of different perspectives in managing freshwater) and time horizons (i.e. the likelihood that participants will do what it takes in the short term to achieve long term sustainability around freshwater management) the average ratings were slightly above neutral (3.3). Leadership (i.e. the prospect that ideas being developed during the Mediated Modelling process will be implemented by those in leadership positions) was anticipated to be borderline positive (3.5). Creativity (i.e. the prospect of innovative ideas being generated during the Mediated Modelling process) was ranked 3.7, positive but below 'good'. When interpreting these results it is important to take into account the fact that most participants were not personally involved in the MRLF, even though their organisations were.

Q6 asked participants about the level of consensus they anticipated in the group on a) 'how the system currently works in regards to managing freshwater'. This was rated on the lower side of neutral (2.7) which indicated that consensus was not strong and looking jointly at the facts about the river had the potential to be beneficial. A consensus on b) 'what the long term goal/vision for freshwater management looks like' rated at 3.5 (above neutral but not quite good). This was surprising considering the Accord Goals were developed by the MRLF just prior to the survey. This could indicate that the vision was not well-shared and the goals negotiated rather than fully committed. Finally, the participants were asked under c) if a consensus was likely to be reached on 'how to manage freshwater toward future goals/vision'. The response was rated neutral (3.0) which may have reflected impartiality as this group was about to embark on establishing an Action Plan.

Q7 provided a list of factors that can be critical for the successful outcome of Mediated Modelling workshops. For each item participants were asked to indicate the degree to which they thought it would contribute. Choices were: to a great extent, to some extent, very little, don't know.

Averaged responses from participants were in order of importance:

1. Scientific data (great extent - 2.8)
2. The mix of knowledge people bring to the table (great extent - 2.7)
3. Participants' ability to keep an open mind (great extent - 2.7)
4. Economic data (some extent - 2.5)
5. Cultural understanding (some extent - 2.4)
6. Communication to the wider stakeholder groups in-between Mediated Modelling workshops (some extent - 2.4)
7. Politics (some extent - 2.4)
8. The facilitation of the sessions (some extent - 2.3)
9. Social data (some extent - 2.2)
10. The MM process (some extent - 1.8)
11. The model itself (some extent - 1.8)

Scientific data was consistently rated as most important, which is interesting considering the One Plan process was largely focussed on science data, often reconciled and lingering in Environment Court. The 'human/social capital' or the ability to keep an open mind and mix of knowledge accessible at the workshops was considered important. As often is the case, 'Economic data' was expected to play a role to some extent. Communication with the wider public, politics and cultural understanding were also important to a lesser extent. The MM process and model itself were unfamiliar to all participants. This is not surprising as the attempts to use a MM process and modelling were driven by the IFS research team who saw potential for items 1-5 and 8 to be well served with the use of these tools.

Reflection: With the benefit of hindsight some of the responses to Q7 were very interesting. Scientific data was considered critical but ultimately, the Action Plan was developed without extensive science sharing. The lesser importance of communication with the wider public, politics and cultural understanding is also worthy of note as these aspects dominated the undercurrent of the workshops.

Q8 responses provides a broad interpretation of what participants thought the task for the workshops was:

- Reach consensus on a programme of action
- Develop a common framework for action
- Dissemination of knowledge
- Discover to what extent the river is compromised

These perceived tasks correspond well with the ranking of the elements that were deemed important under Q7. *They also indicate the eagerness for an action plan within the time limit of 6 months set by the MRLF.*

Q9 asked participants to define the characteristics of an Action Plan. The following are a summary of the answers provided:

- Very simple, concise set of goals and objectives
- Achievable, quantifiable and measurable targets
- Specific actions, owners and timelines
- Strategic context is understood
- Cost benefit assessment has been done

Reflection: The resulting action plan is indeed 'very simple'. The goals and objectives are broad and at a high level. There are no targets or time lines, although the actions have associated owners. The strategic context is considered understood and a rudimentary cost benefit assessment done.

Q10 asked what would be a good outcome from the process. Participants answered:

- An agreed Action Plan
- Enhanced and commonly shared understanding of data
- Consensus amongst the group
- Basis for ongoing, rather than one-off process
- Eventually – improved river quality so people can swim and take food from the river safely

Reflection: An action plan with 130 actions, albeit incremental and without targets was negotiated. A summary of the main indicators of concern in each of the sub-catchments was compiled. Consensus among the group was achieved to the point that the Action Plan was successfully tabled at the MRLF. For most participants, on-going effort was demonstrated by attendance at subsequent IFS workshops on "Economics" and "Account-ability of Collaborations" and the MRLF continues to meet twice a year. It remains to be seen if the efforts will lead to improved river quality by objective standards rather than socially perceived standards.

Q11 asked what would be the worst possible outcome. Participants answered:

- Walk out of participants
- Blame and in-action
- Inability to reach consensus around the Action Plan

Reflection: Participants did not walk out. Most of the conversation was constructive, leading to 130 action tasks to be carried out.

Q12 assessed participants' perspectives on what they thought the main issue, and where this would lead. The answers are summarised as follows:

What is the main issue around water quality in the catchment?	What does it lead to?
Understanding scientifically what is actually true	Misrepresentation of data, abuse of science
Perception – how bad is the problem?	People are feeling ashamed
Sedimentation – mainly run-off from hill country	Loss of habitat, raises river bed and causes flooding
Nutrient loading – caused by run-off from farms and urban discharges	Degradation of water quality, algae, health hazards, loss of mauri
Higher water temperature	

Additional information provided by the interview surveys included: (1) none of the participants had used STELLA (the MM software) before and very few had experience with other types of modelling tools; (2) all participants were happy for their answers to be used for research purposes; (3) no one required additional information before the workshops, and (4) some participants were aware of the website as a source of on-going information. For those unaware the interview served to inform them.

4.1.2 Midpoint-Survey

A Midpoint survey was done after the 3rd workshop. Fourteen out of 18 questionnaires were returned. At the start of the process there were 17 participants and an additional participant (HRC) came in at the 2nd workshop. The following is a summary of the results and comparison with the pre-survey where applicable.

Q1 asked: Reflecting on the first three workshops, how do you think the group rates overall in terms of the four criteria of a) inclusiveness, b) time preference, c) leadership and d) creativity using a scale from 1 – 5, with 1 = very low and 5 = excellent? This question was a repeat from the first questionnaire and the comparison in views is shown in Figure 6. As can be seen the average rating for inclusiveness went up very slightly, but all other ratings went down. Creativity was ranked significantly lower than in the first workshop.

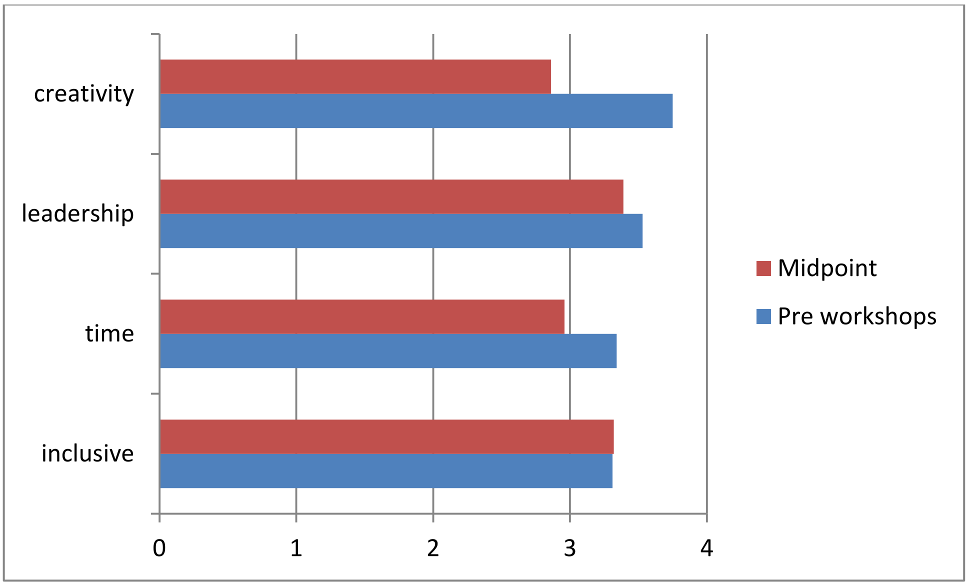


Figure 6: Comparison of Group Attributes (Pre survey and mid survey)

Q2 using the same rating scale, asked "Reflecting on the discussions in the first three workshops, is there from your point of view consensus amongst the participants in the Mediated Modelling workshops on:

- How the system currently works
- What the long term goal/vision looks like
- How to manage freshwater now with future goals/vision in mind

As the mid-survey results in Figure 7 show the average rating dropped slightly across all three questions compared to the pre-survey. It should be noted that the participants had no or little experience with each other before the first survey.

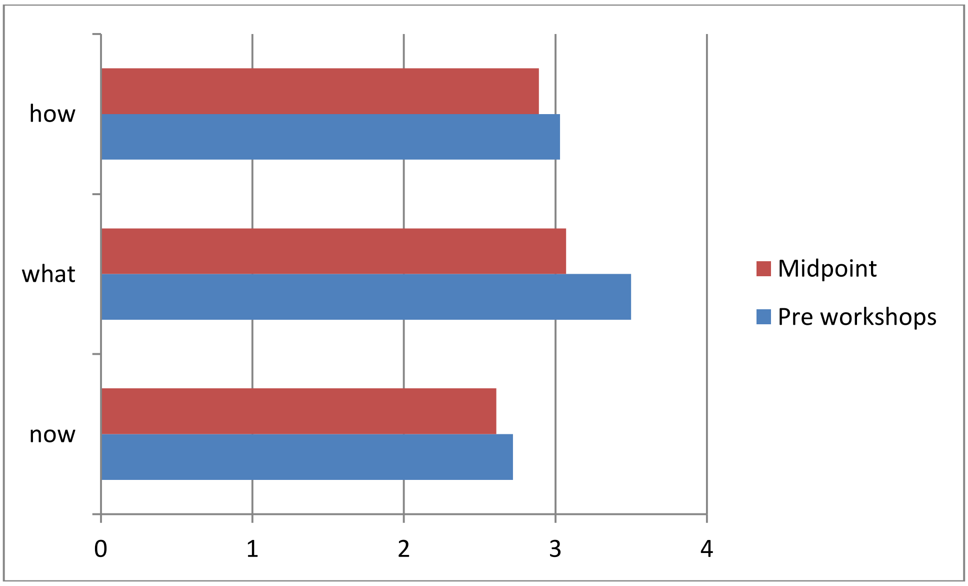


Figure 7: Consensus on 1. How the system currently works, 2. What the long term goal/vision looks like and 3. How to manage freshwater now with future goals/vision in mind

Q3: At the first workshop guidelines/principles of collaboration were presented. These were subsequently updated to the following “Principles for Collaborative Decision Making”:

- Call before going to the media to avoid surprises as a courtesy.
- Maintain good faith and a sense of urgency
- To actively listen and share concerns and information until the group gains a common understanding
- All ideas and solutions belong to the group, rather than individuals
- Differences in perspectives are embraced and seen as an opportunity for creativity and synergy= a challenge to the whole group to push boundaries
- At times the participants might agree to disagree and record this decision together with a pathway to gain further insights in order to arrive at a joint view later
- Ensure that the key messages are clear from each workshop for public consumption. Participants have a responsibility to provide feedback if matters are not clear

This question asked participants to rate on a scale of 1 (Not at All) to 5 (Very Much) how well the guidelines/principles reflected the needs of this group, and the level to which these guidelines/principles were adhered to. The results show an above average rating for the principles meeting the groups’ needs (3.5) and providing guidance for interaction (3.6). However, consistently applied ‘principles of collaboration’ received a low rating (2.4).

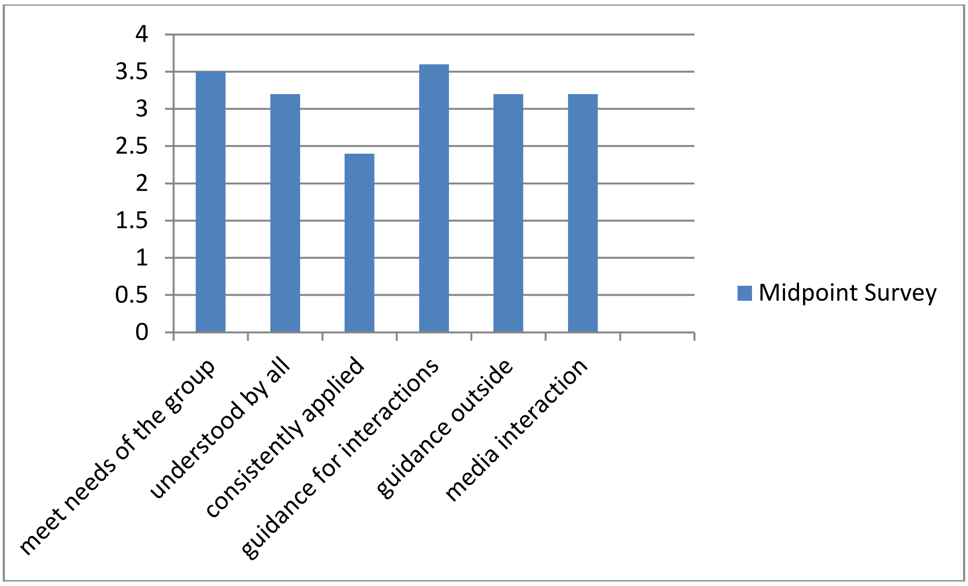


Figure 8: Rating of effectiveness of guidelines/principlesof collaboration

Q4 asked “What is working well for you?” with the workshops. Answers given were:

- Relationship and trust building is working well
- Development of a collective understanding of the issues at hand
- Small groups are working well

Q5 asked “What could be done better?” with the workshops. Feedback was:

- Participants would like more clarity and guidance around expected outcomes and how to get there.
- At times the discussion needs to be more firmly kept on track – remind people of what they have signed up for, do not just give way to the most vocal participants.
- Results from the model need to be presented in a more 'user friendly' way.
- People wanted science to provide the base for decision-making by helping to set baselines/benchmarks from which to measure improvement.
- Change in participants around the table can be disruptive especially if they have not been sufficiently briefed.

Q6 asked the participants if they had any personal 'aha moments'? Feedback was:

- The big surprise for most participants was just how much work HRC appeared to have done. There was also surprise that the HRC relationships with iwi/hapū and others were not better.
- There were mixed messages with regard to iwi/hapū. Some participants felt too much time was spent on cultural values while others felt iwi/hapū were not sufficiently heard.
- For iwi/hapū a need was expressed for HRC to better involve them in the development and sharing of science and decision-making as required under the RMA and Local Government Act.

Q7 asked on a scale of 1 (very low) to 5 (excellent) "What is your confidence level <u>right now</u> that the participants will arrive at a good Action Plan?"

- The overall average score for this question was 3 i.e. neutral. There was one no reply, 1 very low, 2 low, 4 neutral, 2 responses positioned between neutral and good, and 4 good.
- Comments made by those not confident of achieving a good Action Plan were: (1) More science input is required for better informed decision-making at the end, and (2) Attendance and commitment of some participants is questionable.

Q8 asked participants to rate the emphasis on various areas in the workshops, indicating whether they thought more or less focus was required or whether the focus was about right.

- Action Planning: 10 participants requested more Action Planning, while four participants thought the level of Action Planning was right. It was concluded that we need more of this and hence, the linear Action Planning process was endorsed.
- Dialogue: 4 participants wanted more dialogue, while 6 participants thought it to be about right and 3 participants wanted less dialoguing. One participant did not answer the question. It was concluded that the level of dialoguing was about right.
- Mediated Modelling: 5 participants wanted more MM, while 6 participants thought the level of MM was right, however, 3 participants wanted less MM. The balance appeared to be right, but MM was not pursued.
- Trust: 5 participants thought there needed to be more trust, while 8 participants thought the level of trust in this group right. One participant felt there was too much focus on trust. On balance trust was considered about right, but required ongoing attention.

- Science: 11 participants requested more science input, while two participants thought the science input was right, one did not reply. Concern about science input was also raised during the pre-survey and it can be concluded that more science input was wanted.
- Other knowledge: 12 participants wanted more 'other knowledge', while two participants considered the level of 'other knowledge' to be right. It can be concluded that more 'other knowledge' is needed.

Q9 asked on a scale of 1 (very low) to 5 (excellent) "How do you rate the usefulness of the Mediated Modelling process for the on-going cycle of Action Planning?" The responses gave the average score for this question a 3.7 with 6 replies being neutral, 6 good and 2 excellent.

Q10 asked participants whether they found STELLA easy to understand. Only three participants replied with 'no'.

Q11 explored whether participants would like to get some hands on experience in using the modelling software in the New Year. Most participants signalled interest with only four replying with 'no'.

By this stage only three participants were not aware of the IFS website and 8 out of 14 were promoting it actively. All participants gave consent to use their answers for research purposes.

4.1.3 Post- Survey

After the third workshop the co-facilitator employed by HRC and HRC decided that a linear approach to generating a list of actions was to be pursued instead of the MM process due to: 1) pressure to get the Action Plan completed by March 2011; 2) concern expressed by some participants that the dialogue was too diverse and not focused enough; and (3) an inability of some participants to relate to the MM process.

The post-survey was carried out after 7 workshops were completed. The final half day workshop involved editing and agreeing on the text of the Action Plan.

All 17 workshop participants who were asked to complete this survey did so (shown as 'all post' on the bar graphs). One of the original participants who did not participate in any of the workshops after the midpoint survey was not invited to participate. One respondent in this survey had not participated in the previous surveys, even though this person was a regular workshop attendee. The following is a summary of key findings from the survey.

Q1: The overall rating (on a scale of 1 very low to 5 excellent) of the group increased markedly from 3.2 to 3.8 for a) inclusiveness when compared to the initial and midpoint surveys. Figure 9 shows the survey results for the 11 participants who participated in all workshops (post) as well as all 17 people who completed the post-workshop survey (all post). b) Participants' support for actions that take more time but have a greater positive outcome in the long run increased for the 'post' and 'all post' respondents compared to the midpoint survey. c) Leadership rating increased, and d) creativity rating dropped markedly compared to the first survey, but was similar to the mid-point survey.

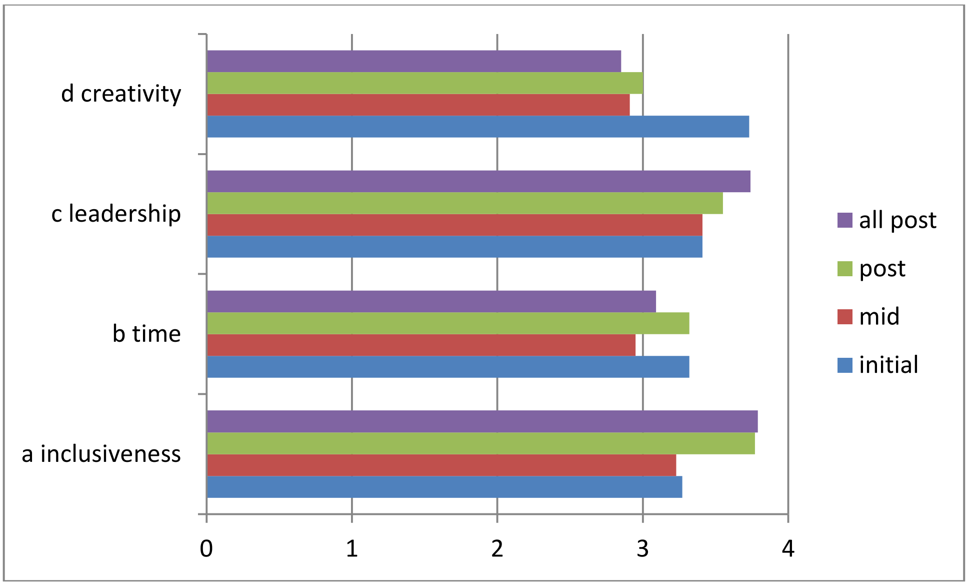


Figure 9: Comparison of group attributes (pre survey, mid survey, post survey)

Q2: The rating (on a scale of 1 very low to 5 excellent) of the group's consensus on: a) how the system currently works in regards to managing freshwater was higher in the pre-workshop survey than at the end of the workshop. b) Census on what the long term goal/vision for freshwater management looks like increased over the workshop duration. The group rated the consensus on c) how to manage freshwater now with the goals/vision in mind as much improved.

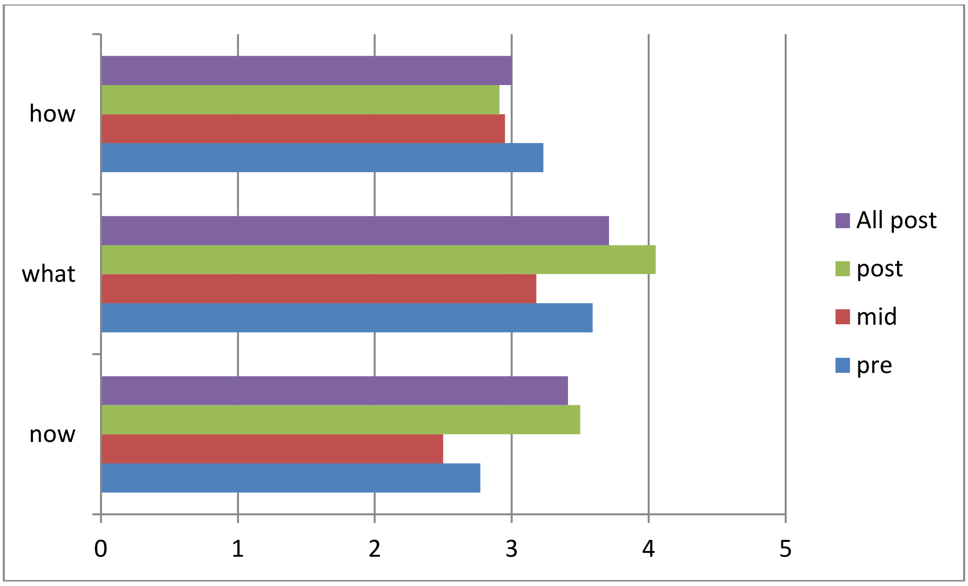


Figure 10: Post workshop consensus on 1. How the system currently works, 2. What the long term goal/vision looks like and 3. How to manage freshwater now with future goals/vision in mind

Q3: Confidence levels that the group arrived at a good Action Plan improved markedly compared with the midpoint survey expectations:

Across all participants it increased from 2.85 to 3.79 out of 5. For the respondents who answered both surveys it moved from 3.08 to 3.63, which while a slightly lower increase, still shows a consistent increase in confidence.

Positive aspects of the plan were seen to be that:

- It is a pragmatic starting point and deals with some of the big issues like hill country erosion, stock exclusion and riparian planting
- It considers increased community involvement
- Good buy-in from a wide range of groups
- Actions are achievable
- Catchment approach makes it more specific and creates local ownership
- Good mix of short term and long term actions and expected impacts

Critique of the plan was that:

- It lacks specific time frames and targets
- The plan is not SMART (Specific, Measurable, Achievable, Relevant and Time-bound)
- There is no prioritisation of the actions

Q4: The following answers were provided to the question: "What worked well over the six workshops?"

- Good general discussions and networking
- STELLA as it showed interdependencies, causes and effects
- Building a shared understanding – with some people shifting from their original positions
- People were prepared to listen
- HRC science was helpful in increasing the understanding
- Shared learning, insights into Māori worldview
- Smaller breakout sessions increased productivity
- Work in-between workshops
- Facilitation

Q5: In response to the question "What could have been done better?" the following insights were obtained:

- Process was rushed, some issues were not resolved and are likely to resurface later
- Introduction to behavioural psychology might have helped participants to gain a better understanding of different styles
- Meeting room could have had better light and acoustics. It was not an environment conducive to fostering creativity and positive energy
- More participation from point source polluters
- Mix of participants – it was not a level playing field
- Some found the process too drawn out, covering too much ground that had already been covered during the Accord negotiations
  Model building appealed to some (who would have liked to see more of it) but not others.

- Sharing of science was a challenge. The assumption was made at times that the group knew more than it actually did. Meeting of the independent science group was potentially too late in the process, but it was good that it happened at all

- Iwi/hapū group did struggle at times to follow due process and to reach consensus amongst themselves. This should have been resolved outside the workshops
- One of the workshops could have taken place on a marae, field trips might have helped to visualise the issues
- Some of the participants could have been a bit more forthcoming
- Attendance by some could have been more consistent

Q6 asked how well the 'voices' of the various groups were heard?

A number of participants commented that their understanding is listening is not equal to agreeing. So a voice might be 'heard', but this would not necessarily be followed by acceptance of the point made. The participants rated the groups in regards to being heard as follows (all the time = 4; most of the time = 3, occasionally = 2, not at all = 1)

- HRC: 3.53
- Iwi/hapū 3.35
- Environmental: 3.32
- Industry: 3.12
- Local Authorities: 3.07

The result correlates relatively well with the level of perceived inclusiveness which rated 3.8 in question 1. The extent to which 'voices' were heard could be assessed by:

- Presence
- Persistence and passion
- Listening skills – if people could respond well to what was going on in the discussion
- Mandate, resources, decision-making power
- Style – well spoken, good arguments, clear perspectives
- Facilitation giving people space to participate
- Expectation to be heard
- General willingness of the group to listen
- Potentially also fear of consequences if voice (of iwi) was not heard

Q7 asked participants whether the focus on the various workshop activities (Action Planning, Dialoguing, Mediated modelling, Trust building, Sharing of science, Sharing of other knowledge) was too high, about right or too low. The focus on activities in the last three workshops was judged to have been about right given that it was a mediated dialogue about Action Planning.

Q 8/9 covered what will the proposed actions lead to? As shown in Figure 11 on average participants are expecting a moderate improvement of the river quality; leading to a quality of 6.2 out of 10 by 2030. This compares with a rating of the current river quality of 3.1 in the pre workshop survey; but is less than what participants expected could be achieved realistically prior to the workshops.

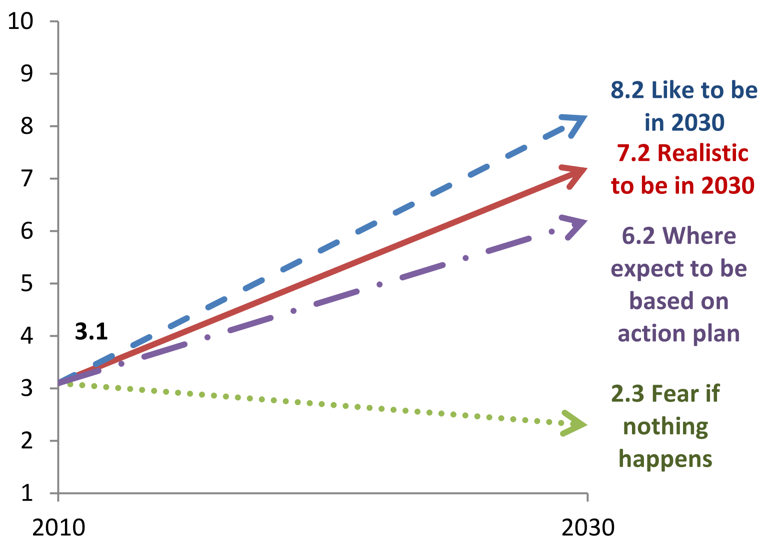


Figure 11: Post survey views on what the proposed Action Plan will achieve

Q10 asked participants if they could commit to the three scheduled IFS workshops in June, September and November 2011?

- 12 participants said outright yes
- 2 indicated that this would be their organisation's call
- 2 said probably not, but would have somebody else from their organisation
- Only 1 said outright no, but would have somebody else from their organisation participate

Overall there appeared to be a strong commitment to continue with the adaptive capacity building.

Q11 asked for any other comments about the workshop process. Responses given were:

- *Several comments were made concerning the need to get back to the discussion on economics*
- *A comment was the STELLA model has the potential power to support decision-making and could be more widely socialised*
- *There were positive outcomes for HRC including better translation of science to make it more accessible to a wide range of people, good overall buy-in and recognition that a lot is already happening*
- *Occasional imbalance of interests around table occurred due to volatile participation from industry and local authority groups*
- *Appreciation to facilitator for addressing iwi/hapū concerns around being heard in the last workshops*
- Some positive feedback/thanks for the provision of a safe environment and the hosting arrangements

Again all participants gave their consent to use their answers for research purposes.

4.1.4 The Bayesian Belief Network (BBN) Process

The BBN model was intended to answer location-specific scientific questions concerning water quality and the impact on aquatic habitat. 'How' questions that stakeholders had during the workshops were to be answered by selecting a desired outcome and assessing the extent to which the independent variables changed. It was also to be used for 'what-if' scenarios by changing predictor variables to states expected in the future, then observing changes in the dependent variables. This modelling was incorporated in the IFS research project to address natural science rather than social and economic concerns.

The compressed timeline for the workshops meant that the BBN was not available to answer questions at the workshops. The spatial component is more data intensive than the scoping Mediated Model and the data required to assign probabilities to potential water quality change, reflecting the different proposed activities, was not able to be sourced. This proved to be a substantial limitation for the BBN modelling. Figure 12 shows the base 'Water Quality in the Manawatū River catchment' map generated. Stakeholders were provided with an overview of the BBN capability but this modelling was not pursued.

Instead, the research team shifted focus to an alternative spatially dynamic approach: Multi-scale Integrated Modelling for Ecosystem Services (MIMES). The MIMES concept was worked on as a collaborative exercise between scientists after the completion of the action planning workshops.

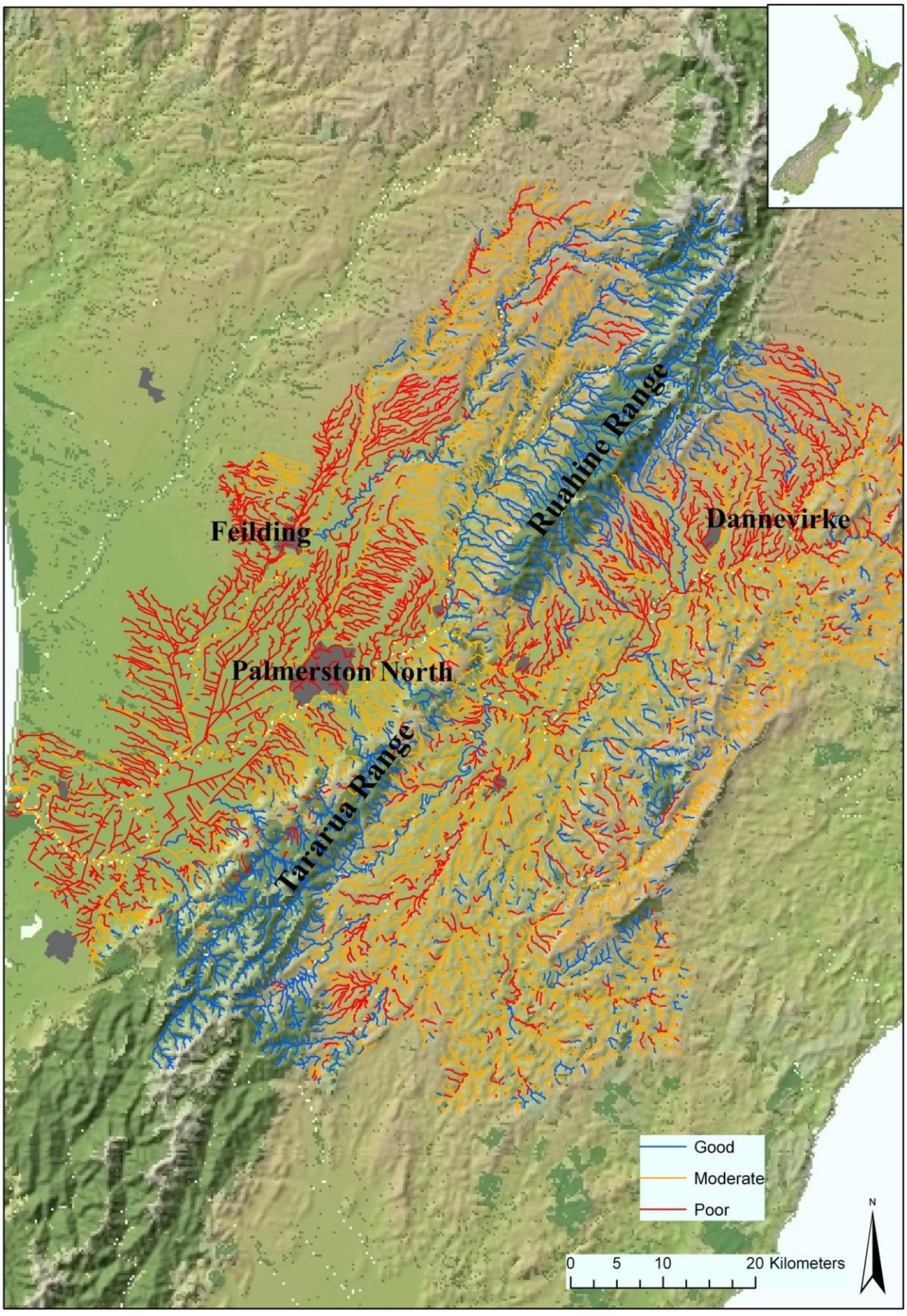


Figure 12: Base Water Quality in the Manawatū River catchment

5. CONTENT – SCOPING MODEL

The 'scoping' model constructed with stakeholders is referred to in this report as the MM-IFS model. A scoping model is developed to increase understanding and is not used for 'predictive' purposes. Instead it is used to develop leading questions to establish what we know and what knowledge and understanding needs to be pursued in order to clear the next step in the complex dialogue toward reaching goals. The objective of mediated model building for the IFS project was for stakeholders to learn about the various factors that impact water quality and how they interconnect.

Priority issues identified by the participants were sediment, nutrient loading, wastewater discharge and aquatic habitat. At a high level, the MM-IFS model therefore attempts to scope for trends and inter-linkages between these issues and water quality. The solutions volunteered by the participants are also incorporated in the model to envision (1) the amount of funding required and from where it would be sourced, and (2) what potential improvements could be anticipated from proposed actions. Again, the model doesn't 'predict'.

5.1 Model description

A detailed model description is provided in Appendix C and what follows here is a summary. The MM-IFS model, at catchment level, connects land use types (including urban) with loadings of sediment and nutrients to the river. Aquatic habitat and some social and cultural values, including 'mauri', as well as ecosystem services derived from land use and land cover are built into the model. Both point and non-point sources are included. Various management options (solutions) are incorporated in the model, such as fencing off waterways, riparian planting of waterways, use of herd homes, reforestation of steeper hill country and restoration of wetlands. These actions/solutions come at a cost, which quickly exhaust potential funding sources. This restricts the ability to achieve the broad Accord goals so funding limits are also included. The scoping model has characteristics akin to a Cost Benefit Analysis[6] (CBA), only in a dynamic framework, where feedback loops and time delays are important. Appendix D provides the background material for the different actions tested using the MM-IFS scoping model.

The IFS model is developed in modules, which interact to replicate the interrelating key pressures and solutions for water quality and quantity in the Manawatū River catchment. Figure 13 shows the overview of the model, the sectors discussed in the workshops, and how they interconnect.

[6] After the action planning was completed a conventional CBA was developed for the alternatives the MM-IFS modelled (Forgie et al, 2012) as part of a workshop on "Economics of the Manawatū – Whose bang for whose buck?" (van den Belt et al, 2011).

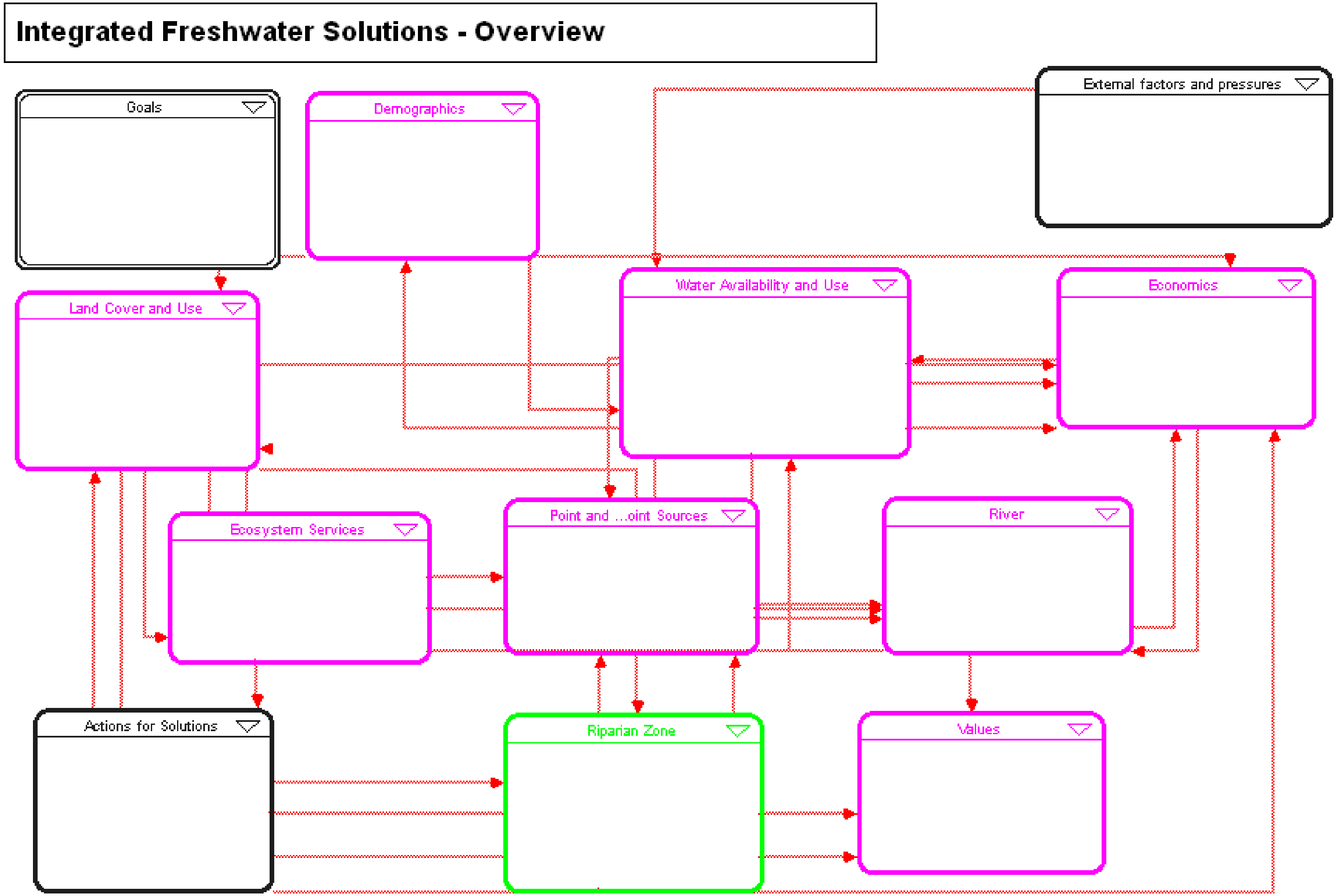


Figure 13: **Integrated Freshwater Solutions (IFS) Model Interface**

At the first IFS project's MM workshop (dated: Oct 20-21, 2010) it was decided to develop the MM-IFS model with annual time steps from 1990 until 2040. It was assumed that going back 20 years would provide reasonable data and information to anchor relevant trends, which would then be simulated into the future until 2040. The Manawatū River catchment as a whole was to be the geographic scale. This was an issue for some participants who were more concerned with localised impacts. Time and data constraints made it impractical to build different sub-catchment models. Instead, HRC provided data at the workshops on each of the nine sub-catchments in the Manawatū River catchment and how the issues of concern ranked in importance in each sub-catchment.

For the Manawatū River catchment overall participants believed sedimentation, nutrient runoff, wastewater discharge and aquatic habitat were the main issues. This was verified by an expert science panel that met for one day (16 March 2011) to discuss scientific questions that had been parked during the workshops. The same issues occurred at the sub-catchment scale (as shown in Appendix B (Table B 1) though the ranking of importance differed by sub-catchment.

Indicators provide a means to assess movement toward the Accord vision of "Kei te ora te wai, kei te ora the whenua, kei te ora te tangata" or "If the water is healthy, the land and the people are nourished" and the Accord goals. The MM-IFS model therefore incorporated indicators to support the dialogue on how such indicators change over time and are interconnected. Western science indicators to track water quality over time include sediment/turbidity, flow, dissolved oxygen/biological oxygen demand, and quantitative macroinvertebrate index (QMCI). Māori indicators cover such things as 'abundant and diverse range of mahinga kai species', 'sound of flow', 'fish are safe to eat' and are often incorporated into a 'Cultural Health Index (CHI)'. The QMCI correlates well with the CHI (MFE, 2012).

To keep the vision and goals in mind, they were sketched into the model at the start of workshop 1, (see Figure 14). During the initial workshops the goals were on one side of the model page projected onto a screen for all to see and the indicators on the opposite side. The scoping model in the middle provided the interconnections and pathways to achieve the goals.

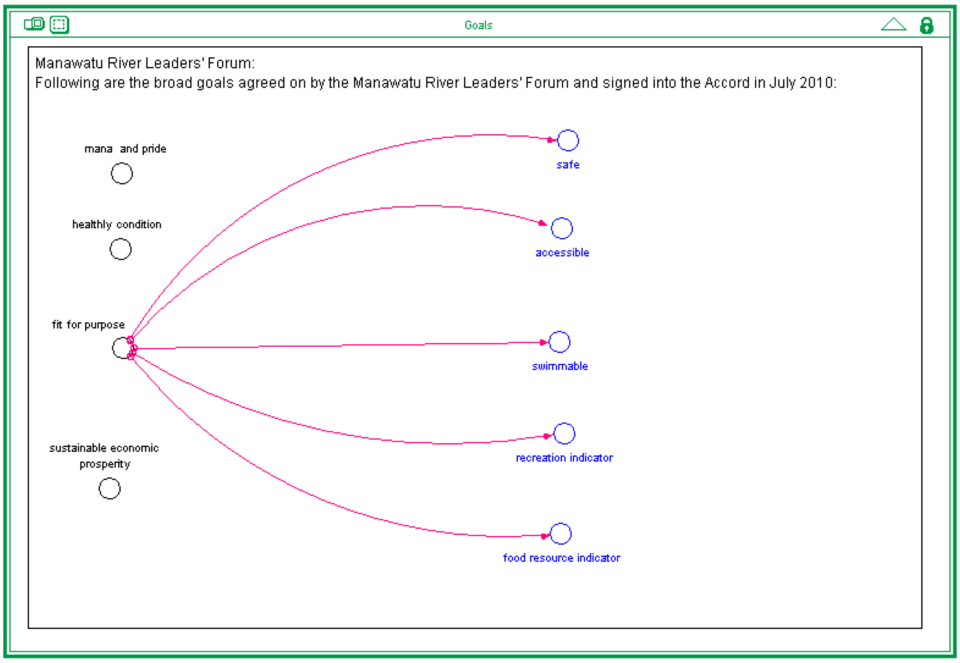


Figure 14: Integrated Freshwater Solutions (IFS) Model

The indicators don't remain on 'the outside' but become part of the story to explain the pathways toward the goals. The entrance point or level of concreteness of an indicator is flexible. A model aim is to solidify the level of indicator agreement that participants can reach, but still allow for different perceptions about indicators where disagreement exists. These differences become the 'assumptions' and can be changed to accommodate the dialogue when running scenarios. Figure 15 shows the MM-IFS user interface where both 'actions' and 'assumptions' can be changed to run different 'what-if' scenarios.

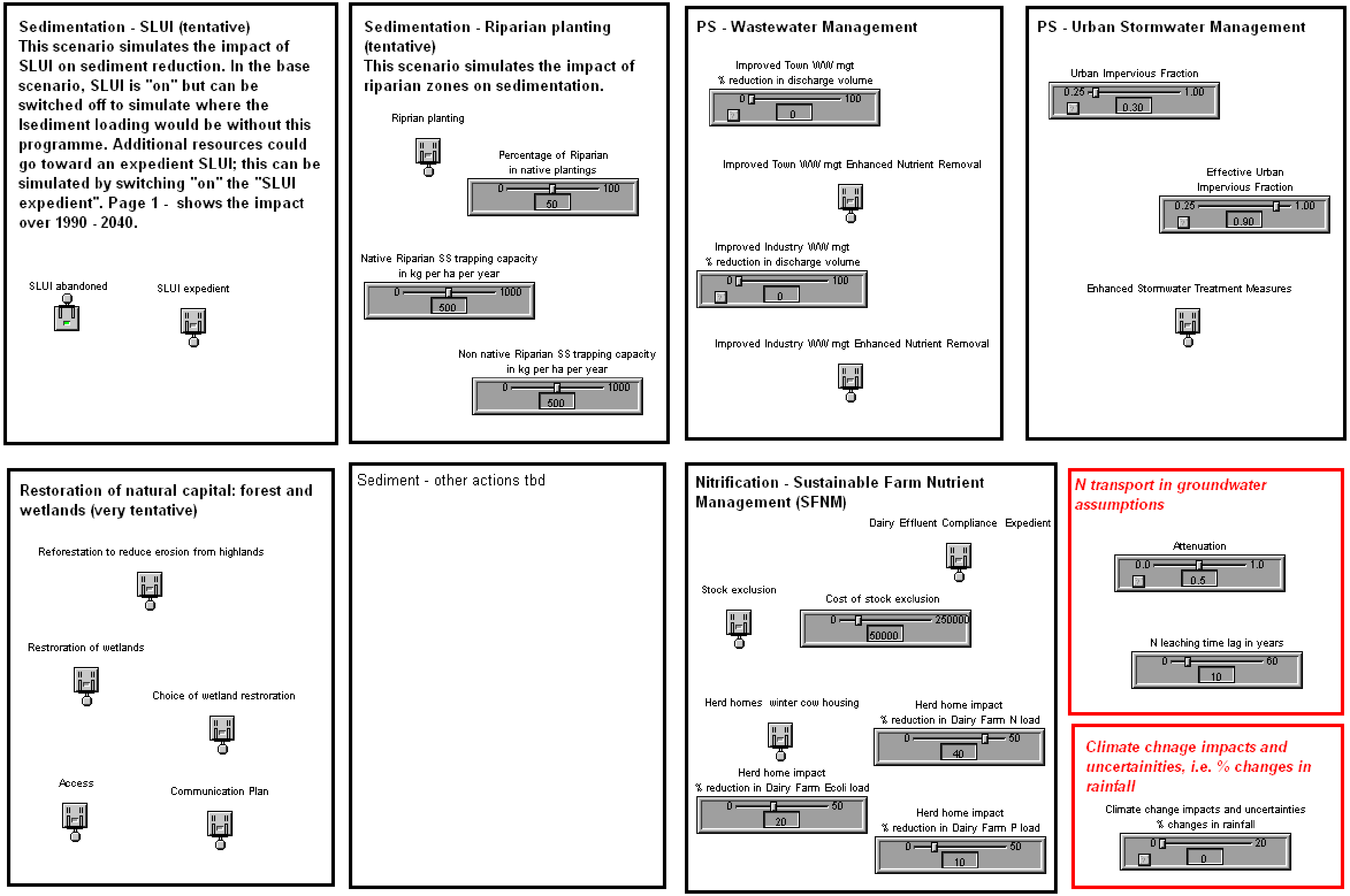


Figure 15: User-interface of the IFS model

5.2 Scenarios

The MM-IFS model has the capacity to simulate multiple scenarios.

The basic scenarios provided for the workshop participants covered sediment and nitrogen runoff in the catchment. Figure 16 shows the base case for annual sediment loading from the catchment into the Manawatū River. This includes the projected positive effects from the Sustainable Land Use Initiative (SLUI) already in place.

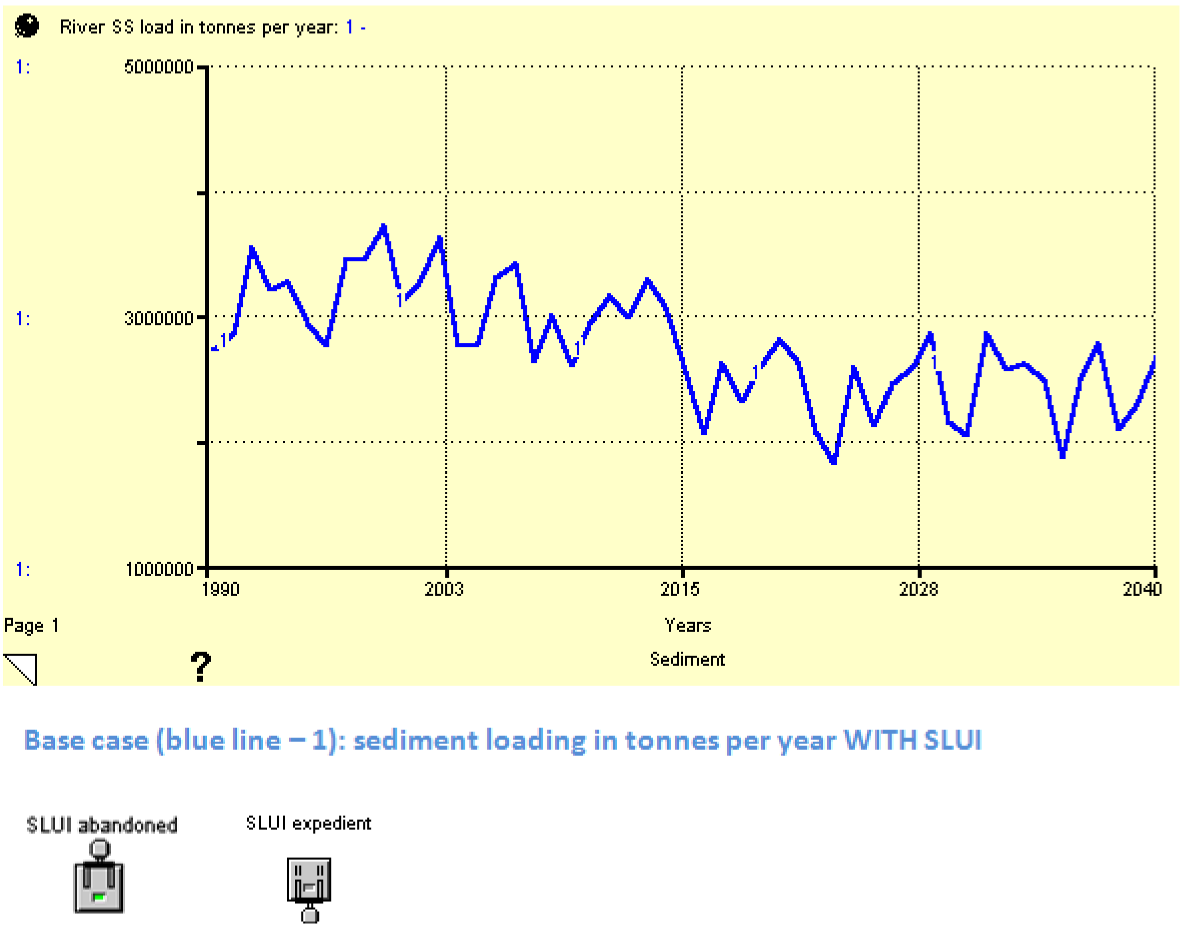
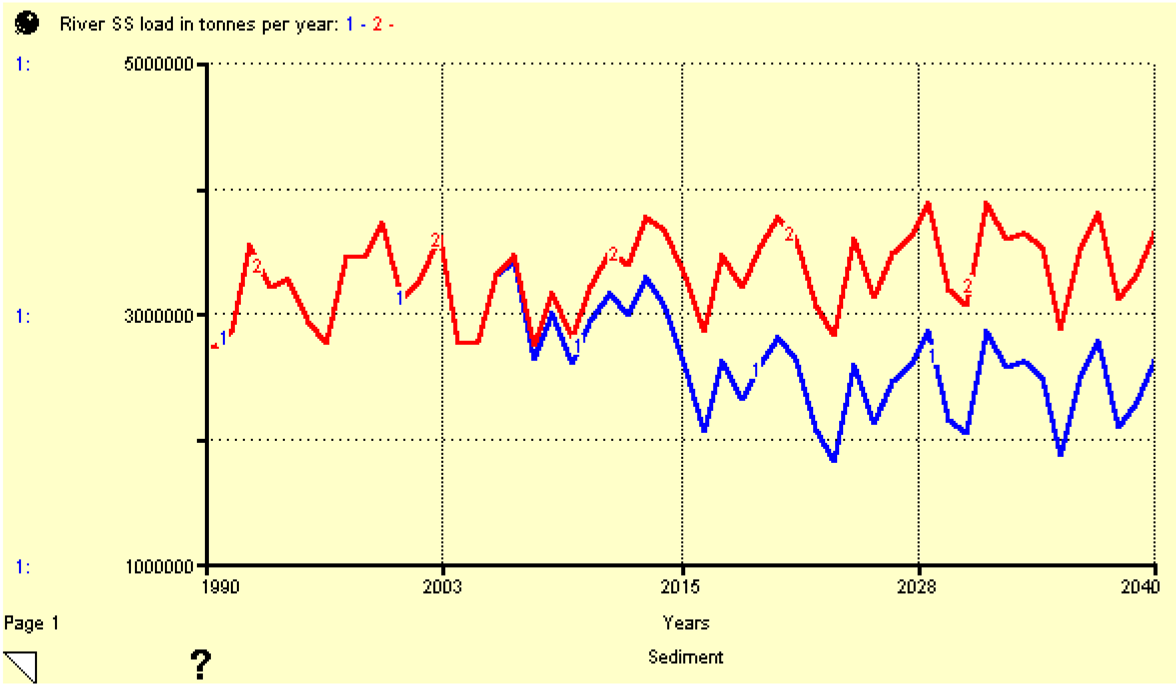


Figure 16: Base case for sediment loading with SLUI

To demonstrate the difference that the SLUI programme is presumed to make, ‘with’ and ‘without’ SLUI is illustrated in Figure 17. This scenario can be run by changing the switch labelled ‘SLUI abandoned’.



Blue line – 1: WITH SLUI

Red line – 2: WITHOUT SLUI

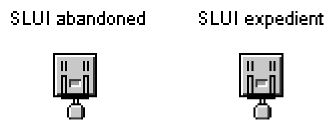
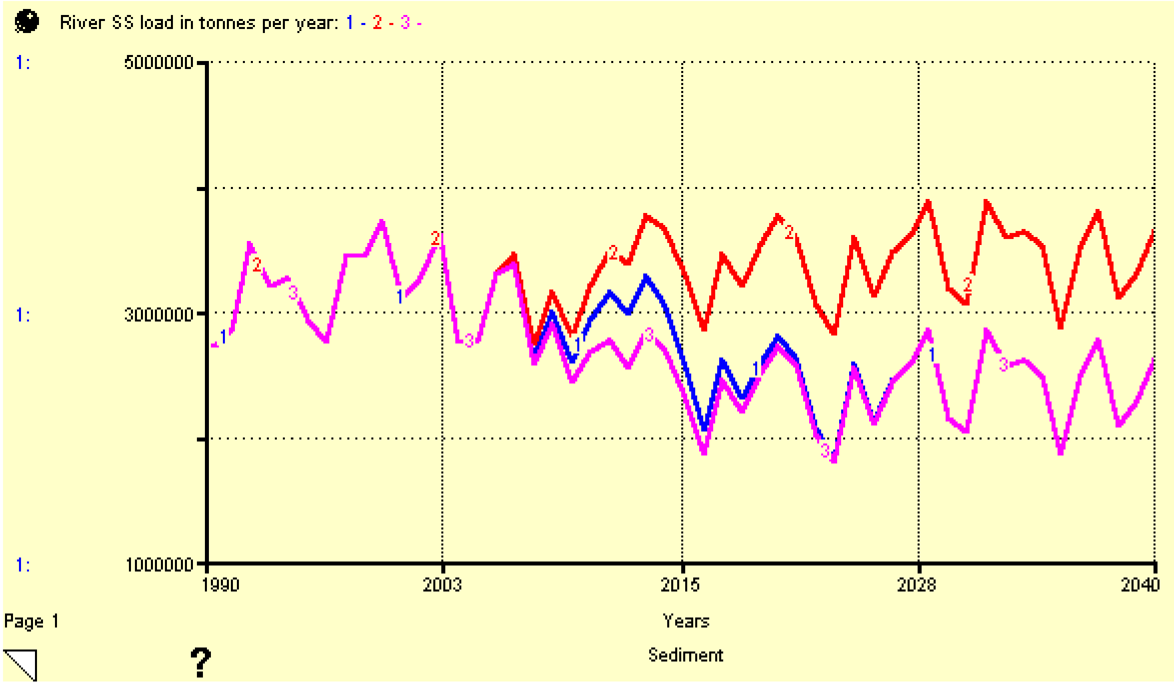


Figure 17: Projected impact of SLUI

A new scenario was explored to demonstrate the projected impact if the SLUI programme was accelerated to reach 2030 goals 10 years earlier. Line 3 in Figure 18, shows there is a quicker reduction of sediment loading but that catches up with the original projection, and sediment loading remains at a similar level. Model outputs such as this graph can be used to discuss whether or not this level of annual sediment loading is sufficient to prevent habitat loss and flooding. Sediment loading is known to ‘fill the nooks’ that aquatic life use as habitat. It also elevates the river bed, increasing over-flow risk during high-flow events.



Blue line – 1: WITH SLUI

Red line – 2: WITHOUT SLUI

Pink line – 3: Reaching SLUI goals in 2020 instead of 2030

Figure 18: Projection of an accelerated SLUI programme

While SLUI improves the sediment situation there are few associated nitrogen runoff improvements discernible with these scenarios. This is illustrated in Figure 19. The model extrapolates current growth trends that show by 2040 there are 98,857 hectares of dairying in the Manawatū River catchment (Appendix C, Table C 5).

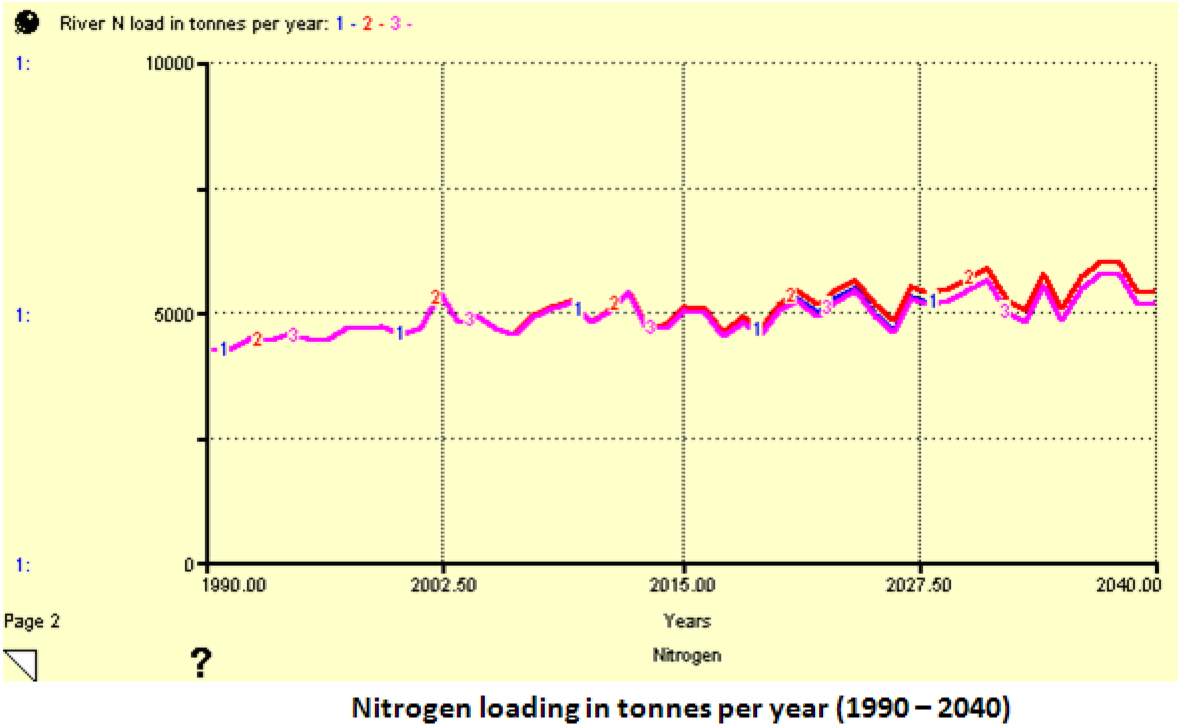


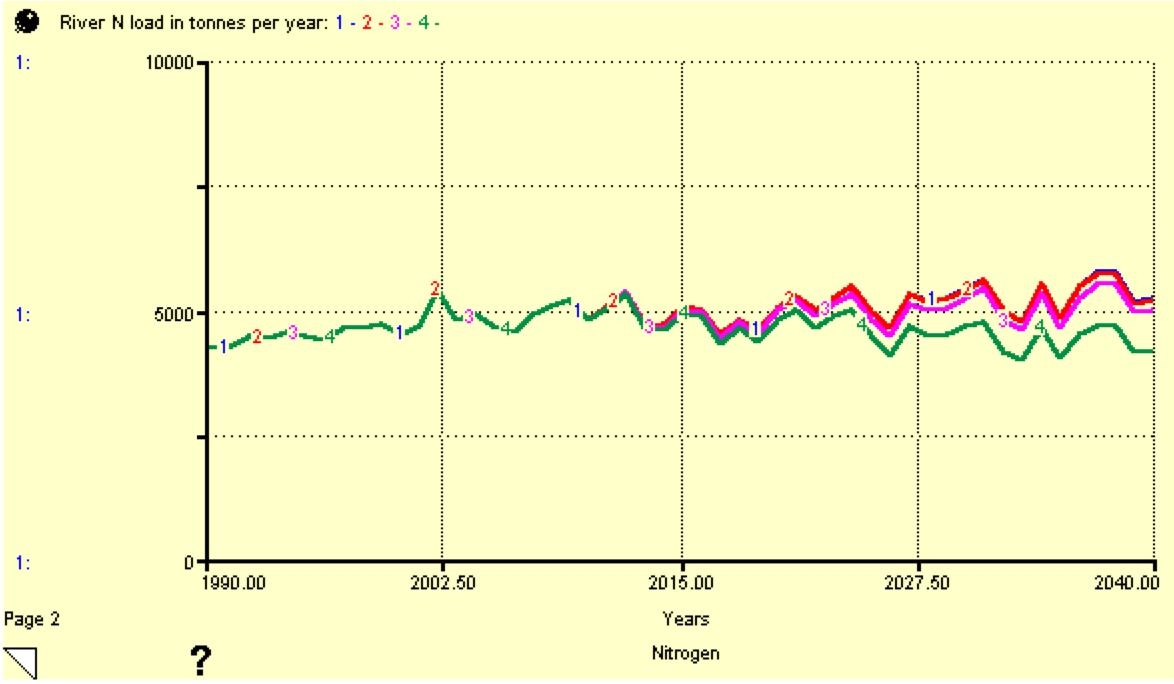
Figure 19: River nitrogen loading in tonnes per year for SLUI options in Figure 18

Additional nitrogen reducing strategies are required to overcome the projected growth of nitrogen loading from the catchment to the Manawatū River.

Stock exclusion was one measure discussed at the workshops. Line 1 in Figure 20 is the base case under current growth projections. The $50,000 fund made available by HRC for fencing makes no real impact (line 2). Line 3 shows the outcome if funding increases to $250,000.

As this scenario doesn't seem enough to curb growth projections, a scenario of using 'herd homes and optimal N management' was run (line 4). This scenario assumes these methods when combined achieve a 40% reduction in dairy nitrogen loading into waterways.

Clearly, Figure 20 is an expensive proposition and the graph of 'available funding' shows a deficit when all mitigation measures are simultaneously 'on'.



Blue line – 1: Base case under current growth projections

Red line – 2: Stock exclusion under current funding ($50,000)

Pink line – 3: Stock exclusion under funding required for subscriptions ($250,000) under assumption resulting that 10% of dairy N load may be reduced.

Green line – 4: Herd homes and optimal N management under assumption that 40% of dairy N load may be reduced.

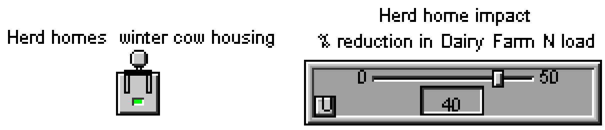


Figure 20: River nitrogen loading in tonnes per year under various N reduction strategies

The scenario in Figure 20 does not incorporate a potential 'feedback loop' that could result if herd homes and improved N management lead to additional intensification which reduces the environmental benefits of the measure. The slide bar in Figure 20 allows for a discussion about how much N reduction this 'solution' could give. Such slide bars provide a lead-in to extend dialogue (including adding feedback loops) or function as a place holder for future research to substantiate or refute current understanding.

Finally, workshop discussions frequently turned to the pollution contributions from Point Source (PS) versus Non-Point Sources (NPS) pollution. From a catchment averaged perspective, NPS are the large annual loading source and therefore a larger overall reduction is achievable by reducing NPS. However, in practice it is easier to reduce PS than a multitude of NPS so more attention goes to PS. In Figure 21 it is shown that reducing 50% of PS (line 3) makes significantly less impact on an annual basis when adverse 'events' are aggregated and included as a trend over time. However, PS have a localised, measurable impact which can be substantial during low flow days or when equipment malfunctions. The actual location of PS discharges is a resolution too high for the IFS/MM scoping model as it is not spatial. This level of detail can be included in a BBN model.

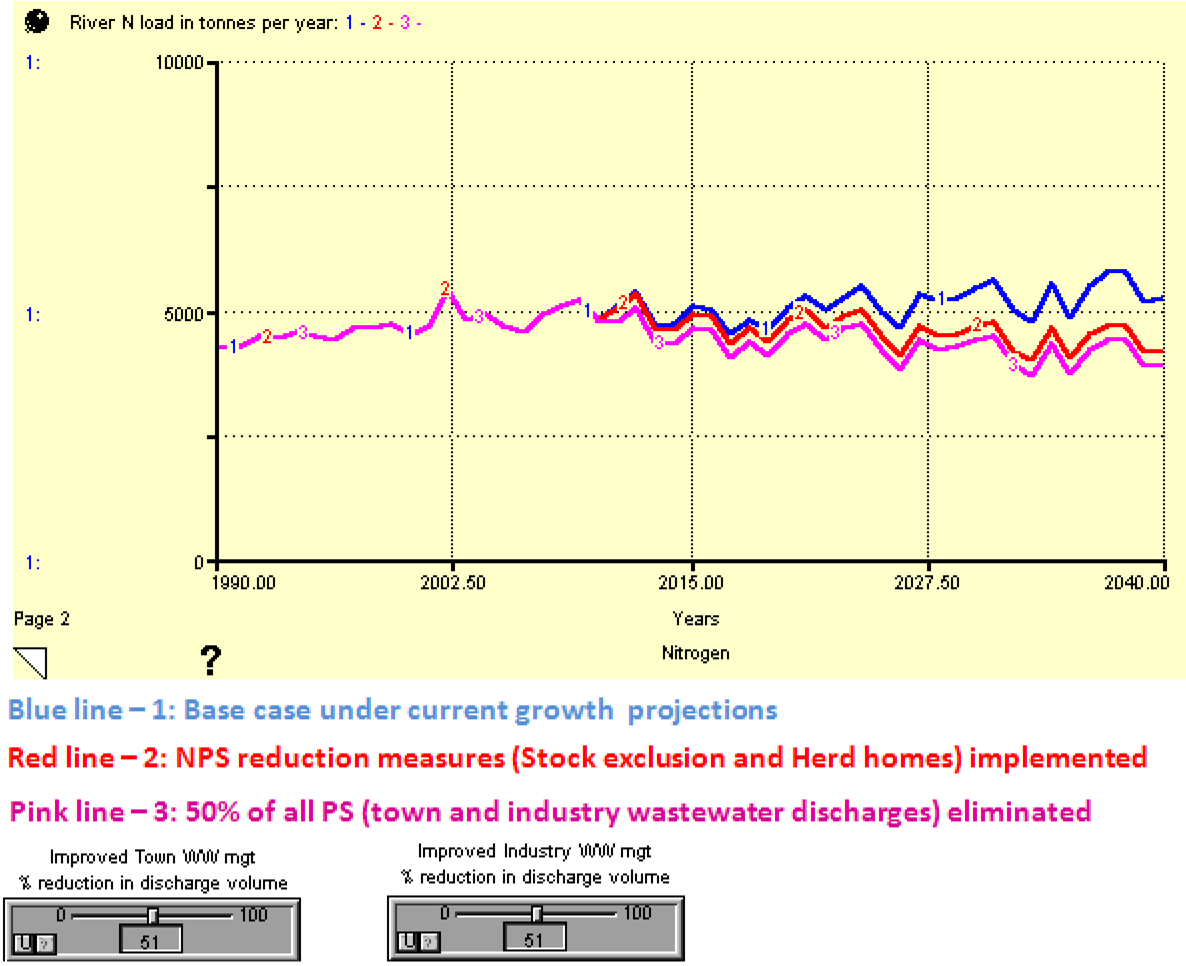


Figure 21: River nitrogen loading in tonnes per year from Point Sources and Non-Point Sources

Additional scenarios can be run with the current STELLA model. A detailed model description is provided in Appendix C – Model description.

6. REFLECTIONS

These reflections are from an IFS research team perspective. This section reflects on: (1) the original IFS project research aims and the extent to which they were achieved; (2) stakeholder analysis and management; (3) the envisioning stage of collaboration; (4) the Action Plan, (5) the on-going role of the system dynamics scoping model; (6) the economics of the Manawatū River catchment workshop; and last, (7) the account-ability of collaboration workshop.

6.1 Revisiting the hypothesis and research aims

Our hypothesis was 'that science and stakeholders' (especially political) perspectives have to be rooted in a shared level of understanding for effective, adaptive, whole systems management'. This hypothesis signifies that both the IFS team, and the stakeholders who supported the research project, considered science a key element in bringing solutions to the table.

From the outset, a fact-based dialogue synthesising available science plus other knowledge was a core goal of the IFS research project. This was a goal shared by stakeholders at the start and at the mid-point of the workshops. The mid-survey had 11 participants requesting more science input, while only two participants thought the science input was right. A similar pattern was observed with regard to 'other knowledge'.

Sourcing science information to feed into the MM-IFS scoping model presented an opportunity for HRC to feature science available in a new, more easy to understand format than previously available. This was done by reconfiguring and converting existing science into an easy to understand map with broad indicators at high level. Much of this science was originally developed to support the One Plan. The need was primarily to make the information more accessible for the participants and the wider public. Posters at the workshops and the document 'OURS' (Horizons Regional Council, 2011) produced by HRC effectively provided comprehensible summaries of the issues for each of the nine sub-catchments.

It proved difficult for the IFS team to engage directly with HRC to source data that could be extrapolated or interpreted for the MM-IFS model to help think about regional trends. The IFS team acknowledge that it is time consuming to source and translate data for scoping purposes and HRC was stretched for resources at the time given competing priorities such as the One Plan hearings. HRC also struggled to a certain extent to see the benefit of doing this given they had already presented their available science in a format they were comfortable with for the workshop audience. Data extraction is challenging. Even when seeking 'straight forward' data trends, one often runs into similar but incompatible data sets. An example is the Land Use and Carbon Analysis System (LUCAS) and the National Exotic Forest Description (NEFD) discrepancies when trying to assess the land cover in native versus exotic forests (see Appendix C – Model description). Similarly, 'Dairy' as a land use and the associated number of cattle has room for interpretation as many dairy cattle are grazed on Sheep and Beef Farms as young stock or when dry. This 'room' can quickly provide the space in which stakeholders talk past each other or base disagreements on.

A further challenge was the MM-IFS ability to venture with experts beyond peer-reviewable data to look at more qualitative trends moving away from the purist 'science' based focus. Logically, this is an uncomfortable space between science and policy, and the problem is not unique to HRC and its stakeholders.

Science issues were contested keenly during the three workshops using model building. For example, it was debated whether trout were responsible for loss of native fish species as opposed to the poor water quality. A lack of definitive science resulted in 'agreeing to disagree' on the causes of fish population decline. Lack of agreement did not prevent 'decline in fish populations' from being included in the evolving MM-IFS model.

Moving to the linear action planning mode meant active stakeholder engagement with science information was not feasible (or desirable by some) in the timeframe allocated. The requirement for a 'science-informed' process was instead addressed by a science panel brought together by HRC. This independently chaired panel met for a day to answer the science questions posed by stakeholders during the workshops and this ultimately proved sufficient to satisfy the needs of stakeholders.

The time pressure to produce the Action Plan relaxed the original aspiration for science-based limits or measurable targets. The hypothesis implies the assumption that science is not absolute but rather the way people relate to science infuses a level of confidence, along with trust in those using and providing the science. In this instance the improved working relationships as a result of the workshops, the dialogue into constructing the MM-IFS model, and the input of the science panel created this confidence and trust.

The research aims (1 to 5 below) were set at the start of the IFS project. The extent they were accomplished, from an IFS perspective, is now commented on.

Research aim 1: Building and testing an adaptive management framework to better understand and value the ecosystem services freshwater systems provide.

> Building and testing an adaptive management framework to better understand and value the ecosystem services freshwater systems provide was not the focus for the MRLF. The ecosystem services (ES) concept was on the agenda for the 3rd workshop on 'Economics of the Manawatū' in November 2011, but not pursued as it was considered a distraction to the development of the Action Plan. ES were sketched into the model, based on the literature and limited dialogue with stakeholders. At a later IFS workshop (Account-ability of Collaborations held June, 2013) without the time pressure for an action plan, the ES approach was more appreciated by stakeholders.
>
> The Multi-scale Integrated Model for Ecosystem Services (MIMES) used the IFS-MM scoping model (in STELLA) as a starting point for a spatially dynamic representation of ecosystem services and their values. A workshop (February 2012) with 10 research providers demonstrated the MIMES model built using Simile software. MIMES has the potential to provide further decision support modelling capacity for the stakeholders as it allows for spatial segregation of the scoping model into 49 sub-catchments and further focus on different Ecosystem Services.

Research aim 2: Examining the current negative trends of various indicators and testing the policy/management options and trade-offs required to achieve improvement and broad societal well-being regarding fresh water resources.

> The negative 'reference trends' are: sedimentation, nutrient run off and aquatic habitat. Management/policy options included are fencing/riparian planting, nutrient management, Sustainable Land Use Initiative (SLUI), reforestation and wetland restoration. The MM-IFS model as constructed shows that, if the assumptions around dairy expansion and intensification are correct, the trend of increased nutrient run off will continue even with the proposed management/policy options implemented. The five main management options were pursued in the model using 'back of the envelope estimates' for scoping purposes. No management targets were set.

Research aim 3: Testing the usefulness of system dynamics based Mediated Modelling (MM) and spatially explicit Bayesian Belief Network (BBN) modelling for assessing progress in an adaptive management context.

> Given the context (especially tight time frame) in which this MM process and BBN played out, the testing was limited and mainly provides insights to 'when not to use MM'. The connection between BBN and MM was only explored from an academic perspective with the IFS project.
>
> As the participants focused on linear action planning, use of the dynamic MM-IFS scoping model was abandoned. The BBN proved of limited use due to data gaps compromising the statistical validity of this tool. The research team redirected this effort toward testing the MIMES approach.

Research aim 4: Assessing how effectively these models can draw on existing research data, apply an ecosystem service valuation approach and integrate value assessments from various stakeholders.

> The MM approach had difficulty sourcing the relevant data in the tight turn-around between workshops. Also a concern existed that information would be used in a way that did not line up with the interests of the information provider, i.e. the concern that 'my model might come to a different conclusion than your model'. With MM this should not be an issue as MM is concerned with bringing together the perceptions of participants to create a common ground from which actions can be developed. Establishing 'agreed upon science' or allowing for a 'margin of negotiation' is frequently sufficient to achieve common ground. Magnitudes, interlinkages and more specific guidelines for implementation/monitoring can be investigated, allowing for deeper exploration of projected scenarios.
>
> The participants were shown what a static BBN map would look like (Figure 12). However, there was no opportunity for stakeholders to interact with the BBN framework simulating scenarios of probable water quality.

Research aim 5: The following bullet points are the expected outcomes set at the start of the IFS project. How successfully they were met is then stipulated.

- a coherent pan-iwi/hapū perspective on freshwater that helps communicate iwi/hapū interests to regional decision makers;
- The IFS project was part of catalysing pan-iwi interaction.
- an economic survey of freshwater ecosystem services;
- To date, a rudimentary outline of ES associated with land use is sketched into the scoping model. The ES integrated into the scoping model are; recreation, food, erosion control, nutrient recycling and flood protection. MIMES has been explored as a further way to integrate ES. An overview of ES was demonstrated to participants.
- a system dynamics model to evaluate scenarios for future adaptive management (MM);
- A system dynamics model is available, which can be improved upon as new data becomes available. The iwi research undertaken as part of the IFS project by Rangitaane O Manawatū used a scaled-down version of the catchment model for the Pohangina sub-catchment. The MIMES model of the Manawatū region can be used for adaptive management. It has 49 sub-catchments and has been trialled with expert modellers.
- end-user capacity to use and maintain the system dynamics model;
- Some capacity was developed with Rangitaane o Manawatū for their project on co-management. No other stakeholders have actively engaged with using or updating the MM-IFS. HRC has indicated a preference for developing its own (rather than a collaboratively developed) system dynamics model.
- linked spatially explicit GIS capacity to evaluate probabilities of impact on freshwater systems from land use change (BBN);

  The data for the BBN model was not available; a journal article documenting the limitations of the BBN approach is in progress. MIMES directly links land use change to freshwater ecosystems.
- a set of consensus recommendations among various scientists, stakeholders and policy makers as to the way forward;
- A list of 130 actions was developed as a way forward. This demonstrated an ability to collaborate. HRC received $5M from central government based on the collaborative process undertaken as part of the MRLF.
- identification of gaps in relevant and pertinent knowledge.
- HRC provided data that filled many of the perceived science gaps. The workshops reduced the distance between the 'social perception and perspectives' of participants but did not eliminate this divide.

6.2 Stakeholder analysis and management

As shown in Figure 22 individuals can be positioned by quadrant depending on their level of interest and decision-making power. MM participants ideally have both high interest, and high decision-making power, and belong in the 'High Interest/High Decision-making Power' quadrant. The 'High Decision-making Power/Low Interest' quadrant is usually occupied by leaders who have the power to make decisions but are not necessarily interested in being directly involved in the solution-finding process. This applies to many of the leaders who signed the MRLF Accord but opted to not participate in the workshops. Regular two-way communication is the best way to engage these individuals. Scientists and engaged members of the public fit in the 'High Interest/Low Decision-making Power' quadrant. Again regular two way communication can keep them informed and abreast of developments. The 'Low Decision-making Power/Low Interest' quadrant covers the wider disengaged public who can be kept informed through regular updates in the media or via websites.

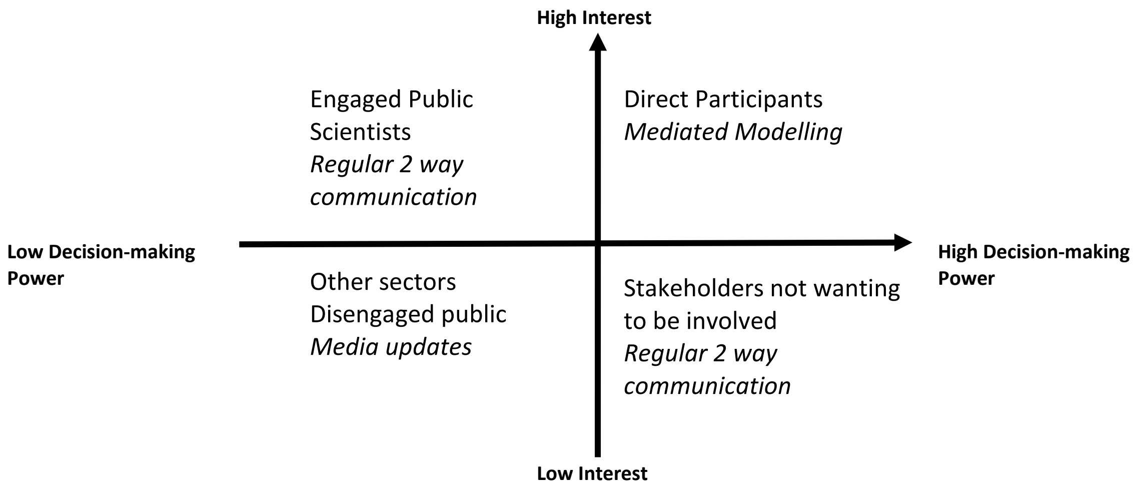


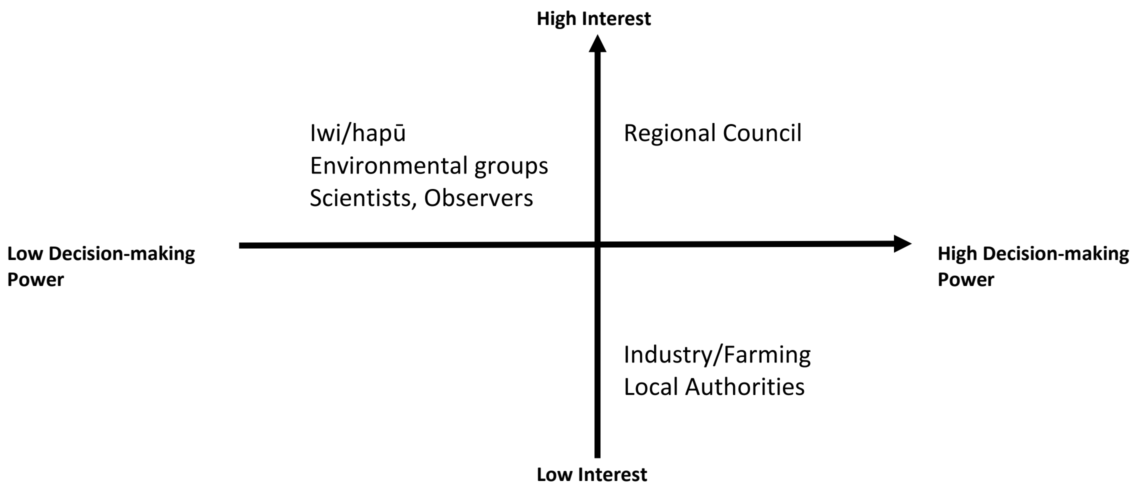
Figure 22: Envisioned stakeholder communication

The IFS research team did not undertake a stakeholder analysis process. Instead the course set by HRC for the MRLF was deferred to for stakeholder selection. Practicality required this as it was not viable for the IFS project to run a parallel series of workshops due to the high degree of cross-over between the organisations involved in the MRLF and the organisations that had provided letters of support for the IFS research proposal.

Interest in participation in the combined MM process and MRLF action planning was greater than could be accommodated so limits were put in place. In the end it was agreed to ask each of 5 stakeholder groups (Local Authorities, Business, Industry & Farming, Environmental, Iwi/hapū and HRC) to nominate 4 delegates to actively participate in the workshops. The restricted numbers proved particularly difficult for iwi/hapū and the environmental groups due to the high level of concern. To accommodate this it was agreed that observers could come to the workshops and contribute indirectly through the participants. Nominated observers also had the right to fill in for participants if necessary. This approach increased transparency and to some extent removed suspicion about 'a process behind closed doors'.

At the planning stage, it was envisioned by the IFS team that a communication plan for those not directly involved in the workshops would emerge during the first year of IFS research. The compressed timeframe meant that this plan was not developed prior to the workshops starting. Meticulous notes were taken during the workshops, consolidated and reviewed by participants for publication on the IFS project website for communication purposes. In addition workshop participants discussed early on how to engage with the media to keep the wider public (Low Interest/Low Decision-making Power quadrant) informed. This was important particularly for political stakeholders, given the bad press around the Manawatū River on one hand and the high expectations raised through publicity of the signing of the Leaders' Accord on the other hand. During the workshop process it became obvious that a communications plan as envisioned by IFS did not meet all of HRC's requirements. IFS as an academic research project was more concerned with the sharing of research outcomes, while HRC wanted a broad public relations effort. As a consequence HRC took ownership of the communications plan from a public relations perspective.

In the course of the workshops it became evident that the participants in the workshops belonged to different quadrants. Figure 23 gives the positioning of stakeholders. HRC given their regulatory role was clearly in the 'High Interest/High Decision-making Power' quadrant. Iwi/hapū and environmental groups were very committed and interested, but it became obvious that their decision-making powers were low compared with HRC, the Local Authorities or the Business, Industry and Farming sectors. While Local Authorities, Business, Industry and Farming sectors had more power to make decisions, at times these groups displayed low levels of interest.



Source: van den Belt & Schiele, 2011

Figure 23: Stakeholder Analysis and Communication after the MM process

Differences in power became more apparent during the linear action planning phase of the project. At this stage negotiations took place outside of the workshops between the MRLF Chairman, HRC and decision-makers in Local Authorities and Industry.

6.3 The envisioning stage of the collaboration process

A gap occurs when participants are not directly involved in the envisioning stage of a collaborative process. Usually, a MM process starts with an envisioning exercise, 'placing participants in the future', imagining how that future looks and back casting the steps to show how to go there. This didn't happen for IFS, as the Accord Vision and Goals were considered sufficient 'vision' for this participant group. The suggestion to engage in a brief (one hour) envisioning exercise at the start of the workshops was rejected, mainly by those involved in the development of the Accord.

A vision should (1) focus on what one really wants; (2) be judged on the clarity of its goals, not by the clarity of its implementation pathway as holding to the vision and being flexible about the path is often the only way to find the path; (3) responsible visions must acknowledge, but not get crushed by physical and political constraints; (4) it is critical for visions to be shared, because only shared visions can be responsible; and last (5) vision has to be flexible and evolving, thus the process of envisioning is as least as important as the particular visions themselves (adapted from D. Meadows, 1996).

While some individuals represented organisations which had signed off on the Accord,[7] most of the participants in the action planning were not the same individuals. Therefore, the Accord Vision and Goals can be considered more as a negotiated outcome than the product of envisioning for the workshop participants. There is a difference between working towards a 'vision' and a 'negotiated outcome'. The full MRLF includes more stakeholders than the action planning delegates and continues to meet twice a year to discuss progress on tasks in the Action Plan.

6.4 The Action Plan

To maintain stakeholder relationships the IFS project supported the progression towards a linear planning process, despite the fact that the core purpose of the IFS research was applying a system dynamics approach to problem solving. This necessary deviation did not move the project away from the research goals of improving collaborative outcomes and assessing the various steps of adaptive management (vision, assessment, planning, implementation, monitoring) in an integrated freshwater solutions context.

The IFS project provided support in the form of workshop organisation, hosting, catering and travel re-imbursements for un-paid participants. The HRC appointed facilitator and members of the IFS team worked hard during and in between workshops to co-develop an Action Plan with 130 actions, albeit without defined targets. Work behind the workshop scenes was important, keeping in mind the power differences reflected in Figure 22 and Figure 23 and the difficulty keeping some stakeholders interested in broad dialogues and engagement. The Action Plan is a negotiated document and can be considered an achievement by the mere fact that it exists. It was welcomed as a step in the right direction by all involved and provided a firm base to put forward a funding proposal to the 'Fresh Start for Freshwater' fund administered by the Ministry for the Environment. The successful HRC application to the 'Fresh Start for Freshwater' fund provided $5.2M to clean up the Manawatū River.

An analysis of the 130 tasks in the Action Plan showed they addressed four areas of the adaptive management cycle. 'Envisioning', was covered by the Accord Vision and Goals. Table 1 shows the distribution of tasks across the adaptive cycle. Only 16% of the tasks are geared toward the implementation phase which is ultimately what will make a difference to the river.

Table 1: Actions aligning with adaptive management phase

Adaptive Management phase	Number of actions addressing this phase
Assessment (incl. modelling and dialoguing)	49 actions = 38%
Planning	28 actions = 21%
Implementation	20 actions = 16%
Monitoring	33 actions = 25%

[7] Federated Farmers choose not to sign the Accord and instead launched its own 'People's Accord'. .

Measurable Targets in the Action Plan

Measurable targets are not part of the Action Plan. Instead, it was agreed to adhere to a structure of 'who is responsible, who does the task, and who leads'. While measurable information is available, it remains difficult to conclusively use science in cause-and-effect relationships; correlation doesn't mean causation. How one sees causation, or the lack thereof, is often rooted in preconceived notions and engrained worldviews.

The scoping model included some quantification and projected high-level outcomes over time. As a tool it can fill the gap between unmeasurable actions, physical indicators and the 'softer' indicators trending towards desired goals. It can also provide a way to avoid economics and science becoming argumentative 'weapons'.

Bold versus familiar solutions in the Action Plan

A projection for three decades, out to 2040, in the MM-IFS was in the scoping model to allow enough time for bold solutions that could be achieved within the life-time of current participants. Tension came about between stakeholders when the discussion moved to taking bold action to achieve long-term goals rather than merely confirming the viability of actions, many already in place.

At the first workshop, an attempt was made to explore 'bold', more structural solutions and investigate for example, 'what-if' in the future there were no discharges to the river. This required considering current 'waste' a resource for land-based alternatives, re-cycling or re-purposing. Only two stakeholders joined a breakout group on this topic so clearly it did not have the attention of the wider stakeholder group.

The time pressure to produce the Action Plan in six months became an impediment to exploring systemic solutions. Innovative scenarios based on a big vision and potentially bold scenarios such as 'what if zero waste was allowed into the river?' had to make room for an Action Plan that formally incorporated many actions that were already underway. The action planning focus was not lifted to 'big solutions' and reverted to 'solving problems' and incremental actions.

Even though a couple of participants wanted to explore bigger solutions, the group went for pragmatism and 'what we were able to get'. In the view of the IFS research team as the action planning process became more incremental and linear, the focus became more political. Concern about completing the Action Plan on time became more important for key participants than, understanding systemic challenges, the 'economic costs' and the 'science'.

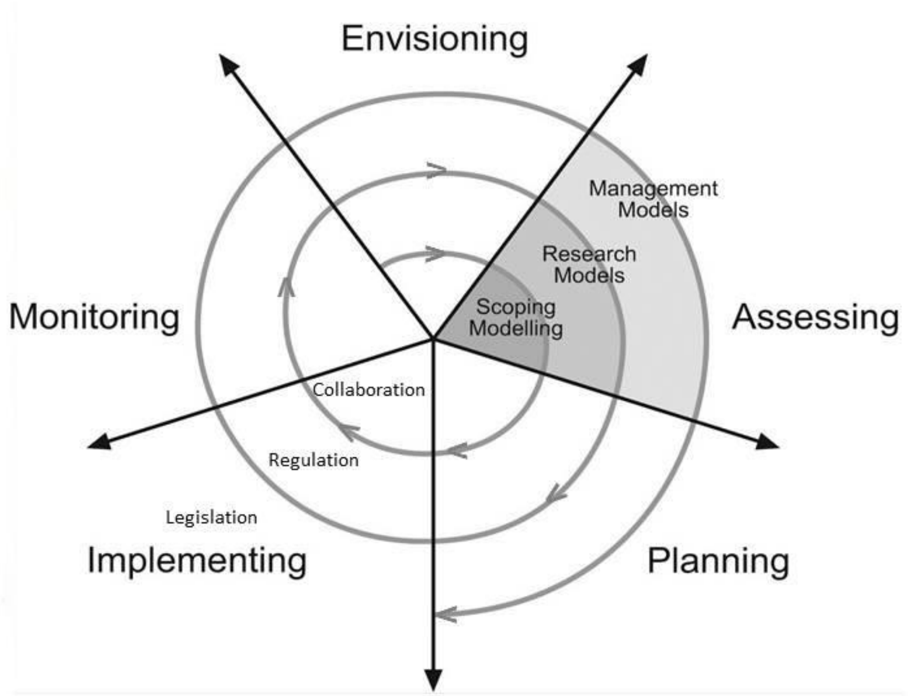
6.5 The on-going role of the system dynamics scoping model

The scoping model built during the first three workshops has been has been used in three further activities:

1. It featured in the workshop on 'Economics of the Manawatū River'
2. It served as a learning framework to communicate the basic issues in the catchment during the Applied Ecological Economics paper at Massey University (2011-2012). One group of students in collaboration with the IFS project leader developed an enhanced flood protection module and have a forthcoming journal article.

3. The catchment model was downscaled for the Pohangina sub-catchment and Rangitaane O Manawatū tested it as a communication tool; journal article forthcoming.

There are 'adaptive' processes happening continually in the local government area. For example, councils are mandated to develop annual and 10-year plans, which are iteratively updated. Other organizations have similar planning processes. Interfacing organisational plans with various stakeholders and political cycles is a challenge. Figure 24 illustrates the iterative steps in adaptive management and highlights how modelling tools can support the assessment phase for scoping purposes as well as the development of increasingly more complex and/or detailed assessments.



Source: van den Belt, 2010

Figure 24: Modelling tools to support Adaptive Management

At the conclusion of the six workshops it was envisioned the scoping model could play a role in the development of the 10-year plan for the region (van den Belt& Schiele, 2011). It remains a desire in the context of IFS research to assess if/how decision-support tools can support such governing processes from the outside.

6.6 Economics of the Manawatū River workshop

The view was expressed in the (pre-) surveys and at the workshops that 'economics' was an important driver for actions.

The move from using a fact-seeking system dynamics approach to an Action Plan using a linear approach came about at the end of the third workshop which focused on the 'Economics of the Manawatū'. The timing of the third workshop (Monday, 13 December 2011) was not ideal as many of the participants concerned about the 'economics' were unable to attend the workshop and share their understanding of 'economics' and how it relates to the biophysical and social aspects relevant to the model building and action planning. Economic evaluation requires, on one hand, a strong focus on costs, clear assumptions and targets and this was not appreciated by some of the more vocal participants present. The benefit side of the ledger, in the form of Ecosystem Services, had been placed in the 'too hard' basket early on by the participants. In the final survey, several comments were made concerning the 'need to go back to the economics discussion'. The IFS team at the end of the Action Planning process hosted a workshop with most of the IFS participants to explore the 'Economics of the Manawatū River'. This workshop on 2 November 2011 featured: (1) a cost benefit analysis (CBA) of 5 actions, drawing on similar work done for the Waikato River catchment. The report summarizing the CBA is available (Forgie at al., 2012)**;** (2) an Economic Impact Analysis (EIA) aiming to determine the impacts on regional and national GDP and employment of the proposed actions provided by Market Economics Ltd (McDonald & Smith, 2013); (3) a Cost Effectiveness (CE) methodology; and (4) case studies using the IFS scoping model. Figure 25 sets out the relationship between the tools presented and the context in which use is appropriate.

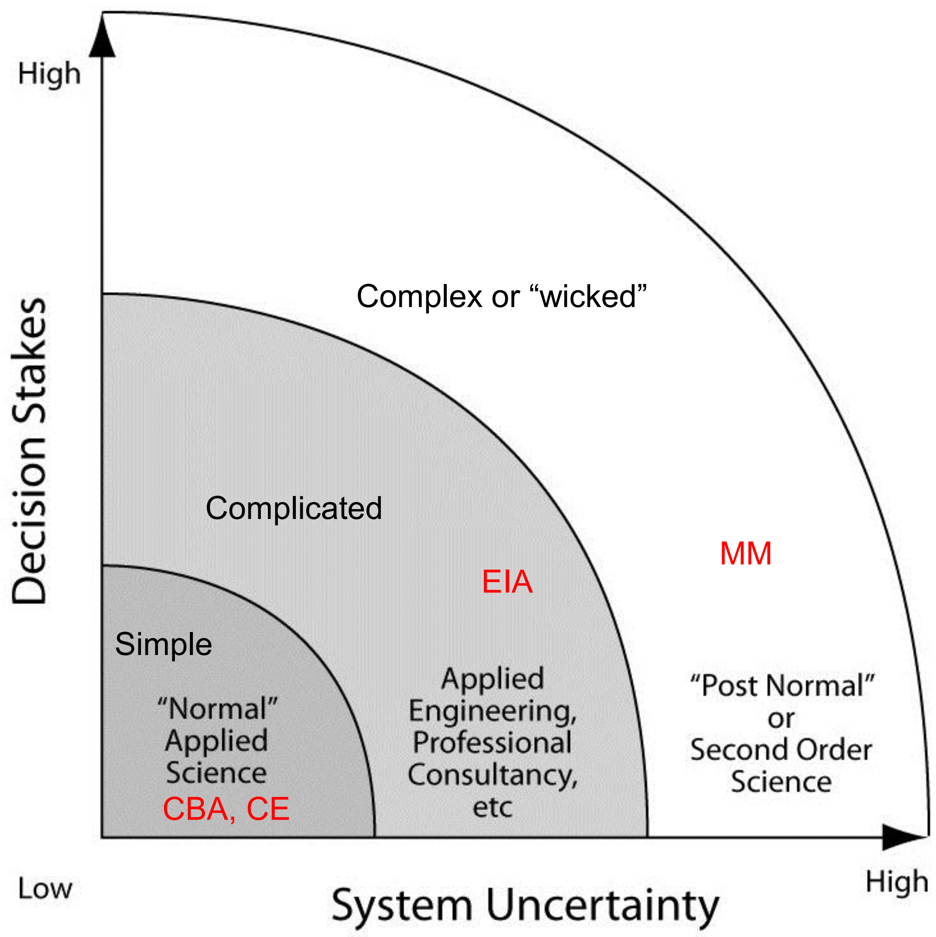


Figure 25: Economic tools in variable decision stakes and levels of uncertainty

An important reason for the workshop on the 'Economics of the Manawatū' was to demonstrate that 'economics' is a broad term covering many different approaches. The workshop spanned the narrow to broad approaches as shown in Figure 26. The fallacy of concreteness behind economic analysis was highlighted by explaining the methodologies used and assumptions required to employ these approaches. It demonstrated how CBA, EIA and CE are all based on significant assumptions and these determine the resultant numbers. A critical analysis of these numbers (such as the internal rate of return) can result in disputed outcomes similar to the debates that arise over different interpretations of science.

Clarification of assumptions and endeavours to get agreement on these is part of the development process with stakeholders when constructing a MM-IFS scoping model. This workshop served to provide a sense of 'when to use what tool in the toolbox'.

6.7 Account-ability for collaboration workshop

The Integrated Freshwater Solutions (IFS) research team organised the final workshop to provide an opportunity to reflect on the 'ability to account for collaborations' and provide a space for the stakeholder community to come together to reflect on the achievements of the MRLF and the action planning and implementation processes. The aim was also to think about Monitoring systems and how to (re-)align outcomes with the Vision and Goals of the Accord. The morning session focused on progress and the changing operating context. The afternoon session reflected more deliberately on a range of available assessment tools.

A goal for the workshop 'Account-ability for Collaboration' was to explore what can and cannot be done using collaboration. Another aim was to explore how we can do things better in the next iteration to foster the adaptive capacity of stakeholders in the region. About half of the group present at the workshop was also part of the action planning process and interviewed before the workshop. The feedback regarding the collaborative process was generally reported as positive (see van den Belt et al., 2013). The workshops built human capital and most people interviewed expressed a desire for the workshops to continue.

The point was made that while there was enthusiasm for collaboration there is also a cost. Collaboration needs to be resourced and outcomes accepted at all levels otherwise it is just a waste of people's time. It was commented that the interview outcomes show there is wisdom in the group and learning can be passed on to others.

While collaboration was regarded positively overall, concern was expressed as to whether 'community' can be damaged by collaboration. While collaboration involves representative stakeholders of the general public it is a different process from the consultation process which provides everyone with an opportunity for input. Consultation also requires controlled management and provides no guarantee that public opinion is adequately taken into account.

7. CONCLUSION

The following conclusions can be drawn at the end of the three year Integrated Freshwater Solutions project.

The research proposal was right on-target in identifying the need to bring stakeholders together for a fact-based dialogue to develop solutions and adaptive capacity. Unfortunately the accelerated political time frame proved to be too short to set up the research project as originally proposed. As it eventuated the MRLF dictated the workshop process, time frames and stakeholder management to produce an Action Plan within six months.

The MM and BBN preparation phase required time to construct models and collate data. Shortening the preparation phase from the one year envisioned in the research proposal to one month to coincide with the start of the MRLF action planning process, was disadvantageous for the IFS project. This, however, was unavoidable as it was untenable for the IFS project to run parallel workshops.

The MM-IFS model was developed over a three month period. The model provides a high level attempt to scope for trends and inter-linkages between sediment, nutrient loading, degraded water quality and aquatic habitat issues. These were the issues identified and prioritised by participants at the IFS workshops. The solutions volunteered by participants are incorporated in the model to envision (1) the amount of funding required and possible sources, and (2) the potential improvements anticipated from proposed actions. The model doesn't 'predict'. Instead, it is used to deductively develop leading questions to establish what we know and what knowledge and understanding needs to be pursued in order to clear the next step in the complex dialogue toward reaching goals.

Given the assumptions made with regard to dairy expansion and intensification in the region, population growth, and placeholders used when no data was unavailable, the first iteration of the MM-IFS model indicates that some actions developed under the MRFL action planning process are unlikely to curb current negative trends. The benefits gained from the preferred actions undertaken are likely to be less than the deterioration resulting from higher stocking and population numbers. More structural, fundamental solutions are required to convincingly show how future trends, especially regarding nutrient runoff, are to be curbed.

Data trends in the MM-IFS model are based on regional averages and therefore will vary at site specific locations. There is no evidence that working at a specific local level with scant data points provides a better basis for systemic regionally dialogue to achieve overall goals. In the absence of mutually agreed upon evidence, a scoping model can play an integrative role. The IFS model can be updated if/when the participants are ready to discuss 'big' solutions. It could also be used as a collaborative, adaptive management tool to re-ignite a systemic dialogue in the future.

MM doesn't aim to provide a highly detailed analytical model, but rather a framework to keep asking better questions. It provides the potential to explore bigger solutions. Developing the scoping MM-IFS model was considered useful by some participants, generally those with lower decision-making power.

Although extremely hard work, it remains important to close the gaps between perceptions and synchronise how we understand facts and design support tools to navigate toward shared visions. Evidence and facts leave much room for interpretation and political interests. How to bridge the gap from the narrow toward the broad tools/approaches and work collaboratively toward systemic solutions should remain the focus of future IFS-like research.

8. APPENDICES

Appendix A Participant attendance

Table A 1: Participants integrated freshwater solutions workshops

Name	Organisation	Oct 20 2010	Oct 21 2010	Nov 25 2010	Dec 13 2010	Jan 27 2011	Feb 24 2011	Mar 24 2011
Wallace Potts	Horowhenua District Council	✓	✓	✓	✓ am	✓		
Paul Horton	Tarenuiarangi Manawatū Incorporated	✓	✓	✓	✓ pm	✓ am	✓	✓
Christina Paton	Water & Environmental Care Assn Inc and Manawatū Estuary Trust	✓	✓	✓	✓pm	✓	✓	✓
Joan Leckie	Forest & Bird	✓	✓	✓	✓	✓	✓	✓
Brendan Duffy	Horowhenua District Council	✓		✓	✓am		✓ am	✓
John Hutchings	Fonterra	✓		✓				
Alistair Beveridge	Horizons Regional Council	✓	✓	✓		✓ pm	✓	✓
Gordon McKellar	Federated Farmers	✓	✓	✓		✓	✓ am	✓
Murray van der Maas	Fonterra Manufacturing	✓	✓	✓	✓	✓		✓
Jenny Mauger	Te Kauru (Eastern Hapū Collective Rangitane)	✓	✓	✓	✓		✓	✓
Jason Roxburgh	Department of Conservation	✓	✓	✓	✓	✓		✓
Robert Warrington	Muaupoko Tribal Authority	✓		✓	✓	✓	✓	✓
Marokopa Wiremu-Matakatea	Muaupoko Tribal Authority		✓			✓		✓
Michael Cribb	Te Kauwhata	✓	✓		✓	✓	✓	✓
Jon Roygard	Horizons Regional Council	✓	✓	✓	✓	✓	✓	✓
Jill White	Horizons Regional Council			✓	✓	✓	✓	✓
Murray Guy	Horizons Regional Council	✓	✓					
Jono Naylor	PNCC	✓	✓		✓pm			✓
Michael McCartney	Horizons Regional Council				✓	✓ am	✓ to 11	
Corina Jordan	Wellington Fish & Game Council	✓	✓		✓	✓		✓
Phil Teal	Wellington Fish & Game Council			✓			✓ am	✓
Ian Cairns	Independent Forestry Representative				✓			
Fred Jager	Water & Environmental Care Assn Inc and Manawatū Estuary Trust				✓am			
Elaine Reilly	Vision Manawatū	✓	✓	✓		✓ 11 on	✓	✓
Mark Maxwell	Vision Manawatū					✓ to 11		

Appendix B Summary of workshops

The following is a summary of the discussion that took place at each of the workshops. This information plus other material provided at the workshops can be found at www.ifs.org.nz. Participants had the opportunity to review the discussion summaries before they were uploaded.

Integrated Freshwater Solutions: Workshop 1, 20-21 October 2010

What happened on 20-21 October 2010:

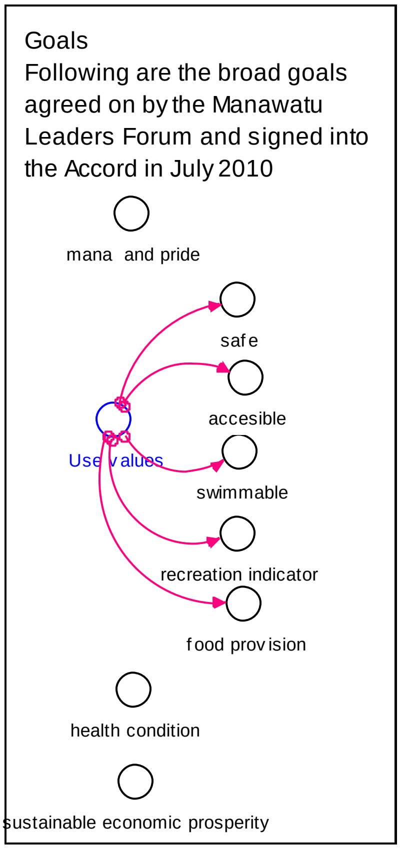
1. Overview of Integrated Freshwater Solutions project, how it aligns with the Manawatū River Leaders Accord and how Mediated Modelling workshops are structured. The workshops will be used to generate an Action Plan required by the Accord.
2. A preliminary model was presented but participants decided they would prefer to build a model from scratch for understanding. Initial model construction and discussion to identify key drivers that influence water quality, water quantity and habitat quality in the river system then took place.
3. Breakout groups to discuss: (1) Use of science and knowledge (2) Economic measures (3) Values (4) Actions and Solutions. The report back from each of these groups is documented.
4. Horizons presented data they have available and an update on work underway to improve water quality.
5. A dialogue covered the linkages between values, (health) indicators, and performance measurements. How these factors, causes, effects, and potential solutions, (some of which are already work in progress – e.g. riparian planting, fencing, etc) should be reflected in the model was reviewed.
6. A list of what information is perceived to be available, and how it can be obtained as well as a list of indicators to be used to measure success was generated.
7. Breakout groups to discuss indicators and measures of: (1) Mana and pride (2) Healthy river conditions (3) Sustainable economic prosperity. The report back from each of these groups is documented.

Summary of the discussion and the model modules that link this discussion

Aim – The Stakeholders have a mandate from the Accord to improve the river. The stakeholders unanimously expressed a desire to do something that is going to make a difference. The agreed timeframe for simulating the scenarios and solutions portfolios into the future is 1990 to 2040. The questions we would like to use the model to answer are:

- Can social, economic, cultural and natural science information be meaningfully integrated?
- How clean can the Manawatū River catchment be in 2040?
- Who will pay the cost and who will benefit?

Accord goals – The Accord with its four goals indicate a broad direction of what is meant with a desirable state of the river. The Accord goals are: The Manawatū River becomes a source of regional pride and mana (2) Waterways in the Manawatū Catchment are safe, accessible, swimmable, and provide good recreation and food resources (3) The Manawatū Catchment and waterways are returned to a healthy condition (4) Sustainable use of the land and water resources of the Manawatū Catchment continues to underpin the economic prosperity of the Region.

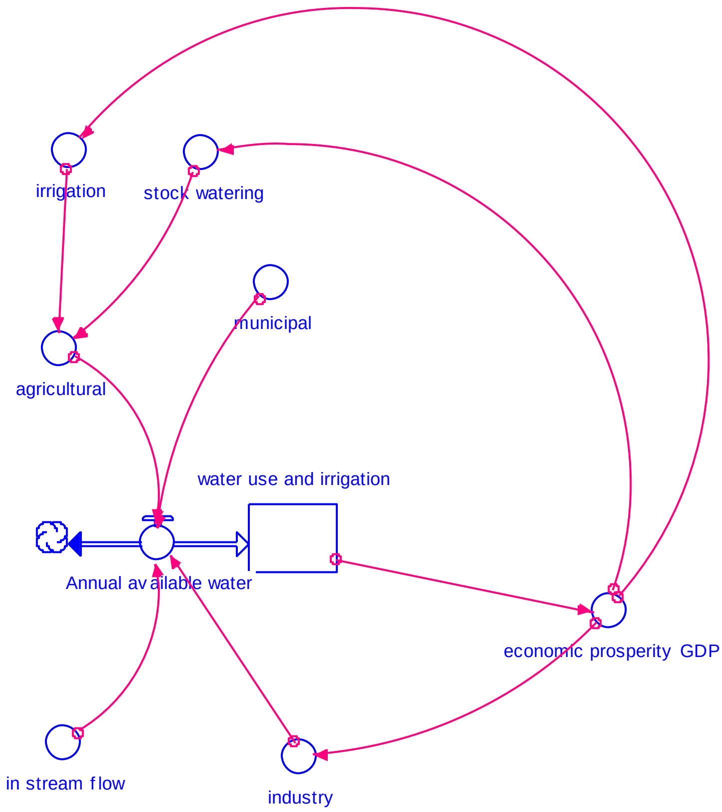


Module 1 – The Accord goals

Science – Science is not just natural science but also social, cultural, economic 'science'. It needs to come from a range of sources and conflicting data and definitions need to be sorted. There seems to be an agreement that there is a downward trend in water quality, water quantity and habitat quality. The extent of the problem and appropriate solution is not agreed on. There is a wealth of science available for the project to draw on. There are also gaps which stakeholders are identifying. The Land and Water Forum findings relevant to the Manawatū River are to be identified and placed on www.ifs.org.nz website to work within the national context.

Water use – The economic development of the region is linked to irrigation. It was estimated that 75% of available surface water in the Manawatū catchment is currently allocated. Demands on the river will increase in the future. The cost impacts on water supply for small towns also need to be considered. Hydro electricity is generated on the river. Currently Horizon's monitor over 60% of the Manawatū catchment's consented surface water takes using telemetry.

> Across the Region, the total consented water abstraction has more than doubled from 1997–2010. The demand for water for agriculture has increased by over 300% since 1997 (HRC, 2011).



Module 2 – Water use relationships

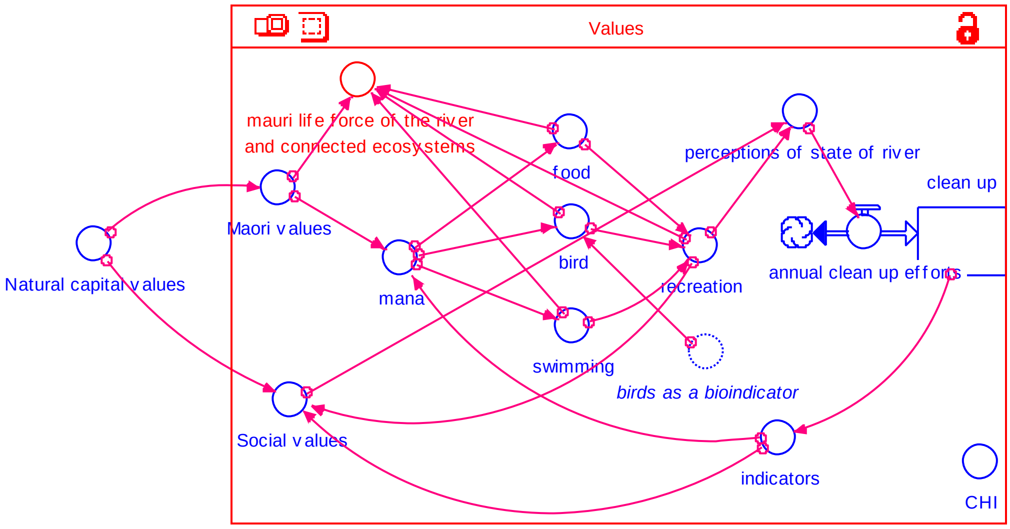
Indicators of river health – The group agreed that there is a need for a simple measure of improvement, easy to communicate to the community on a regular basis; suited to the Manawatū River. Measuring fish is expensive as it is time consuming and also some iconic fish migrate out to sea for part of their lifecycle. Koura and dwarf galaxias are not migratory. Horizons measures the biological environment that needs to exist to provide a habitat conducive to maintaining species; invertebrates and periphyton are also measured and this data will be made available. Freshwater shellfish has cultural value to Maori so the re-establishment of beds in the Manawatū catchment may be a relevant indicator.

Birds are difficult to use as a direct water quality indicator because of their migratory pattern. Cultural Health Index (CHI) is used by Maori and could be used in parallel to western science Macroinvertebrate Community Index (MCI), specifically because the relationship of both MCI and CHI to nitrogen is very similar. The CHI looks at resources available in the area. Whoever lives in area does the monitoring. The CHI includes birds as forest, birds and habitat count also as a measure of a river's health. Preference is to take a holistic view and create a vision of healthy water and surrounds. Retaining RAMSAR wetland status for the estuary is an important indicator of the success of the river clean-up.

Costs and benefits – Science needs to be used to clarify who, what and where the solutions are; as well as what intended and unintended consequences may result from interventions. Are interventions going to be economically sustainable? Water users such as industry, farmers and towns have had generations of getting economic benefits without paying for the ecosystem services the river provides. It is important that costs fall where most appropriate. All members of the community benefit from recreational use and the pride generated by the health of a river as unique as the Manawatū.

If nutrients from dairy sheds are used to grow grass (irrigation is generally over 2-3% of a dairy farm) there is a positive payback. It has been estimated there is potential for a $6000/ha average fertiliser saving for farmers (this is a positive feedback loop). Fonterra and Horizons are both looking at on-farm practices and new initiatives. DairyNZ is also involved. Synergies will allow system to do better.

Values – maintaining the natural capital of the river and its environs is important for both Maori values and social values. If the river has 'mauri' it is able to produce food, provide safe swimming and meet spiritual needs and this increases the mana of iwi/hapū who are tangata whenua. Likewise important social values are meet by other groups being able to swim, fish, watch birds and undertake other types of recreational activity on the river.



Module 3 – How values relate to water quality

What has been done – Currently 80 farm management plans are in place for farms in the Manawatū catchment. Horizons intends to model, based on the whole farm plans, to see what difference adding extra farms makes to water quality at the catchment scale. The SLUI program end target would cover 500 farm management plans in highly erodible areas; this could achieve a 48% decrease in sediment yield from the catchment by 2030. Dannevirke and Feilding have recently put in phosphorous stripping equipment which is likely to provide a very quick improvement in discharge water to the river tributaries.

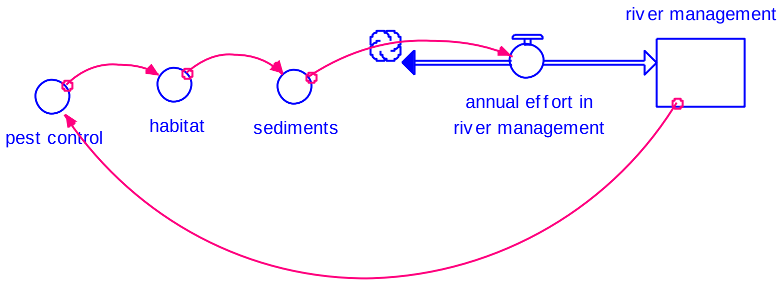
Dairy farmers used to have 419 discharges allowed into waterways in the MRC. There are now just half a dozen. A Dairy Effluent Storage Calculator to determine needed pond size has been developed for farmers.

For fencing off waterways Horizons have offered dairy farmers in the Tararua District a 30% subsidy for fencing (with a special deal of 50% to November 2010). A subsidy up to 75% is available if four or more farmers apply together to fence off a contiguous area.

River Management –

Flood Control – man made flood control measures can lead to a negative feedback loop. Erosion of stop banks can add up to 50% of the sediment carried by the river. Growing urbanisation is increasing the need for flood protection.

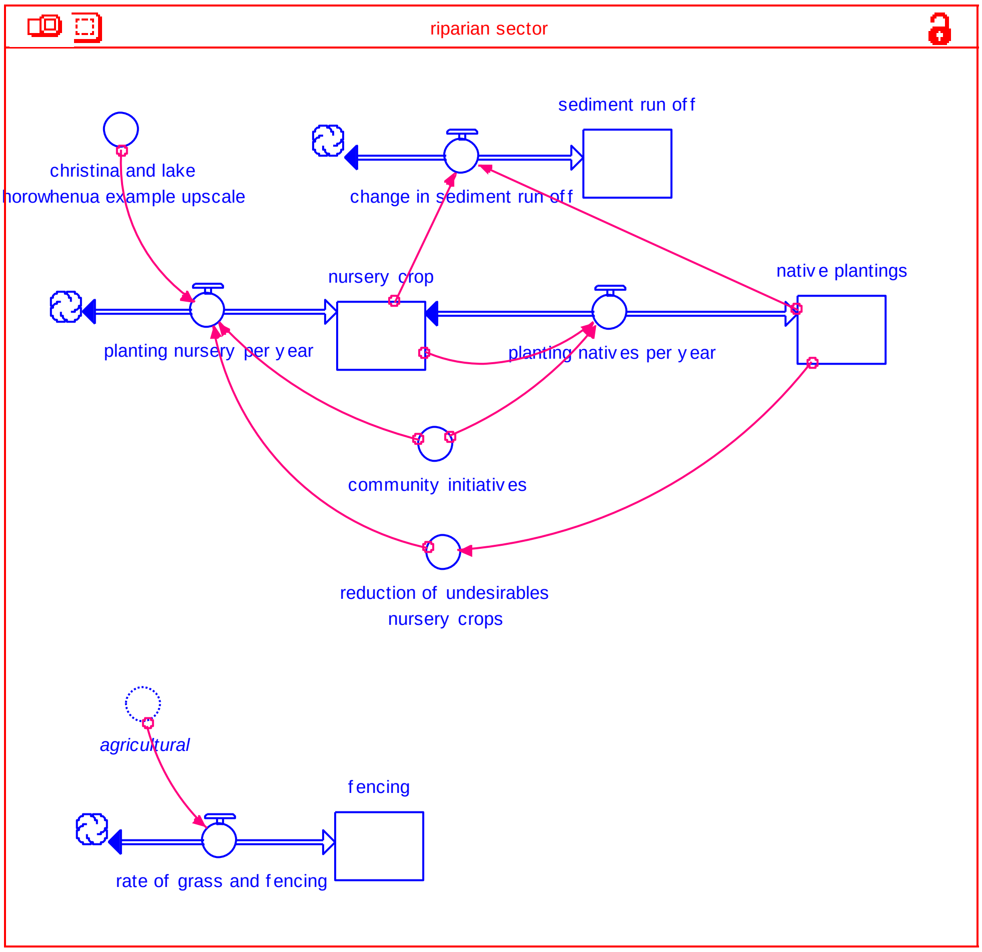
Riparian Planting – Iwi prefer native planting along waterways and taking a holistic approach to improving the river ecosystems. Riparian planting can encourage weeds and provide habitat for pests such as possums (negative feedback loop).



Module 4 – The required link between river management and pest control

Pest control is linked to improved biodiversity and healthy vegetation. Die back of large trees is an issue in Ruahines, e.g. around Rangi Hut. Roots hold soil in place especially in areas with steep slopes and high rainfall which transports the sediment into the river. In the short term exotic plant species can be used to stabilise erodible areas in order to establish more desirable plant species in the long term. Council owned land could be used for species diversity that will provide habitat corridors for native plants and animals which form most of the cultural native Waahi taonga inventory. Nurseries and community supported planting events were mentioned as catalysts for riparian management for which there are examples that could be upscaled.

If on flat land (<10% slope) the riparian margin needs to be at least 1 metre of ungrazed vegetation. For dairy cattle it is possible to fence using a 2 wire fence with the protected strip left in grass as unless a very wide strip is fenced off the riparian margin will not take out nitrogen leached into soil. On steeper slopes (>10% slope) at least a 5 metre strip is required. Grass is a good vegetation cover as does not impede water flow in flood conditions. Tall woody vegetation can blow over and block water ways, cause bare patches and provide shelter for stock which draws stock closer to the water. Ways to prevent weed establishment is a big issue. For Sheep and Beef farmers the key is to keep cattle out which can be done with a one or two wire fence or by provision of water troughs away from small streams. A one or two wire fence will still let sheep graze which will reduce weeds.



Module 4 – Riparian Planting Relationships

Day 1: Small group report back on inputs into the Mediated Model

There were four groups (1) Science (2) Economics (3) Values (4) Solutions

(1) Science group

Information available: What we know and may be able to incorporate in the model

1. Interaction Trout and native species
2. Interaction Trout and periphyton
3. Impact of commercial harvest on native fish species
4. Relative impact of point and non-point history
5. Historical land use changes of categories that are available
6. Water quantity, allocation and use
7. Predicted management scenarios, impact on aquatic health
8. Biosecurity; existing and new pest threats, possum control, old man's beard/ riparian management
9. Biocontrol
10. Sediment; what is the current understanding on sediment transport regimes, where does it come from, how it is measured and what are the impact on freshwater and estuarine systems and habitats

11. Estuarine and coastal species decline due to habitat change
12. Cultural values and knowledge; matauranga and species information, breeding, mahinga kai
13. Trends in Trout population over time and current state (from Wellington Fish and Game)
14. Trends in Native fish population overtime and current state.

Science gaps:

1. Cultural needs - eel catch in region and eel populations
2. Populations dynamics (fish and birds) and habitat change relations. Don't understand the morphological change and aquatic and fish population change.
3. Whitebait catch

Questions:

Do we want to have a science forum on a different non-workshop day? Suggested speakers were proposed but was decided not to go ahead with at this stage. There is a presentation from the Land and Water Forum in PN on 28 October.

What is the link with the Accord goals? Is there sufficient science to address the Accord goals?

Need to get information in a way that is easy to digest. How does the science relate to the Action Plan? What is the cause and effect?

(2) Economics Group:

What are the necessary interventions, to get the level of improvement we want, at what economic impact/cost, to who and how should this cost be funded (equity/priorities against other project options)?

1. Need clarity about necessary interventions.
2. What do the Accord goals mean in value terms?
3. What existing interventions will show results, and when?
4. Who should pay?
5. How could costs be shared?

If we get this right then:

1. Provides opportunity to optimise Treaty outcomes
2. Economists can compare options fairly
3. Ecosystem services value taken into account
4. Benefactors/exacerbators identified
5. More than carrots and sticks; some cost sharing may be needed- say with riparian planting
6. Bottom lines are exceeded now; some clean up needed TODAY. Quick wins may include fencing off of all waterways on dairy farms
7. Should be fully aware of impact on regional economy of interventions.
8. Need to build resilience and diversity into our economy

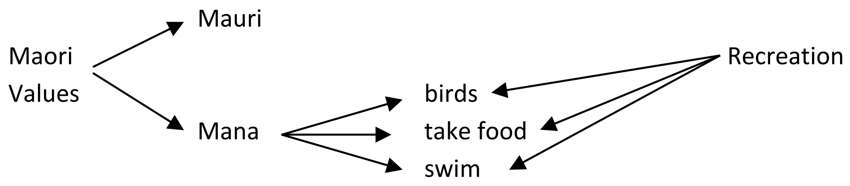
9. Recognise national benefits; collaborate to attract govt dollars: e.g. $210 M to iwi for cleaning up Waikato River
10. Search out existing and cutting edge technology
11. Need to rank opportunity cost, net present value, benefits etc to judge interventions

Projects	Cost	Water quality benefit	Who should pay
a			
b			
c			
d			

(3) Values Group

What do values such as mana, social values mean? Regional pride and mana is reflected in how people see the river. Communication can improve perceptions of the river as it gets cleaner OR make more people aware that current state is worse than they thought! Mauri – is a way to measure the quality of the waterbody. It is a collective (holistic) indicator. If the state of natural capital is high the mauri is also good.

There are different values associated with different parts of the river. Values are inter-connected (iwi and other). In regards to the intrinsic values of the river – improvements in natural capital should improve these values automatically.



Need to "Integrate values concept into model structure"

- Monitoring for social values – record the number of positive stories about the river and the number of people using.
- Economic values need to be recognised. As the river goes through a modified landscape we are focusing on 'sustainable use' .

(4) Solutions Group

Point Sources

26 Industrial and municipal discharges of concern. Definition needs to be clarified. Would it be possible to combine five outdated and scattered wastewater treatment plants into one and divert waste stream predominately to land (nutrients) and derive by-product from a bio-digester and

generate energy? Cost sharing options? Reduction of N loss? Economies of scale possible but would transverse TLA boundaries.

Education of consumers: don't purchase products that end up in waste water – such as certain types of detergent. A third of all phosphorous use goes to making detergents. Shortage of phosphorous has the long-term potential to be more limiting than oil supplies.

Urban storm water: How is it monitored?

Non-point sources

10% of hill country with steep slopes and certain soil type has been identified (in hectares and location) with a potential to be managed in order to reduce 47% of sediment runoff and erosion to water. Farm plans (advice and service) for the 10% of farms worse affected can potentially reduce sediment run-off by 25% incrementally over the next 10 years.

A programme is underway with Dairy NZ and Fonterra to improve efficiency of dairy effluent irrigation and fencing off of streams. If this happens what reduction in nitrogen leaching is likely to be achieved? Can Fonterra provide projected data and curves for the model to reflect this potential change?

River management

50% of sedimentation is assumed to come from low lands and river banks.

Gravel extraction and stop-banking cost \$. The prevention of flooding cost \$. Wetland restoration can give some floodplain back to the river and provide some storm/flood protection and biodiversity benefits. The build-up along the river and tributaries is such that areas would have to be taken out of commercial use. The scale of this solution is questioned. This issue in the model then connects to (1) riparian zone management and fencing, (2) farm management practices to reduce leaching such as herdhomes and artificial wetlands proposed, however the positive impact may have a 80 yr time lag due to slow ground water flows (3) N fertiliser use limitations and timing, and (4) educational field days to stimulate best practices acknowledging that some farmers are simply better managers than others. Farmers at the wrong end of the bell curve have to be brought in line.

Discussion

Some gravel extraction sites along Rangitikei being looked at for wetlands.

Some interventions to make a farm environmentally sustainable may make farming operation uneconomic.

The fertiliser industry now focuses more on selling services rather than maximizing fertiliser use.

Need to retain water in the landscape – HBRC water initiatives team looking at need for water in the economic systems and building storage dams for rural users.

Day 2: Small group report back on indicators and measures to use for river water quality

The 4 goals of the Accord were discussed. Mana and Pride was discussed by the whole group. River use values, Healthy conditions and Sustainable economic prosperity were covered by breakout groups. The following list of potential indicators to measure improvements in water quality, water quantity and habitat in the river system resulted from the discussion.

Indicators and Measures of Mana and Pride

- Abundance of species = life on/in the river
- Birds in the estuary/retain RAMSAR
- Good Cultural Health Index (CHI)
- Support for and doing remediation – e.g. measures of kms of stream fenced
- Life force or mauri of the river to be strong. It is a source of pride not just a conduit
- Living organism – water quality and the amount of bush that cloaks the river

Indicators and Measures of River Use Values

A Safe river

- Navigation of river/taking out logs/cars
- Toxicity – number of landfill and sewerage outlets
- Flood protection
- River wardens/Kaitiaki - no. of incidents
- Ecoli, bio-toxins levels as monitored

An Accessibility river

- Length of walkways, cycleways connected to the river with toilet facilities
- Access to river, number of places to connect to the river, including for people with disabilities vehicle access points (see webpage walking access commission)
- Physical access plus "wanting to be there"

A Swimmable river

- Measure the number of days people use urban patrolled beaches
- Number of days that the river is swimmable: 48 hours after a rain event December to April
- Proportion of kids using the river regularly

A river used for Recreation

- Surveys people's interaction with river
- Measure using mauri-o-meter
- Number of boat ramps
- Places to connect to birds on the river, bird viewing from vehicles
- Spiritual connection to river, artistic expressions; poetry, music, painting
- Use for kayaking, jet skis, rafting, waka, tubing

Edible food from the river (need to protect and enhance before harvesting)

- Edible fish and shellfish, watercress, fresh water cockle etc…… abundance and distribution. Measure by lab testing for edibility and number of fish kill incidents

Indicators and Measures of Healthy River Conditions

- 97% wetland loss, shortened river 10 km, 75% forest loss compared to 300 years ago.
- Degree of naturalness
- Area forest – trees
- Area of wetlands, water storage and water retention
- Length of the river, bendiness
- In-stream habitat variability
- Removing barriers (define barriers and count?)
- Management drainage scheme
- Area of sustainably functioning ecosystems
- Footprinting
- Fish as an indicator to measure water quality and catchment
- Insects
- Cultural Health Index
- How many projects do we have?
- Input and outcome focus and indicators
- Softer approach to water management – holding water in the landscape
- Slime, periphyton

Indicators and Measures of Sustainable Economic Prosperity

- Wastewater, number of discharges (27+). Need to identify exact number
- Stormwater, chemical use from domestic sources, chemical use industry and agricultural, total and per unit production
- Level of spending on improvements: (1) rates – elected officials dependent on achievements? (2) industry paying through consents, number of cows and productivity measurements kg N/kg milk solids (3), more use of SLUI farm management plans and implementation.
- Mana related indicators, harvest food to feed ourselves and provide hospitality
- Area of forest (distinctions of what kind of forest?)
- Number of visitors using the river
- Sustainability of gravel extraction
- Efficient irrigation systems (on what systems?)– water extractions
- Jobs - unemployment, GDP, on farm profitability
- Hectares retired or vegetated, riparian
- Tradable economic instruments

Action Points

The following actions will be undertaken prior to the next workshop:

	Action	By
1	Trends overtime for pollutants/nutrients and explanatory cause and effect.	?
2	Invertebrate counts	Jon Roygard
3	Statistics on fish populations and how they have changed overtime should be available from the National Fish Database.	Russell Death
4	Bird counts (native and exotic) can be sourced from Forest and Bird	Joan Leckie
5	Relevant Land and Water Forum findings summarised on web.	Vicky Forgie
6	Provide list of effluent, nutrient, stock exclusion/ reduction measures. Identify what is underway at present and the likely impact. Identify possible new measures and their likely impacts	Murray van der Maas, Jon Roygard , and the Dairy Link Team
7	Provide list of sediment reduction measures. Identify what is underway at present and the likely impact. Identify possible new measures and their likely impacts	John Dymond, Jon Roygard
8	Science (Macroinvertebrate Community Index (MCI) and Cultural Health Index (CHI) aligned to see how closely they relate to each other	Heike Schiele

Parked Issues

The following issues were recognised as important but not needing to be dealt with immediately:

1. Get an agreement on accepted 'science' and matauranga māori to be used in the model.
2. What are the costs of the various alternatives?
3. Who pays?
4. Biosecurity issues.
5. What are the market drivers for better environmental performance?

Food For Thought

Due to the tight time lines and work programme it is not always possible to pursue every line of thought or idea as they come up during discussions. The purpose of this section is to document some of these points so that the workshop participants can refer back to them and bring them back into discussion at a later stage if so desired.

Workshop 1 – October 2010

- The fertiliser industry is shifting from a product sales focus to a farm service focus. The idea is to help farmers to apply the right quantities at the right times to achieve optimum output, rather than maximise sales of fertiliser.
- A shift from rules enforcement and litigation towards pro active collaboration around solutions has been welcomed by farmers and others who cause undesired discharges → is there data showing farmers' investments and returns around environmental improvements?
- Why do we create waste in the first place – isn't there a better way of doing things?
- How can looking after the river create new income streams and economic wealth?
- The promotion of reforestation in mono cultures poses a number of risks:
    - Economic risk – forests get harvested after 20 – 25 years and no replanting takes place = subsidies provided to reduce erosion could be lost as the harvesting process can cause large scale erosion.
    - Mono cultures are not conducive for the overall health of the river system/biodiversity.
- A special workgroup could be formed to look at the most desirable species mix, looking at aspects of carbon credits, traditional plants for healing purposes and potential new income streams for (hill) farmers
- Science – what is right in any given context – do the scientists need to get together and agree on what is the 'right' science for the Manawatū catchment?
- Point sources for discharges – how many consents – large and small – exist in total throughout the catchment?
- Change some of the physical aspects of the river – revert from 'drainpipe' to a natural river flow, thus increasing habitat, natural flood protection, biodiversity and food in the river. Over time the river has lost 8 – 10 kms in length and 97% of wetlands have disappeared.
- Create a register for all existing and future actions on improving the river
- How can progress be made visible over time in instances where the desired outcome will not be immediately visible/measurable → use input based measurements in the short term. E.g. kms of fence line erected over a certain period of time.

Integrated Freshwater Solutions: Workshop 2, 25 November 2010

What happened on 25 November 2010:

1. Marjan van den Belt gave a Powerpoint presentation that covered the agenda for the day, action points from Workshop 1, and key issues to be covered.
2. After morning tea the participants worked through the model and the interlinkages. Paul Horton presented model changes relating to how Maori values are best linked into the model. These had been worked on between workshops.
3. Small groups discussed proposed solutions (listed below).
4. Report back and discussion on small group outcomes (See reports from small groups).

<u>Summary of the discussion from Workshop 2</u>

Questions the model should answer

These were refined to:

1. How can social, economic, cultural and natural science information be meaningfully integrated?
2. How big of an impact can a portfolio of solutions make toward the goals of the Accord and intermediate indicators?
3. How will environment and societal values benefit and who will lose as a result of actions taken?
4. Who does what? (This is a fourth question important for the Action Plan)

The second question was seen to be a key one. The portfolio of solutions in the Action Plan to be delivered at the end of March needs to achieve the Accord goals.

Horizons in a process separate from the Mediated Modelling workshops have brought scientists together to find out what questions need to be answered. A 4-5 page list has been made.

Collaborative decision-making

This discussion emphasised the need to understand collaborative principles at the outset and work together in good faith. These need to be revisited and built on during the mediated modelling workshops. At times participants might agree to disagree but the disagreements should not be fought out in the media. It was agreed participants could talk about the process to others as an individual but not speak on behalf of the group. The difficulty associated with extending this from individuals in the workshops to the organisations they came from was acknowledged.

Courtesy, good faith and urgency are additional good principles for collaboration and give more heart to the process. A list of names, emails and phone numbers will be circulated to workshop participants so they can contact each other if any contentious issues arise.

Media

We need a more proactive approach towards developing community support. Success requires the community to understand, be supportive and be actively involved. There will be internal differences but we need to have public statements that we all agree on.

It was decided Marjan van den Belt would be spokesperson for the Integrated Freshwater Solutions project and Richard Thompson would be as spokesperson for the MRLF.

Key Issues

The Action Plan needs to address the key issues of concern with the river. Therefore it is important to agree on what the key issues are and what the benchmarks are from which we can measure.

Are the key issues: What is in the river?; Wet areas in the river?; Economic health?; Ecosystem health?; Food sources from river? Safe place to recreate?

Key Solutions

It was stated that it was very early in the process to be discussing solutions. As there is a big difference in the level of understanding of issues within the workshop participants generating solutions is difficult for some participants. However, the MRLF committed to developing an Action Plan by March so we have to start now. A decision has been made to reduce the amount of time spent on direct interaction with the model and instead use the time to produce an Action Plan. If we had more time it would good to be able to do the mediated modelling at a slower pace. This would allow capacity building and more considered appraisal of the proposed actions. However, this can still be achieved by not locking in solutions. The mix and priority of solutions is important. Where are low hanging fruit? This will not be the final Action Plan – but something to feed into the 2011 March Annual Plan process. In 2012 the Long Term Plan has to be revisited so there will be a longer timeframe to work in.

The solutions sent to the IFS team by workshop participants after workshop 1, ranked roughly in order of popularity were:

- Point Source reduction/land-based options
- Riparian zones
- Enhance value of the river to people
- Reforestation of accelerated erodible land
- Public education
- Nutrients management and benchmarking river quality
- Allocation rules
- Co-management
- Technology (sustainable dairy research/ultra filtration)
- Demand management: water metering/new pipes

Explanation of the Model

A model description (20 pages) is available for participants on the www.ifs.org.nz website. (Note also see Appendix C of this report). This interlinks the key issues, key indicators and solutions so far. Various sections of this model were examined in the workshop and the following comments reflect evolving thinking. Some of the terminology used in the model was questioned. To get this right the 20 page model documentation will be emailed to participants and feedback is welcome. What we are trying to do is help people to assimilate information.

The need for science was seen as evident across the model so the next important step is populating the model with data. The data and science for the model is available and the IFS team is working on a process to efficiently extract it. We have not yet found the appropriate way to get the vast amount of science available into a readily assimilated format for participants. Landcare, Ag Research, Crop and Food, NIWA, Massey, and Horizons are working together and direction will help focus the science. This is not seen as a parallel process but a way to feed into the MM process. Maori units from some CRIs are involved.

Aspects of model discussed in detail were: (1) erosion, (2) access (3) seasonality (4) resource consents (5) vegetation cover:

1. Erosion is related to geology. For example, sandstone has different effects from greywacke. Target actions need to be in line with soil type. There are several different options such as tree planting in gullies to reduce accelerated erosion or on hill slopes. It is important to integrate tree planting into hill country farm management as there are links into property rights, economics, drivers, carbon sinks and sequestration. The distinction also needs to be made between when planting takes place and when the benefits result. SLUI responds to these types of issues and targets key farms.
2. Increased access to food sources, or special places can be detrimental from a certain point/level onwards. A positive increase in access could lead to negative impacts. Feedback loops need to pick this up. There are also economic effects associated with access such as lambing disruption and freedom campers leaving rubbish. A good management system for access and getting permission is needed. Safety can also be an issue where multiple activities take place. This needs to be allowed for in the Action Plan.
3. The model can be adjusted to provide a seasonal capability and be run for all year and low flow. Town water needs to be split into volume and concentration and need information on mass load, rate and timing. Information on water extraction and access through permits is also needed as eventually there will be over harvesting.
4. The timelines for the Action Plan need to fit in with existing resource consent timelines as this makes a difference as to when targets can be met. The process needs to find better ways to deal with resource consents. Right now Fonterra is spending $0.5m fighting a case in the Environment Court which is money that could be better spent. Can the model be used to show impacts of large scale consents?
5. Agreed to add percentage of Manawatū catchment in native bush to the model.

Bayesian Belief Network (BBN) Model

The BBN model is intended to answer specific questions from the workshops. It is a different tool to look at the same questions being asked. It has a spatial component and is more data intensive than the mediated model and oriented to natural science rather than social and economic concerns. The BBN might be able to have feedbacks into the MM. BBN is more ecology specific in terms of the questions and perspectives it looks at. What questions the BBN model will look at will be determined by the Action Plan and what is identified as important.

Reports from small groups

Point source discharges

1. Point source discharges (covers both domestic and industrial)

- Compliance needs to be well monitored: the permitted quantity and loading rates associated with resource consents should be more visible to the public.
- The long term goal is land-based treatment. While this is desirable the economic cost of setting aside productive land needs to be recognised.
- Consolidation of treatment: Replacing existing wastewater treatment plants with a single plant may provide economies of scale.
- Controls on inputs into waste water from trade wastes are needed. There are some mechanisms in place but these are not sufficient.
- Regulation frameworks need to be reviewed: RMA, LGA, byi-laws, technologies.
- General feeling is point source can be dealt with over time.
- Stormwater effluent (both point and non-point) needs to be tackled in the future. Stormwater can be as toxic as secondary treated effluent.

2. Demand management:

- Water metering for all use is achievable in 5-10 yr timeframe. This will reduce wastewater outflows and treatment costs. Implementation needs leadership from governance structure (TLA, RC, CG, stakeholders, iwi). Water metering should include price changes/incentives as in Auckland. There is a strong user-pays philosophy.
- Hydraulic neutrality for new developments (i.e. pre and post development water impacts are the same). Can put storm water tanks on private property which reduces storm water and provides clean water to lower the demand on water resources. Again needs leadership.
- Action: A letter will be drafted on behalf of the MRLF to all point source dischargers to ask them what actions they can take to improve river water quality. The letter will ask if there are any proposed improvements that they are willing to bring forward. This is asking for help and sharing the challenge. The letter needs to go out soon to gauge the response.

3. Allocation rules:

- Governance of water should involve iwi.
- RMA system of 'first in best served' is not the best use of the water resource. Tradable permits are an alternative option.
- Efficiency of use is needed by industry, households, irrigators etc. Loss of water from community water providers has to be reduced. A tool kit of options for various users is needed. This could include: re-use of waste water for irrigation; cluster end users so discharges can be positive resource; water storage facilities so water can be used when it is needed.
- Economic growth is related to water. Where allocated takes are permitted compliance monitoring is important.

Enhancing values

- The number of 'red alerts' can be used as a tool to measure improvement over time.
- A community survey could be taken to understand community perception baselines.
- Enhancing the river is about education therefore schools are important as it is a long-term project.
- To enhance the river value need an increase in pride and a positive perception of the river. Iwi have an incredibly important role in enhancing value, education, and co-management.
- What does "Manawatū" mean? We can provide some simple messages to the community. These can come from historical teachings of the river and by understanding the past to improve the future. Physical signage at the river could be used to inform people about the river.
- What do people value about the river? We can collect stories about the river, ecology, science, cultural sites, contact recreation etc. tailored to different audiences. Public art and interpretation of it (Te Manawa exhibition, opening next year) can also be used to promoted pride and a positive perception.
- Volunteer day for community to be actively engaged. This can make communities personally connected and responsible. What are the ways we can get people to celebrate the river through involvement?
- Economic activity in the region is related to water. Dairy provides $1.74 to the community for every $1 milk solids payout. 1 out of 10 jobs in the region is dairy related. There is a need to establish if projected dairy activities fit within the "carrying capacity" of the environment. Information to the community on limits to "carrying capacity" and information about what the community thinks is acceptable in relation to natural science based "carrying capacity" is needed.
- Resilience is needed in the economy – all eggs should not be in the dairy basket.
- Even if every dairy farmer farmed to best practice the river would still not be pristine as it is part of a pastoral landscape.
- Need good standards for the river. Values can be debated, standards have to be met.
- Need to acknowledge the commercial contribution of the river. Contribution to economic well-being is a better description than "commercial contribution"

- There is tension between economic well-being and environmental degradation. Need to be able to determine if the economic benefit to the region, measured in increase in GRP, is worth it? Investment into enhancing the river may provide a better outcome.

Reducing erosion from steep hill country

- SLUI needs wider community understanding about what it is achieving. Initiated after the 2004 flood, SLUI is designed to reduce sediment; P and some N are other benefits. The SLUI programme has targets in terms of the number of whole farm plans and the number of hectares under farm management plans. These targets will be revisited in five years. The SLUI initiative is also achieving protection of infrastructure, protection of the community from floods, increasing biodiversity, providing carbon sequestration, and increasing on-farm productivity. $5M per year (one third farmers, one third central government, one third HRC ratepayers). There needs to be better communication about what the rates money is used for.
- On public conservation land pest management is needed to enhance ecosystem service functioning. Loss of high-altitude forest cover can have a long term impact as it causes accelerated erosion where rainfall intensity is high. The peak flows are lower if vegetation is intact. 7-8% of the conservation estate is currently targeted for pest control for biodiversity outcomes. The workshop participants could endorse additional funding. Advice on priority areas would be required. Any action to improve water quality across the Tararuas or Ruahines would require a 1080 drop.
- Removal of anything 4-legged (deer, possum, pigs etc.) from forest parks is also a tangata whenua value.
- To maintain carbon sinks already in place are rules to protect and provide biodiversity credits in the form of rates rebates needed?
- For acceleration of SLUI more experts (human resources) and funding are required. Communication of benefits and speed of action needs to improve. People currently accept paying the $33.91 Sustainable Land Use Initiative cost on rates bill but don't want to pay $50. To add an extra $15 would need to make cuts elsewhere in the HRC budget.
- We need to prioritise across available funds from central government, HRC, PNCC, HDC.
- If going to pay extra for SLUI this needs to be compared with other alternatives such as wastewater improvement, riparian planting etc. What is the best choice and why needs to be effectively communicated.

Nutrient Management

- Nutrient management of non-point sources from farm land requires managing N & P concentrations at low flow periods.
- Trout eat native fish and also invertebrates that eat algae. Research has been done but wider communication is needed for the public to better understand what occurs and how.

- Targets: exclusion of dairy in all streams. What is the definition of a stream? Are nutrient management plans compulsory for Tararua area? Need to prioritise farms higher in catchment and focus on dairy farms.
- For nutrient budgeting need to provide bell curve of performance for nutrient efficiency use per catchment (kg N/ kg of milk solids as a productivity measure). Resource efficiency requires bench marking about where a farmer sits. N is a valuable nutrient so farmers need to know how much N they are using and how to manage it. Having a toolkit available provides options. For example, if you want to be more intensive then you need to go deeper into the toolbox. For example if cows numbers are increased by using introduced feed then herdfarm are required to take the waste.
- Fencing off dairy from streams can deliver pride and biodiversity for farmers.
- Horticulture interests should be included in the project or at least kept aware of progress. **Action:** Horticultural interests will be contacted.

Action Points

Action points from Workshop 2	**By**	**When**	**Status**
Science "hot tub" meeting outcomes – how to link science available into the model?	Jon	By 13 Dec	
Key messages of the day and spokesperson	All	End of day	done
Update model terminology in 20 page documentation	All interested	By 13 Dec	
Write to point source polluter to ask about their intentions and if they can bring forward any actions	Richard	By 13 Dec	
Discharge consents to the river, their waste type and volume and date for renewal	Jon	By 13 Dec	
Opinion on impact of pest control on water quality from experts	Jon to advise who	By 13 Dec	
Definition of what a 'stream' is	Russell	By 13 Dec	
Contact Horticultural industry representatives	IFS/Richard	By 13 Dec	
Circulate email and phone contacts to IFS participants	Vicky	now	done
Action points still to complete from Workshop 1			
Trends overtime for pollutants/nutrients and explanatory cause and effect.	Jon	By 13 Dec	
Invertebrate counts	Jon	By 13 Dec	
Statistics on fish populations and how they have changed overtime should be available from the National Fish Database.	Russell	By 13 Dec	
Provide list of effluent, nutrient, stock exclusion/ reduction measures. Identify what is underway at present and the likely impact. Identify possible new measures and their likely impacts	Murray, Jon and the Dairy Link Team	General overview provided 25/11. More detail needed if available	
Provide list of sediment reduction measure. Identify what is underway at present and the likely impact. Identify possible new measures and their likely impacts	LCR (by IFS team) Jon	By 13 Dec	

Key Messages

1. There are useful communication exchanges among participants.
2. There is a need to better understand the impact of point-source discharges and develop solutions for improvement. It is felt that systems are in place to deal with point-source discharges over time.
3. The long term goal is land treatment for wastewater.
4. Stormwater is a future issue to deal with to improve the water quality.
5. Demand management and allocation processes have potential to help allocation pressure – tools identified
6. We invite people to share their stories about what they value about the river –email, write, website forum, photos.
7. The number of "red alert" indicators can be used to measure improvement in river quality.
8. Understanding community perceptions is important. What does "Manawatū" mean to the community?
9. Iwi are important: education, values, and relationship with Horizons
10. Would like to engender a sense of personal responsibility for the river.
11. SLUI is already providing key benefits. Need better communication about what SLUI is achieving. Is targeted at problem areas with 5, 10 year etc improvement targets.
12. Pests are causing accelerated erosion on public conservation land. This is an important issue to tangata whenua.
13. Important to maintain existing vegetation cover on erosion-prone land. Ways exist to do this.
14. Nutrient management, dairy stock exclusion and riparian management – tools for nitrogen, phosphorous and nitrogen reduction. Can also deliver other benefits e.g. pride, biodiversity
15. Interaction of fish species needs to be understood better
16. In subsequent workshops we will be looking at: prioritisation of actions, targets of actions, timeframes for actions.

Integrated Freshwater Solutions: Workshop 3, 13 December 2010

What happened on 13 December 2010:

1. The workshop schedule for the day was to focus on:
   a. the economics of proposed actions
   b. the time frame of proposed actions
   c. who funds the actions and equity considerations associated with this
   d. progress the Draft Action Plan
2. The model was to be used interactively to develop thinking in these key areas and explore ways in which new solutions can be generated that are collectively beneficial .
3. The participants needed to confirm the Draft Action Plan was in a format that was suitable for all the groups represented in the workshop to include in their annual/business/organization/agency/iwi plans to ensure implementation and monitoring phases are achievable.

Summary of the workshop discussion

Economics of the River

The workshop objective was to understand and 'value the economy of the river'. This is a wider concept than 'the value of the river to the economy'. The economy of the river involves understanding the contribution made to the market value (for example, for every $kg of milk solids what proportion can be attributed to the Manawatū River) and the non-market value (the ecosystem services freely provided by the Manawatū River that allow the productive capacity to be maintained and people to thrive).

As there were many different ideas of 'economy' held by participants it was a struggle to bring these together and proceed in a new direction.

To understand the economy of the river there is a need to separate the market and non-market values (direct, indirect, intrinsic). Some activities such as recreation and forestry straddle both direct and indirect values. Horizon's has a report on value of water to the region but not the catchment. The report has limitations as it is based on assumptions, but it may be possible to extract data from that report for the model. This type of understanding pushes beyond using contribution to GDP and employment as a measure of value to including the indirect and intrinsic values associated with the river and the ecosystem services it provides. It requires including non market values which is always difficult.

> Exploring economic value introduces conflict such as irrigation versus consumption in urban areas versus ecosystem heath and access to recreation. Looking after the river is important for both economic and environmental motives.

This workshop is to decide how we best manage the river at the macro level.

Important Questions

1. What is the economy of the river? (this is a point of reference from which we can measure)
2. What is the likely cost of intervention?
3. What will be the consequential short term and long term economic impact of those actions (including the opportunity cost)?
4. What will be the cost of doing nothing?

Draft Action Plan (AP) and Format

Participants were provided with a Draft Action Plan. Feedback on whether the final Action Plan should just be the bare bones or also present a narrative was sought. The general consensus was the final Action Plan should set out simple, readable achievements and objectives. The target for Year 1, 3 and 5 need to be fleshed out. The proposed solutions will likely be multi-faceted. It will be necessary to interlink the solutions and the timeframes so they are not presented linearly. If given the time the models supports required thinking in this space. The Action Plan needs to be in a format that the MRLF can report on achievements. There is a wide public expectation of the Action Plan so it needs to be in a format available/accessible to the public.

Whether or not it was best to leave detail to those implementing the various actions was not resolved. Steps for monitoring results do need to be included. Stakeholders are willing to be involved in this, for example F & B could count bird numbers etc.

There will need to be a communication plan to disseminate the Action Plan to the wider community at the end of the workshops. The Action Plan is what we ‘sell’ to the community so it needs to be a product the community is happy with. There is also a need for supporters to know what is going on now. Reporting is currently done through newspapers and the website.

The Action Plan needs to be more specific in terms of who takes a leadership role and who the key players are. These are not always the same people/organisations. There was general agreement that the Action Plan in its current format would meet the needs of the various groups the stakeholders represented.

There is national interest in the Action Plan as a template for use elsewhere. It will therefore need to include a definitive set of costs and actions. Discussion of these is the next step.

Model and its role in the Action Plan process

If stakeholders are interested in actively using the model between workshops the IFS team can provide a Stella license. The model can be accessed and run using instructions provided on the www.ifs.org.nz website. Questions the model will provide insight on:

1. How can social, economic, cultural and natural science information be meaningfully integrated? **This is a question that is being addressed globally and nationally so it would seem to be the right question to be asking regionally and locally.**

2. How big of an impact can a portfolio of solutions make toward the goals of the Accord and intermediate indicators? **Information is trickling in to get models up and running to help with these decisions.**

3. What are the cost and who will benefit? **These are the issues for today.**

For question 1 there also needs to be consideration for HOW the inspirational goals of social, economic, cultural and natural science are integrated as sometimes goals compete. An understanding of the ambitions of each and trade-offs is needed before they can be meaningfully integrated.

The model is evolving but it takes time to build together. This step is required for people to fully understand how it works. How to best do this was discussed. Most participants felt that model building interactively in the workshops was an inefficient use of time. It was better to have the discussion to determine what needed to be included and why and then do the model building off-line. Marjan explained that if changes are not made to reflect the dialogue when it is on-going there is the risk that it becomes too much of a "spaghetti junction" that participants do not understand or have ownership of. The general feeling of the group was that as many concerns were specific to individuals and the groups they represented (eg fishing licences) and it was an inefficient use of collective time to discuss whether or how they should be included.

The workshops are envisaged as a way to develop a tool-box to deal with long term issues. It is important in the workshop to identify the boxes needed but not try to fill in those boxes. If model building is done outside the workshops participants were keen to know if their concerns were included in the model. It was suggested that items to include should be listed and then ticked off when incorporated.

For the economic section of the model we need to know the cost of alternative actions and where the money is coming from as well as what is being spent at the moment.

How the model deals with conflict was a question raised but not answered.

Who will pay

Sources of funding for implementing the Action Plan were identified as:

1. District/City Councils (ratepayers)
2. Regional Council (ratepayers)
3. Central Government Agencies i.e. DOC (taxpayers)
4. Industry/Primary Producers (private enterprise)
5. Treaty Alignments (iwi)
6. Recreational Groups (individuals)
7. Interest groups (Fish and Game; Forest and Bird) (individuals)
8. Philanthropic Trusts (individuals)
9. QEII (taxpayers and individuals)
10. Public Private Partnerships (PPP). Waste water may be a recession proof business. Farmers who want to take effluent utilization more seriously may also be interested (private enterprise/ratepayers/taxpayers)

The point was made that workshop stakeholders also represent the network of funders.

Costs and Priority of Potential Solutions

For any potential solution how much it costs is important. Before prioritising the group felt more information is needed on costs and alternatives. It is not possible to prioritise without knowing more about potential outcomes from actions and where and when they will take place. It is wasting time prioritising without knowledge. All options have costs and we need to use science to inform the discussion. However the science is often disputed.

Water metering was one suggested solution to reduce water use and wastewater. Currently 94% of water use in the Horizon's region is metered (69% directly metered and 25% metered by the town supply provider). Storage facilities are being constructed to reduce takes from the river at Dannevirke and Eketahuna. The view was expressed that installing water meters in areas such as the Horowhenua would be a cost that would not make a difference to the river. But others felt that reduced waste and efficiency gains brought about in water consumption as a result of metering would be beneficial all round in the longer-term.

Providing for land based disposal for PNCC waste water has been estimated to cost $100m. It would cost $1.4m to run the phosphate removal plant all year instead of just 4 months of low flow. Both these costs could make small contributions to improving river water quality compared to the same or less money spent elsewhere. Alternatives need to be explored. For example, can you create a market for waste water to reduce the $100m. Transport and pipelines are the main costs involved. Distribution costs are accepted for phones, power, internet etc so could also be charged for waste water.

Horizons have a Draft Action Plan (HAP) with 85 proposed actions which they are willing to bring to the 27 January workshop with back of the envelope cost calculations. These are all actions intended as ways to do things better. Improvements have already been made. There have been massive gains from reducing 800 discharges down to 200; a lot of work has been done on reducing and understanding the impacts of discharges; P and N balances for the catchment are underway; research has found N contributes to good water quality at high water levels. Horizons are proud of their science programme and know what the main issues are. The problem is how costs are going to be met and how much alternatives cost.

The question that needs to be asked is if we had $20m how could it best be spent? There is potential for PPPs, waste water to land as a nutrient etc. We can use the model to take a bigger look and help make decisions. The model is intended as a tool to help Horizon's communicate issues and determine how to get the best overall solutions.

Equity Issues

The work programme to improve the Manawatū River is currently underway, for example all Horizon ratepayers contribute to the SLUI project.

It is not intended to improve catchment water quality by forgoing the polluters pay principal. Polluters have a responsibility to get to a certain level but some things can be collectively decided. There are different levels of responsibility and action. The best solutions will depend on research and science.

Everyone contributes to the issue in some way and we will all benefit from having a cleaner river. How costs should be allocated needs to be decided. An example given was for dairying where if a new farm was being converted to dairying, polluter costs should be budgeted for. If a farmer has been dairying for 50yrs it may be considered unfair to impose new costs.

It is important to take a catchment wide perspective on costs and solutions so funding goes to the actions that can make the biggest difference.

Goals of the workshop

The MM workshops are about finding synergies between initiatives so we can gain from them. We are trying to put a number of different mental maps and budgets together. The different groups at the table all have their own long term plans. We have been informed about the 85 actions in Horizon's Action Plan that will be in place next year. Fonterra will also have their own Action Plan that feeds into business planning going forward. There is also on farm actions underway from what farmers are currently doing. Fish and Game have their strategic plan. Iwi have their management plans. And so on … The Action Plan from the IFS workshop wants merge these together to achieve something that is bigger and better than working individually.

We are trying to be courageous and do things differently for the river. We are progressing to thinking about funding issues, actions and the level of investment needed for the Action Plan. The economic aspects are always difficult and this is added to by having new people at the table.

Short term vs Long term tensions

The timeframe for decisions was a source of tension. Some stakeholders focused on ways to find improvement for the river here and now, whereas, others preferred to take a longer term view. The long term view was wastewater could be renamed 'asset water' to see how disposal could be an investment for the future. By changing thinking there would be positives for the river. For those looking at the long term availability of water actions such by bringing in composting toilets and reusing grey water were feasible options. These are big ideas require a long term research budget to explore.

A tension resulted from those interested in looking at options such as composting toilets (or other ways of reducing water use) and participants seeking more immediate concrete actions. For those seeking concrete decisions for the immediate future such discussions were considered "off track ". The pressure for immediate solutions was also felt by participants with senior people above them pushing for solutions.

Horizons Action Plan (HAP)

It was generally felt more knowledge of the potential solutions was needed for participants to make choices and prioritise. It was therefore agreed by the group that Horizon's present their proposed actions and priorities. Agreement reached was on the basis that people were "happy to see the cards but reserve the right to reject".

Horizons also made it clear they were likewise interested in what others propose for solutions. In terms of whether there was sufficient science to make a decision it was accepted that it was always going to be a chicken and egg situation. The Horizon's Action Plan stocktake of ideas was based on current scientific knowledge. Current initiatives underway cost around $4m annually. In the view of HRC 90% of the water issues of concern for the MRC were related to water quality and 10% related to water quantity/allocation.

Water quality issues of concern (90% of problem)

Non point sources

- Horizons is mapping 55,000 ha/year and funding 5,000 ha of tree planting for erosion control. In the SLUI project 500 farm plans are proposed and 364 have been completed so far. If all 500 plans are implemented this should reduce sediment to the river by 50% over 20 years.
- Sediment is a key issue as impacts on capacity to prevent flooding, turbidity and smothers habitat. Lots of Phosphate (P) comes with sediment. Horizon's consider it is just as important to deal with the P associated with sediment as it is to deal with the P in discharges to the river.
- There are 40,000 ha of land with no woody cover that needs to have it.
- Tararua project – have interest in fencing off 150 km waterways ($300,000 funding available)
- 10% of Nitrate (N) loss is from leaky effluent ponds. Other N loading from farms = fertiliser N, non-point sources (urine) and direct impact of stock in waterways.
- Wetland and Bush retirement – the overall target is 100 wetlands and 200 bush remnants being fenced off and retired from agricultural use. The annual target for wetlands is 10 per year which is currently being exceeded. The annual target for bush retirement is 20 per year. The current focus is the Tararua area where land owners are receiving subsidies to fence off these areas.

If there was greater funding the priorities would be to: employ more rural advisors, increase effluent discharge to land, check every farm every year for compliance and provide dairy farmers with pond size calculators.

Point sources

- Working with TLAs and industry to resolve consent issues. Currently get sampled up and downstream of discharge 12 times/year and organizations are visited 3 or 4 x per year. Need to resolve consents that have been on books for > 1 year. Always looking at ways to improve resource consent conditions.

Water allocation/quantity issues of concern (10% of problem)

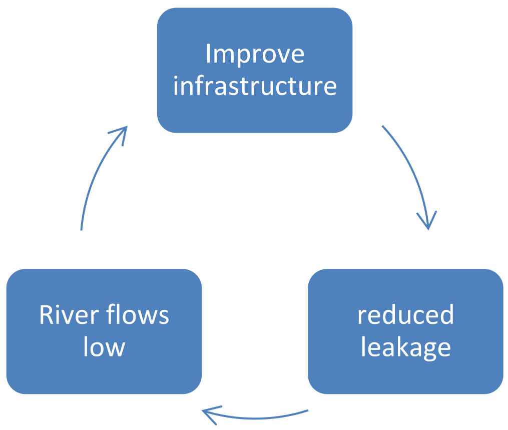
- Only 2 areas in the Manawatū catchment are currently over-allocated. Currently monitor 69% of water takes by meter.
- Fish stream requirements on all takes.
- The quantity of groundwater in the region is good this year.
- Irrigation is monitored. Water use efficiency tests are done for irrigators. Some irrigators have already been switched off this summer due to low river flows.
- Woodville and Dannevirke have built storage dams so they can reduce takes in low flow situations.
- The economics of storage are difficult as water storage is not needed every year. Investment costs are therefore spread over a long time period.
- Reality of resource consent is they are about allocating a scarce resource. Stock and people get first take. The allocation for some towns has been reduced. Allocation processes are improving. More work is needed on groundwater allocation issues. Infrastructure in some places e.g. small towns is leaking which district councils need to address to free up water for other more economic uses.

Discussion on HAP

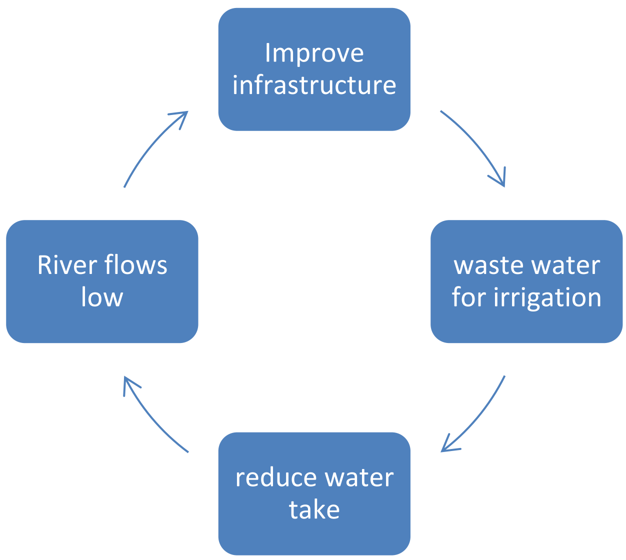
- Is there opportunity for the Accord group to have a role around water allocation and better use of waste water? Opportunity exists for input but Horizons has the legal mandate to manage the process.
- Do Horizon's charge for water? Only a monitoring charge as water is for collective use. Does charging require some regulatory change? This would require a high level input into regulatory process.
- If it is in the best interest of the Manawatū River to invest in Dannevirke water infrastructure why don't we all pay for it? We can use collective buying power to get the best outcome and benefit downstream. Proposed actions will go into the Draft Action Plan and this is where we draw the line in terms of acceptability.
- Different ways of prioritising - lots of resources into big issues or resources into many small issues
- 50 sites of significance for fish monitoring. Removal of fish barriers which may have a small cost (say $20,000) may have a big impact on fish numbers. 91 fish barriers and removal is a high priority. Horizon's is reviewing the fish monitoring processes and working with DOC and others to improve fish breeding habitat. Need to do a lot of learning. Iwi are keen to be involved. Disappointed about not knowing about research on the river recently in paper. It was explained the project had been underway for some time and the newspaper article was a way to share information about it.

- Horizons is releasing regular media information to inform people about the river conditions. Communication is via the media. After heavy rain Ecoli concentration are very high. There is currently no warning system for whitebaiters. This needs to be looked at.
- Is there a feel for how usable the river is? A clean and clear river is safe in most places. If it has not rained for a couple of days it is ok to swim in. For swimming and recreation there is a need to learn more about cyanobacteria management.
- A big investment has been made by Horizon's in monitoring. This is where the science comes in but there is a cost. In 2010 water quality monitoring in the Manawatū estuary started. The first report will be available late February. The scientists also hope to get funding for habitat improvement.
- There are annual vs seasonal problems associated with water quality and quantity.
- Foxton has already had trouble this year with farmers taking water from aquifers and drying up neighbouring bores.

Feedback loops in discussion:



Another option would be to fix up town water supply and use waste water for irrigation:



Action Points from discussion:

1. Other stakeholder groups at the IFS workshop were asked (other than main dischargers who have already been approached) to provide a summary of what they are currently (2010) doing to maintain water quality and quantity.

2. Any actions currently underway to improve river to be provided to the IFS team by the 14 January so they can be incorporated into the model.

Action Points

Action points from Workshop 3	By	When	Status
Provide list of effluent, nutrient, stock exclusion/ reduction measures etc (ball park) Identify what is underway at present and the likely impact. Identify possible new measures and their likely impacts	DairyLink and HRC	Before 27 Jan	
Provide list of sediment reduction measure. Identify what is underway at present and the likely impact. Identify possible new measures and their likely impacts	IFS team	By 27 Jan	
Science into model & actions	HRC	By end Jan	
Remind dischargers (follow-up) and ask for details of current spend	Richard	By 18 Dec	
Obtain from other workshop participants (not part of discharge group) what of their current spend/actions can they bring forward and possible future actions	All workshop participants	By 24 Dec	
Iwi to revisit engagement goals and put into model and Action Plan	iwi	By 27 Jan	
Jon and Marjan to work on science input into model	Jon/Marjan	By 27 Jan	
Trial run of updated model	All	On-going	
Jon and iwi to meet re iwi input into science and monitoring	Jon/iwi	On-going	

To be included in the Model:

1. Total economic value: indirect, direct and intrinsic need to be captured in the model (direct should include things like trout license, recreation)
2. Cost of intervention actions
3. Impact of actions
4. Opportunity cost
5. Cost of doing nothing

Estimated Costs of Actions:

1. PNCC land based disposal of wastewater $100m (less any benefits from ‘asset’ water)
2. PNCC running Phosphorous removal plant all year round an additional $1.4m (over the 4 month current cost)
3. Feilding waste water to land costs $10m

Integrated Freshwater Solutions: Workshop 4, 27 January 2011

What happened at the workshop on 27 January 2011:

The workshop focus was on:

a. The Action Plan and how to best progress it (notes below)
b. Getting a better understanding of what is happening at the sub-catchment level (separate document)
c. Specific actions to be undertaken by the following players: (1) iwi (2) environmental groups (3) Councils and industry, and (4) land-users (separate document)

The Action Plan and how to best progress it

The Contribution the MRLF can make:

- If the MRLF can give full support to the Action Plan going forward this show of solidarity has the potential to exceed the sum of what individual players can achieve.
- Endorsement of the actions that individual organizations are undertaking by including them in the broader spanning Action Plan will potentially provide more visibility to those actions and also engender greater community support. This is important even for actions already underway as without political and community support they may not receive the funding required to continue.
- All organizations are have their own actions underway as part of their regular strategic planning process. This will continue but the MRLF role is to integrate these to see if there are synergies.
- Actions already being undertaken by farmers and others need to be acknowledged. Environmental standards are increasingly being raised and this will continue. Farmers, industry and local government have made progress in terms of reducing point discharges to waterways.
- Communicating the Action Plan to the wider community and getting support.
- The MRLF acting as a united group, with a consensus driven Action Plan is more strongly positioned to approach central government or other organizations for funding.

Action Plan process going forward:

1. The IFS team will consolidate the current Draft Action Plan with the detail we have from Workshops 1-4. This will consist of a narrative around each issue and then detail sub-catchment specifics.
2. Richard Thompson will work with the Land use small group and the Industry and Local Government small group between Workshop 4 and Workshop 5 to flesh out greater detail for the actions to be included in the Draft Action Plan.
3. Iwi will hold a hui to discuss the questions proposed for the iwi small group in Workshop 4. A one hour plenary session will be included in Workshop 5 to bring issues to the wider workshop group.
4. Richard Thompson will organise a field trip from the start of the river to the coast for those who expressed interest.
5. The model will continue to be developed working with individuals between workshops. There was a discussion on how assumptions can change outcomes. The

example given was the skill level of anglers can influence the time required to catch a trout. Taking a longer time might not just be a factor of lower trout numbers. There needs to be an opportunity to look at the assumptions in the model and get agreement on these so it can be used to test different scenarios that will arise from the Action Plan.

6. A Draft Action Plan will be brought back to the February 24 workshop. If there are science questions that remain unanswered or are disputed then a Science Group will be convened by Richard Thompson to resolve these issues.
7. The Draft Action Plan will then go out to the MRLF prior to 24 March workshop to confirm that there are no issues of concern at this level. The process to date has been that workshop participants have been communicating with the appropriate people to ensure there are no surprises.
8. There is a public release of the Action Plan by the MRLF in April.

Getting a better understanding of what is happening at the sub-catchment level

The workshop discussed each of the sub-catchments to identify the present condition, the issues facing the sub-catchment and the targets for improvement. The comments are listed in the Subcatchment analysis document. Comments were based on anecdotal evidence. Horizons are currently preparing fact sheets for each of the sub-catchments. The following issues arose as part of the Tiraumea sub-catchment discussion but the points made are relevant to other sub catchments.

We need to get a consensus on what water quality is *acceptable* at various locations in the catchment. Is a definition of *acceptable* a state where we can swim, fish and being able to take food? The *desirable* state is people can take drinking water from the catchment without getting sick which would mean meeting the NZ drinking water standard. Iwi desire water suited for cultural purposes. It therefore needs to be "pristine" which means a zero tolerance of all pollutants. It is however, recognised the water quality goals for the Action Plan need to reflect the river runs through a modified landscape and that even prior to human settlement the lower river water was not suitable for drinking. All people and animals living and visiting the catchment contribute to its pollution. It is not possible to turn the clock back but it is possible to improve the water quality to a level we can all live with. Drinking water from any waterway in New Zealand is not recommended due to giardia.

Actions suggested:

1. Exclude stock from water ways. There is no accurate measure of how extensively this is done at present. It may be possible to start with a goal of 100 kms per year.
2. Reduce sediment – how this can be measured needs to be decided.
3. Provide access to the river for recreation so the river and tributaries become a source of value to the community.
4. Involve the community especially kids in riparian planting to increase ownership of the need for actions to improve water quality.

Workshop 4 Summary Small Groups

The afternoon session was split into four small group sessions (Iwi, Environment, Land-use and Councils and Industry) each assigned specific questions to answer.

Iwi

Questions:

1. Collaboration in governance has been identified as an aspiration of iwi. What could it look like in the Manawatū catchment under the current RMA and Local Government legislation? (We need to recognise that this process is not part of the wider treaty negotiations process).
2. What actions could increase mana and pride that have not, or may not be, captured by other proposals? Are there opportunities for additional actions specifically targeted towards mana and pride?
3. Is the Action Planning process meeting iwi needs? If not, what would improve it?

Iwi opted to not answer the questions posed. Instead they will have a one day hui before the next workshop hosted by Ngati Kauwhata. Section 33 of RMA and 7a and Schedule 10 of LGA provide for co-management and iwi want to explore how this can be incorporated in the Action Plan.

There is a need to decide 'what is an acceptable state for the river'. It may be that some parts of the river network need to be 'pristine' for the mauri to be intact but for others a lower quality than this is acceptable. If possible it would be good if the environment group and iwi worked together and came up with a joint agreement on an 'acceptable state for the river'.

Environment

Questions:

1. What actions can the environment sector contribute (or is already contributing e.g advocacy, monitoring)?
2. How should the Action Plan be formatted so it flows logically and is accessible and understandable to a wide audience?
3. Communication and community buy-in: How can we communicate what we are doing and ensure that the public understands and supports the eventual plan? This will mean considering how to get buy-in from farmers.
4. Is there anything else that this group thinks we should be addressing i.e have we got the focus on the right things?

Answer: Question 1

- State of environment monitoring – could be improved.
- Fishery monitoring – could be improved.
- Analysis of above for trends.
- Contribute to info and understanding (magazines, web,...).
- Advocacy.
- Holding an open forum with public to share info.

- Identification of places/projects for restoration, and on the ground assistance/ expertise.
- Providing speakers to groups.
- Communication and engagement plan.
- Participation/watchdog role in RMA processes.
- Able to bring in specialists.
- Can be a "conscience" for the River & MRLF.
- Wetland rehabilitation (is increasing).
- Advocate for and support reviews of existing consents affecting the river (common catchment expiry dates).

Answer: Question 2

Needs: (we support the "alternative suggestion").

- Clear outcomes at a high level.
- Different versions for different layers of engagement.
- Needs to be inspiring.
- Needs time frames (short, med, long).
- Needs to be able to measure progress of improvement.
- Be able to state what you're going to achieve, and by when.
- Be able to state who is responsible for delivering what (accountability).
- Actions targeted to both common issues and to issues specific to sub-catchments.

Answer: Question 3

- Catchment care groups → education, ownership, best practice implementation, recognition.
- Support for restoration/planting days.
- Link the river to "Green Prescriptions" for health and well being.
- Learning journeys →taking people to show them the river and issues.
- Work with Destination Manawatū to tell the story of the Manawatū.
- Magazines, web pages, media, schools.
- School curriculum, mesh what we do with it.
- Develop 'Communication & Engagement Plan'.
- All efforts need to be coordinated and communicated between all Accord parties.

Answer: Question 4

Advocate for appropriate funding to Central Government and NGOs.
Continue as an environment sector group.

Land-use

This covers mostly non-point sources, but includes minor point source discharges such as dairy shed effluent.

1. Does the material gathered so far include all the actions and proposed actions in this sector? If not, please identify the gaps and preferably initiate or at least suggest ways to collect this material.
2. Considering what we know about the agreed issues and condition of the catchments, and actions (existing or proposed), are there opportunities to do more? If so, please identify, cost and prioritise them?

Answers

- Hill country erosion is under control with SLUI and poplar planting
- Farm dairy effluent is ok. Mainly under control and tidying up last of problems. Deferred irrigation storage required on many farms.
- Stream fencing – still place for more gains. Need more incentives. Early adopters already in. Need to deal with the usual bell curve of early adopters, the great mass and laggers. The question is how to capture the minds of those who are lagging behind. The Clean Streams Accord needs tightening up. Reported numbers not verifiable.
- Education needs to be provided with a voluntary timeframe for implementation. Then implementation of stream fencing needs to be mandatory. This will require co-ordination across stakeholder groups.
- Non point run-off - the framework for action is there, but the targets need to be firmed up, debate around timing and roll out needs to be had. Sometime in future need to have cut off point and advocate for farmers to come in early. Nutrient management plans – need to agree on what the best method is. All dairy farmers have to have NMP. Bigger challenge getting compliance.
- Gaps in information. What is being spent by farmers and how this money is being spent. For example, there is no data on waterways fenced. A catchment by catchment survey of fencing by employing university students over summer break may be the best way to measure this.

Councils and Industry (point source)

1. Does the material gathered so far include all the actions and proposed actions in this sector? If not, please identify the gaps and preferably initiate, or at least suggest, ways to collect this.
2. Considering what we know about the agreed issues and condition of the catchments, and actions (existing or proposed), are there opportunities to do more? If so, please identify, and, if possible, cost and prioritise them?
3. Ways to address accessibility issues

Answer: Question 1

- Compliance of consents not covered. Progress requires regular review and action to deal with non-compliance.
- Gaps in material provided by Councils and industry on point source discharge. Information lacks detail, lacks definition and no standard format for analysis. All MRLF and workshop members need to fill in gaps, note other gaps and suggest ways to collect information.
- Contaminants – wastewater and industry
  - Primary – N, P, Bacto and DO/BOD
  - Secondary – Oils, Greases, Paints
- Stormwater (Cu, Zn, N,P, Bacto)
  - Education
  - Engineering
  - Enforcement
- Current position we are in is one of ever increasing environmental regulation. New regulation needs to be:
  - Appropriate
  - Based on good knowledge/sound science
  - Not creating another problem when trying to find a solution

Answer: Question 2

- TLAs meet to share knowledge. An action for the Action Plan could be to set up a TLA Officers forum.
- Industry forum to share knowledge? An action for the Action Plan could be to set up an Industry forum.
- MRLF to lobby central government for more support for environmental funding and community schemes such as the Incentives Community Assistance Programme (CAP).
- Stormwater – First flush capture (shown to be expensive for results). An action for the Action Plan could be to make mandatory water sensitive urban design for new developments and daylight drains where appropriate.

Answer: Question 3

- Accessibility for walking, cycling, and the disabled can be improved with walkways and toilet facilities. Also the provision of information boards, signs, history etc to increase public appreciation and build community values.
- Dischargers have open days so people can see impact of sewage etc. PNCC has wastewater monitoring meetings twice a year.

Other: The question of impacts of pesticides in both urban and rural areas was raised. This may be an important issue around Levin where intensive horticulture is practiced.

Integrated Freshwater Solutions: Workshop 5, 24 February 2011

What happened at the workshop on 24 February 2011:

Horizon's data

Horizons provided the following information in poster format for the workshop: (i) Ecologically significant sites in the catchment; (ii) for each subcatchment a summary of monitoring data. The results were presented in coloured bars. For example, for Nitrogen loading measured against set targets; Red = <40% achieved; Orange = 40-60% achieved; Green >60% achieved. The data came from 63 different sites in the Manawatū catchment. An additional five sites will be monitored from March. The information provided on the posters will be on the Horizons website first week in March.

Mediated Model

Understanding trends over time and how trends interact, is where the modelling work may help us going forward. Scenarios from the MM-IFS model were presented:

Scenario 1 – SLUI programme as currently planned and with actions brought forward in time.

Scenario 2 – Nitrogen leaching under status quo and new initiatives with a baseline of continued growth in dairy cow numbers. This showed that under the current growth projections used as assumptions in the model, the proposed actions may not lead to improvement but prevent the situation from getting worse.

Question: Nitrogen and Phosphorous nutrient loss encourages algae growth but is it toxic too?

Answer: Not as far as stock drinking it is concerned, but can become toxic in algae and thus become fatal to fish. Some locations are experiencing this toxicity. The blue-green algae can be toxic to cattle. HRC started sampling in January on a weekly basis to see how toxic certain stretches of the river catchment are.

It was agreed that the IFS team will endeavour to play out more scenarios based on the submitted actions to give the groups some idea about the likely impact prior to signing off on the Action Plan.

Iwi Presentation

Iwi expressed they were feeling increasingly uncomfortable in the workshop group and marginalised in terms of how things are going. Iwi prior to this meeting had a hui to ratify they were all still speaking with a united voice. Four Goals with Actions associated were presented to the MRLF at the outset of the process. These are still agreed on. They are:

1. Maintenance of the Spirit of Okatia.
2. Enhancement and re-establishment of cultural areas of significance eg mahinga kai.
3. Enhancement and re-establishment of natural communities alongside the Manawatū River.
4. Enhancement of community awareness of all cultural values of the Manawatū River.

While there is a resonance between iwi and the collective workshop goals iwi do not want their contribution to go unrecognised.

The need to sustain, maintain and grow partnerships was expressed. The Accord was always established on the basis of community involvement and partnership. Iwi have a sense of pride and satisfaction about what they are trying to achieve and the final document must reflect we are working together.

The IFS project has three iwi research initiatives.

1. Rangitaane is looking at how to develop their co-management aspirations. This will feed into later workshops.
2. Ngati Kauwhata is working with Massey University on water monitoring at the confluence of the Oroua. Russell Death to assisting to develop good monitoring skills.
3. Muaupoko is looking at shellfish on the coast. The intention is to get hapū together to learn the knowledge their whakapapa were aware of.

Te Kauru is not part of the IFS project but interested in monitoring and measuring toxin levels in species.

The Action Plan

The Draft Action Plan was provided a day before the workshop for people to read. While it was generally agreed that it captures the essence of what the workshops are trying to achieve the point was reiterated that everyone had to be happy with the contents and there should be no surprises in it.

1. The Action Plan will go to the MRLF on the 15th of April. They will make the formal release to the public.
2. Plan Format:
   a. Priority actions will be the main part of the plan. They will be ranked 1, 2, 3 … etc. A named person/s will be responsible for seeing each action is carried out.
   b. Additional Actions – can go into the plan if there is a name/s responsible.
   c. Supporting Action and Solutions including “Aspirational” ideas will be in an Appendix.
3. Every action in the plan needs a name against it for who is responsible for carrying it out. It will be a commitment by the MRLF to get the actions approved so the political process will be part of it.
4. Iwi and the Environmental Group both produced a list of goals for the Action Plan. It was felt that long-term visions or aspirations should not be left out. These will be included under (c) “Supporting Action and Solutions” so they are not lost sight of. In subsequent Action Plans it may be possible for them to be brought into sections (a) or (b).

5. As MRLF will have to commit to Action Plan they will need to make provisions in future Annual Plans for funding purposes. Getting actions into the draft annual plan for 2011-2012 will not be possible. The goal now is for inclusion in the Long term Plan which will be produced in 2012 for the next 10 years out.[8]
6. The Action Plan should provide ball park economic costs if practicable.
7. Timeframe for when the river is cleaned up will not be set. Individual actions will have target times set against them.
8. Indicators need to be linked to the sub-catchments rather than total catchment. Birds (as they are migratory) and eels (as their fishery collapsed some time ago) are not suitable. Trout is a possibility.
9. The Action Plan document is likely to have a couple of different levels:
    a. The full document to go on the web
    b. A summary 3-4 page version for the public

<u>Action Plan Structure</u>

Mine	I do	I lead
Joint	We do	One (or both) leads
All	We all agree/We all do	One (or several) leads

Note: Joint and All incorporate other's ideas and involvement by agreement.

Changes to be made to current Action Plan	**Partnered/Promoted by**
Add catchment care groups to the physical and biological tables	Fed Farmers/Kaitiaki groups
Wetlands and water harvesting. Paul Horton to refine wording and find an owner for this action.	
Resolve all consents within a set timeframe (refer to mayors group meeting)	HRC
Commitment to on-going exploration and use of appropriate knowledge, science and technology to enhance quality of discharge to the river (refer to mayors group and industry meetings)	
Merge communication and other actions	
Communication of the Action Plan could be assisted by the Vision Manawatū/Destination Manawatū communication forum.	Vision Manawatū/Iwi
Te Manawa , video, demonstration stream to go into "Supporting Action and Solutions" until owner found	
Iwi information day	Iwi/HRC
Trout monitoring/CHI	F & G/ Iwi
Remove F & B estuary monitoring	
Include native fish in biological indicators on triangle diagram	

Communication section of Action Plan

[8] This is an added note for information on the Annual Plan and 10 year plan timeframes and was not discussed at the workshop. In general terms the planning process follows the following annual timelines:
September through February - preparation of draft for council's consideration. This is an important phase for stakeholders to place proposals before council officers for consideration of inclusion in the preliminary draft. The further the development of the plan has progressed the less possible it becomes that a proposal will receive consideration for inclusion in the next Plan;
February through May - Council considers and approves Draft Plan for public consultation;
May through June - Council hears/considers submissions and approves Plan.

One of the challenges is we have a very big catchment, with different problems in different sections. The challenge is how to get this group to understand it, and then to get the wider community to understand it.

What is currently happening needs to be covered. For example, Horowhenua District Council is progressing with:

1. Considering land disposal for Foxton
2. Floating wetland experiment at Shannon
3. Continuation of land disposal for Foxton Beach
4. Wetland at Tokomaru with ring fencing to exclude more connections
5. Promoting RAMSAR wetland of international significance at Estuary

Progress reporting on change in the condition of the river is to be part of communication plan.

Expert Science Group Meeting (16 March 2011)

It was requested that the science group include a social scientist and woman to be more representative. As the questions pertain to water quality, targets and measurements a social scientist was not considered needed. A woman/women scientists would be invited to be representative.

Possible question are:

1. Is dissolved oxygen a pollutant or an indicator of ecosystem health? How effective is it as a measure of river health?
2. What is the interaction between introduced and native species. If we remove fish barriers, will trout get upstream and damage native fish populations?
3. Effect of introduced species on algae grazing – does trout eliminate natives which normally would be grazing the algae?

What's happening next:

1. Mayors meeting.
2. Further refinement of actions, dates and resources by Land use , Environmental and Iwi groups.
3. A revised copy of the Action Plan will be sent out in about two weeks for comment on. It will include who is going to do things, by when.
4. Science meeting – questions are welcome.

Table B 1: Summary of sub-catchment issues from HRC and workshop participants

Catchment	Condition	Issues	Targets
TIRAUMEA	• Predominantly hill country. Mainly sheep and beef in hill country • 10 dairy farms. • Makuri has water conservation order.	• Makuri issue with N • Sediment P – highest of sub catchments. Big issue at high flows. More P on average than rest of river predominantly from sediment. Geology rather than LU • Priority for SLUI • Makuri valued as trout fishery ▪ Numbers stable in drift dives ▪ Sediment on natives in drift dives ▪ Riparian clearance impacting on habitat ▪ Stock in water • Very few irrigation takes • No point source	• Community access to river for recreation. • Stop removal of riparian margin. • Stock excluded from water for x kms of stream • Reduce sediment. Is a priority area for SLUI. Total SLUI plans for MRC= 80. About third here. • Acceptable State = swimming, fishing, taking food • Consent compliances
UPPER MANAWATŪ	• Some good water quality • Significant trout fishing • Some public water supplies (about 5) • 2 wastewater discharges • More dairying and intensive farming • Demand irrigation • Steep headwaters in forestry • Different geologies in sub-catchment	• Fully allocated – been so for years. Fully monitored • Waste water discharges – Dannevirke, Norsewood • N and bacteria big issues • N,P, Sed & Ecoli. Water quality declines as you go downstream • Stock N, P impacts • Sediment is significant • Habitat loss • Historical Oringi leaching through land still taking place. High concentrations of N?? • Negative trends for subcatchment • Intensification of farming • Cynobacteria	• Point source • N • Ecoli • Allocation • 100% stock exclusion from waterways • Consent compliances

Catchment	Condition	Issues	Targets
MANGATAINOKA	• 2007 upgraded discharge monitoring • Toxic blooms from low flow point sources and non point high flows	• Point source discharges (Eketahuna, Fonterra, Pahiatua, DB) • N, P • Low summer flows = High temps and toxic blooms • Fully allocated • Low flow impacts from point source • NPS non-point in high flows • DB actions tied to resource consents • Actions for all dischargers tied to consent processes. Dischargers are aware conditions tightening and raising of the bar. Ability and willingness to speed up is the issue of concern. • Significant LU change in last 20 years	Consent compliances
UPPER GORGE	• Hydro take • Pretty good water quality • Water quality improves in upper gorge • Much is forested	• Woodville – discharge – intake	• Possible benchmark conditions to aim for in other subcatchments? • Consent compliances
POHANGINA	• Low abstraction • Good swimming • No point source • Limited data but seems to be stable trout fishery • Native fishery not good in lower. • Waahi tapu site • Recent discovery of new fish species not known in Pohangina River • Glow worms	• River management impacts on habitat. • Bank erosion • Sediment in high flows impacts visibility • Historical habitat loss (wetland). Valley floor used to be wetlands. Swamp forest gone so habitat disappeared. • Riparian work focussed on erosion. Less being done as now not funded by Horizons • Could also target habitat • State of Ruahines with large trees dying could impact on this catchment? • N and P impact from geology. Less P impact (due to soil type) • Eel fishery collapsed (early 70s onwards.) Used to get 1/hr now 10 days for 3. Commercial eeling in 70s and 80s. Wetlands drainage removed breeding ground • Bed movement.	• Is a priority area for SLUI. • Riparian work focussed on erosion. Could also target habitat. Willows outside of bends. Native inside. • Consent compliances

Catchment	Condition	Issues	Targets
OROUA	• Trout lost but recovering • Water good to Fielding though farmed • Recovering Whio in upper • High MCI index upper	• Major point source with large impacts (Feilding big impact; Affco smaller) • Town water supply (Feilding) • Fully allocated – under pressure • Unstable-bed movement. • River management. Flood protection causing sediment • Non point nutrient load. • Fielding effluent to PN? • Intensive agriculture – dairy and cropping. • Eel fishery collapse • No fish south of Awahuri bridge • Septic tanks • Consent compliances (applies to all sub catchments) • Highly modified/channelled in lower river • Sedimentation high • High Ecoli	• Is a priority area for SLUI. • Consent compliances

MIDDLE MANAWATŪ
 	
Gorge to Fitzherbert Bridge
	• PNCC water supply from Turitea
	• Dilution from good water upstream improves water quality. Water quality better than Hopelands and Mangatainoka from dilution from cleaner sources. Wide river bed strips out nutrients.
		• <u>Cumulative impacts</u> – includes “culturally corrupt”
		• Shannon water quality
		• Flood protection schemes
		• Storm water
		  • Risk of spills/contamination from toxins
		  • Solid wastes (plastic bags etc)
		  • Faecal contamination
		• River can have high temps due to hydrology
		• Ashhurst – wastewater (possibly minor)
		• Weed growth
		• Volatile and growing population
		  • Increased P
		  • Stormwater impacts from domestic and trade
		• Possible flushing effects - volatile flows
		• Intensive farming
			Consent compliances

Catchment	Condition	Issues	Targets
LOWER MANAWATŪ	• Substrate change in river bed – different ecology. Change from gravel to sand has impact on periphyton	• Cumulative impacts – includes “culturally corrupt” • PNCC discharge most significant (includes Linton & NZP). Inconsistent P extraction. P, N, Bacteria have high impacts • Landfill leaching • Longburn discharge to PN? (relatively minor) • Fonterra – winter discharge • Gravel extraction • Heavily channelised – loss of natural character esp streams in urban areas • Storm water – Ashhurst, PNCC • Intensive farming	Consent compliances
COASTAL MANAWATŪ	• Tidal	• Cumulative impacts – includes “culturally corrupt” • Shannon & Foxton discharges; SFF tannery discharges. More N, P, Ecoli but proportionally low • Significant decline in shellfish in estuary and southern coast (also other contributing factors) • Whitebait decline (water quality) • Historical loss of wetland (whole area used to be wetland) • Significant native fisheries in decline or gone due to water quality, habitat loss and loss of access due to barriers • Hydro discharge & abstraction (flow impacts) but provides recreation benefits • Intensive farming • Debris causes of sand dune formation	Consent compliances

Integrated Freshwater Solutions: Workshop 6, 24 March 2011

What happened at the workshop on 24 March 2011:

1. Actions that had taken place between meetings were reported on
2. The Draft Action Plan was reviewed
3. An update of the progress with the mediated model and information about a new project for a Common Asset Trust were presented

<u>Actions undertaken between meetings</u>

The Environment Group met and came up with 15 actions. These were merged with iwi/hapū actions where there was a cross-over. There was no specific meeting of the Land use group though Federated Farmers are taking the lead on some actions. The Mayors' group met and Council staff were delegated the task to provide information on what is currently done or proposed to improve water quality. All Councils have sent something back except for Manawatū District Council. The Industry group did not meet, but Affco, (who were initially missed out) DB, and Fonterra have sent through some actions. Silverfern Farms still have actions to come. The Science meeting took place and the minutes are available.

<u>Review of the Draft Action Plan</u>

Timelines

Lack of timelines was seen as an issue for the Action Plan. Some workshop participants regarded timelines as essential to determine whether or not the Action Plan was achieving its purpose. Others felt that providing timelines was pointless and would destroy trust as the workshop group was not able to ensure timelines were met. The Operative Water Quality Plan produced by Horizons Regional Council in 1998 is a good example of this occurring.

Iwi Working Relationships

Desire was expressed by iwi to strengthen relationships with both regional and territorial local government.

Iwi are keen to work with HRC on flood protection plans. This has been done successfully in the Hawke's Bay Region. Tangata whenua see themselves as hosts and want to protect property as well as river ecosystems. Cuts in the Manawatū River and the use of willows are also issues of concern. Iwi would also like to ensure waahi tapu sites are not damaged by protection schemes.

Iwi boundaries

Iwi are divided between those who want iwi/hapū named specifically against actions in the Action Plan and those wanting it left generically as iwi/hapū.

Catchment Care Groups (CCG)

It was decided to merge the idea of a Customary, Conservation, and Recreation Fisheries Management Group (CCMCG) into the proposed Catchment Care Group. It was accepted that landowners need to be involved since any group without them is not likely to succeed.

As Federated Farmers members are volunteers with limited resources, setting up Catchment Care Groups for all the sub-catchments would be too ambitious. Instead it is proposed to set up a pilot CCG in the Tararua area as this has been identified as having the greatest need. The exact location would be determined by where the most impact would be achieved and the degree of community willingness. Once up and running the organisation of the CCG would be handed to locals. All landowners, forestry and community/iwi/hapū groups would be invited to participate. WEKA and other existing groups are a good place to start.

Lessons from the pilot CCG and information on funding sources could be used elsewhere. A parallel urban catchment care group could be established by iwi/hapū/others. One iwi would like to take the whanau ora approach and just get going due to concern about the mauri of the river. There is scope for several groups to be leaders. An example was cited of a small stream near Hastings where rehabilitation had been done in strips of 800m each. Strip 1 was the regional council, strip 2 and 3 community led, strip 4 and 5 iwi/hapū led. Progress each year was based on affordability.

Whether or not the Action Plan should include an action for evaluating the pilot scheme, who should lead this and how to take the CCG further was discussed. The preferred process is to get started at grass root or flax root level and then see if it is possible to tap into HRC processes and funding. Issues remain around funding and priorities. HRC might not be able to fund, but is willing to provide advice. It is better if groups bring projects to HRC than the other way round. The community needs to be organised first, otherwise it is a struggle.

Resource Consents

Some existing consents have expired and are still operating. Feilding's discharge consent expired two years ago. There are others that have been expired for up to 10 years. While this is legal provided the discharger applied for a new consent before the old ones expired it was felt that those who complied with consent requirements should be recognised.

The compliance goal was intentionally included in the Action Plan as there appears to be a general attitude 'close enough is good enough'. Unfairness becomes an issue when industry and farmers get prosecuted for breaches when TLAs do not.

Tighter review conditions were considered. Other regions in New Zealand used 'shall' be reviewed rather than 'may' be reviewed more regularly. Every month, 30 – 40 consents come up with the opportunity for review. Reviews are very strict and limited in scope. When consents can be 10 years overdue many workshop participants felt that it would be good to have compulsory reviews.

Economic Indicators

An action around exploring economic indicators for regional prosperity was requested because of the link between the economy and environmental expenditure. The contrasting view expressed was the environment underpins the economy so whether it is growing or not is irrelevant. The objective is to protect the river and environment.

Earthworks

PNCC have a new earthwork bylaw. All of the workshop groups should promote the need for good earthwork practices. If this is re-enforced it will have more impact. This can be done through our relationships, ratepayer notices, etc. An approach will be made to Sheep and Beef NZ to endorse this action as it is mainly in the hill country where the greatest problem is.

Expert Groups

In the Wairarapa, Greater Wellington have been successful in bringing different expertise together to look at improving the quality of discharges. It has been found that consent applications are much better when this is done. There are already some groups in the HRC region e.g. Shannon and Palmerston North Wastewater group. While it was accepted these groups work well, whether their formation was a HRC or TLA responsibility was unclear. HRC are willing to provide expertise.

Integrated Freshwater Solutions: Workshop 7, 1 April 2011

Workshop 7 was required in addition to the six originally planned workshops in order to finalise the wording for “OURS: The Manawatū River Leaders’ Accord Action Plan” that went to MRLF on 8 April for signing off on 15 April 2011.

Whose Bang for Whose Buck: Workshop 8, 2 November, 2011

The presentations from the day are also on the website.

Cost Benefit Analysis (CBA)

1. Cost benefit analysis was done for 5 different actions as per the handouts provided. Participants agreed costs from the Waikato study were acceptable to use. The difference in capital costs would be insignificant though the Manawatū region is possibly more sophisticated in pond storage.
2. Reduced water treatment costs would benefit places that extract water from the river and are required to treat this to drinking water standard.
3. If we can determine where the cost and benefits fall for the catchment and allocate funding accordingly this may make more sense than individual local initiatives.
4. Waikato study showed that some farmers didn’t have enough income to pay for the actions but benefits to the wider community justified these actions. Focus in the study on how to make the mitigation strategy work *and* protect people’s livelihoods. Farmers were involved in the process.

5. For the Waste Water Treatment Plants (WWTP) options looked at in the CBA. The PNCC $20m budget is thought to be mainly dedicated to asset renewal rather than improvements. Not all investments listed will improve water quality to the river. IFS team need to put some effort into establishing what proposed investment benefits will be. The benefits of improvements in WWTP are difficult to quantify. Some of the percentages can be obtained, e.g. phosphorus 95% under certain conditions – but you need to know the relativity of numbers. Dannevirke as an example would give us more recent numbers but this is one data point not cumulative information.
6. Asset value of wastewater provided by a Lincoln study. The point was made that you also need a market for wastewater.

Economic Impact Assessment (EIA)

1. This analysis shows the impacts on the different bundles of actions on value added and employment from an economy wide perspective. Linkages within the economy and the multiplier effects are analysed. As an illustration; if logs are exported there are few added benefits for the national economy whereas sheep and beef farming or dairying with the processing component done in New Zealand have a significant value added component.
2. EIA does not look at debt and foreign investment. It does not measure the value of change in Balance of Trade from primary production for the NZ economy.
3. The financial ability to pay is not analysed. This is a separate process. EIA does show how the money in the economy is reallocated as a result of the 5 different options worked through but does not analyse where the money comes from to get outcomes.
4. In the Waikato non-market benefits (social, cultural) were not included. There is no exactness in numbers but always a range. The selection of activities should be based on cost abatement curve showing what gives the best bang for buck.

Cost of Actions

1. The costs of the actions required are much greater than funds available.
2. The cost of doing nothing has to also be measured/determined as it could be much greater than anticipated.
3. People need to be made aware of the benefits of better water quality and support the reprioritising of expenditure. For example, paving stones and clock towers dropped for better water quality.

Manawatū River Leaders Forum (MRLF) process

1. The Draft application to MFE freshwater fresh start fund circulated did not include a project with cultural significance to iwi.
2. The river clean up pressure in Waikato was from tangata whenua. Two participants who had been involved in the Waikato project felt the MRLF/IFS approach was better than the Waikato process. While there were more resources available in the Waikato, agreement was still not achieved on what the specific actions should be done. The Waikato tribes want to be in harmony with natural environment which developments such as hydro dams etc do not allow. The goals for the Waikato River are drinkable and swimmable water, similar to the goals for the Manawatū.

Interesting Ideas Generated

1. Subsidising a local detergent that is Phosphorus (P) free may be cheaper option than improving the WWTP. For most communities in NZ P is not a problem as is it is not the limiting nutrient in coastal environments. Using P free detergents would produce a behaviour change at the start of the process rather than a need to clean up pollution at the end of the process. Participant would like to see a gift package that is MR friendly. Ideally, it would be best if a company like Unilever would make cheap P free detergent. If the detergent was to be subsidised by PNCC, the council would have to increase rates to pay for this. However, there may be considerable savings from not having to run the P removal plant at a cost of $0.5m for 4 months of the year.
2. Local currencies to keep money in the community (Note: Ashhurst have already set up such a system).
3. Turn town waste water into an asset. Irrigating wastewater to retain nutrients. Anticipate peak phosphate. Note: MAF study in Wairarapa see http://maxa.maf.govt.nz/sff/about-projects/search/10-110/index.htm
4. Carbon trading was seen as a risk at the moment with the economic crisis in Europe (Note: Australia have just brought in a carbon tax of $23/tonne)

Flood protection

To provide flood control and drainage there is a Horizons budget of $110m for the 2009-2019 period. While there is an economic benefit from preventing flooding there is also an ecosystem services cost. There is a need to reinstate some of the natural river system including water pools to improve river health. Horizons are part of the Green Tiki movement in the Rangitikei which is a move in this direction.

Creative solutions for sediment targets:

- Decrease focus on land engineering as the fix is not whole of system approach (LT)
- Increase soft engineering (ST) solutions, such as reinstating meanders and loops, erosion buffers through wetlands, riparian planting and enhance SLUI. Such options are more sustainable and provide better aesthetics.
- Decrease of funding for SLUI means it will now be over 10-15 years period rather than 10 years. This will have a potential impact on flood protection costs.

Setting Targets for the Cost Effectiveness Analysis Approach

1. There are no targets set in the Action Plan. These are important to measure if achieving desired outcomes.
2. It was felt that the environmental limits in the One Plan were acceptable. If these limits are not enough they can be reset. One Plan has N and P targets for each subcatchment (N levels are in One Plan Section D). RC staff would need to translate One Plan targets into model targets.
3. What percentage of streams in region need to be fenced to meet targets?
4. The Freshwater NPS has a different set of definitions and no agreed targets yet.

Ecosystem Services presentation discussion

1. Not only environmental statisticians poorly represented at Statistics New Zealand. There are no environmental health statisticians.
2. Biodiversity is not really bad in urban areas. There are lots of non- natives but these still provide biodiversity. The issue is more about the large impervious areas.
3. One participant thought that there is a breakdown in the loop between ‘Evaluation ->Policy and Management’ rather than ‘Policy and Management -> Natural Capital’. The short-term political cycle is divorced from the long-term adaptive management cycle. The public needs to be informed as politicians reflect what the public wants.
4. Public ownership of ecosystem services can result in a ‘Tragedy of the Commons’ situation. Under the current system payment is for the allocation process not the water itself. Power of a Common Asset Trust framework is the reinforcing loop that goes back to enhance the river system. Currently there is no reinvestments as ownership is not determined. Iwi have different ideas on ownership of water and movement of water.

Where do you want to go with the IFS project?

This section is more detailed to guide the project going forward.

Firstly, should we pursue the model? If yes should it be as an academic exercise? For story telling? Or engaging with stakeholders? Secondly, do you want us to come back to you with a polished product? Overall the model structure is there. It needs more refining to tell a story and answer questions but is there a need for a model to do this? The MM process is not to build a model and then convince people to use it. No clear answer was given to whether the model should be a desktop academic model or a stakeholders participatory model.

Possible uses suggested by participants:

1. Mediated modelling could be used by the Manawatū River Leaders Forum (MRLF) to provide an adaptive approach and follow through on actions. The first step is to know if MRLF wants the model to help inform them. Should we promote the model at the MRLF meeting 16/12?
2. From an RMA approach the model could be used to communicate science but commissioners would need to be prepared to learn how it worked. Currently the Environment Court system is not flexible enough to use MM but the process is getting better.
3. Test out the effects of reducing cow numbers.
4. There have always been two parallel processes with the MRLF and IFS coming together for only as long as beneficial. What is needed is to see the bigger picture. Will the actions get to where we want to go? Will the costs be much higher than budgeted for? If so how do we communicate this message?
5. If we could answer questions such as “Is it better to put dollars into WWTP upgrades or riparian planting upstream?” this would be a good use of the model. [Note: Is this more specific than a catchment level model can deal with?]
6. MDC, TDC and Horizons could use the model to look at what plants to build for point source discharge.

7. Can we get the most impact for the river by pooling available funding/resources in the region and applying them to the solution with the greatest impact?
8. The model could be used for target setting and how to reach them. If we don't have targets how do we know when we are successful?
9. Most solutions are about treating rather than prevention.
10. A prioritised list of actions is required. The model could be used to detail the actions, show the synergies between solutions, capture feedbacks and evaluate options. When people stop reacting we have the final list.

Actions for the Day:

M. McCartney to provide the final MFE 'Fresh start for Freshwater' application to workshop participants.

Account-ability for Collaboration: Workshop 9, 6 June 2013

Executive Summary

The Integrated Freshwater Solutions (IFS) research team organised this workshop to provide an opportunity to reflect on the 'ability to account for collaborations' and provide a space for the stakeholder community to come together to reflect on the achievements of the MRLF and the Action Planning and Implementation. The aim was also to think about Monitoring systems and how to align outcomes with the Vision and Goals of the Accord. The morning session focused on progress and the changing operating context. The afternoon session reflected more deliberately on a range of available assessment tools.

Throughout the workshop we aimed to record 'common ground'; i.e. statements all participants agreed on. Similarly, 'parked issues' were recorded to acknowledge important ideas that required follow up. This summary first provides the 'common ground and parked issues' as the highest level of agreement/disagreement. This is followed by detailed narratives of workshop discussion, outputs from small group discussions answering specific questions, and results from feedback on one of the models presented during the workshop.

Common Ground from Morning Plenary Session

1. Collaboration needs to be adequately resourced by government and members within the group.
2. All group members need to be treated as equals in the collaborative process.
3. If you are involved in collaboration and it is not your paid job, it is a struggle. Volunteers need support.
4. Maori have a kaupapa on how to interact in a group which needs to be followed. Respect for this and time needs to be allowed for Maori and (others if required) to work through their 'kaupapa' as part of any collaborative process.
5. Collaborative workshops provide a means for deeper thinking and thereby add greater value than a forum.

Common Ground from Small Groups Morning Session

1. Evaluation is an important part of the collaborative process. Report cards were suggested as a way of assessing progress.
2. Honest feedback is needed on outcomes so the group can support those not achieving. The trust built in the group makes asking for help possible.
3. Honest communication of progress is important. There is a need to communicate technical information in a way that can be understood. Communication is part of education and awareness building and requires utilising various media types to involve/reach many people.
4. Goals need to be revisited (every 2 years) as part of collaborative process to ensure relevance and bring new people on board. The vision of 'our healthy river' should hold.
5. Capacity to collaborate is important (volunteers time, money, people with the required skills e.g. facilitators, iwi, government, Non-Government Organisations etc)

Common Ground from Small Groups Afternoon Session

1. Visualisation and story-telling are important to communicate the river story
2. Interactive models can articulate the benefits of different strategies
3. Wananga/Education/Monitoring tool kits are ways to learn
4. Base data and a level of knowledge are needed at the outset
5. Guidelines for collaboration are important
6. User friendly language is required. Non-technical but not dumbing down; no jargon
7. Environmental levies are an option

Parked issues for the day

The flood of 1880 was the worst experienced in the Manawatū. It should be established the extent of forest cover at the time.

Summary of Discussion

This summary documents the responses of stakeholders to the 'Account-ability of Collaboration Powerpoint Presentation' material provided during the workshop.

The objective of the morning session was to identify the gains generated from collaboration and address the challenge of Account-ability. Account-ability- to whom or to what and in what way - is the question. One assumption/interpretation made by IFS and therefore discussed by the participants, is as the Ministry for the Environment (MfE) is seeking to institutionalise collaboration and rigorous economic evaluation the MRLF/IFS workshops have the potential to provide insights for the rest of New Zealand.

The focus of the afternoon session at the workshop was the various tools developed during the IFS project, some of which are on the MfE agenda. The pros and cons of their use was reviewed based on the experience of the workshop participants.

Ministry for the Environment (MfE) Framework for Freshwater

The MfE framework for collaboration was presented (National Objective Framework – Appendix 1). The iwi response was, for them, the framework is incomplete as the freshwater system is connected to the coastal system and this was not shown. Iwi, therefore, see the process differently from MfE and the question was asked about the role of iwi in Freshwater Reform 2013 and beyond. Participants familiar with the MfE process thought that MfE is clarifying iwi involvement and the role of iwi. RMA reform has big implications for freshwater and the MfE discussion document has to be considered alongside the RMA reform documentation.

MfE Clean-up fund

It was pointed out there is a discrepancy between what was agreed on through collaboration and in the Action Plan (AP), and what was funded by the Clean-up Fund. Funding went to:

1. Wastewater treatment (bulk of funds)
2. Stream fencing on Sheep and Beef farms. Horizons Regional Council has 110 km signed up and more fencing is being done under SLUI. In addition Horizons Regional Council is working with Fonterra doing planting, Massey University, the Defence Force and Tanenuiarangi Manawatū Inc in specific locations.
3. Whitebait restoration. The spawning area at Whirokino Bridge is the biggest in NZ. Foxton community group is doing great work also, especially for whitebait.
4. Fish Barriers - co-funding has been received to fix six fish barriers. Projects put forward for Clean-up funding have to get a third or more co-funding but are typically getting half.
5. Environmental farm plans for the Mangatainoka area. 80 out of 90 farmers have signed up for plans.
6. Community involvement – 10 projects underway in first funding round and going well. Community project about the river in the Reel Earth film festival.

It was stated that the Clean-up Fund has allowed a ten year work programme to be consolidated into three years. The bulk of funding went to point source discharges and Mangatainoka farm plans. It was noted by all present that the Councils that got the most funding were not in attendance at the workshop. The participants reflected on the notion that MfE now realise that community monitoring is a project important to fund. The reason given for the Clean-Up fund including additional projects to those in the AP is many AP projects did not meet the MfE funding criteria. This illustrates the need for consistent vertical integration when promoting collaboration. Central government support needs to align with collaboratively agreed decisions.

Nitrogen Leaching and Ecoli

The interaction between point and non-point source discharge needs synergetic solutions going forward. The point sources being addressed will give improvements. It is anticipated that if Dannevirke wastewater issues are resolved this will have a big impact. Dannevirke and Kimbolton show up as spikes on the Horizon's graph because of the relative size of the receiving waters. Palmerston North remains the biggest point source discharger in absolute terms. Bacteria is improving with fencing but EColi readings at Foxton remain very high (13,000). The point was made that complying with consents might not be enough to achieve the Accord Goals as most Nitrogen leaching in the Manawatū Catchment is from land-use.

Environmental Farm Plans (Nutrient Management Mangatainoka)

There are 24 Environmental Farm Plans completed. Only 3 can meet One Plan limits in year 1 and none can meet the 20 year limit. The 4th goal of the Accord is sustainable use of the land and water resources underpinning economic prosperity. If One Plan limits prove unworkable a suggestion was to use collaboration to rework them. A benefit of farm plans is getting information together to inform discussion. This is a voluntary process and fits with the view expressed that voluntary and collaborative spaces should be used to create a shared vision which regulatory processes help to enforce, rather than the other way round.

Collaboration

A goal for this workshop 'Account-ability for Collaboration' is exploring what can and cannot be done using collaboration. Another aim is to explore how we can do things better in the next iteration to foster the adaptive capacity of stakeholders in the region. About half of the group present at the workshop was also part of the AP process and interviewed before the workshop. The feedback regarding the collaborative process was generally reported as positive. The MRLF/IFS workshops built human capital and most people interviewed expressed a desire for the workshops to continue.

The point was made that while there was enthusiasm for collaboration there is also a cost. Collaboration needs to be resourced and outcomes accepted at all levels otherwise it is just a waste of people's time. It was commented that the interview outcomes show there is wisdom in the group and learning can be passed on to others.

Research into collaboration in the USA indicates that the outcomes reached are not necessarily the right ones and that people give too much away to reach a negotiated agreement. In addition, collaborations can make people feel pressured. The view was put forward that collaborations also provide a way for everyone to say 'yes' we will do this which, while not being 'best', maybe what is 'possible'. For this group actions for the river are key and it is accepted this may require compromise. A focus on 'what's possible' is important to move forward in the short run. Space to reflect on 'what's best' needs to be created as well, to achieve the long term goals.

For iwi there are additional components of collaboration that need to be taken into account. The first is the need for Maori stakeholders to account back to hapū/iwi on what they are doing to make the river better based on a set of principles (whakapapa, mana, mauri, others?). The second is to understand the nature and extent of relationships. Iwi have a set of values and if it is possible to establish those at the outset iwi can work with anyone.

While collaboration was regarded positively overall, concern was expressed as to whether 'community' can be damaged by collaboration. While collaboration involves representative stakeholders of the general public it is a different process from the consultation process. Consultation provides the general public with the opportunity for input.

Morning - Small group break out to address 4 questions:

Note: All points reported are listed below. Those mentioned more than once are also listed under 'common ground'.

1. Reflecting on the context presented this morning are there any additions or observations you would like to make?
   - Evaluation is an important part of the collaborative process. This is required to know if outputs are achieving outcomes. Evaluation is a way to link/demonstrate progress towards goals and determine if the AP is delivering. Evaluation comes out of monitoring and drives the adaptive process of change we are talking about. Evaluation could be based on i) on-the-ground difference ii) Completion of the MRLF Accord tasks.
   - Graphic/ visual communication of technical information is needed to get everyone on-board and understand issues. Information needs to be simplified, but not dumbed down. E.g. use of term 'aquatic bugs' instead of 'macroinvertebrates'.
   - Involving and resourcing participants is needed for collaboration to be effective both in the short term and long term.
   - Collaborative process early on has benefits but (i) may not always be possible/appropriate (ii) a mix of methods may work better (e.g. side rooms) (iii) can result in stakeholder fatigue (iv) there is limitation in NZ regarding collaboration capacity (e.g. lack of facilitators, available Non-government representatives, demands on iwi etc.)
   - Voluntary initiatives are not captured when reporting on Accord achievements. These early adopters are outside/additional to the AP tasks. There is a need to capture what's happening collaboratively for 'innovators / early adopters' and reserve legislation for the 'laggards'. Examples of voluntary initiatives are i) SLUI ii) Taranaki Riparian Initiative.
   - A system needs to be in place for regular progress reports on actions. Who to report to needs to be determined as there is a distinction between the Action Plan workshop group and the MRLF. Who is the reporting to and on what needs to be decided.
   - MfE diagram ends at water-take and not at the sea. What about estuarine health e.g. taonga species?
   - Underground aquifers water quality and quantity need to be included going forward. [This addition was made post-workshop by email]
   - There is a need to understand each other better, for example, culturally and in terms of economic/ecological/corporate/global expectations.

2. Is there a need to revisit the vision for the river (as in the Accord Goals)? Should there be future iterations of the action planning process (working through the adaptive management cycle)? If yes, when and how should this happen?
   - Vision 'for a healthy river' is unlikely to change but should be continually referenced and revisited. Vision represents the key things people want to see; that is what motivates people at a deep level.
   - Goals need to be revisited more often. Ways of implementing the Accord Goals should change over time as new solutions are developed. Therefore, goals have to be more flexible as they might need to change according to the checkpoints.

- The AP process should be revisited as part of Adaptive Management (AM) process. ‘When’ such a revisiting should take place should tie in with evaluation and timing of evaluation.
- Revisiting the Accord is needed to integrate mountains-to-sea into goals/actions. There are freshwater-seawater interactions and not just ‘fresh’ water effects.
- Need to aim for over-compliance (the innovators) as voluntary actions can be greater than regulatory requirements (geared toward the laggards).
- New fora, will need new sources of funding e.g. polluter pays, rates, levies. Therefore there needs to be prospects for new institutions and ways of developing new sources of revenue. Contributions from central government?

3. What mechanisms provide the ability to account for outcomes from the collaborative process?

    - The AP provides a check list of actions for accountability. Accountability requires articulating progress - outputs and outcomes. For accountability: (i) Need to ensure a timeframe is incorporated, for example, the Clean Stream Accord with a date required by and financial impacts. (ii) Need measures and monitoring to account for what is also being done by others to achieve the overall goal. For example, the Green Ribbon Award does not capture the work others are doing. (iii) An audit process with an independent body (with no attachment to region or Accord) could be put in place.
    - Accountability can be achieved with regular meetings and report back. Bench marks need to be set so that in, say two years, it is possible to measure what has been achieved.
    - A report card system could be used. Specific report cards could be designed for different groups e.g. iwi report cards could include mauri and mana.
    - When reporting back (factually not for PR purposes) to the wider community a range of tools such as media, social media, websites, Horizons communications can be used. Technical information needs to be understandable. There is a need to understand and report on context and emerging constraints for evaluation as well as deal with the spin.
    - Openness and honesty about the on-going challenges and the nature of the message need to be communicated. This is part of ‘trust-building’
    - There is shared responsibility between the private and public sectors. Public good/Private good is often a shared cost and how budgets are set needs to be discussed openly.
    - Facilitate science/indictors with (i) funding (ii) LT monitoring of key species (iii) social environmental research (iv) public GIS maps and information. These will provide evidence for evaluation.
    - There is a need for new knowledge/ indicators for e.g. eels/mana/mauri/the Genuine Progress Indicator. A collaborative process needs to be used for shaping the new measures/indicators.

4. What additional mechanisms would strengthen the ability to account for outcomes from the collaborative process?

    - Actions taken in addition to the AP inspired by work in progress.

- Stock take/honest appraisal. Find ways to measure progress towards goals. Could do by measuring perceptions of groups in the community e.g. iwi/other groups/ local government/ Non-government organisations and repeat this at regular intervals
- Community based monitoring.
- Use media as a tool – uncompromised. Boost communication and educative package of Accord which has fallen by the way-side.
- Political and moral accountability e.g. a set date to account is established at the outset.
- New iwi roles in council
- Build up trust and maintain it with two-way communications.
- Small scale collaboration for each action. Identify all partners.
- A central government that listens and sets appropriate rules/regulations/funding provisions. For example a national policy statement could be used to enforce implementation of Shannon's wastewater system.
- IFS research continues for on-going 'monitoring' at a holistic level.
- Revisit where consultation fits into the collaboration/communication timeframe? Provide information that is up to date and current and well presented. Allow time and value silence (people are thinking!!)

Report Cards

How report cards, if implemented, would work was discussed. If a report card indicates a group is not doing well there is no way to impose punishment when the commitments are voluntary. The main 'stick' is the power of peer pressure which should not be underestimated. Not judging is important as there could be all sorts of reasons for non-completion. Also there are different levels for targets with some easy to achieve, others very difficult. If committed group/s front up and say they need support to deliver this is an opportunity to pull together and help each other. It is possible others are in a similar position and this provides a space to examine underlying resources, collaborate on understanding and think about how to do things efficiently/differently. If this approach is not used, the group will break down. The collaborative process is about providing a safer environment and enhancing people's mana not making them feel small. The goal is to help solve problems as opposed to taking an adversarial approach where you only tell what is good and opponents only tell what is bad. A question is who would the report cards go to?

Economics of Collaboration

The view was expressed that problems go away if there is sufficient money. The question was then asked if the issue was the desire for people to 'have money' or 'money being available' to solve a problem. Iwi expressed the view that while money is important it is not the only thing. For Maori the awa is important.

Affordability is an issue. Putting up fences is relatively easy but removing cows may not be affordable. Cows contribute to nitrogen – taking them off at the right time of the year costs $30 a head, feeding palm kernel only cost $ 20 a head. Spending money on a river that is not that bad is difficult for farmers, industries and some Council in the current economic environment. As money spent, and money not earned, by farmers has an impact on the wider economy this will affect the income of everyone. One offered answer is to just accept things will change overtime and keep building on progress.

Herd homes as an option introduces more intensive farming to New Zealand. Intensive farming is possible but is the food as safe? Other issues arise such as animal welfare. If you focus solely on one aspect, you are locking people into investments over long periods of time for a solution that may only fix one part of the problem. The solution for nitrogen might not be the solution for other issues. There are 'time lags' in the system. Solutions and investments need to be worked through time together taking 'time lags' into account.

Long Term Vision for New Zealand

When planning long term New Zealanders need to value what they want and how they pay for it. When you put up a vision this is what you do.

One view presented is that demands people put on the region to supply goods has to be taken into account in decisions regarding the river. People demand a life style where you can get in your car and drive to buy what you want. This is called a better standard of living and progress.

Are people ready for the Chinese factory model of farming in New Zealand? There would be sustainability issues with herd homes such as the need for energy. It is possible to create energy from effluent using highly engineered systems. But is this just shifting the problem? Would New Zealanders prefer to sacrifice a bit of leaching for grass fed cows and high animal welfare? Otherwise New Zealand might get to be a country of foreign owned factory farms.

In terms of a long term vision, government and Maori are looking to the year 2040. Key issues are: clean water, population growth, cultural diversity, more competition for resources. For Maori an issue is how to maintain cultural integrity with current trends?

Ecosystem Services and how do you value them

Ecosystems Services (ES) are broadly defined as the goods and services humans get free from nature. These include: hydrological cycle, water purification, storm protection, pollination, soil formation, carbon and nitrogen cycling etc. Ecosystem Services have been briefly discussed over the course of the IFS project. The question was asked as to how you come up with values for Ecosystem Services? New York city saving billions of dollars by protecting the Catskills catchment that provides water for the city rather than treating polluted water is a well-known example. Also there are tools like; Contingent Valuation, Travel Cost, Payment for Ecosystem Services etc. With Payments for Ecosystem Services these are usually considered for activities over and above what you need to do under the RMA. This is a way of compensating for the opportunity costs associated with, for example, protecting wetlands rather than converting to pasture.

Property Rights

There are different ownership models (Private/Public/Common) each with property rights. The need to develop a rights system for 'Common' assets (those shared by both the private and public sectors) was touched on. The view was expressed that if this collaborative continues, this would be a good topic to work on.

Cost benefit Analysis (CBA)

The government is asking for tools like CBA to be deployed for decision-making about freshwater in New Zealand. Therefore, there is a need for collaborators to be informed about their strengths and limitations to enable them to ask the right questions. When completing a CBA the direct and indirect costs of an activity need to be understood and included and you need to be aware of *who* the costs and benefits get attributed to. In general, benefits tend to be private whereas costs are public - though this can be vice versa. CBA are useful for small, confined cases when assumptions can be explicit; not for a more holistic situation. For example, you cannot include iwi health etc. in a CBA.

The view was expressed that CBAs are just a means of playing 'economics' and this level of detail was not needed at this workshop. It was re-iterated that the reason for overviewing available tools at the workshop is the government is asking for tools like CBA to be deployed for decision-making about freshwater in New Zealand.

Another view was expressed that we don't need to spend lots of money on a river that is not so bad. While improvements are needed the region also need jobs… it is not important who benefits. The bigger debate will come when people are hungry because of the economic compromises made by the country. NZ also needs a trade surplus. If we take the pressure off exports, imports will not be sustainable.

A contrasting opinion was "economics is just one view". Alternative paradigms to economic growth exist. Applying an 'economic' approach in the Horowhenua has been very detrimental. Some areas can move Nitrogen quickly (such as rivers) but lakes like Horowhenua capture Nitrogen. This is now a cost to the economy and to cultural values. Some farmers have fully contained ponds and iwi would like to see all do this.

Mediated Modelling (MM)

Reflecting on the 'big picture' the MM model provides a question was whether 'targets' can be put into the mediated model and then different ways to get to the targets explored taking into account interconnections. A participant thought in the case of Nitrogen it would be good to see where the targets need to be per ha.

Eels

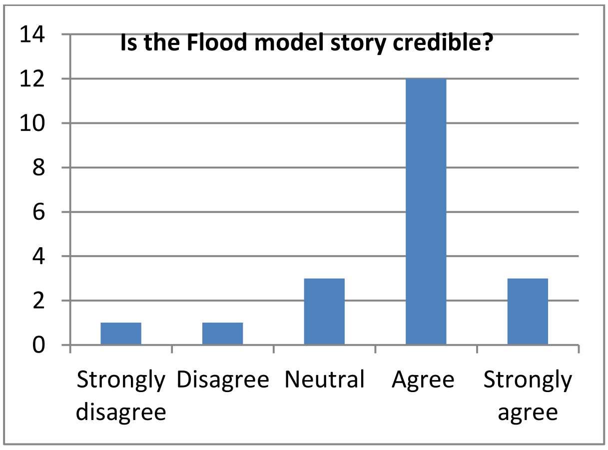
The IFS project for Rangitaane was co-governance. A down-sized mediated model was constructed for the Pohangina sub-catchment to see what would happen to eel stocks with greater iwi input. Eel numbers in the Pohangina continued to decline in the model.

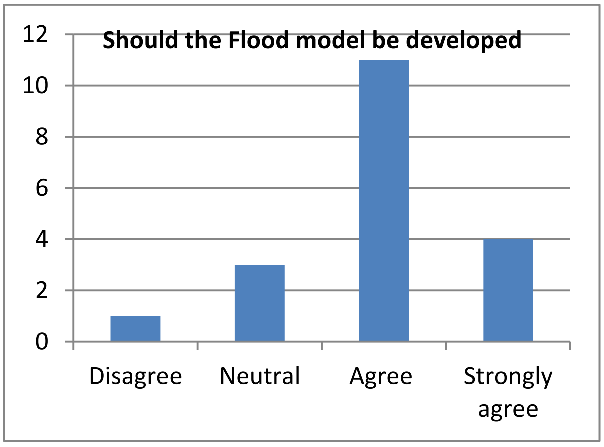
In the sub-catchment indications are eel numbers have decreased. Possible causes are commercial eeling, dairy herd size increases and farming marginal land. The point was made there used to be eels and pollution in the 1970s. It may be what has changed is communication and people over-react as now they have data and benchmarks. The Ministry of Primary Industry reports commercial eel catches are increasing but Rangitaane find customary takes are no longer sustainable.

Flood Model

Discussion on the flood model touched on the following points: 1) The need for climate change to be included. 2) Can you correlate forests and flooding? 1880 was the greatest recorded flood in the Manawatū and what we need to know is the extent of forest cover then[9]. 3) Regardless of flood protection efforts there is still a risk from weather bombs. 4) SLUI investment was partly for flood protection because of the realisation stop banks cannot be raised again. 5) There is a difference between a model and theory and the data that goes into it. Data used needs to be valid. 6) Is it credible to depend on ecosystems services? 7) The biggest problem is the assets behind the stop banks. 8) Lack of possum control on the Department of Conservation estate is destroying the canopy and will cause major erosions as trees fall off and root systems lose their grip. 9) The value of assets/land is not necessarily increasing in line with engineering costs. Are the costs of maintaining flood banks to protect unproductive land worth it? 10) Do you continue to drain or do you keep natural sponges? 11) Do engineers at Horizons Regional Council agree that wetlands provide flood protection services? Soft engineering has been part of Horizons Regional Council language for some time. 12) In other places around the world, Europe for example, it is accepted wetlands act as sponges. 13) Better urban design could reduce flooding. 14) People who have been paying rates for flood protection in the expectation of getting it further down the track could feel hard done by if things now change. 15) People have the right to be involved in flood protection planning. 16) The model is about starting a different conversation that includes 'time lags'.

Survey Results - answers to 4 questions, filled out by 20 respondents after presentation/discussion of 'flood protection model'



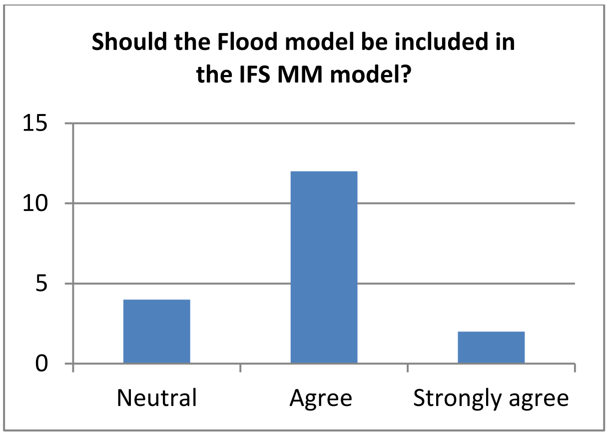


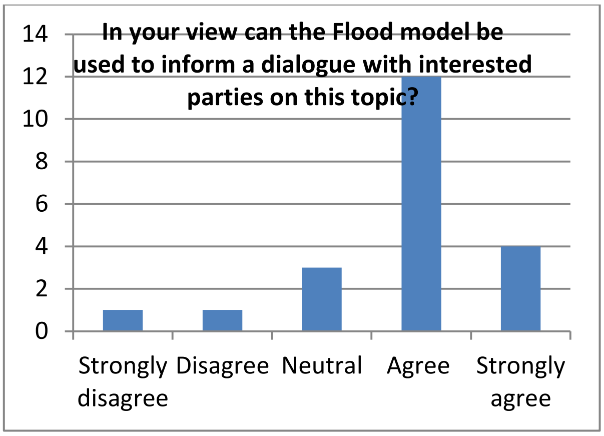
[9] *Follow up from Parked Issue:* "Horizons Regional Council group manager Allan Cook said the largest flood recorded in Manawatu was in 1880, with 4000 cumecs of water flowing down the Manawatu River. In 2004, it was 3500 cumecs."[9]. According to Warr[9] for early settlers in the Manawatu timber was the principal source of income. When the Wellington-Manawatu railway was completed in 1886 flax and timber were the main products of the district. "A widely held view in the [1870s] seventies was that the Manawatu possessed almost an inexhaustible supply of milling timber – it took but ten years to prove the fallacy of such an assumption!"(1964, 153) By the early 1900s sediment build-up in the Foxton Estuary made the river unnavigable[9]. Fires were widely used for land clearance, and often got away.

[9] http://www.stuff.co.nz/manawatu-standard/news/4541564/Horizons-flood-protection-work-going-well

[9] Warr, E. (1964) The Rise of Pastoral Industries. In B Saunders and A Anderson (EDs) Introducing the Manawatu. Geography Dept Massey University

[9] Parliamentary Commissioner for the Environment (2012) Water quality in New Zealand: Understanding the Science





Multi-Scale Modelling of Ecosystem Services (MIMES)

MIMES can add a spatial visualisation to the impacts of solutions/problems over time taking into account interdependencies. MIMES can go to any level of detail, but there are tradeoffs between its ability to integrate and its ability to be precise. An observation was that the relative profitability of land use drives land use change and this cannot be predicted in a model as prices are unpredictable. The purpose of MIMES is to assist in understanding interconnections, e.g. sub-catchment and catchment level, between short and long term, between issues of sedimentation and nutrient runoff, between economic and societal values. It is correct that MIMES is unsuitable to 'predict accurately'; very few tools have this ability.

Afternoon Small groups break out to address 2 questions:

1. What 'tools' (for information gathering, knowledge creation, visualisation and learning through modelling) would help to adaptively manage river water quality and quantity for the long term?

- Storytelling and visualisation with visual display and videoing. This allows remembering.
- Bringing children into the discussion – they are impacted
- User friendly language. Know how to communicate and who your audience is
- Use clear definitions at outset. Don't use acronyms as this is dangerous when the same letters have different meaning for different people
- Foster succession planning for collaborative groups in Non-government organisations, iwi, government and industry
- Interactive models with baselines for different values e.g. fishing, swimming, mahinga kai
- Mediated modelling is useful for feedback loops and identifying limitations on growth for industry and farming
- Mediated modelling is useful for getting dialogue going. The 'flood model' is useful in this regard.
- Modelling can be used to articulate and understand the issues involved in different investment pathways, without attempting to be predictive.
- Spatial modelling is good for monitoring/evaluation/action (a cyclical process)
- Remain open to innovations and efficiencies (in modelling, wastewater, multiple small sewage treatment plants versus one big one etc.)
- Education tool kits

- Know what tools are there – avoid duplication
- Fieldtrips are a great reality check. Practical demonstrations – water clarity at top and bottom of catchment
- SHMAK (stream health monitoring assessment kit). Can involve kids, be an early collaborative process, community modelling
- Permeable concrete
- Improved urban design
- Environmental levies
- Adopt specific tools for knowledge creation
    - Continuous sediment flow monitoring to help understand cycles, access volume changes, understand impacts. (Spot monitoring is the current method used).
    - Estuarine habitat/ecological monitoring
    - Core sampling to understand settled sediment
    - Water quality and consent monitoring

2. How do they help?

- Wananga – builds trust and condenses time
- Sharing stories enables common themes to drop out (pecha kucha, informal groups)
- The story-telling/information and envisioning process engages people
- An eco-levy or ecological tax provides funding to allocate to a specific environmental project. Examples: (i) GST on primary produce as the Waikato region has done for Nitrogen into Lake Taupo (ii) Eco-levy on soap powders with phosphate (this requires legislation to do).

How to help Collaboration?

- Survey participants before the start of the process.
- Provide guidelines – be open, agree to disagree, establish base information at the start, guiding principles circulated prior to start, ensure everyone has an equal say
- Strong and sensitive facilitator
- Human activity - working together as a group, small group work, joint solution finding
- Action listening and hearing the stories of others- this makes people more inclined to work together. Searching out the quiet voices.
- Basics plus models
- Model as a conversation starter
- Defining ‘accountability’ is an on-going goal

Questions that remain: How do we …..

1. Involve ‘time poor’ people?
2. Collect good data that is useful?
3. Get buy-in to this data? Need trust/relationships?
4. Take information to people?
5. Remind people of basics e.g. roof water collection, home based sewage treatment?
6. Get acceptance of water metering and pricing as a tool for managing?
7. Create enthusiasm and keep people interested over time?

8. Make the problem real and relevant for people –floods, contact with water bodies, droughts e.g. 20 days of water in Wellington?

Appendix C Model description

This appendix provides a more detailed description of the IFS model presented in ‘Section 4’ Content – Model’ and various sectors it covers. Here data needs are described and if included in the IFS model data sources given. Scoping models, such as the one described here, have defined purposes which include exploring feedback loops and timelags in a system and developing new ideas or hypothesis for which there may not be data available. If a need is established a scoping model can be improved and populated with data (if available) to become a ‘management’ model (see Figure 24: Modelling tools to support Adaptive Management). The following description aims to make transparent what is and what is not incorporated in the current version of the scoping model. In the IFS model where data is not available ‘place holders’ are inserted to ensure the ‘train of thought’ is not overlooked.

Demographic Module: This module simulates the demographic (population) changes from 1990 till 2040. It includes the resident population and tourists in the Manawatū River catchment (MRC) to calculate the ‘effective people pressure’. There is also a casual-effect relationship that establishes how increases or decreases in the ‘economic prosperity GDP’ for the MRC increases or decreases population and tourists in the catchment. The ‘effective people pressure’ is further linked to the municipal water use in the ‘Water Availability and Use’ module.

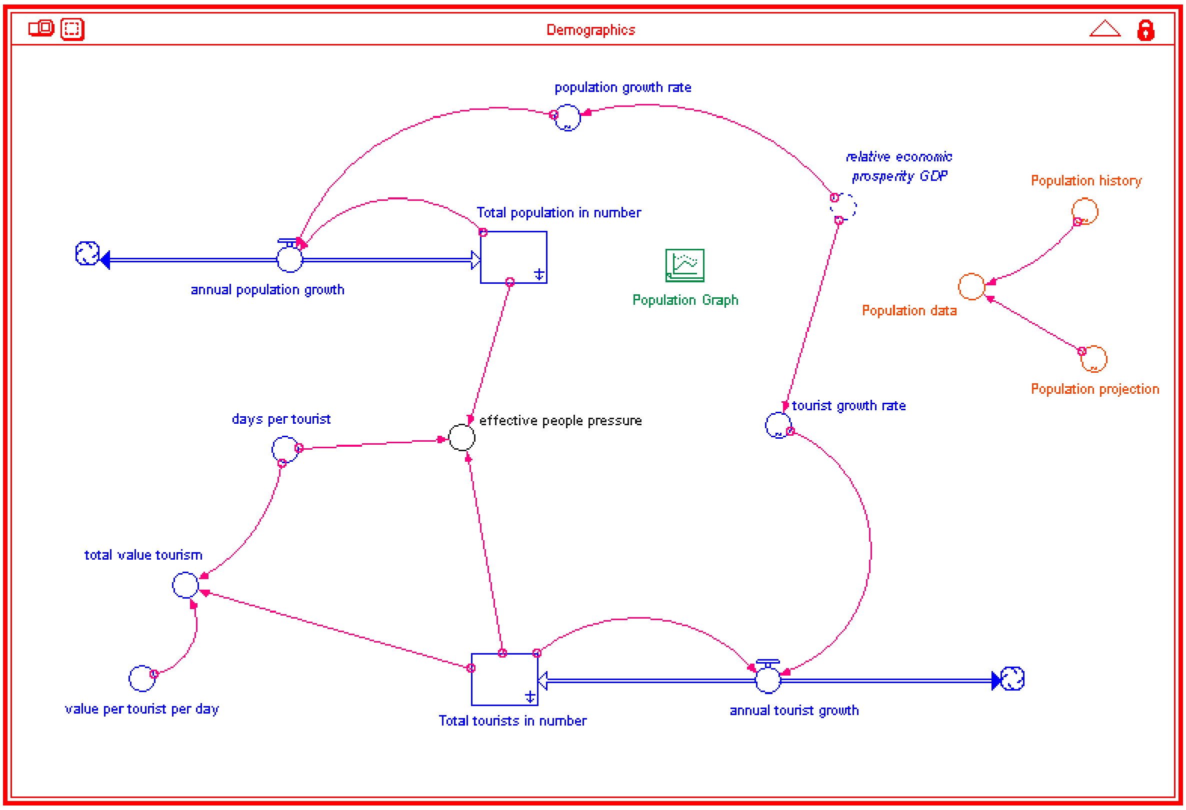


Figure C 1: Demographics model sector.

Data needs:

- Information on population of the catchment
    - Total population from 1990 to 2010 (Population History)
    - Projected/ expected population from 2010 till 2040 (Population Projection)
- Information on tourists in the catchment:
    - Total number of tourists from 1990 to 2010 (Tourist History)
    - Projected/ expected tourists from 2010 till 2040 (Population Projection)
    - Average days per tourist
    - Average value ($) per tourist per day

Input data used and calculation procedure for Population and GDP:

The Manawatū River catchment covers an area that is part of the Manawatū, Tararua and Horowhenua District Councils, and the entire area of the Palmerston North City Council.

Population: To calculate the annual population statistics for the four TLAs the following process was used:

i. Population figures for the TLAs from 2001 to 2010 where obtained from Statistics New Zealand (Estimated resident population, Territorial authority areas, as at 30 June 2001-10) http://www.stats.govt.nz/browse_for_stats/population/estimates_and_projections.aspx
ii. Data points for 1991, 1996 and 2001 were obtained from Census data using Tablebuilder.
iii. The two data sets were aligned and the rate of change over the five year census period used to annualise population for the 1990 to 2000 time period. This gave a 1990 to 2010 annual population figure for each TLA.

To calculate the population of each TLA that resides in the Manawatū Catchment area:

i. A GIS boundary of the MRC was placed over census data and meshblock census population numbers extracted for 1996, 2001 and 2006. Most meshblocks were 100% within the catchment. Where the catchment boundary dissected a meshblock a visual assessment was used to determine the percentage to include.
ii. Meshblock data was then summed for each TLA using a Statistics NZ meshblock/TLA concordance for the three years 1996, 2001 and 2006.

To calculate the annual population of the MRC from 1990 to 2000:

i. The percentage of the population of the TLA in the MRC in 1996 was calculated and applied for the years 1990-2000. The percentage of the TLA in the MRC in 2001 was used for 2001-2005 and the percentage of the TLA in the MRC in 2006 used for 2001-2010.
ii. These totals were summed for each year to get the annual total MRC population data for 1990 to 2010.

Projected population numbers for the MRC were obtained by:

i. Using the 'Projected Population Age Structure and Components of Change' (Territorial authority areas 1996-2031 (2006-base) update, medium series) from Statistics New Zealand as the base data.

ii. The percentage of the population of the TLA in the MRC was calculated for each of the TLA population projection figures and summed for the total MRC. Projected population figures for the MRC were calculated for 2011, 2016, 2021, 2026 and 2031.

Full Time Equivalent Employees and GDP: to calculate the following procedure was used:

i. Data for calculating employment in the primary sector and GDP was obtained from the "Wider Manawatū Region: Profile and Projections: TLA Analysis". This Berl Economics report provided data for the four TLAs in the MRC for 1997, 2005, 2006, and 2007. The percentage of population in the MRC as a percentage of the total TLA population was used to estimate employment in the MRC by TLA for the years 1997, 2005, 2006, and 2007. These figures were summed to get the total for the MRC.
ii. Value added or GDP in $2007m was estimated for the MRC as per FTEs.
iii. The BERL economics report provided projections for employment and GDP in 2016 and 2026 for each TLA. Two different scenarios were used. "The first is a neutral scenario, where industries in the region grow at the same rate as nationally. The second is a historical scenario, where industries in the region grow relative to how they have grown over the last 10 years. The neutral scenario provides a more positive projection of employment and GDP growth for the region as it is based on absolute national industry projections. However, we would suggest that the historical projection is the more likely outcome as it reflects the relative performance of the Wider Manawatū Region over the last 10 years." Berl economics, 2009, p.3). GDP per person was calculated for the MRC for both scenarios for 2016 and 2026. This was done by dividing the GDP for the MRC by the population estimate for the MRC.

Based on the given total population in the year 1990 (Table C 1) for the MRC and an estimated annual population growth rate, the module estimates the total population each year from 1990 to 2040. Similarly, the number of tourists each year is estimated based on the given total tourist in the year 1990 (Table C 1) and an annual tourist growth rate. The annual population and tourist growth rates are determined by the annual 'economic prosperity GDP' (see Economics Module). A graphical function is used to estimate annual population growth rate from -0.80 to 1.00 corresponding to the relative changes in annual 'economic prosperity GDP' from 0.50 to 1.50, respectively. Likewise, the annual tourist growth rate is estimated from -0.50 to 3.00 corresponding to the relative changes in annual 'economic prosperity GDP' from 0.50 to 1.50, respectively. The numbers in the graphical functions relating annual population and tourist growth rates with relative changes in annual 'economic prosperity GDP' are 'place holders' to be calibrated and validated with more information on population and tourists growth rates becomes available.

The annual 'effective people pressure' is estimated by adding the 'estimated annual population' and 'number of effective tourists' in the catchment. The annual number of effective tourists is calculated by multiplying the annual number of tourists with the average days per tourist (Table C 1) divided by 365. The estimated 'effective people pressure' derives the municipal water demands in the 'Water Availability and Use Module'.

Table C 1: Population and tourist information and its sources

Description	Value	Source
Total Population in 1990	125942	Estimated based on the population data from Statistics NZ (http://www.stats.govt.nz/infoshare/)
Total Tourist in 1990	10000	A place holder
Average days per tourist	3	A place holder
Average value per tourist per day	NZ$200.00	A place holder

Figure C 2 depicts the annual population simulated by the model (line 1) and compares it with the actual population estimates for the MRC to 2010 and the population projections out to 2030 as estimated by Statistics NZ (line 2), in the Manawatū River catchment. From Figure C 2 it can be seen that the module is able to reproduce the trend of increasing population in the catchment.

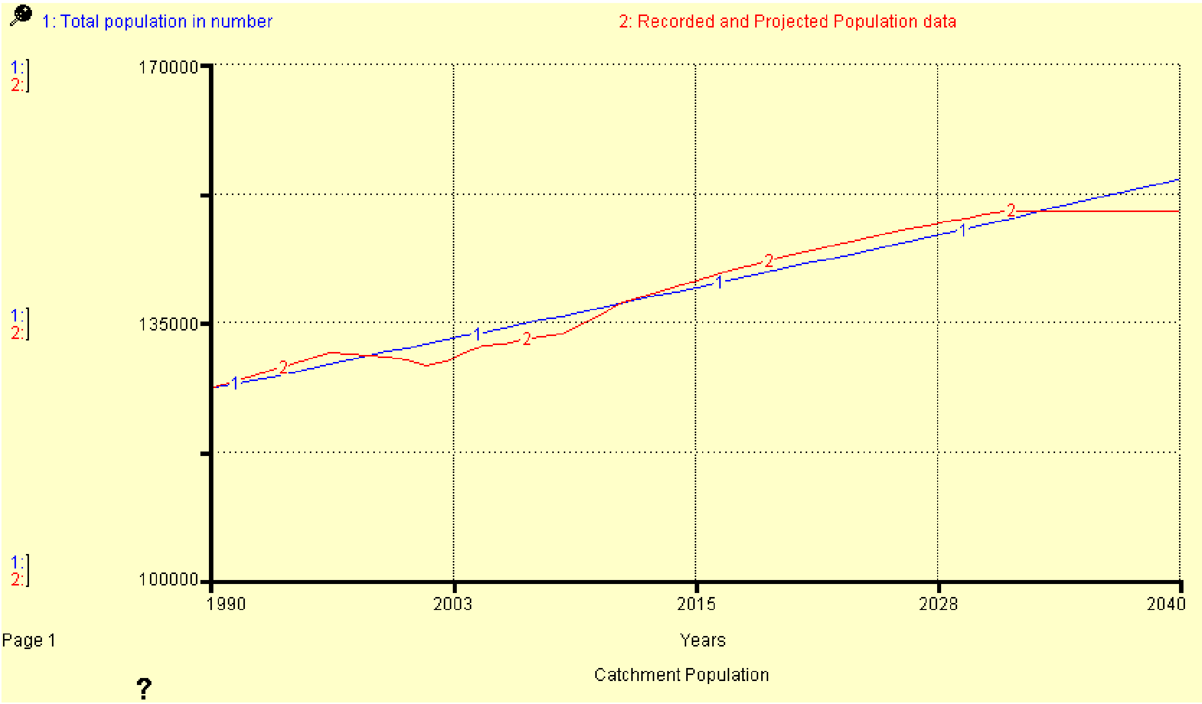


Figure C 2: Simulated (blue line 1) and recorded or projected (red line 2) population in the Manawatū River catchment from 1990 to 2030.

The 'demographic' module estimates the annual value of tourism based on the annual number of tourist and average value of NZ$200 per tourist per day. In the absence of tourist information, most of the tourist input data and estimated tourist numbers and values are considered 'place holders', to be calibrated and validated as information becomes available.

Further development:

- Validate the assumption of increasing or decreasing population and tourists with the increase or decrease in economic prosperity GDP
- Calibrate and validate the annual population and tourist growth rates

Historic Land Cover Module: (simulation period from 1840 to 1990): This module captures the historic land cover changes which was pre agricultural development to 1990 in the catchment.

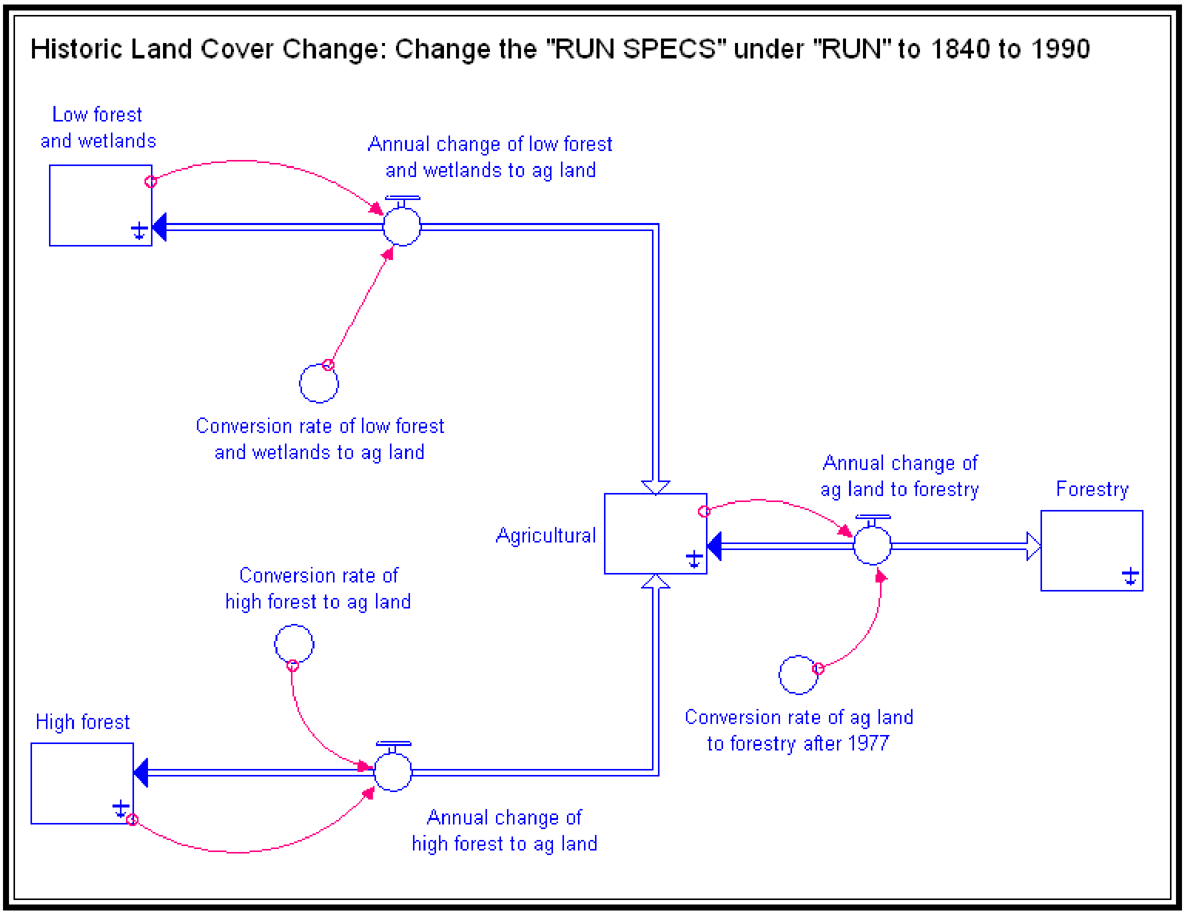


Figure C 3: Historic land cover (1840-1990) model sector.

Data needs:

- Broad brush land cover categories and their area from 1840 (or pre agricultural development) till 1990
- Conversion rates/trends of changing land cover area from 1840 (or pre agricultural development) till 1990
- Information on special programmes (promoting/subsidizing) land cover change since 1840

Input data used and calculation procedure:

The current structure of the 'Historic Land Cover' module assumes that the whole of Manawatū Catchment was under high forest, and low forest and wetlands before pre agricultural development. In absence of actual land cover information in 1840, the low forest and wetlands area is set at 93,098 ha and the high forest at 495,368 ha. These numbers are based on the landuse information available for 1990 (see Table C 2 in the Landuse Module) and are estimated assuming that the 1990 landuse categories of cropland, dairy, woody grassland, wetlands, water, other and unexplained (Table C 2) were all under low forest and wetlands category in 1840, and the 1990 landuse categories of Sheep Beef and Deer, natural forest and planted forest (Table C 2) were under high forest category in 1840.

The Historic Land Cover Model simulates the conversion of pre agricultural development landuse categories, i.e. low forest and wetlands and high forest to agricultural landuse using the specified annual conversion rates as follows:

*Annual_change_of_low_forest_and_wetlands_to_ag_land = Low_forest__and_wetlands*Conversion_rate_of_low_forest_and_wetlands_to_ag_land*

Conversion_rate_of_low_forest_and_wetlands_to_ag_land = IF TIME < 1970 THEN 0.0075 ELSE 0.0005

*Annual_change_of_high_forest_to_ag_land = High_forest*Conversion_rate_of_high_forest_to_ag_land*

Conversion_rate_of_high_forest_to_ag_land = IF TIME > 1970 and TIME < 1977 THEN 0.05 ELSE 0.0082

> The high conversion rate from forest to agricultural land between 1970 and 1977 is applied to capture the effect of government subsidy to clear forest for agricultural development during this period. The conversion of agricultural land to forestry after 1977 is lower using the specified annual conversion rate as follows:

*Annual_change_of_ag_land_to_forestry = Agricultural*Conversion_rate_of_ag_land_to_forestry_after_1977*

Conversion_rate_of_ag_land_to_forestry_after_1977 = IF TIME > 1977 THEN 0.0015 ELSE 0

Based on the above equations and landuse conversion rates, Table C 4 depicts the estimated historic land cover changes in the Manawatū River catchment. In the absence of actual land cover information, estimated land cover changes are considered to be 'place holders', and should be calibrated and validated as information becomes available. However, from the Table C 2, it can be seen that the 'Historic Land Cover' module is able to simulate the estimated landuse for the Manawatū River catchment in the year 1990. The simulated agricultural area is slightly higher than the estimated as it does include the 'other' landuse category of the estimated area in 1990.

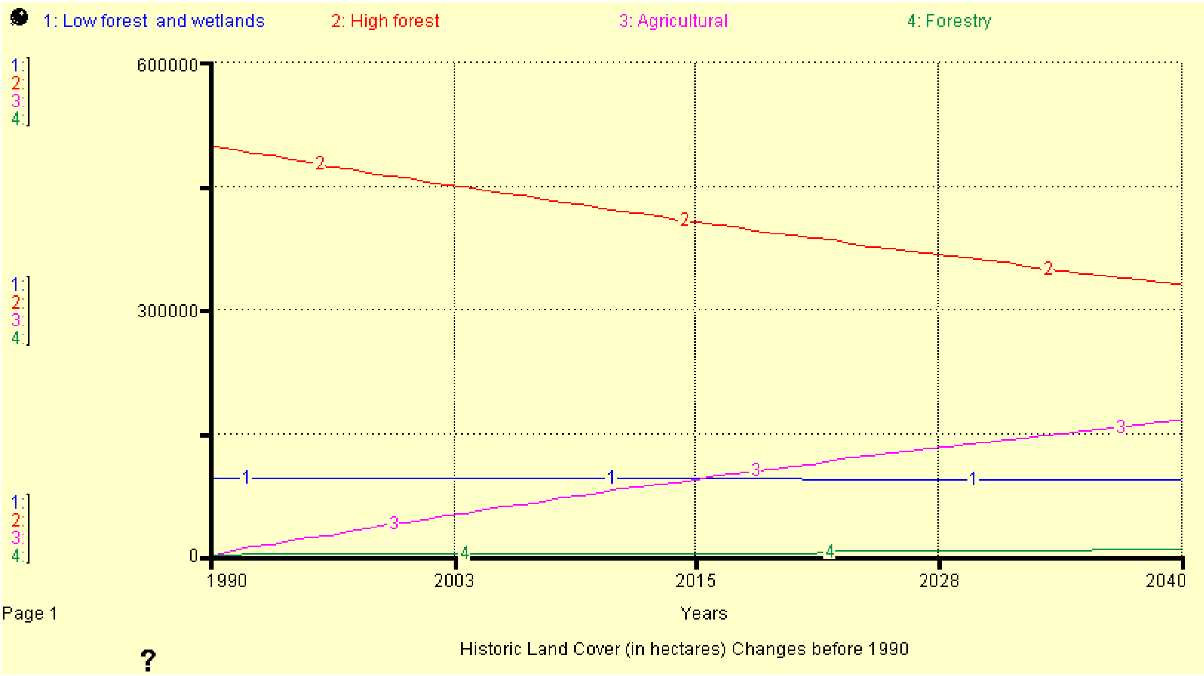


Figure C 4: Simulated land cover changes in the Manawatū River catchment from 1990 to 2040.

Table C 2: Landuse in Manawatū River catchment in year 1990

Landuse Category	**Estimated Area (ha)***	**Simulated Area (ha)**
Low forest and Wetlands (i.e. Woody Grassland, Water, Wetland and Unexplained in 1990)	34,573	34,639
High forest (i.e. Natural forest in 1990)	81,997	82,307
Agricultural (i.e. Cropland, Dairy, and Sheep Beef and Deer in 1990)	456,219	463,318
Forestry (i.e. Planted forest in 1990)	8,393	8,203
Other	7,284	
Total Area	588,466	588,466

* Based on the 1990 landuse data reported in Table C 3 In the Landuse Module

Further development:

- Develop the module according to the identified major land cover categories over the period from 1840 (or pre agricultural development) to present. For instance, to include urban area
- Calibrate and validate the module with collected and estimated land cover and conversion rates information

Land Use Module: This module simulates the predominant and projected land use changes in the Manawatū River catchment from 1990 to 2040. It is linked with the proposed land use changes from the 'Actions for Solutions' module, for instance 'Reforestation to reduce erosion from high lands', 'Riparian planting' and 'Restoration of wetlands' to simulate their impacts on nutrient and sediments loadings in the river.

Data needs:

- Main land use categories and their area since year 1990
- Predominant land use change dynamics. What is changing to what?
- Projected/ expected growth rates of different land use, for instance dairy growth rate

Input data used and calculation procedure:

The land use data for 1990 and 2008 was obtained for the catchment using the Land Use and Carbon Analysis System (LUCAS) satellite imagery for land-use classes (Ministry for the Environment, 2010). The LUCAS contains GIS based Land use maps for New Zealand constructed for eight different land-use classes for the years 1990 and 2008. The landuse classes are:

1. Cropland (perennial and annual)
2. Grassland (high producing and low producing)
3. Other (settlements; montane rock/scree; bare ground)
4. Water (lakes, rivers)
5. Wetland (herbaceous and/or non-forest woody vegetation periodically flooded; estuarine/tidal areas)
6. Woody Grassland (grassland with tall trees such as golf courses, small (<30% cover) erosion or riparian plantings, grassland with shrubs not expected to reach >5 metres over next 30-40 years)
7. Natural Forest (forest on conservation land, tall, non-planted forest, broadleaved hardwood shrubland, manuaka/kanuka shrubland)
8. Planted Forest (radiata pine, Douglas-fir, eucalypts, or other planed species; harvested areas within forest land assumed for replanting in the future)

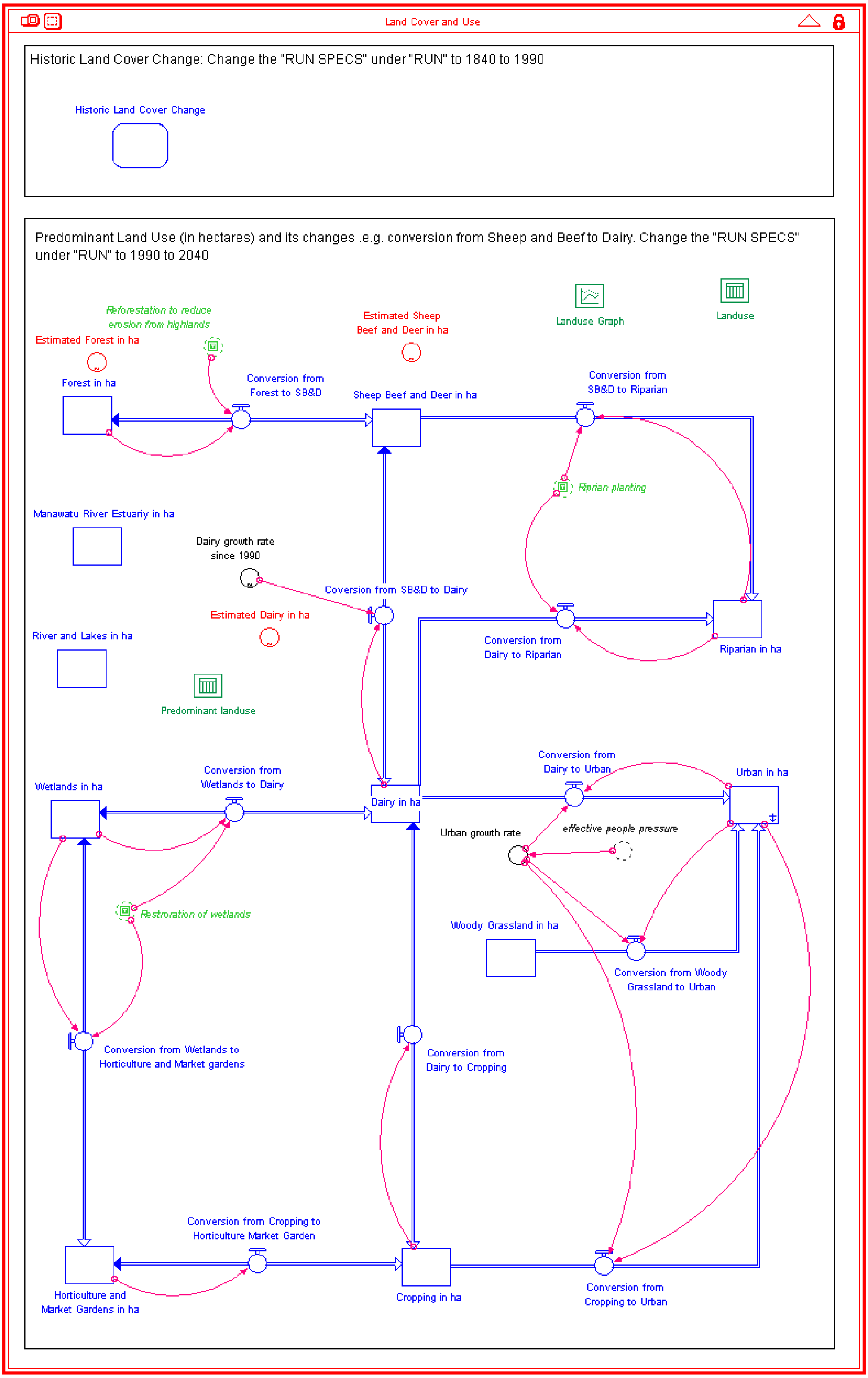


Figure C 5: Land cover and use model sector.

For the Manawatū River catchment, the change in land use between 1990 and 2008 for each of these classes was estimated as follows:

Table C 3: Landuse changes in Manawatū River catchment from year 1990 to 2008 (based on the Land Use and Carbon Analysis System (Ministry for the Environment, 2010).

Landuse Class	Total 1990 (ha)	Decrease (ha)	Increase (ha)	Total 2008 (ha)
Cropland	6,241	0	52	6,293
Grassland	449,978	7,647	1,158	443,490
Other	7,284	71	10	7,224
Water	2,338	0	0	2,338
Wetland	241	11	0	230
Woody Grassland	31,975	2,117	1,495	31,353
Natural Forest	81,997	593	0	81,403
Planted Forest	8,393	182	7,904	16,115
Unexplained	20			20
Total	**588,466**	**10,620**	**10,620**	**588,466**

To provide annual landuse data for the IFS model, the total change in hectares for each land-use was apportioned equally to each year between 1990 and 2008. The same rate of change was assumed for 2009 and 2010 completing the landuse data set from 1990 to 2010.

The landuse class 'Grassland' in Table C 3 was further separated as 'dairying' and 'Sheep/ Beef/Deer' farming hectares. This separation was achieved by the follows steps:

1. Effective hectares in dairying for each of the 4 TAs (MDC, PNCC, HDC, and TDC) in the Manawatū River catchment was obtained from LIC statistics data (Livestock Improvement Corporation and Dairy New Zealand, various). The percentage of dairying in the Manawatū catchment was estimated using the Land Use New Zealand (LUNZ) dataset for 2003. LUNZ was initially developed to provide land-use information for the Catchment Land Use for Environmental Sustainability (CLUES) project (Woods et al 2006). LUNZ uses AgriBase, LCDB2 and LENZ data improved with local landscape understanding (Robert Gibb pers. communication).
2. For each TA, the number of hectares in dairying in the catchment as a percentage of the TA total was calculated.
3. The 2003 percentage (from Step 2) was applied to the TA LIC effective ha in dairying to estimate for each year the effective ha of dairying within the catchment for 1990-2010.
4. The hectare of land (from Step 3) was summed to get the catchment ha for each year from 1990 to 2010.
5. For each year, the area in landuse class 'Grassland' (Table C 3) was reduced by the effective ha in dairy (from Step 4) to get the hectares in Sheep/Beef/Deer farming from 1990 to 2010.

An attempt was made to get the trend in exotic forestry for the Manawatū River catchment from the *National Exotic Forest Description* (NEFD) data for the period 1991 to 2010 (MAF, various). The methodology set out below was followed but the trend data is not able to be used due to the degree of inconsistency between datasets.

The NEFD statistics give " the net stocked area of the planted production forest estate; that is, all forests planted with the primary intention of producing wood or wood fibre as at the 1 April each year" (NEFD, 2009). The land area under exotic forestry for the Manawatū River catchment for the period 1991 to 2010 was calculated as follows:

1. Ha in forestry for each of the 4 TAs (MDC, PNCC, HDC, and TDC) obtained from NEFD statistics.
2. To calculate forestry in the catchment the total catchment ha in 'Planted forest' as a percentage of the total TA hectares in 'Planted forest' in 1990 and 2008 was estimated from the LUCAS dataset.

The total ha in exotic forestry in NEFD and LUCAS for New Zealand overall lined up reasonably well for 1990 and 2008. The LUCAS hectare was higher in both instances by about 20%. This may be explained by the inclusion of cut-over forestry in LUCAS which is not included in the NEFD. At the TA level there was a significant difference between the total NEFD ha of exotic forestry for MDC, PNCC, HDC and TDC and the LUCAS figures. In 1990 the NEFD total was 6,373 ha compared to 15,197 ha in LUCAS (i.e. only 42% of LUCAS). In 2008 the NEFD total was 29,963 ha compared with 34,835 ha in 2008 (86% of LUCAS). The NEFD data is from surveys of forest owners and consultants who own or manage planted production forests, complied by the National Forest Association and Ministry of Agriculture and Forestry. Given the survey base of the data a possible explanation for this large discrepancy is an under reporting of forestry in 1990 NEFD. Applying the trend from NEFD was therefore considered spurious and not attempted.

Based on the above landuse information for the Manawatū River catchment (Table C 3) and the discussion during MM workshops regarding the sources of non-point pollutants the following 11 landuse types categories were included in the 'Landuse' Module (Table C 4).

Table C 4: Landuse type and their estimated area in 1990 used in the IFS model.

Landuse Type	Total 1990 (ha)	Source
Forest	90,390	Table C 3 (Natural + Planted forest)
Sheep, Beef and Deer	404,978	Table C 3 (Grassland = Dairying + Sheep, Beef and Deer farming)
Dairy	45,000	Table C 3 (Grassland = Dairying + Sheep, Beef and Deer farming)
Cropping	4,641	Table C 3 (Cropland) minus Horticulture and Market Gardens
Horticulture and Market Gardens	1600	A place holder
Wetlands	241	Table C 3 (Wetland)
Woody Grassland	31,075	Table C 3 (Woody Grassland) minus Riparian Planting
Riparian Planting	900	A place holder
Rivers and Lakes	2,138	Table C 3 (Water) minus Manawatū River Estuary
Manawatū River Estuary	200	http://www.wetlandtrust.org.nz/documents/spring2005.pdf
Urban	7,304	A place holder
Total	**588,466**	

Using the initial estimated landuse area in 1990 (Table C 4) and estimated landuse conversion rates, the 'Landuse' module simulates landuse changes in the Manawatū River catchment from 1990 to 2010. Figure C 6 shows a good match between the time-series of simulated and estimated Dairy and Sheep Beef and Deer farming areas in the catchment from 1990 to 2010. Also, the other major landuse types are simulated in good agreement with the estimated landuse area in 2010 (Figure C 7).

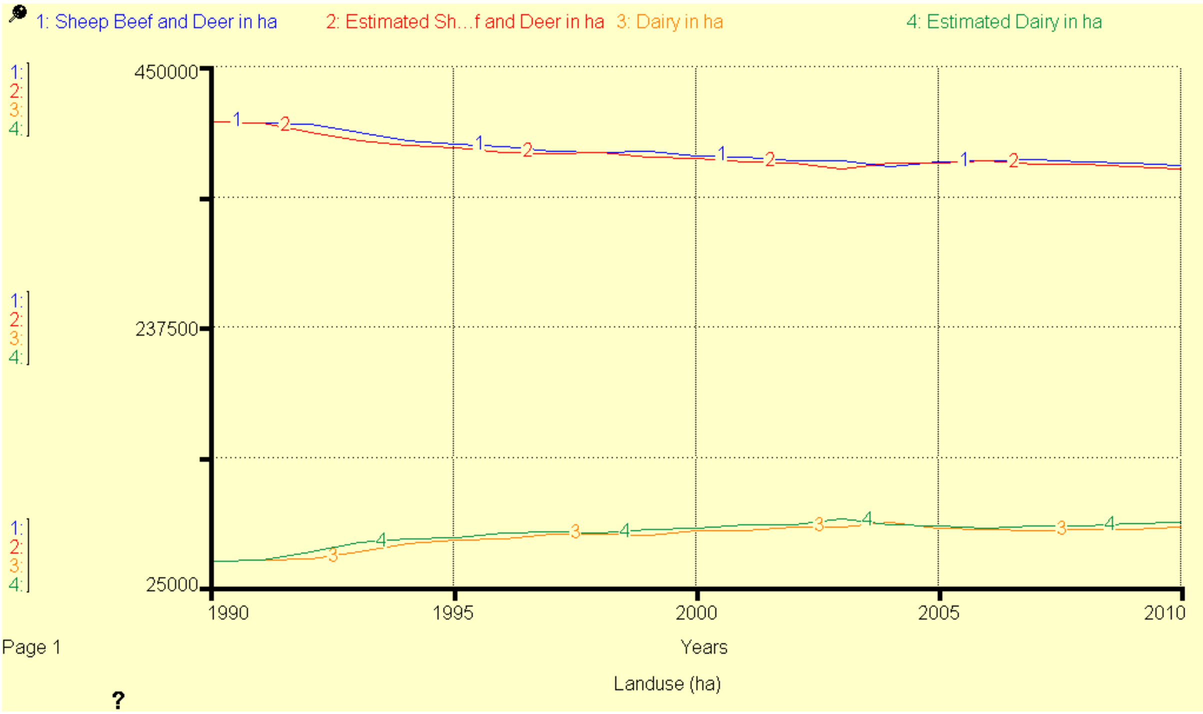


Figure C 6: Simulated (line 1 and 3) and estimated (line 2 and 4) predominant landuse in the Manawatū River catchment from 1990 to 2010.

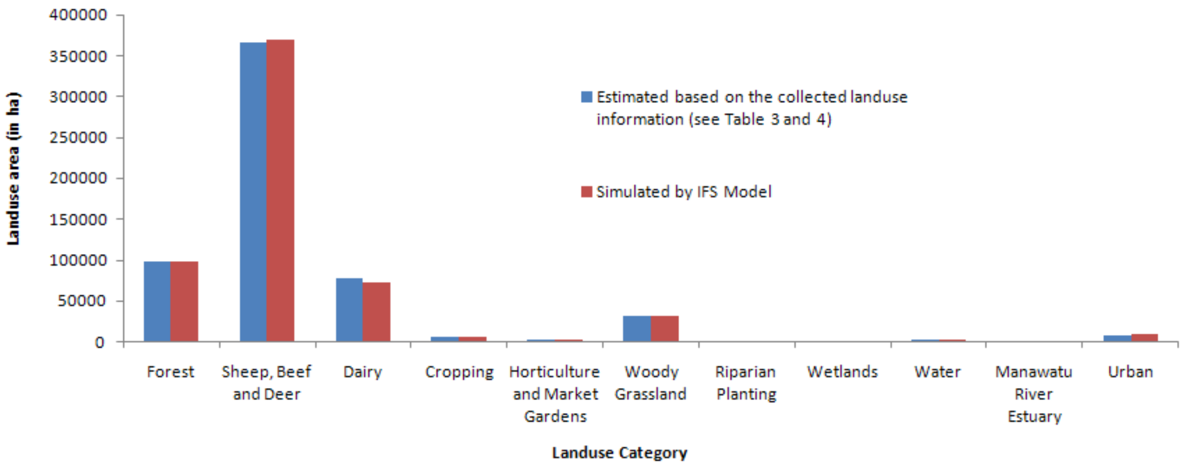


Figure C 7: Landuse in the Manawatū River catchment in 2010.

Table C 5 summarises the simulated landuse changes based on the current landuse information provided as input to the IFS model. The model captures the current trend of increasing Dairy farming while decreasing Sheep Beef and Deer farming area in the Manawatū River catchment. It is estimated that the simulated Dairy grew by 61% (from 45,000 to 72,641 ha) during last decade (from 1990 to 2010) and if the current annual growth rate (estimated about 1.0% in the last 10-years from 2000-2010) continues the simulated Dairy area would grow by 36% to 98,856 ha in 2040. On the other side, the simulated Sheep Beef and Deer farming decreased by 9% from 1990 to 2010, and would decrease further by 11% from 2010 to 2040.

Table C 5: Simulated landuse changes in the Manawatū River catchment from 1990 to 2040.

Landuse Type	Total 1990 (ha)	Total 2010 (ha)	% Change from 1990 to 2010	Total in 2040 (ha)	% Change from 2010 to 2040
Forest	90,390	98,293	9%	111,463	13%
Sheep, Beef and Deer	404,978	369,315	-9%	329,744	-11%
Dairy	45,000	72,641	61%	98,856	36%
Cropping	4,641	4,704	1%	4,796	2%
Horticulture and Market Gardens	1,600	1,605	0.3%	1,611	0.4%
Woody Grassland	31,075	30,535	-2%	29,618	-3%
Riparian Planting	900	900	0%	900	0%
Wetlands	241	232	-4%	218	-6%
Rivers and Lakes	2,138	2,138	0%	2,138	0%
Manawatū River Estuary	200	200	0%	200	0%
Urban	7,304	7,904	8%	8,923	13%
Total	**588,467**	**588,467**		**588,467**	

Further developments:

- Collect predominant land use change dynamics. What is changing to what?
- Collect projected/ expected growth rates of different land use, for instance dairy growth rate from 2010 to 2040
- Calibrate and validate the module with collected and estimated land use and conversion rates information

Water Availability and Use Module: This module simulates water availability and use in the Manawatū River catchment from 1990 to 2040. It is linked with and designed to handle the climate change impacts and uncertainties (if any) through simulating percent changes in the annual rainfall received in the catchment.

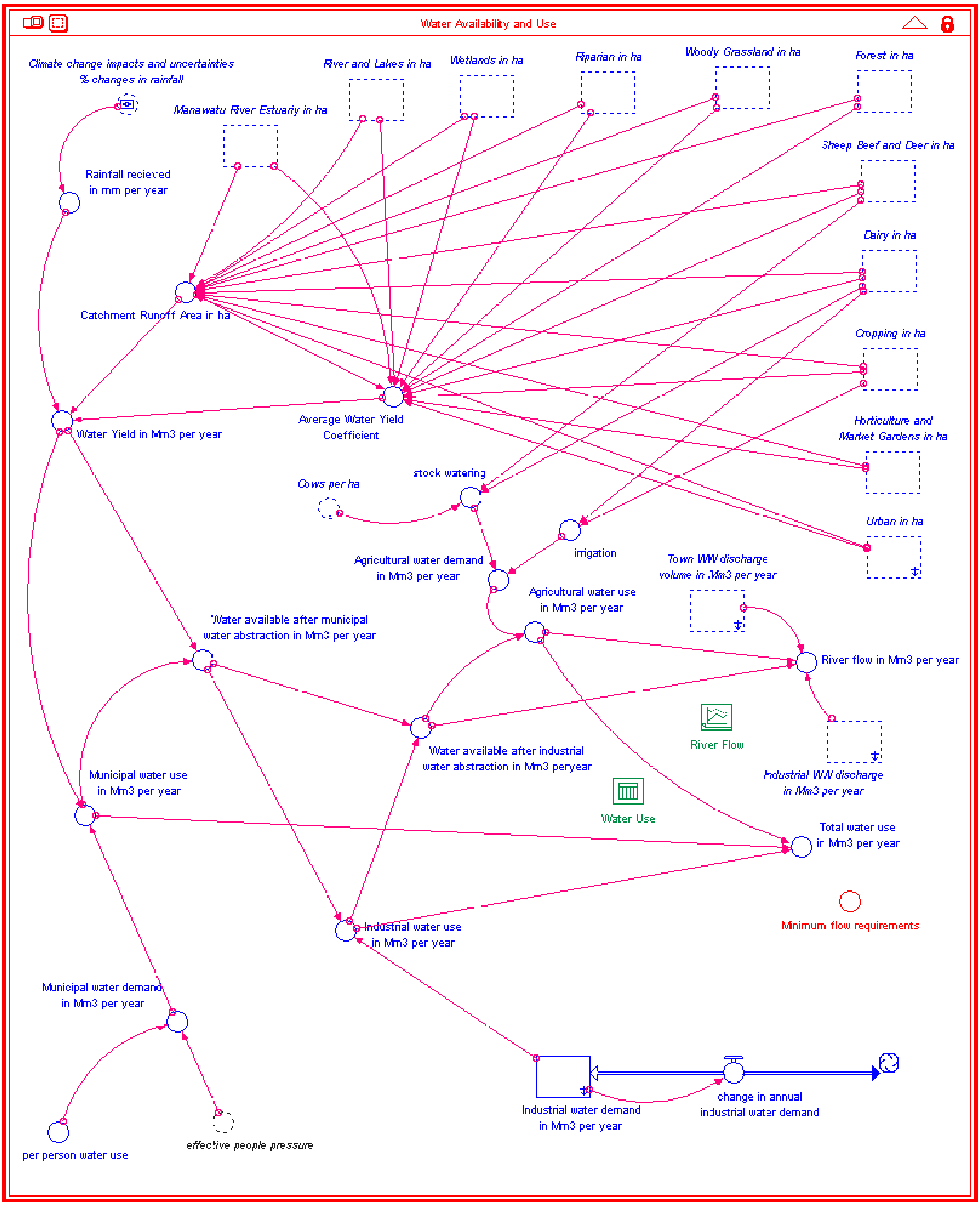


Figure C 8: Water availability and use model sector.

Data needs:

- Time series of average annual rainfall and river flow measurements
- Average water yield coefficient for different landuse types in the catchment
- Water allocation and use for different water use categories, such as municipal, industrial and agricultural (stock watering and irrigation)
- Irrigation rates, in mm per year or ML per ha per year for irrigation of different landuse such as cropping, dairy pasture, irrigated sheep and beef pasture (if any)
- Stock water rates, in ML per ha per year for Dairy and Sheep Beef and Deer
- Extent of irrigation and stock watering (what % of the area is irrigated or supplied with stock watering)
- Projected/ expected water use changes, for instance irrigation of dairy farming area

Input data used and calculation procedure:

Water availability is estimated by converting the mean annual rainfall received into water yield (.i.e. quickflow and baseflow drainage) volume in the catchment (Dymond et al., 2012). The average water yield coefficient, i.e. the proportion of rainfall that becomes water yield, for different landuse in the catchment is specified 0.30 for forest area; 0.35 for Woody Grassland areas; 0.36 for Riparian areas; 0.40 for Dairy, Cropping and Horticulture areas; 0.45 for Sheep, Beef and Deer area; 0.75 for urban area; and 1.0 for water (river, lakes and Manawatū Estuary) and wetlands areas. These numbers are considered ‘place holders’, to be calibrated and validated for different combinations of land use and soil types in the catchment.

The annual rainfall ranges from 800 mm near the coast to more than 2000 mm in the Tararua and Ruahine ranges of the Manawatū Catchment. The mean annual rainfall over the whole area is specified from 1000 to 1400 mm per year in the Manawatū Catchment. The rainfall received is linked to the climate change impacts and uncertainties, i.e. % changes in the rainfall received (in the External factors and pressures module). In the current model, the % change in rainfall due to climate change is specified as zero as a ‘place holder’, simulating no climate change impacts.

The municipal water demand is estimated based on ‘per person water use’ multiplied by the ‘effective people pressure’ from the ‘Demographic’ module. The industrial water demand is initially estimated, and then simulated to increase or decrease in proportion to the relative annual ‘economic prosperity GDP’. In a feedback loop, the ‘economic prosperity GDP’ is simulated to increase or decrease in proportion to relative annual water use in the catchment. The agricultural water demand is estimated based on stock or irrigation rate (mm or ML per ha per year) multiplied by the different landuse area requiring the stocking and irrigation water. Table C 6 summarises the parameters used for estimation of annual water demands for municipal, industrial and agricultural purposes in the catchment.

Table C 6: Estimated water use parameters

Parameter	Value	Source
Per person water use (in m^3 per year)	165	Based on the daily average water usage of 450 litres per person (MfE, 2003)
Industrial water demand in 1990 (in million m^3 per year)	2.75	A place holder
Stock Water Rate		
Sheep Beef and Deer (m^3 per ha per year)*	40.52	Based on the reported reasonable stock water requirements (Stewart and Rout, 2007)
Dairy cows (in m^3 per cow per year)	14.00	As above
Irrigation Rate		
Pasture (in mm per year)	173	Based on irrigation water demand estimation in Manawatū (Hedley, 2009)
Crop (Maize) (in mm per year)	277	As above
Irrigation Area		
% of dairy pasture under irrigation	15	A placeholder
% of cropping under irrigation	5	A place holder

*Based on the assumption of stocking rate of Sheep and Beef (70:30 ratio) with an average of 10 stock units per hectare

Depending on the estimated water demands and availability (i.e. water yield), the water use is estimated in a priority order, first the municipal water use, then industrial water use and in last agricultural water use. The total water use is estimated by adding up the municipal, industrial and agricultural water use. The total water availability minus total water use results into the river flow. The estimated town wastewater and industrial wastewater discharge volumes are also added to the river flow.

With the given model inputs (to Table C 6), Figure C 9 depicts the estimated annual water use and Figure 10 depicts the river flow in the Manawatū River catchment (at the outlet of the catchment, i.e. Manawatū River Estuary) from 1990 to 2040. It is simulated that the average annual water use during period 2011-2040 (the next 30 years) increased by 11% for municipal, 17% for industrial and 16% for agricultural purposes as compared to the average annual water uses during period 1990-2010 (the last 20 years) (Figure C 9).

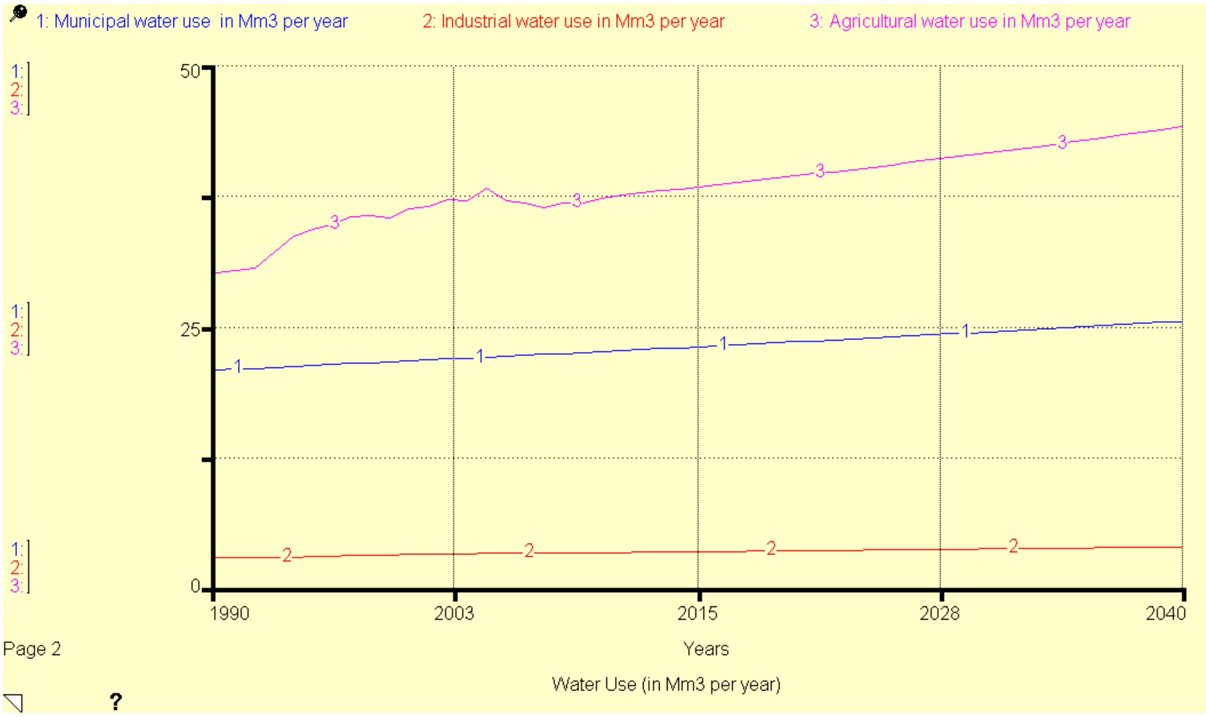


Figure C 9: Water use by different user sectors (1990 – 2040).

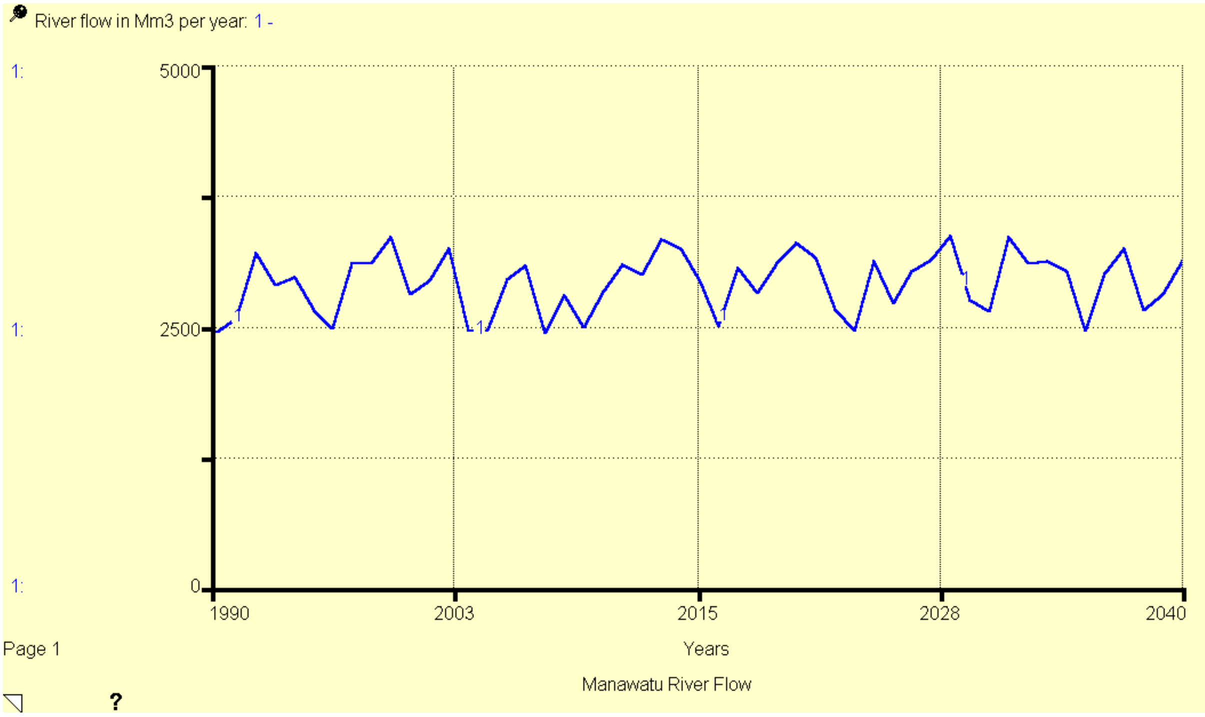


Figure C 10: Estimated river flow (in Mm^3 per year) in the Manawatū River (at the outlet of the catchment, i.e. Manawatū River Estuary) from 1990 to 2040.

The river flow is estimated from 2478 to 3422 million m^3 (Mm^3) per year with an average of 2964 Mm^3 per year during the period from 1990 to 2040 (Figure C 10). This represent well the Manawatū River' mean annual discharge about 95 m^3 per second, i.e. 2996 Mm^3 per year.. However, the industrial and agricultural water use parameters, especially % of dairy pasture and cropping area under irrigation are used as 'place holders', and should be calibrated and validated as information becomes available.

Further developments:

- Further develop the module according to the identified main water use categories from 1990 to 2040
- Calibrate and validate the water use and river flow with estimated water yield coefficient and water use parameters

Point and Non Point Sources Module: This module estimates the pollutants loads from all major point and non-point sources in the Manawatū River catchment from 1990 to 2040. It is linked with and handles the proposed changes from the 'Actions for Solutions' module, for instance 'WW mgmt improvement' and 'Farm Nutrient mgmt improvement' to simulate the possible impacts on pollutant loadings to the river.

Data needs:

- Identify and list all major pollutants to be considered
- Identify major point sources and their average annual loading rates in terms of quantity discharges (e.g. m^3 per day or year) and concentrations (g per m^3) of identified pollutants

- Identify major non-point sources and their average annual loading (leaching) rates (e.g. kg N per cow per year from Dairy farming OR kg N per ha per year from Sheep Beef and Deer farming). These loading rates should not consider the attenuation coefficients.

Input data used and calculation procedure:

In the process of MM workshops, nitrogen, phosphorus, sediments and Ecoli were identified and discussed as major pollutants for the Manawatū River. Toxins were also mentioned, but there was limited discussion and information available about toxins; what their sources are and how they affect the river health and condition? Town wastewater, industrial wastewater and urban stormwater were identified as major point sources, while Dairy farming, Sheep Beef and Deer farming, and Crop farming were identified as major non-point sources. The background level (outside of harvest periods) of erosion from forest land was also discussed as this is a non-point source of sediment. Wetlands were regarded as a net sink for sediments and nutrients though it was acknowledged had the potential to be a source if washed away in floods or subject to extensive vegetation decay. The riparian planting was also discussed as a control for sediment loads to the river. The impact of riparian planting on nutrients loads, especially on subsurface nitrate loads to river was identified as a knowledge gap.

Based on the above discussion, it was decided to include and estimate the loads of soluable inorganic nitrogen (SIN), dissolved reactive phosphorus (DRP), sediments (SS), Ecoli and toxins (as a place holder for particular toxins to be identified) from the following point and non-point sources:

- Town wastewater discharges
- Industrial wastewater discharges
- Urban stormwater
- Dairy farming
- Sheep Beef and Deer farming
- Crop farming
- Forest land

The Wetlands and Riparian Zones were also included to simulate their impact, by attenuation of nutrients and trapping of sediment, reducing loadings of the identified pollutants to the river.

Further developments:

- Further develop the module according to the identified pollutants and sources
- Populate the module with collected and estimated point and non-point sources pollution information
- Calibrate and validate the pollutant loads from different point and non-point sources in the catchment

Town wastewater loads: This sub-sector module estimates different pollutants loads in all town wastewater discharges. There are a number of town wastewater treatment plants which discharge in the river. As expected, they will have different amounts of loadings both in terms of quantity and quality. It was decided to aggregate them as total town wastewater loadings (total discharge quantity and weight average concentrations of each pollutant in the discharge).

The town wastewater loads are linked to the 'Actions for Solutions' module to simulate the possible impacts of (if any) proposed changes in town wastewater treatment and/or management, for instance 'Improved Town WW mgt % reduction in discharge volume' and 'Improved Town WW mgt Enhanced Nutrient Removal' (Figure C 11). If there are any proposed changes (i.e. improved town wastewater treatment and/or management) in one particular source in the Manawatū River catchment, then that would need to be translated to changes in the aggregated loads in the model to simulate the impacts. It would require determining what proposed improved town wastewater treatment and management means, i.e. % reduction in total town discharge volume or in pollutant concentrations, or both.

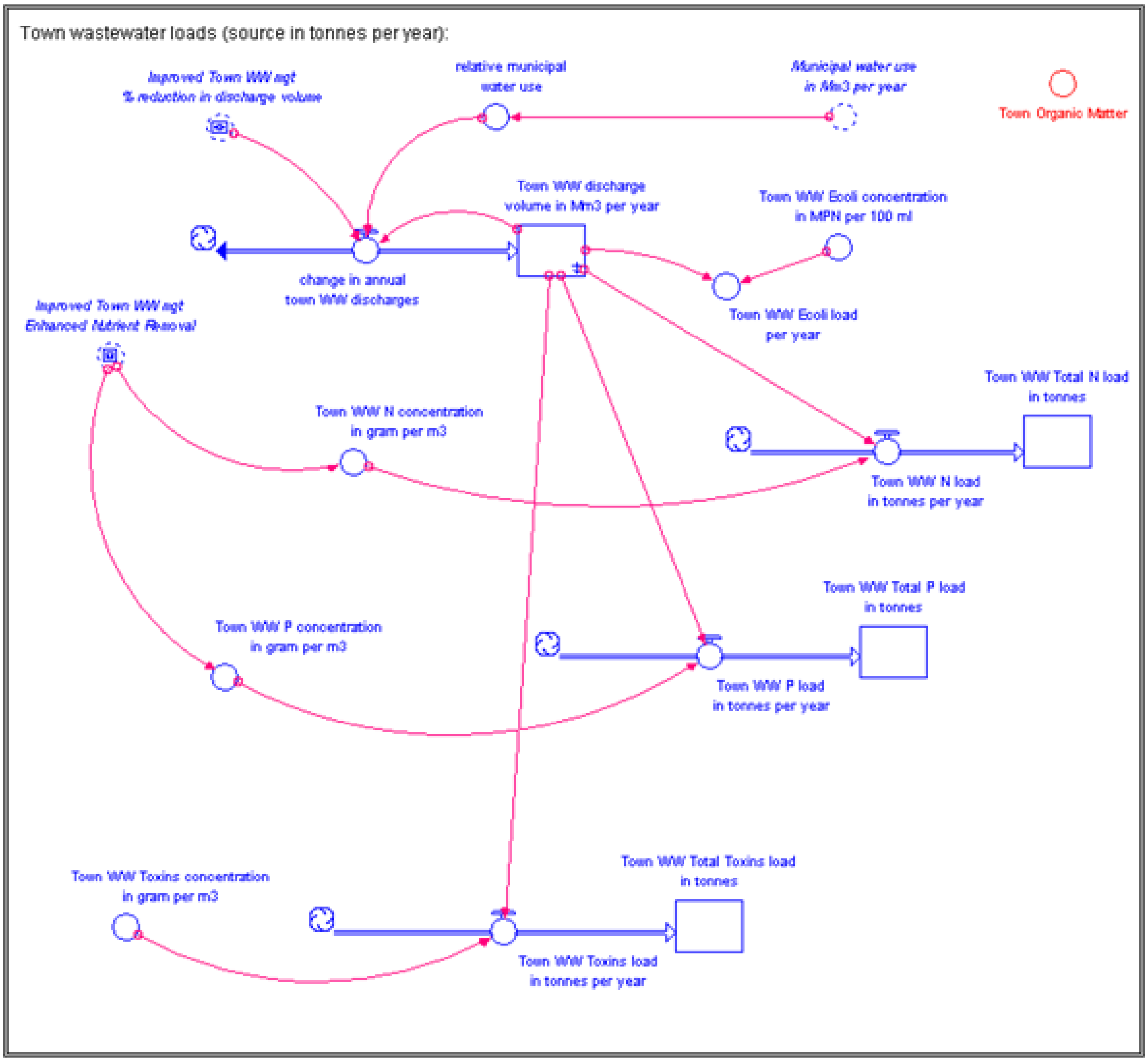


Figure C 11: Town wastewater loads (in tonnes per year) model sub-sector.

Data needs:

- List of all major pollutants to be considered in town wastewater discharges. The start list is as below:
  - Nitrogen (SIN)
  - Phosphorus (DRP)
  - Ecoli
  - Toxins - used as a place holder for particular toxins to be identified.
- All town wastewater discharge consents and their loading rates of identified pollutants: quantity discharges (e.g. m^3 per day or year) and concentrations of different pollutants (g per m^3)
- What % of each pollutant would be removed by 'Improved Town WW Management Enhanced Nutrient Removal'

Input data used and calculation procedure:

The town wastewater loads are estimated by multiplying the discharge quantity (e.g. m^3 per year) with the discharge quality, i.e. concentrations (g per m^3) of identified pollutants in town wastewater discharges.

The town wastewater discharge in 1990 was estimated about 18.702 million m^3 (Mm^3) per year. This estimation was based on a calculation using per person water use of 165 m^3 per year (i.e. 452 litres per person per day) (Table C 6) and assumption that 90% of the water used is discharged as wastewater. The estimated town wastewater discharge in 1990 is linked with municipal water use (see Water Availability and Use module) to simulate the effects of increasing or decreasing municipal water use on town wastewater discharges from 1990 to 2040. The model simulated about 20.217 Mm^3 of town wastewater discharges in 2010. This simulated town wastewater discharge is in reasonable agreement with 20.508 Mm^3 of consented treated wastewater discharges to the Manawatū River, based on an analysis of the current discharge consents dataset.

The nitrogen (SIN) and phosphorus (DRP) concentrations in town wastewater (Table C 7) were estimated using a total nitrogen (TN) and total phosphorus (TP) load of 4.2 and 1.5 kg per person per year, respectively (based on Table 2 data in Ledein et al., 2007, adapted from MfE, 2002). It was assumed that TN losses from domestic wastewater are in the form of Soluble Inorganic Nitrogen (SIN) and the ratio of DRP/TP is about 0.85 for effluents of sewage treatment plants (typical ratio used by the environmental agency of England and Wales) (Ledein et al., 2007). A conventional secondary wastewater treatment was assumed to remove 23% (i.e. average of 5 to 40% removal efficiency) of nitrogen and phosphorus loads from domestic wastewater (Ledein et al., 2007). The estimated town wastewater SIN and DRP loads per person per year were finally multiplied with the total catchment population to get the total town wastewater SIN and DRP loads, which were further divided by the estimated town wastewater discharge volume to get average town wastewater SIN and DRP concentrations. This calculation done for year 1990 data resulted in an average SIN and DRP concentration of 21.92 and 6.65 g/m^3, respectively in town wastewater discharge for Manawatū River catchment. In a recent study, PDP (2011) observed a TN (~SIN) concentration from 24 to 35 g/m^3, and DRP from 3.2 to 3.8 g/m^3 from the Waiouru Sewage treatment plant in Manawatū region during December, 2009 to March, 2010.

The indicator of bacterial pollution, Ecoli is measured in MPN per 100 ml, where MPN stands for Maximum Probable Number. An average Ecoli in town wastewater was set at 220,700 MPN/100mL (Table C 7), based on a mean value indicated in the Waiouru Sewage treatment plant effluent over the period from 2007 to 2009 (Pattle Delamore Partners Ltd, 2011).

In the current IFS model, toxin is used as a 'place holder' for particular toxins to be identified in town wastewater discharges (Figure C 11).

Table C 7: Average pollutants concentration in different point sources.

Point Source	Pollutant	Concentration (g/m^3)	Source
Town Wastewater	Soluble Inorganic Nitrogen (SIN)	21.92	Based on reported data (Table 2, in Ledein et al., 2007)
	Dissolved Reactive Phosphorus (DRP)	6.65	as above
	Ecoli*	220700	Based on reported in PDP (2011)
Industrial Wastewater	Soluble Inorganic Nitrogen (SIN)	25.00	A place holder
	Dissolved Reactive Phosphorus (DRP)	5.00	A place holder
Urban Stormwater	Soluble Inorganic Nitrogen (SIN) (NO_3 and NH_4)	0.61	Based on reported data for Motorway catchment in Auckland (Williamson, 1986)
	Dissolved Reactive Phosphorus (DRP)	0.04	as above
	Suspended Solids (SS)	686	as above

* Ecoli is measured in MPN/100 mL - where MPN stands for Maximum Probable Number

Further developments:

- Further develop the sub-sector module according to the identified pollutants in town wastewater discharges, in particular toxins
- Calibrate and validate the sub-sector module with collected and estimated town wastewater discharges data, both quantity discharges (e.g. m^3 per day or year) and concentrations of different pollutants (g per m^3)
- Should the Organic Matter loads in town wastewater discharges be considered for biological oxygen demand (BOD), if yes then how?

***Industrial wastewater loads*:** This sub-sector module estimates different pollutants loads in all industrial wastewater discharges. There are a number of industrial wastewater discharges in the river. As expected, they will have different amounts of discharges and pollutant loadings both in terms of quantity and concentrations. It was decided to aggregate them as total loadings (total quantity and weighted average concentrations of each pollutant in the discharge).

Similar to the town wastewater loads, the industrial wastewater loads are linked to the 'Actions for Solutions' module to simulate the possible impacts of (if any) proposed changes in industry wastewater treatment and/or management, for instance 'Improved Industry WW mgt % reduction in discharge volume' and 'Improved Industry WW mgt Enhanced Nutrient Removal' (Figure C 12). If there are proposed changes (i.e. improved industrial wastewater treatment and/or management) in one particular source in the Manawatū River catchment, then that would need to be translated to changes in the aggregated loads in the module to simulate the impacts. It would require determining what proposed improved industrial wastewater treatment and management means, i.e. % reduction in total industrial discharge volume or in pollutant concentrations, or both.

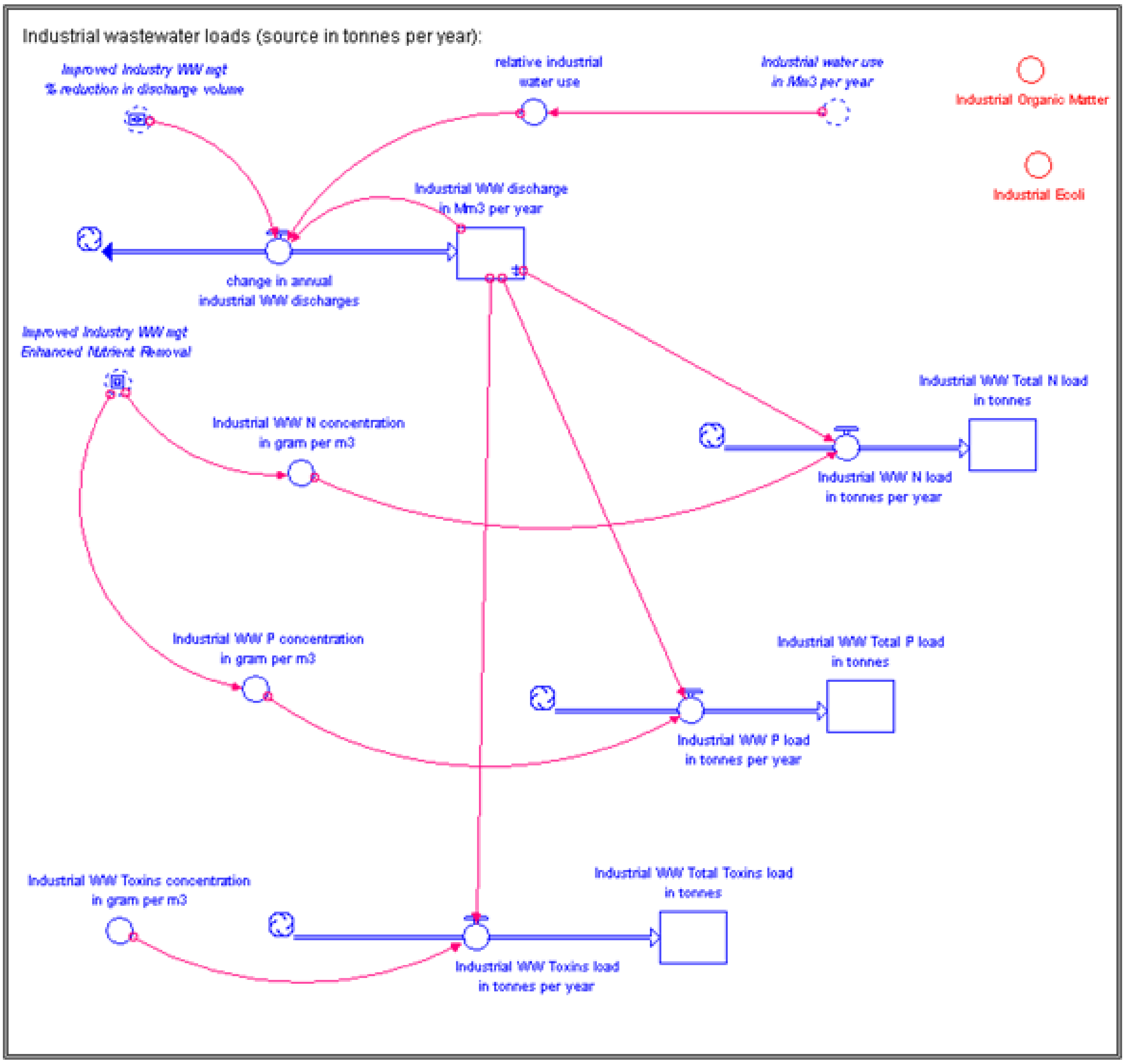


Figure C 12: Industrial wastewater loads (in tonnes per year) model sub-sector.

Data needs:

- List of all major pollutants to be considered in industrial wastewater discharges. The start list is as below:
  - Nitrogen (SIN)
  - Phosphorus (DRP)
  - Toxins - used as a place holder for particular toxins to be identified.
- All Industrial discharge consents and their loading rates of identified pollutants: quantity discharges (e.g. m^3 per day or year) and concentrations of different pollutants (g per m^3)
- What % of each pollutant would be removed by 'Improved Industry WW mgt Enhanced Nutrient Removal'

Input data used and calculation procedure:

The industrial wastewater loads are estimated by multiplying the discharge quantity (e.g. m^3 per year) with the discharge quality, i.e. concentrations (g per m^3) of identified pollutants in industrial wastewater discharges.

In the absence of the actual data, the quantity of industrial wastewater discharge in 1990 was set as a 'place holder' about 2.613 Mm^3 per year, assuming that 95% of the industrial water use (Table C 6) is discharged as industrial wastewater. The estimated industrial wastewater discharge in 1990 is linked with industrial water use (see Water Availability and Use module) to simulate the effects of increasing or decreasing industrial water use on industrial wastewater discharges from 1990 to 2040. The model simulated 3.091 Mm^3 of industrial wastewater discharges in 2010, is in a reasonable agreement with 3.500 Mm^3 of consented industrial wastewater discharges to the Manawatū River, based on an analysis of the current discharge consents dataset.

In the absence of industrial wastewater pollutant concentrations, the nitrogen (SIN) and phosphorus (DRP) concentrations in industrial wastewater are set as a 'place holders' about 25.00 and 5.00 g/m^3, respectively (Table C 7). Therefore, all industrial wastewater nitrogen and phosphorus loads are considered to be 'place holders', and should be calibrated and validated as information becomes available. Also, toxin is used as a 'place holder' for particular toxins to be identified in industrial wastewater discharges (Figure C 12).

Further developments:

- Further develop the sub-module according to the identified pollutants in industrial wastewater discharges, in particular toxins
- Calibrate and validate the sub-module with collected and estimated industrial wastewater discharges data, both quantity discharges (e.g. m^3 per day or year) and concentrations of different pollutants (g per m^3)
- Should the Organic Matter loads in industrial wastewater discharges be considered for biological oxygen demand (BOD), if yes then how?
- Should the Ecoli loads in industrial wastewater discharges be considered, if yes then how?

Urban Stormwater loads: This sub-sector module estimates different pollutant loads in urban stormwater from urban areas. It is linked with 'Urban area' to simulate the effects of increasing urban area on stormwater generation and pollutant loads. It is also linked with the 'Actions for Solutions' module to simulate the possible impacts of (if any) proposed changes in stormwater management, for instance 'Urban Impervious Fraction', 'Effective Impervious Fraction' and 'Enhanced Stormwater Treatment Measures' (Figure C 13).

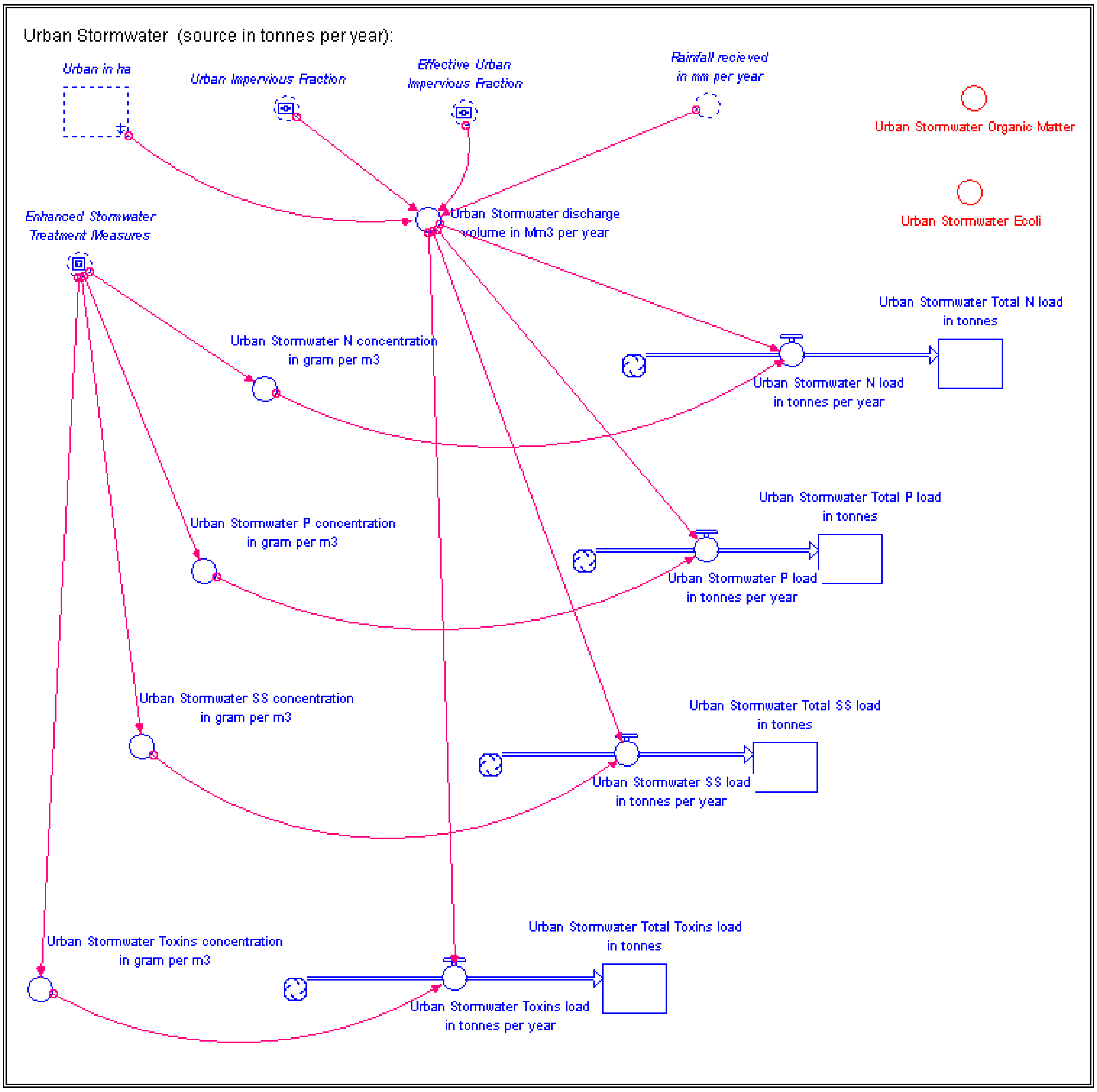


Figure C 13: Urban stormwater loads (in tonnes per year) model sub-sector.

Data needs:

- List of all major pollutants to be considered in urban stormwater. The start list is as below:
    - Nitrogen (SIN)
    - Phosphorus (DRP)
    - Suspended Solids (SS)
    - Toxins - used as a place holder for particular toxins to be identified

- Flow mean concentrations of identified pollutants in urban stormwater, i.e. concentrations of different pollutants (g per m^3)
- What % of each pollutant would be removed by 'Enhanced Stormwater Measurement Measures'

Input data used and calculation procedure:

The urban stormwater loads are estimated by multiplying the stormwater quantity (e.g. m^3 per year) with the stormwater quality, i.e. concentrations (g per m^3) of identified pollutants in stormwater from urban areas. The urban stromwater quantity (m^3 per year) is estimated by as follows:

Urban Stormwater discharge_volume_in_Mm^3_per_year =

> (Urban_Impervious_Surface_Runoff_Coefficient*Rainfall_recieved__in_mm_per_year)*(Effective_Urban_Impervious_Fraction*Urban_Impervious_Fraction*Urban_in_ha)/100000

The urban impervious surface runoff coefficient is set at 0.80 (Table C 8) based on the runoff coefficients for developed surface types (from Compliance Document for New Zealand Building Code, Clause E1, Surface Water, Department of Building and Housing 2006)(NZIE 1980). The urban impervious fraction is the fraction of urban area which is developed as imperious surface, and the *effective* urban imperious fraction is the fraction of urban impervious area which is directly connected to the urban stormwater system. The rainfall-runoff from *effective* urban impervious surface directly flows to the stormwater drainage system and contributes to urban stormwater discharges. The urban impervious fraction and *effective* urban impervious fraction are set at 0.30 and 0.90 as 'place holders' (Table C 8) based on the reported landuse data for Motorway catchment in Auckland (Williamson, 1986). Based on the urban stromwater parameters (Table C 8) and urban area (Table C 5), the model simulated an average annual urban stormwater discharge of 18.98 Mm^3 per year from during the period 1990-2011 (the last 20 years), and 22.44 Mm^3 per year during period 2011-2040 (the next 30 years) in the catchment.

Table C 8: Urban stormwater parameters

Parameter	Value	Source
Impervious Surface Runoff Coefficient (-)	0.80	Based on the runoff coefficients for developed surface types (from Compliance Document for New Zealand Building Code, Clause E1, Surface Water, Department of Building and Housing 2006)(NZIE 1980)
Urban impervious fraction (-)	0.30	Based on reported data for Motorway catchment in Auckland (Williamson, 1986)
Effective Urban impervious fraction (-)	0.90	as above

The concentrations of different pollutants (NO3, DRP and SS) considered in urban stormwater (Table C 7) are based on the reported data for Motorway catchment in Auckland (Williamson, 1986). The toxin is used as a 'place holder' for particular toxins to be identified in urban stormwater discharges (Figure C 13).

Further developments:

- Further develop the sub-sector module according to the identified pollutants in urban stormwater discharges, in particular toxins
- Calibrate and validate the sub-sector module with collected and estimated urban stormwater discharges data, both quantity discharges (e.g. m^3 per day or year) and concentrations of different pollutants (g per m^3)
- Should the Organic Matter loads in urban stormwater discharges be considered for biological oxygen demand (BOD), if yes then how?
- Should the Ecoli loads in urban stormwater discharges be considered, if yes then how?

Dairy farming loads: This sub-sector module estimates loadings of different pollutants from dairy farming. The dairy farming loads are linked with the 'Actions for Solutions' module to simulate the possible impacts of (if any) proposed changes in dairy farming sector, for instance 'Sustainable Farm Nutrient Management (SFNM) Impact' and 'Dairy Effluent Compliance' (Figure C 14).

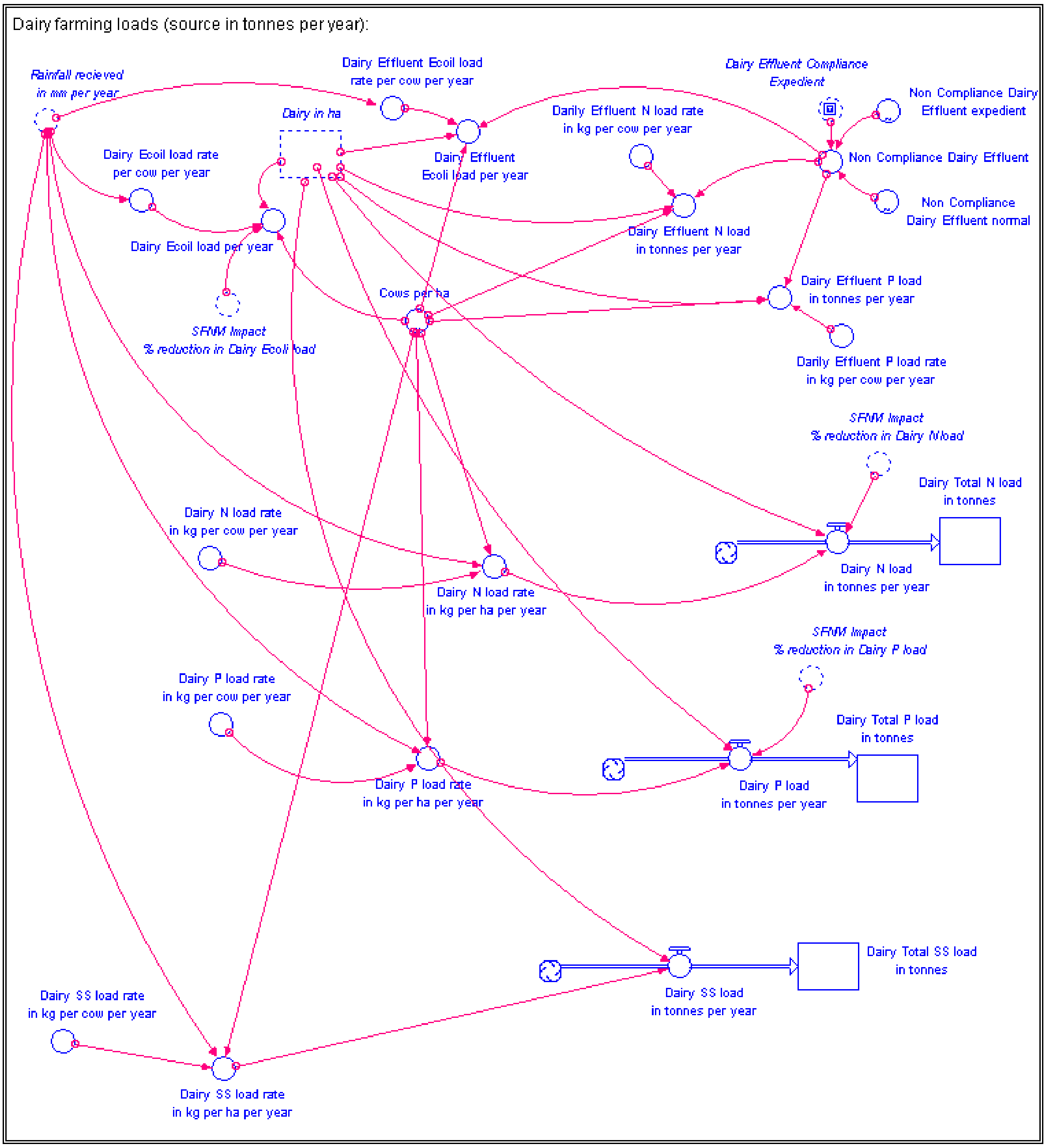


Figure C 14: Dairy farming loads (in tonnes per year) model sub-sector.

Data needs:

- List of all major pollutants to be considered from Dairy farming. The start list is as below:
  - Nitrogen (NO_3)
  - Phosphorus (DRP)
  - Sediments (SS)
  - Ecoli
- Stocking rate, in cows per ha per year
- Nutrient loading rates, e.g. in kg nitrate-nitrogen (NO_3) or DRP per cow per year. These nutrient loading rates should consider the attenuation coefficients for DRP, but not for NO_3 as it is included separately in the model.
- Sediment loading rates, in e.g. kg SS per cow per year. The sediment loading is estimated separately from dairy in low lands than from dairy in sloppy lands.
- Dairy shed effluent pollutant loading rates, e.g. in kg NO_3 or DRP per cow per year
- Percentage of dairy shed effluent compliance
- What % of each pollutant (NO_3, DRP and Ecoli) would be removed by the proposed actions such as 'SFNM Impact'

Input data used and calculation procedure:

Table C 9 summarises the estimated pollutant loads from identified non-point sources in the catchment. The nitrate-nitrogen (NO_3) and phosphorus (DRP) loads are based on the reported nutrient export coefficients for different land uses (Table 1 in Ledein et al., 2007). Note that the nitrate-nitrogen (NO_3) loading rate does not consider attenuation, as it is considered separately in the model (see Total Nitrogen Loads in the 'Total River Loads' module). The Ecoil loads are based on the reported Ecoli loadings from Dairy and Sheep and Beef farming (Table 3.1 in Wilcock, 2006). Dymond et al., (??, Landcare Research) estimated about an average rate of 5330 kg per ha per year sediment yield in the Manawatū River catchment (see Table D 3 in appendix D). With this information, the average sediment loadings (kg per ha per year) were set at 6500 for Dairy and Sheep Beef and Deer areas, 4500 for Cropping area and 4000 for Forest area (Table C 9). The specified average sediment loadings for different landuse types (Table C 9) are used as 'place holders', and should be calibrated and validated as information becomes available.

Table C 9: Average pollutant loads from different non-point sources.

Non Point Source	Pollutant	Pollutant load (in kg per ha per year)	Source
Dairy	*Nitrate (NO_3)**	*40.00*	*Based on reported data (Table 1 in Ledein et al., 2007)*
	Dissolved Reactive Phosphorus (DRP)	0.30	As above
	Ecoli**	1.74E+11	Based on reported data (Table 3.1 in Wilcock, 2006)
	Sediments (SS)	6500	A place holder
Sheep Beef and Deer	Nitrate (NO_3)*	14.40	Based on reported data (Table 1 in Ledein et al., 2007)
	Dissolved Reactive Phosphorus (DRP)	0.20	As above
	Ecoli**	1.00E+11	Based on reported data (Table 3.1 in Wilcock, 2006)
	Sediments (SS)	6500	A place holder
Cropping	Nitrate (NO_3)*	45.00	Based on reported data (Table 1 in Ledein et al., 2007)
	Dissolved Reactive Phosphorus (DRP)	0.25	As above
	Sediments (SS)	4500	A place holder
Forest	Nitrate (NO3)*	3.00	Based on reported data (Table 1 in Ledein et al., 2007)
	Dissolved Reactive Phosphorus (DRP)	0.01	As above
	Sediments (SS)	4000	A place holder
Wetlands	Nitrate (NO_3)*	-50.00	Based on reported data (in Burns and Nguyen, 2002)
	Dissolved Reactive Phosphorus (DRP)	-0.50	A place holder
	Sediments (SS)	-500	A place holder

* Note that the nitrate loading rate does not consider attenuation, as it is included separately in the model (see Total Nitrogen Loads in the 'Total River Loads' module)

** Ecoli is in MPN - where MPN stands for Maximum Probable Number

The dairy farming loads are estimated by multiplying the diary area (in ha per year) with cows per ha and the loads (in kg per cow per year) of the identified pollutants from dairy farming. The estimated pollutant loadings from the dairy farming area are converted from 'per ha per year' (Table C 9) to 'per cow per year' (Table C 10) using 2.70 cow per ha as current average stock density in dairy farming. This approach of 'cows per ha' is used to allow simulation of the impact of dairy intensification (increasing stock per ha) as well as increase in dairy area in hectares. The model assumes that the stock density (cow per ha) has been increased as 'a place holder' from 2.26 in 1990 to 2.70 in 2010, and would further increase to 3.24 in 2040. The average dairy pollutant loads are linked to the rainfall received (in mm per year), simulating higher loads during wet (high rainfall) years as compared to dry (low rainfall) years.

Table C 10: Average pollutant loads from Dairy farming

Non Point Source	Pollutant	Pollutant load (in kg per cow per year)	Source
Dairy	Nitrate (NO3)*	14.82	Based on reported data (Table 1 in Ledein et al., 2007)
	Dissolved Reactive Phosphorus (DRP)	0.11	As above
	Ecoli**	6.45E+10	Based on reported data (Table 3.1 in Wilcock, 2006)
	Sediments (SS)	2038	A place holder
Dairy shed Effluent	Soluble Inorganic Nitrogen (SIN)	5.40	Based on reported data (Table 2 in Ledein et al., 2007)
	Dissolved Reactive Phosphorus (DRP)	0.20	As above
	E-coli**	6.67E+09	Based on reported data (Table 3.1 in Wilcock, 2006)

* Note that the nitrate loading rate does not consider attenuation, as it is included separately in the model (see Total Nitrogen Loads in the 'Total River Loads' module)

** Ecoli is in MPN - where MPN stands for Maximum Probable Number

In addition to different pollutant loads from dairy farm lands, the model also simulate loadings of different pollutants (NO_3, DRP and Ecoli) from dairy shed effluent ponds in case there is non-compliance with dairy shed effluent management. Ledein et al. (2007) reported total nitrogen (TN) and total phosphorus (TP) loadings (in kg per cow per year) in dairy shed effluent (Table 2 data in Ledein et al., 2007, adapted from MfE, 2002). These dairy shed effluent TN and TP loads are converted to soluble inorganic nitrogen (SIN) and dissolved reactive phosphorus (DRP) loads (Table C 10) assuming that TN losses from dairy shed effluent are in the form of SIN and the ratio of DRP/TP is about 0.30 for dairy shed effluent (Ledein et al., 2007). The model assumes that the non-compliance with dairy shed effluent management has been dropped as 'a place holder' from 100% in 1990 to 20% in 2010, and would drop further to 10% in 2020 to 2040.

Further developments:

- Further develop the sub-sector module according to the identified pollutants from the Dairy farming
- Calibrate and validate the sub-sector module with collected and estimated pollutant loadings data from Dairy farming, especially average sediment loads (in kg per ha per year)

Sheep Beef and Deer farming loads: This sub-sector module estimates different pollutant loads from Sheep Beef and Deer farming. The Sheep Beef and Deer farming loads are linked with the 'Actions for Solutions' module to simulate the possible impacts of (if any) proposed changes in Sheep Beef and Deer farming area, e.g. 'SLUI Erosion Impact' through whole farm plans and 'Reforestation to reduce erosion from highlands' (see Landuse module linked through Sheep Beef and Deer farming area).

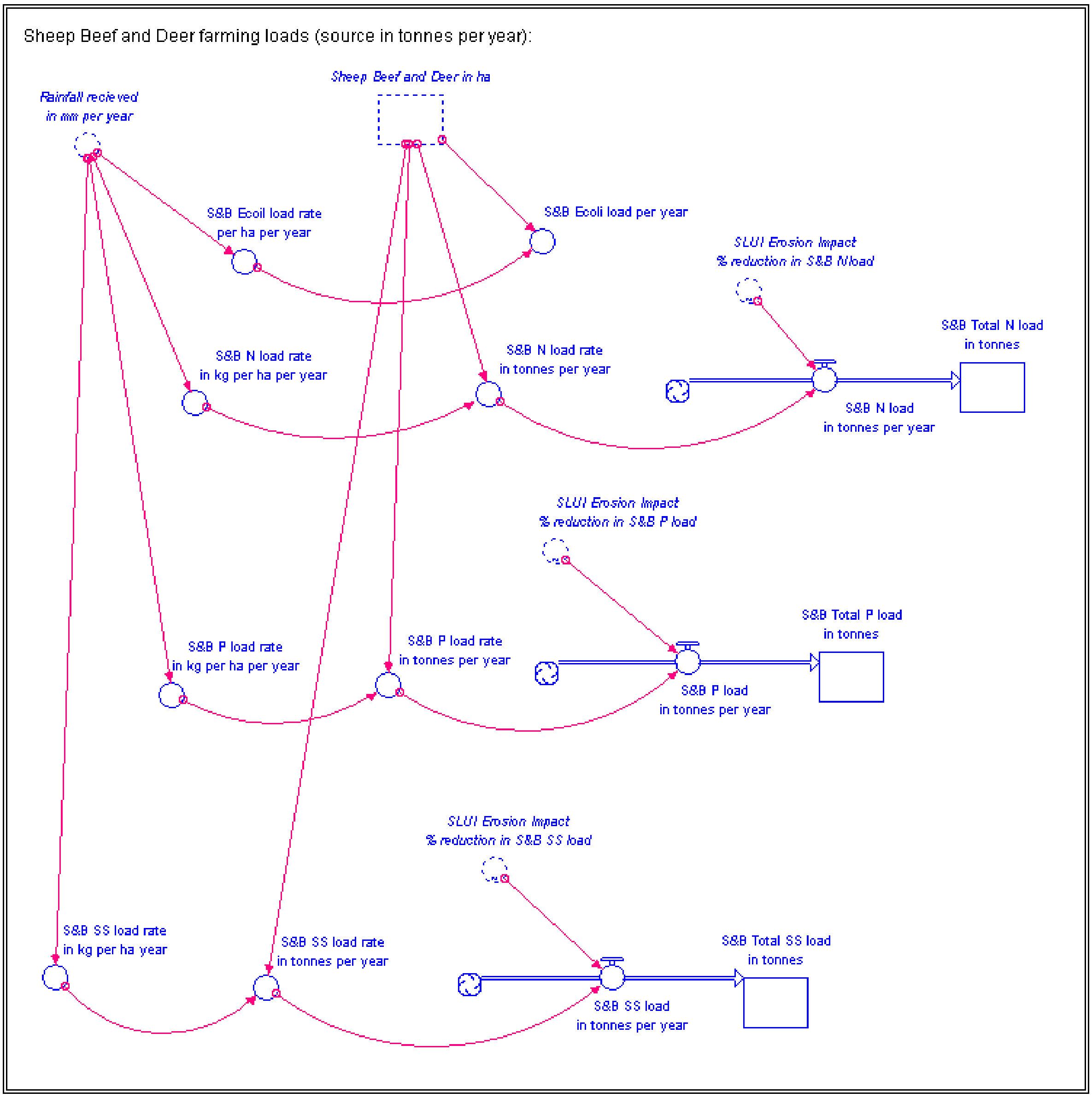


Figure C 15: Sheep Beef and Deer faming loads (in tonnes per year) model sub-sector.

Data needs:

- List of all major pollutants to be considered from Sheep Beef and Deer farming. The start list is as below:
  - Nitrogen (NO_3)
  - Phosphorus (DRP)
  - Sediments (SS)
  - Ecoli

- Nutrient loading rates, e.g. in kg NO_3 or DRP per ha per year. These nutrient loading rates should consider the attenuation coefficients for DRP, but not for NO_3 as it is included separately in the model.
- Sediment loading rates, in e.g. kg SS per ha per year.
- What % of each pollutant (NO_3, DRP and SS) would be removed by actions such as 'SLUI Erosion Impact'

Input data used and calculation procedure:

The Sheep Beef and Deer farming loads are estimated by multiplying the Sheep Beef and Deer farming area (in ha per year) with the loads (in kg per ha per year) of the identified pollutants from Sheep Beef and Deer farming. The 'Landuse' module provides the simulated Sheep Beef and Deer farming area in ha, and

Table C 9 summarises the estimated average pollutant loadings in kg per ha per year from Sheep Beef and Deer farming. The average Sheep Beef and Deer farming pollutant loads are linked to the rainfall received (in mm per year), simulating higher loads during wet (high rainfall) years as compared to dry (low rainfall) years.

Further developments:

- Further develop the sub-sector module according to the identified pollutants from the Sheep Beef and Deer farming
- Calibrate and validate the sub-sector module with collected and estimated pollutant loadings data from Sheep Beef and Deer farming, especially average sediment load (in kg per ha per year)

Crop farming loads: This sub-sector module estimates different pollutant loads from Crop farming. It could be linked with the 'Actions for Solutions' module to simulate the possible impacts of (if any) proposed changes in Crop farming, e.g. improved nutrient use efficiency, precision irrigation and fertiliser application as mentioned during the MM workshops. If there are proposed changes in Crop farming, it would require determining what proposed changes mean, i.e. % reduction in different pollutant loading rates from % of Crop farming area.

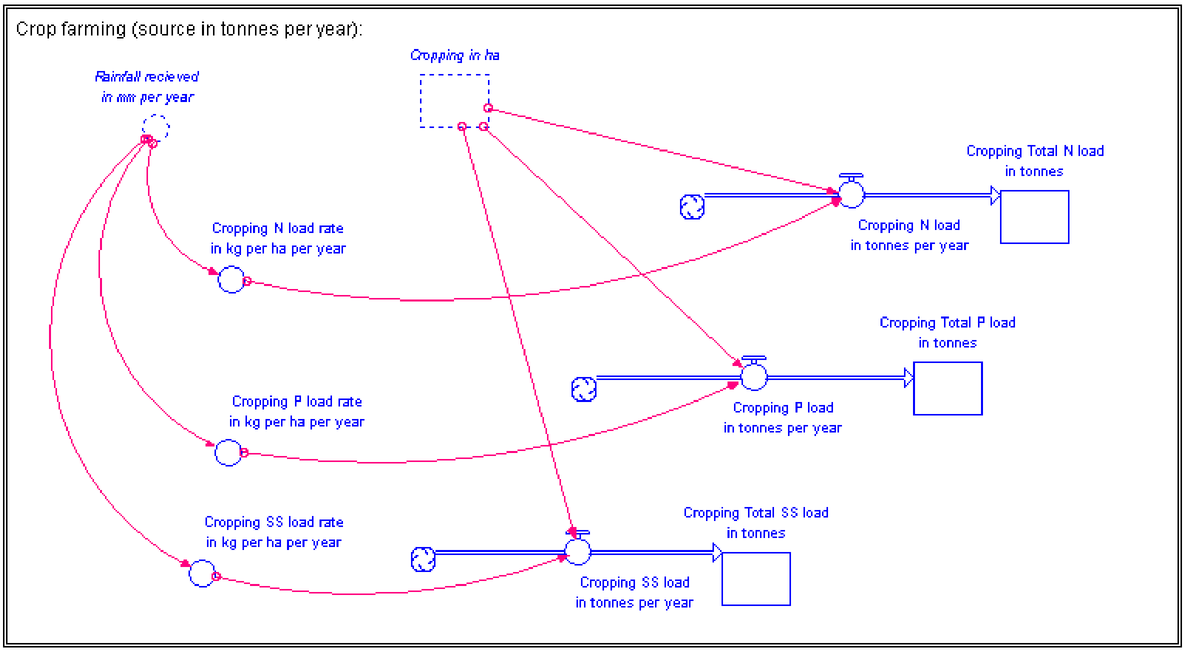


Figure C 16: Crop farming loads (in tonnes per year) model sub-sector.

Data needs:

- List of all major pollutants to be considered from Crop farming. The start list is as below:
  - Nitrogen (NO_3)
  - Phosphorus (DRP)
  - Sediments (SS)
- Nutrient loading rates, in e.g. kg NO_3 or DRP per ha per year (these loading rates should consider the attenuation coefficients for DRP, but not for NO_3 as it is included separately in the model)
- Sediment loading rates, in e.g. kg SS per ha per year

Input data used and calculation procedure:

The Crop farming loads are estimated by multiplying the Crop farming area (in ha per year) with the loads (in kg per ha per year) of the identified pollutants from Crop farming. The 'Landuse' module provides the simulated Crop farming area in ha, and Table C 9 summarises the estimated average pollutant loadings in kg per ha per year from Crop farming. The average crop farming pollutant loads are linked to the rainfall received (in mm per year), simulating higher loads during wet (high rainfall) years as compared to dry (low rainfall) years.

Further developments:

- Further develop the sub-sector module according to the identified pollutants from the Crop farming
- Calibrate and validate the sub-sector module with collected and estimated pollutant loadings data from Crop farming, especially average sediment load (in kg per ha per year)

Forest loads: This sub-sector module estimates different loads from Forest area. It is linked with the 'Actions for Solutions' module to simulate the possible impacts of (if any) proposed changes in Forest area, e.g. 'Reforestation to reduce erosion from highlands' (see Figure C 5 Landuse module linked through Forest area). It could be linked with the 'Actions for Solutions' module to simulate the possible impacts of (if any) proposed changes in forest management, e.g. pest control on Department of Conservation land as discussed during the MM workshops. If there are proposed changes in forest area, it would require determining what proposed changes mean, i.e. % reduction in different pollutant loading rates from % of forest area.

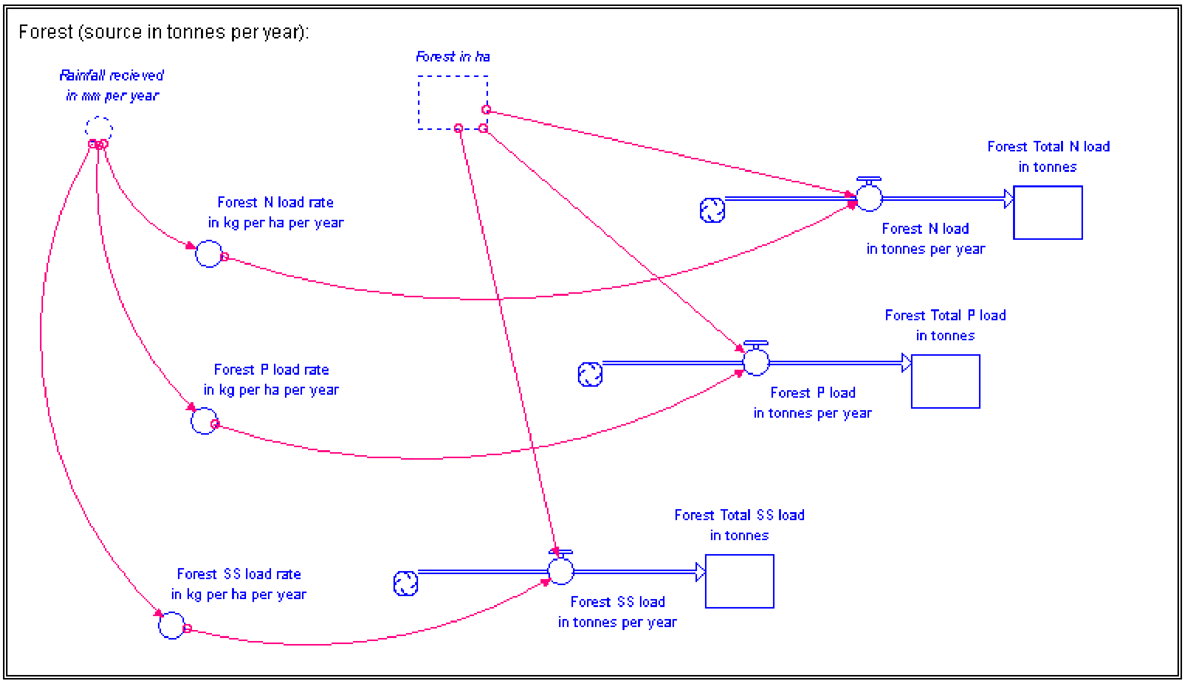


Figure C 17: Forest area loads (in tonnes per year) model sub-sector.

Data needs:

- List of all major pollutants to be considered from Forests. The start list is as below:
  - Nitrogen (NO_3)
  - Phosphorus (DRP)
  - Sediments (SS)
- Nutrient loading rates, in e.g. kg NO_3 or DRP per ha per year (these loading rates should consider the attenuation coefficients for DRP, but not for NO_3 as it is included separately in the model)
- Sediment loading rates, in e.g. kg SS per ha per year

Input data used and calculation procedure:

The Forest area loads are estimated by multiplying the Forest area (in ha per year) with the loads (in kg per ha per year) of the identified pollutants from Forest areas. The 'Landuse' module provides the simulated Forest area in ha, and Table C 9 summarises the estimated average pollutant loadings in kg per ha per year from forests. The average Forest pollutant loads are linked to the rainfall received (in mm per year), simulating higher loads during wet (high rainfall) years as compared to dry (low rainfall) years.

Further developments:

- Further develop the sub-sector module according to the identified pollutants from Forest area
- Calibrate and validate the sub-sector module with collected and estimated pollutant loadings data from Forest area, especially average sediment load (in kg per ha per year)

Wetlands loads: This sub-sector module simulates the impact of wetlands on the river pollutant loads. It is linked with the 'Actions for Solutions' module to simulate the possible impacts of (if any) proposed changes in Wetlands area, e.g. 'Restoration of wetlands' (see Landuse module linked through Wetlands area).

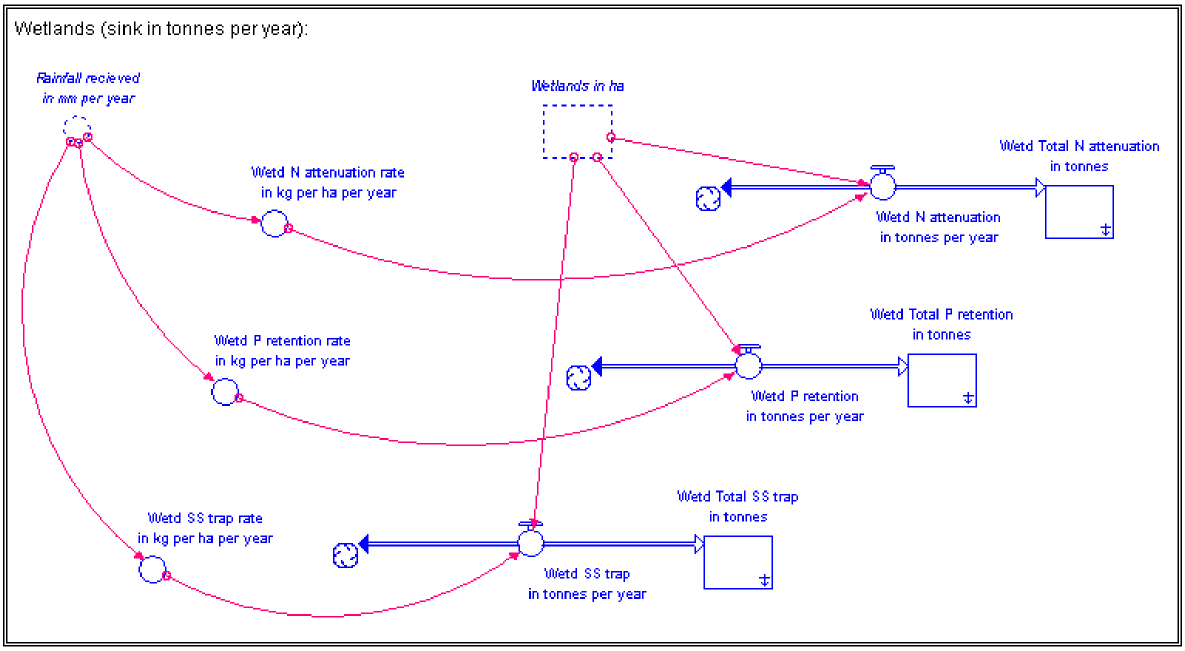


Figure C 18: Wetlands model sub-sector.

Data needs:

- List of all major pollutants to be considered from Wetlands. The start list is as below:
  - Nitrogen (NO_3)
  - Phosphorus (DRP)
  - Sediments (SS)
- Nutrient loading/trap rates, in e.g. kg NO_3 or DRP per ha per year
- Sediment loading/trap rates, in e.g. kg SS per ha per year

Input data used and calculation procedure:

The wetlands loads are estimated by multiplying the Wetlands area (in ha per year) with the loads (in kg per ha per year) of the identified pollutants from wetlands. The 'Landuse' module provides the simulated wetlands area in ha, and Table C 9 summarises the estimated average pollutant loads from wetlands. The negative numbers of nutrient (NO_3 and DRP) and sediment (SS) loads from wetlands simulates the wetlands as a sink, attenuating NO_3 and DRP and trapping sediments. The wetlands, however, are considered both sinks and sources of nutrients and sediments. This needs further discussion, and accordingly update this module to estimate the pollutants loads/trap from/in wetlands. The average wetland pollutant loads are inversely linked to the rainfall received (in mm per year), simulating less nutrient attenuation and sediment trapping during wet (high rainfall) years as compared to dry (low rainfall) years.

Further developments:

- Further develop the sub-sector module according to the identified pollutants from Wetlands
- The current wetland module simulates the wetlands as a sink, attenuating NO_3 and DRP and trapping sediments. The wetlands, however, are considered both sinks and sources of nutrients and sediments. This needs further discussion, and accordingly update this module to estimate the pollutants loads/trap from/in wetlands
- Calibrate and validate the sub-sector module with monitored and/or estimated impact on wetlands on different pollutant loadings

Riparian zone loads: This sub-sector module simulates the impact of riparian zones on the river pollutant loads. It is linked with the 'Actions for Solutions' module to simulate the possible impacts of (if any) proposed changes in riparian zones, e.g. 'Riparian Planting' (see Landuse module linked through Riparian area).

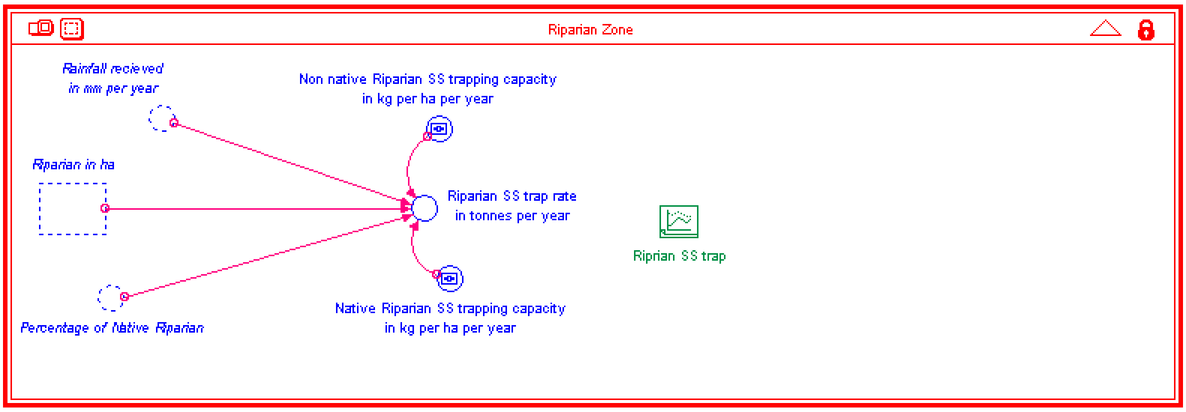


Figure C 19: Riparian zone model sub-sector.

Data needs:

- List of all major pollutants to be considered from Riparian Zone. The start list is as below:
  - Sediments (SS)
- Percentage of Riparian in native planting

- Riparian (Native and Non-Native) sediment loading/trap rates, in e.g. kg SS per ha per year

Input data used and calculation procedure:

The Riparian zone loads are estimated by multiplying the Riparian area (in ha per year) with the loads (in kg per ha per year) of the identified pollutants from riparian zones. The 'Landuse' module provides the simulated riparian area in ha, and Table C 11 summarises the riparian zone parameters, such as percentage of riparian in native planting and sediment loads (in kg per ha per year) from both native and non-native riparian zones.

Table C 11: Riparian zone parameters

Parameter	Value	Source
Percentage of Native Riparian Planting (-)	0.5	A place holder
Sediment trapping rate (in kg per ha per year)		
Non Native Riparian	-500	A place holder
Non-Native Riparian	-500	A place holder

The negative numbers of the sediment (SS) loads (Table C 11) from riparian zones simulate the riparian zones as a sink, trapping sediments. The riparian zones, however, are considered both sinks and sources of sediments. This needs further discussion, and accordingly update this module to estimate the sediment loads/trap from/in riparian zones. The average riparian zone sediment loads are inversely linked to the rainfall received (in mm per year), simulating less sediment trapping during wet (high rainfall) years as compared to dry (low rainfall) years.

Further developments:

- Further develop the sub-sector module according to the impact of riparian zones on other pollutants, e.g. Nitrate-Nitrogen (NO_3) and Dissolved Reactive Phosphorus (DRP). The impact of riparian planting on nutrients loads, especially on subsurface nitrate loads to river was identified as a knowledge gap
- The current riparian zone module simulates the riparian zones as a sink, trapping sediments. The riparian zones, however, are considered both sinks and sources of pollutants. This needs further discussion, and accordingly update this sub-sector module to estimate the pollutants loads/trap from/in riparian zones
- Calibrate and validate the sub-sector module with monitored and/or estimated impact of riparian zones on different pollutant loadings

Total River loads: This module adds up all the pollutants estimated from point and non-point sources to estimate the total pollutant loads to the river.

The river nitrogen (N) load is estimated by adding up all N loads from the identified point and non-point sources in the catchment. Note that the nitrogen (NO_3) loading rates from different non-point sources did not consider attenuation Table C 9, as it is considered here while estimating river N loadings from land to river (see Total Nitrogen Loads in the 'Total River Loads' module Figure C 20).

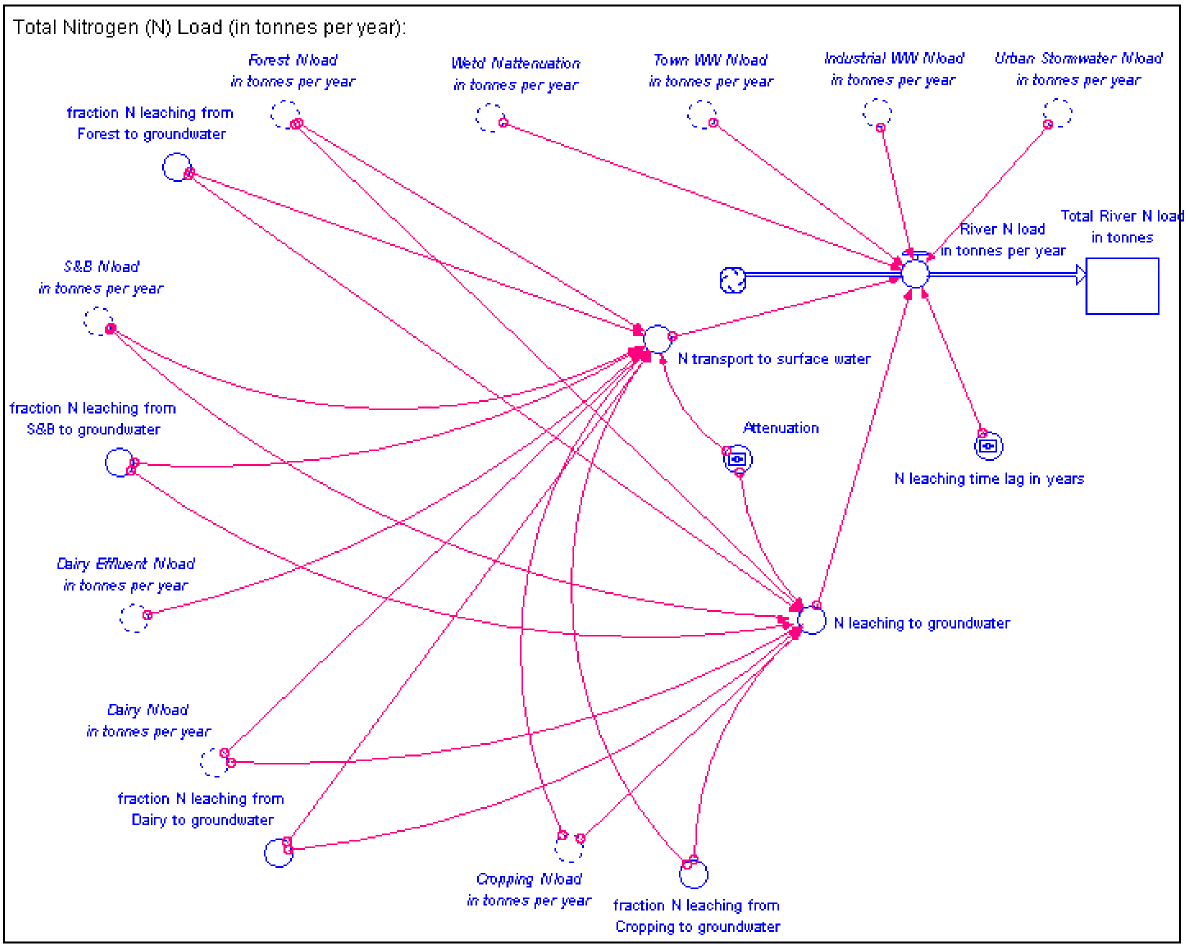


Figure C 20: Total nitrogen load in tonnes per year.

The transport of nitrogen from land to river includes a 'time lag' and 'attenuation' of nitrogen in the groundwater systems. Table C 12 summarises the parameters used for simulating attenuation and time lag in N transport from land to the river. The fractions of N leaching from Dairy and Cropping areas to groundwater are assigned low to represent presence of artificial subsurface 'mole' drainage, which quickly drains some poorly drained low lying crop and dairy lands in the catchment. The specified nitrogen transport parameters (Table C 12) are used as 'place holders', and should be calibrated and validated as information becomes available.

Table C 12: Nitrogen transport parameters.

Parameter	Value	Source
Attenuation Coefficient (-)	0.50	A place holder
Time lag (years) in groundwater	10	A place holder
Fraction of N leaching to groundwater from:		
Forest area	0.90	A place holder
Sheep Beef and Deer area	0.80	A place holder
Dairy area	0.60	A place holder
Cropping area	0.70	A place holder

With the estimated model inputs, Figure C 21 reproduces the simulated average annual pollutant (SIN, DRP, SS and Ecoli) loads to the Manawatū River over a period from 1990 to 2040. *Note that a number of model input parameters, are used as 'place holders' in the absence of information, therefore the simulated pollutant loads and their sources should be considered as 'place holders' and interpreted carefully.*

The river sediment (SS) load is estimated from 2.61 to 3.73 million tonnes (Mt) per year with an average of 3.12 Mt per year during the period from 1990 to 2010 (Figure C 21). This is in agreement with the sediment yield estimated in the Manawatū River catchment (see Table D 3 in appendix D). It is simulated that the average annual river sediment load would decrease by 20% from 3.12 Mt per year during period 1990-2010 (the last 20 years) to 2.51 Mt per year during period 2011-2040 (the next 30 years) (Figure C 21). This decrease is due to the 'SLUI Erosion Impact' simulating a scenario of 500 whole farm plans implemented reducing the Sheep Beef and Deer farming erosion by 47% (Schierlitz et al., 2006).

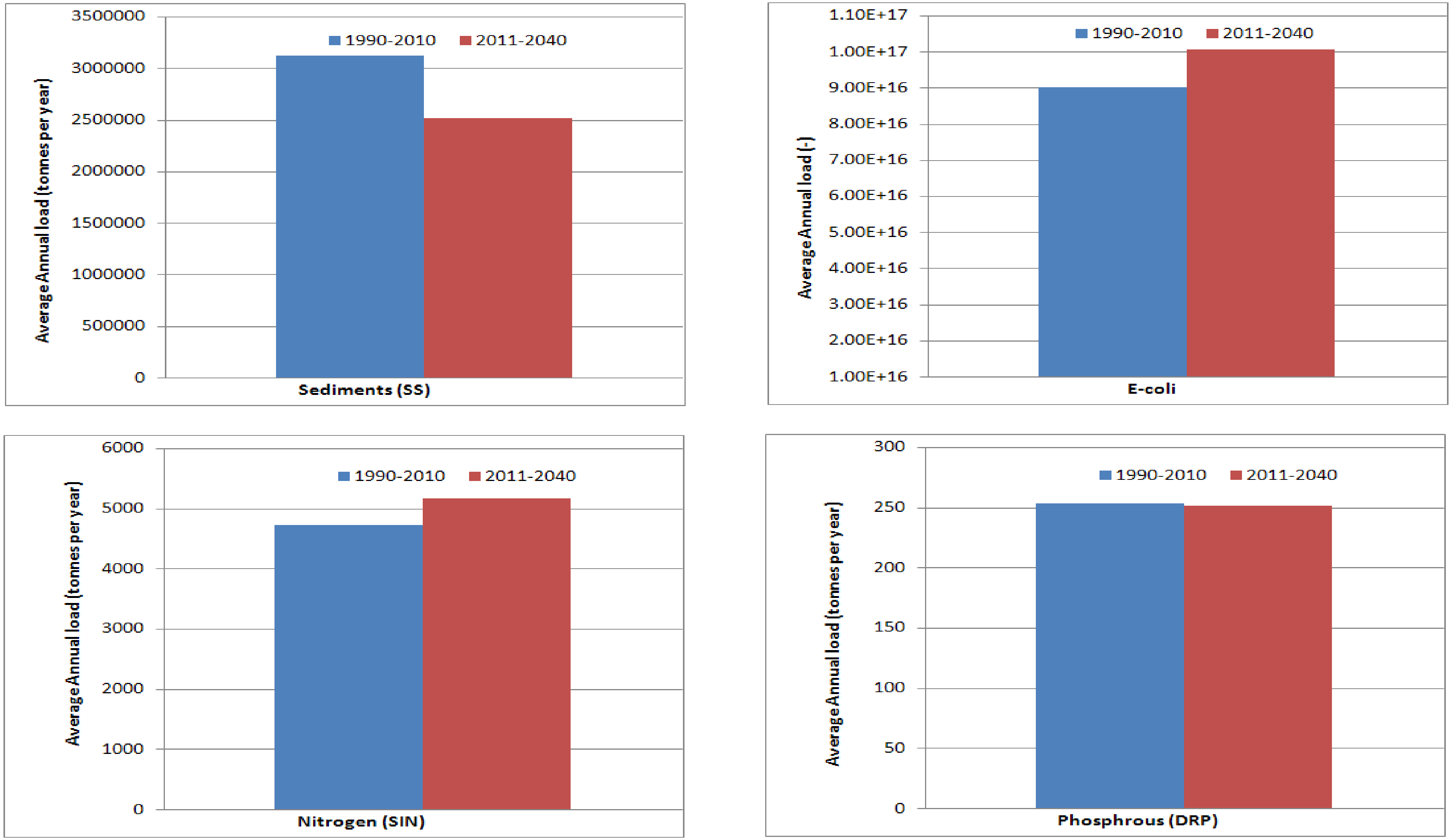


Figure C 21: Simulated average annual pollutant (SIN, DRP, SS and Ecoli) loads to Manawatū River catchment over a period from 1990 to 2040.

Ledein et al. (2007) estimated about 1021 tonnes per year of nitrogen (SIN) loadings in Upper Manawatū (1260 km^2) subcatchment. A pro rata of this estimation for Upper Manawatū indicates an average annual nitrogen load of 4768 tonnes per year for whole of the Manawatū River catchment (5885 km^2). This validates the model estimation of river nitrogen (SIN) load from 4,274 to 5,458 tonnes per year with an average of 4,728 tonnes per year during the period from 1990 to 2010 (Figure C 21). The model estimated average annual river nitrogen (SIN) load is about 94% from non-point sources (NPS) (Sheep Beef and Deer farming, Dairy, Dairy Effluent, Cropping and Forest) as compared to 6% from point sources (PS) (Town Wastewater, Industrial Wastewater and Urban Stormwater) for whole of Manawatū River catchment. This is also in agreement with the estimation of Ledein et al. (2007) for Upper Manawatū subcatchment, where 98% of annual nitrogen (SIN) load (1021 tonnes per year) came from NPS (mainly from Sheep Beef and Deer, and Dairy farming) as compared to 2% from PS (from the Dannevirke Sewage Treatment Plant discharge). It is simulated that the average annual river nitrogen load would increase by 9% from 4,728 tonnes per year during period 1990-2010 (the last 20 years) to 5,161 tonnes per year during period 2011-2040 (the next 30 year) (Figure C 21). The nitrogen loadings are simulated to decrease from Sheep Beef and Deer farming due to its decreasing area, i.e. conversion from Sheep Beef and Deer farming to Dairy Farming. This simulated increase in Dairy farming area (72, 641 ha in 2010 to 98,857 ha in 2040) and its intensification (cows per ha, from 2.26 in 1990 to 2.70 in 2010, and to 3.24 in 2040) would increase the average annual Dairy (including Effluent) nitrogen loadings by 62% during the period from 2010 to 2040 (the next 30 year). Note that this estimation of river N loadings is based on an attenuation coefficient of 0.50 and a time lag of 10 years in N transport from land to river via groundwater (Table C 12). The nitrogen loadings parameters, especially dairy growth and intensification, attenuation coefficient and time lag parameters are used as 'place holders' (Table C 13) in the absence of information, and should be calibrated and validated as information becomes available.

Ledein et al. (2007) estimated about 26.3 tonnes per year of phosphorus (DRP) loadings in Upper Manawatū (1260 km^2) subcatchment. A pro rata of this estimation for Upper Manawatū indicates an average annual phosphorus load of 123 tonnes per year for whole of the Manawatū River catchment (5885 km^2). However, the model estimated a river phosphorus (DRP) load from 236 to 273 tonnes per year with an average of 253 tonnes per year during the period from 1990 to 2010 (Figure C 21). The model estimated average annual river phosphorus (DRP) load is about 43% from non-point sources (NPS) (Sheep Beef and Deer farming, Dairy, Dairy Effluent, Cropping and Forest) as compared to 57% from point sources (PS) (Town Wastewater, Industrial Wastewater and Urban Stormwater) for whole of the Manawatū River catchment. In Upper Manawatū subcatchment, Ledein et al. (2007) estimated about 80% of annual phosphorus (DRP) load (26.3 tonnes per year) came from NPS as compared to 20% from PS. These differences in phosphorus (DRP) loadings for the whole of the Manawatū River catchment as compared to the Upper Manawatū subcatchment are mainly due to the simulated higher PS contributions in the Manawatū River catchment as compared to Upper Manawatū subcatchment. It is simulated that the average annual river phosphorus (DRP) load would decrease by 1% from 253 tonnes per year during period 1990-2010 (the last 20 years) to 251 tonnes per year during period 2011-2040 (the next 30 year) (Figure C 21). This slight decrease in DRP river load is simulated mainly due to the improved dairy shed effluent compliance from 80% in 2010 to 90% in 2020-2040. A further increase in dairy shed effluent compliance from 80% in 2010 to 95% in 2020 and 100% in 2025-2040 would decrease the river DRP load by 3% from 253 tonnes per year during period 1990-2010 (the last 20 years) to 247 tonnes per year during period 2011-2040 (the next 30 year).

The model estimated a river Ecoli load from 8.11E+16 to 9.87E+16 with an average of 9.02E+16 uring the period from 1990 to 2010 (Figure C 21). Nearly 47% of the average annual river Ecoil load is estimated to come from point sources (Town Wastewater), while the rest 53% from non-point sources (Sheep Beef and Deer farming, Dairy and Dairy Effluent). It is simulated that the average annual river Ecoli load would increase by 11% from 9.02E+16 during period 1990-2010 (the last 20 years) to 1.01E+17 during period 2011-2040 (the next 30 years) (Figure C 21). This simulated increase is mainly due to an increase in Dairy farming area and its intensification, and town wastewater discharges.

River Module: This module simulates the impact of different pollutant loadings and management options on 'River Management', 'Fish Habitat', 'Birds Habitat' and 'Swimming Conditions' in the Manawatū River.

River Management: This sub-sector module simulates the impact of sediment loadings on the management of the Manawatū river.

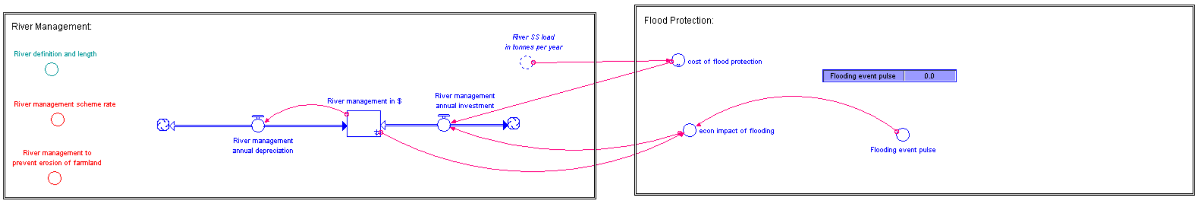


Figure C 22: River management and flood protection model sub-sectors.

Data needs:

- Relationship of sediment loadings to cost of flood protection
- Economic impact of flooding, and threshold of total river management in $
- Cost of river management in 1990, and since then annual investment and depreciation in river management

Input data used and calculation procedure:

The impact of sediment loadings on river management is simulated in terms of 'cost of flood protection' and 'economic impact of flooding', which are incorporated as the annual investment required for river management. The required annual investment is added to total river management 'River management in $', which is reduced by an annual depreciation of 5% as a 'place holder'. The total river management determines the 'economic impact of flooding'. The threshold 'place holders' is if there is no 'River Management' then the 'economic impact of flooding' is $1 million per flood event.

Further developments:

- Further develop the modules according to the collected and estimated river management information

Fish Habitat: This sub-sector module simulates the impact of river flow and pollutant loadings on the fish habitat and fish population (longfin eel as indicator native species and trout as indicator non-native species) in the Manawatū River. It further links with the 'Economic' module to simulate the impact of changes in fish population 'Trout as indicator non-native species' on the annual recreation value (in $) in the Manawatū River catchment (see 'Fisheries and Tourism' in the Economic module). In a feedback loop, the 'angler days' are linked with the 'trout harvest rate' which determines the changes in trout population.

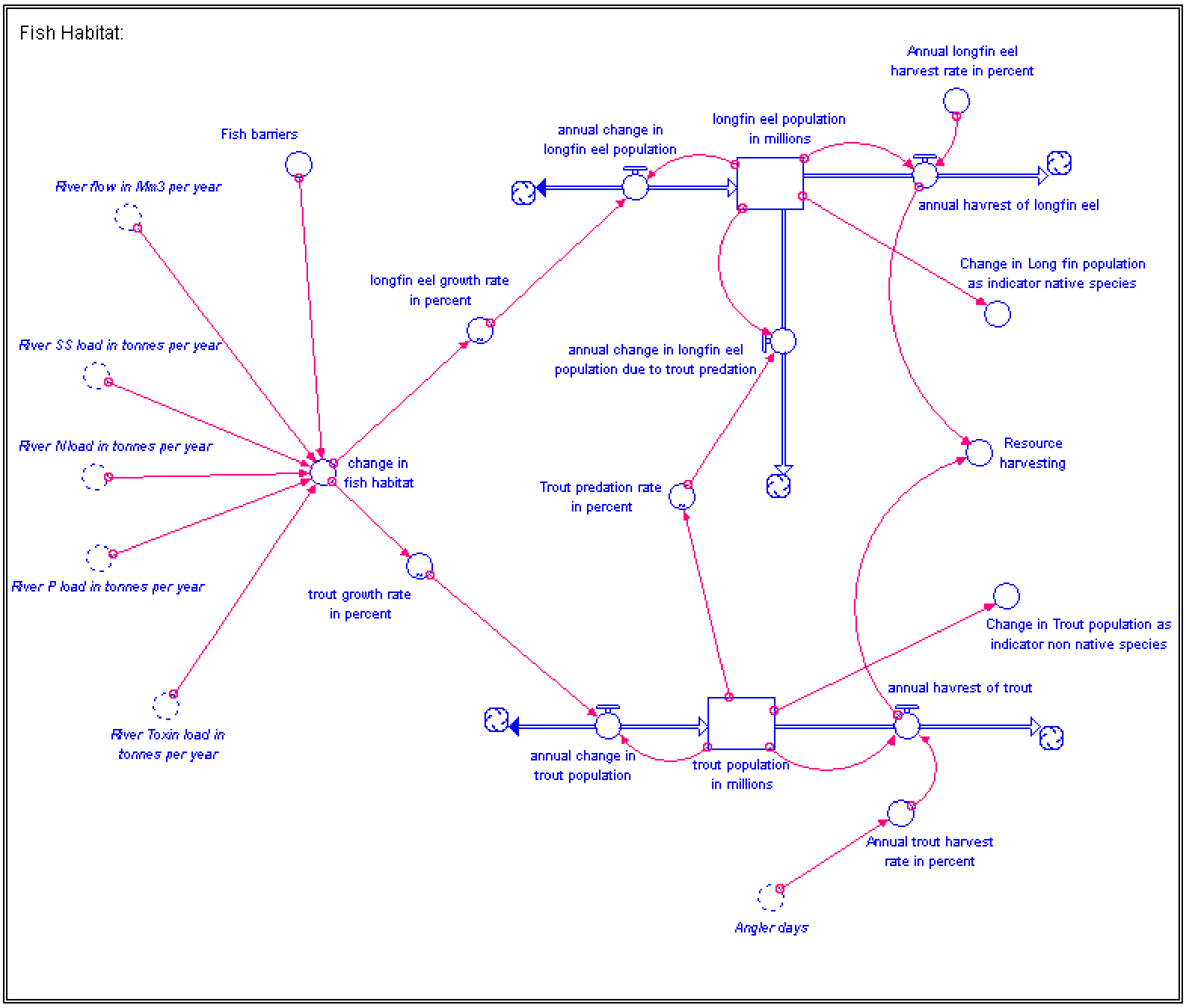


Figure C 23: Fish habitat model sub-sector.

Data needs:

- Relationship of changes in different pollutant loadings to changes in fish habitat
- Estimates of longfin eel (native) and trout (non-native) fish population, their annual growth and harvest rates
- Trout predation rate (on longfin eel) is included in the current module structure, therefore needs data on 'trout predation rate'.

Input data used and calculation procedure:

The relative change in fish habitat is simulated in proportion to relative change in different pollutant (SS, N, P and Toxins) loadings, river flow and fish barriers as follows:

change_in_fish_habitat =

-(-(0.35((River_flow_in_Mm^3_per_year/HISTORY(River_flow_in_Mm^3_per_year,TIME=1))-1))*

+(0.25((River_SS_load_in_tonnes_per_year/HISTORY(River_SS_load_in_tonnes_per_year,TIME=1))-1))*

+(0.15((River_N_load_in_tonnes_per_year/HISTORY(River_N_load_in_tonnes_per_year,TIME=1))-1))*

+(0.15((River_P_load_in_tonnes_per_year/HISTORY(River_P_load_in_tonnes_per_year, TIME=1))-1))*

+(0.00((River_Toxin_load_in_tonnes_per_year/HISTORY(River_Toxin_load_in_tonnes_per_year,TIME=1))-1))*

+(0.10((Fish_barriers/HISTORY(Fish_barriers,TIME=1))-1)))*

This estimation of relative change in fish habitat requires a weighted factor for river flow, different pollutant loads and fish barriers (60 used as a ‘place holder’). The weighted factors are set as a ‘place holders’ at 0.35 for river flow, 0.25 for river sediment (SS) load, 0.15 for river nitrogen (N) load, 0.15 for river phosphorus (P) load, 0.00 for river toxin load and 0.10 for fish barriers. This implies that river flow has the highest role in determining the change in fish habitat, followed by river sediment (SS), nitrogen (N) and phosphorus (P) loads, and fish barriers. In the absence of information, the ‘River Toxin load’ (Figure C 23, has a weight factor of 0.00 as a ‘place holder’. According to this above equation, a relative change in fish habitat would be estimated equal to 1 (perfect condition) when the river flow is doubled and all pollutant loads and fish barriers are reduced to zero in the river. On the other side, a relative change in fish habitat would be estimated equal to -1 (worst condition) when the river flow is reduced to zero and all pollutant loads and fish barriers are doubled.

The relative change in fish habitat determines the longfin eel and trout fish growth rate. A relative change of 1 (perfect condition) in fish habitat is specified to increase both longfin ell and trout population by 5% per year as ‘a place holder’, and a relative change of -1 (worst condition) in fish habitat is specified to decrease the fish population by 100% as a ‘place holder’ in the model.

Longfin eel and trout populations are also simulated to change with harvesting for food (commercial fishing) and recreation (fishing). The harvest rate for both longfin eel and trout are set as a ‘place holder’ at 5% per year. Further, the trout harvesting rate is linked with the estimated ‘angler days’ (see ‘Fisheries and Tourism’ in the Economic module) simulating higher harvest rate with increasing angler days. As discussed during the MM workshops, trout predation on elvers is also included in the simulation by setting annual trout predation rate as a ‘place holder’ at 1% of longfin eels if trout population reaches at 100 million or more. The trout predation rate is simulated to decrease with a decrease in the trout population.

With the inputs described above and setting initial longfin eel and trout population as a ‘place holder’ at 100 million in 1990, Figure C 24 depicts the simulated longfin eel and trout population in the Manawatū River from 1990 to 2040.

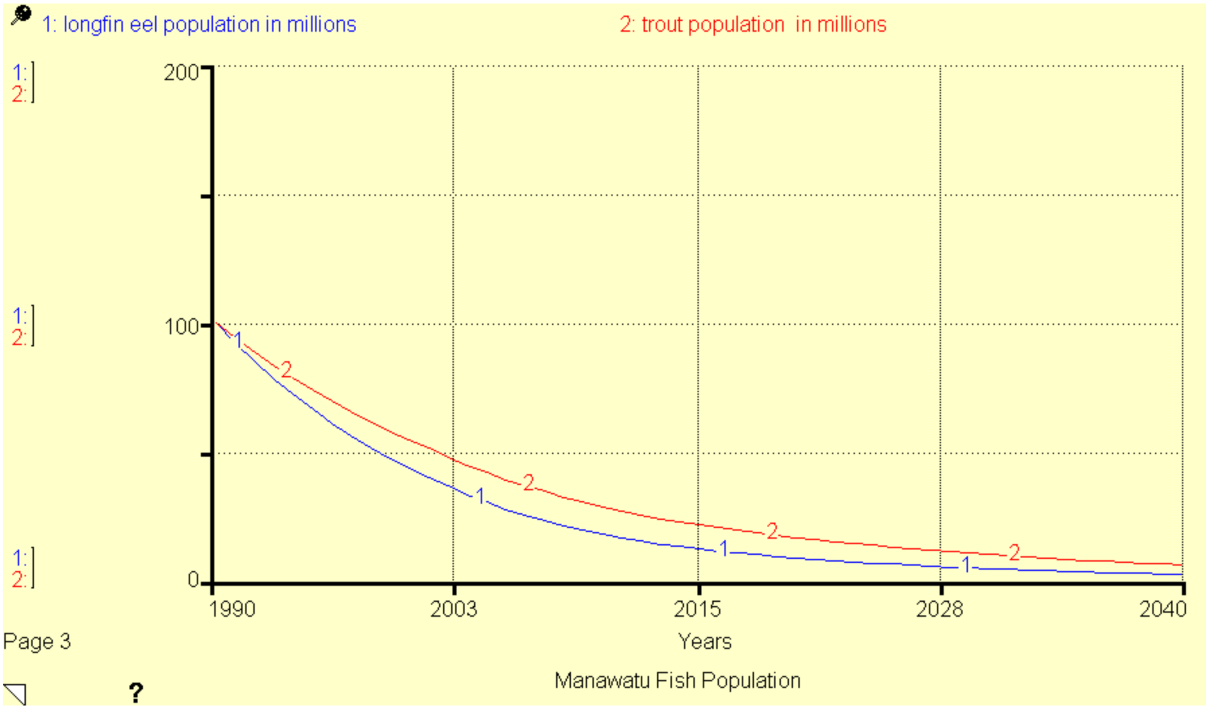


Figure C 24: Estimated fish population (long fin eel as indicator native species and trout as indicator non-native species) in the Manawatū River from 1990 to 2040.

Figure C 24 suggests that, if current practices continued, the longfin eel and trout population would decrease in the Manawatū River catchment. *Note that most of the model input parameters for fish population simulations are 'place holders' in the absence of information, therefore the simulated fish population decline should be considered as 'place holder' and interpreted carefully.*

Further developments:

- Understand and develop the cause-effect relationships for fish habitat; what effects fish habitat and how?
- Develop and populate the module according to the collected and estimated fish habitat and population information; most of the model input parameters for fish population simulation are used as 'place holders' in the absence of information
- 'Rare Fish', and 'Flora and Fauna Biodiversity' were discussed during the MM workshops, but not connected in the current model.

Bird Habitat: This sub-sector module simulates the impact of landuse change, in particular changes in wetlands on the bird's habitat and their population (both native and non-native birds) in the Manawatū River catchment.

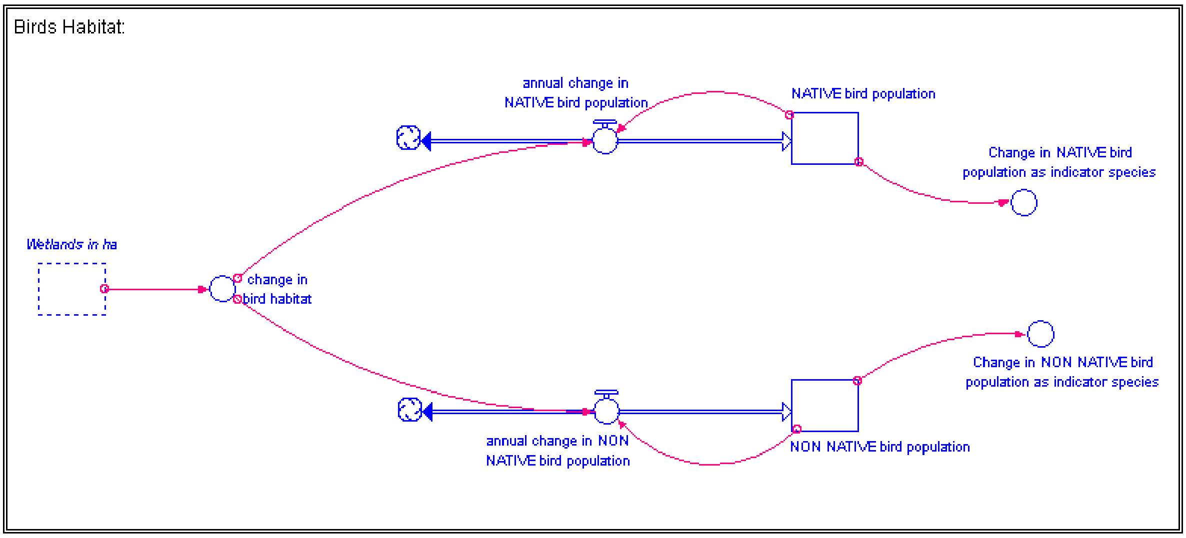


Figure C 25: Bird habitat model sub-sector.

Data needs:

- Relationship of changes in wetlands to changes in bird habitat
- Estimates of native and non-native birds population, and relationship of their population changes with changes in their habitat

Input data used and calculation procedure:

The relative change in bird habitat is simulated in proportion to relative change in wetlands (in ha) as follows:

change_in_bird_habitat = (1.0((Wetlands_in_ha/HISTORY(Wetlands_in_ha,TIME=1))-1))*

This estimation would result in a relative change of 1 in bird habitat when the wetlands area (in ha) is doubled. On the contrary, it would result into a relative change of -1 in bird habitat when the wetlands area is reduced to zero. The relative change in bird habitat determines the annual change in both native and non-native bird's population as follows:

annual_change_in_NATIVE_bird_population = 0.02(change_in_bird_habitat)*NATIVE_bird_population*

annual_change_in_NON_NATIVE_bird_population = 0.01(change_in_bird_habitat)*NON_NATIVE_bird_population*

A relative change of 1 in bird habitat is specified to increase native and non-native birds population by 2% and 1% per year, respectively as 'place holders' in the model. A relative change of -1 in bird habitat to decrease native and non-native birds population by 2% and 1% per year, respectively as 'place holders'.

With the inputs described above and setting initial native and non-native bird population as a 'place holder' at 1000 in 1990, depicts the simulated native and non-native bird populations in the Manawatū River catchment from 1990 to 2040.

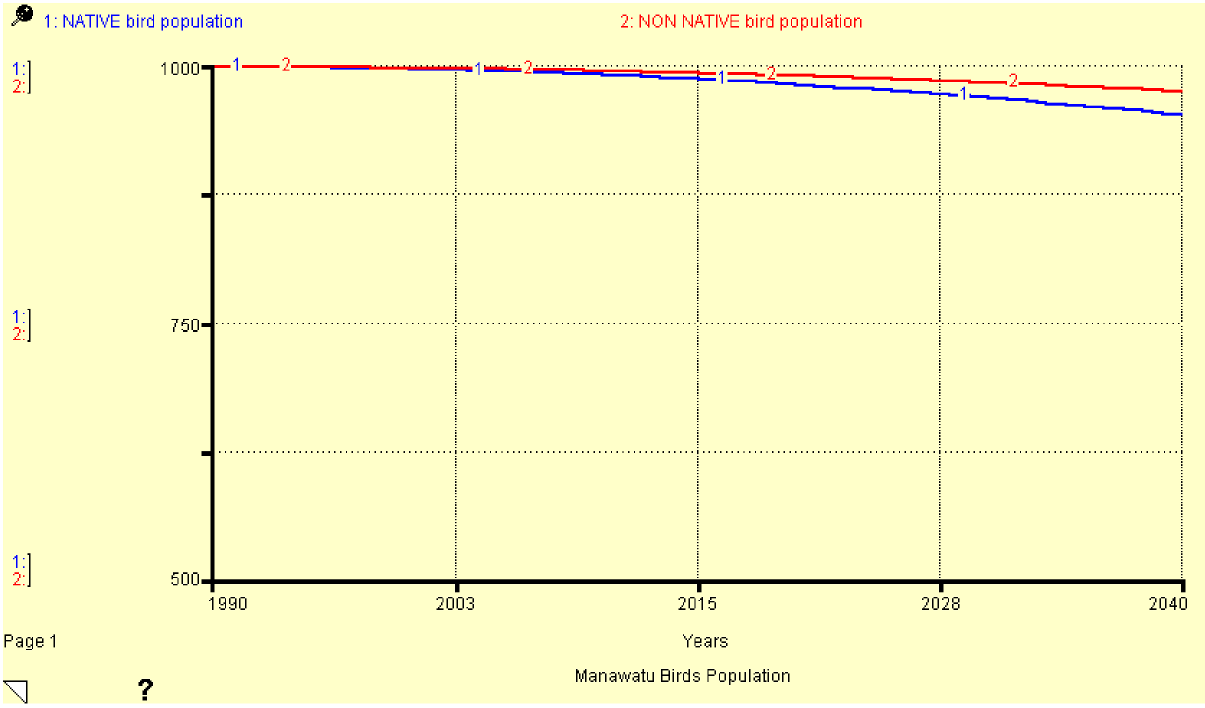


Figure C 26: Estimated bird population (NATIVE as indicator species and NON-NATIVE as indicator species) in the Manawatū River catchment from 1990 to 2040

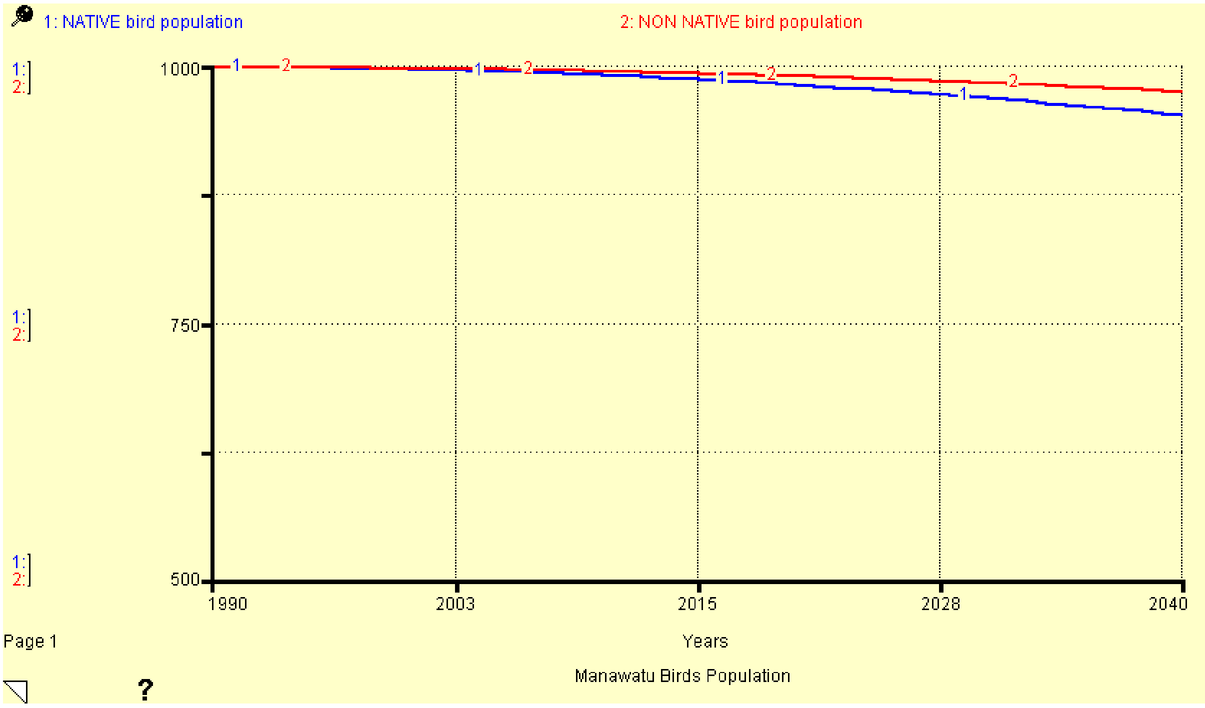


Figure C 26 suggests that, if current practices continued, the native and non-native birds population would decrease in the Manawatū River catchment. This decrease in bird's population is simulated corresponding to the simulated decrease in wetland area in the catchment (Table C 5). *Note that most of the model input parameters for bird population simulation are 'place holders' in the absence of information, therefore the simulated native and non-native birds population should be considered as 'place holders' and interpreted carefully.*

Further developments:

- Understand and develop the cause-effect relationships for bird habitat; what effects bird habitat and how!
- Develop and populate the module according to the collected and estimated bird habitat information

Swimming Conditions: This sub-sector module simulates the impact of river pollutant loadings on swimming conditions in the Manawatū River.

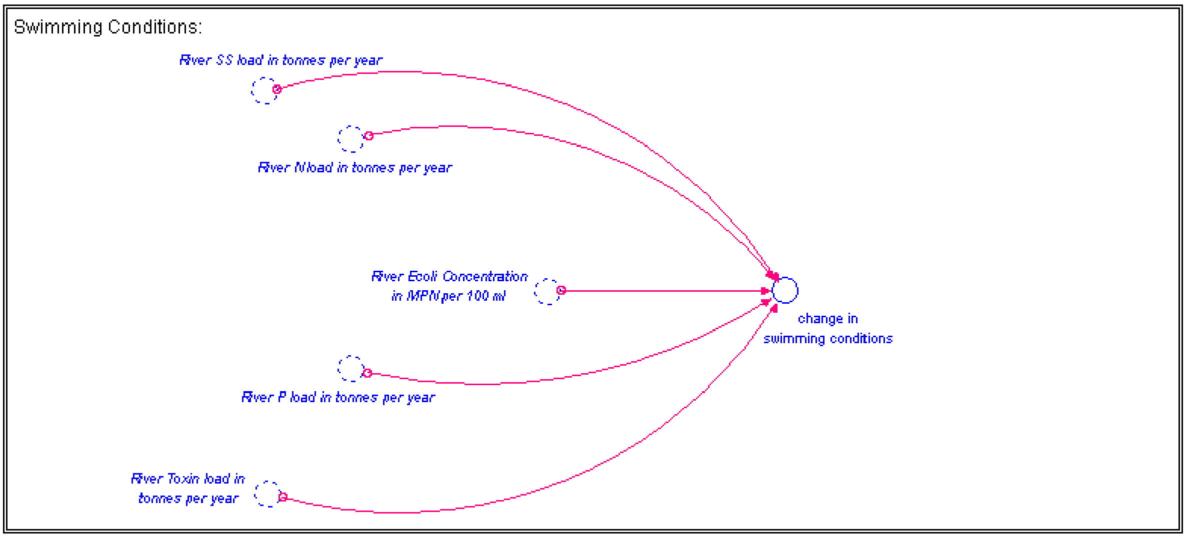


Figure C 27: Swimming conditions model sub-sector.

Data needs:

- Relationship of changes in different pollutant loadings to changes in swimming conditions

Input data used and calculation procedure:

The relative change in swimming conditions is simulated in proportion to relative change in different pollutant (Ecoil, SS, N, P, and Toxin) loadings as follows:

change_in_swimming_conditions =
-((0.50((River_Ecoli_Concentration_in_MPN_per_100_ml/HISTORY(River_Ecoli_Concentration_in_MPN_per_100_ml, TIME=1))-1))*
+(0.30((River_SS_load_in_tonnes_per_year/HISTORY(River_SS_load_in_tonnes_per_year,TIME=1))-1))*
+(0.10((River_N_load_in_tonnes_per_year/HISTORY(River_N_load_in_tonnes_per_year,TIME=1))-1))*
+(0.10((River_P_load_in_tonnes_per_year/HISTORY(River_P_load_in_tonnes_per_year, TIME=1))-1))*
+(0.00((River_Toxin_load_in_tonnes_per_year/HISTORY(River_Toxin_load_in_tonnes_per_year,TIME=1))-1)))*

This estimation of relative change in swimming conditions requires a weighed factor for different river pollutant loads. The weighed factors are set as a 'place holders' at 0.50 for river Ecoil load, 0.30 for river sediment (SS) load, 0.10 for river nitrogen (N) load, 0.10 for river phosphorus (P) load, and 0.00 for river toxin load. This implies that river Ecoil load has highest impact on river swimming conditions, followed by river sediment (SS), nitrogen (N) and phosphorus (P) loads. In the absence of information, the river toxin load is a 'place holder' (Figure C 27), with a weight factor of 0.00 in determining the relative change in swimming conditions. This estimation would result in a relative change in swimming conditions equal to 1 (perfect condition) when all river pollutant loads are reduced to zero. On the contrary, it would result into a relative change in swimming conditions equal to -1 when all river pollutant loads are doubled.

With the inputs described above, Figure C 28 depicts the simulated changes in swimming conditions with (blue line 1) and without (red line 2) 'SLUI Erosion Impact' in the Manawatū River from 1990 to 2040. The Sustainable Land Use Initiative 'SLUI' erosion impacts are simulated by assuming a scenario of 500 whole farm plans implemented reducing the Sheep Beef and Deer farming sediment yield by 47% in 2030 (Schierlitz et al., 2006).

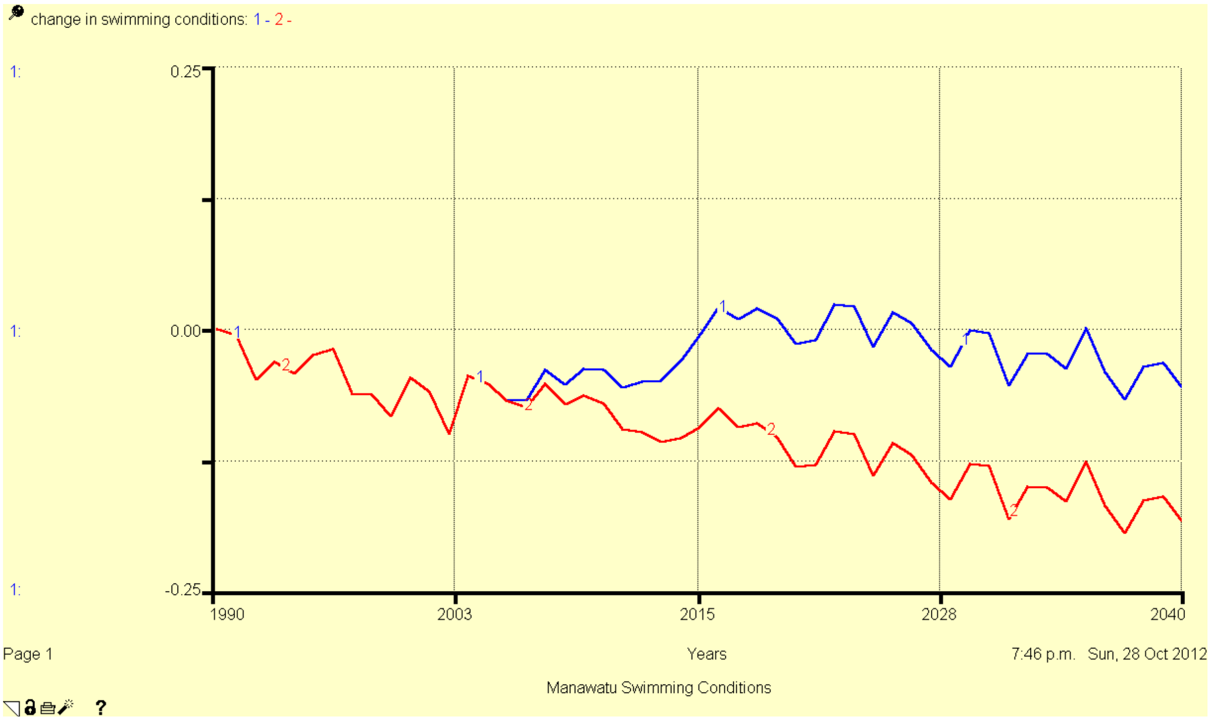


Figure C 28: Simulated changes in swimming conditions in the Manawatū River from 1990 to 2040.

Figure C 28 suggests that, if current practices continue, the swimming conditions would first improve due to simulated reduced sediment loads 'SLUI Erosion Impact', but then decline corresponding to the simulated increasing pollutants (E-coli and N) loads in the Manawatū river (Figure C 21). *Note that the model input parameters for swimming conditions simulation, such as the relationship between changes in different pollutant loadings to changes in swimming conditions are used as 'place holders' in the absence of information, therefore the simulated changes in swimming conditions should be considered as 'place holders' and interpreted carefully.*

Further developments:

- Understand and develop the cause-effect relationships for swimming conditions; what effects swimming conditions and how!
- Develop and populate the module according to the collected and estimated swimming conditions information

Values Module: This module links the impact of different management actions by simulating changes in catchment landuse and river condition (changes in fish and bird habitat and swimming conditions) (see River Module) to the values identified to reflect the goals to be achieved (see the Goals module). It is linked with the 'Actions for Solutions' module to simulate the possible impacts of (if any) proposed changes on values and indicators, e.g. 'Access', 'Choice of Wetland Restoration' and 'Communication'.

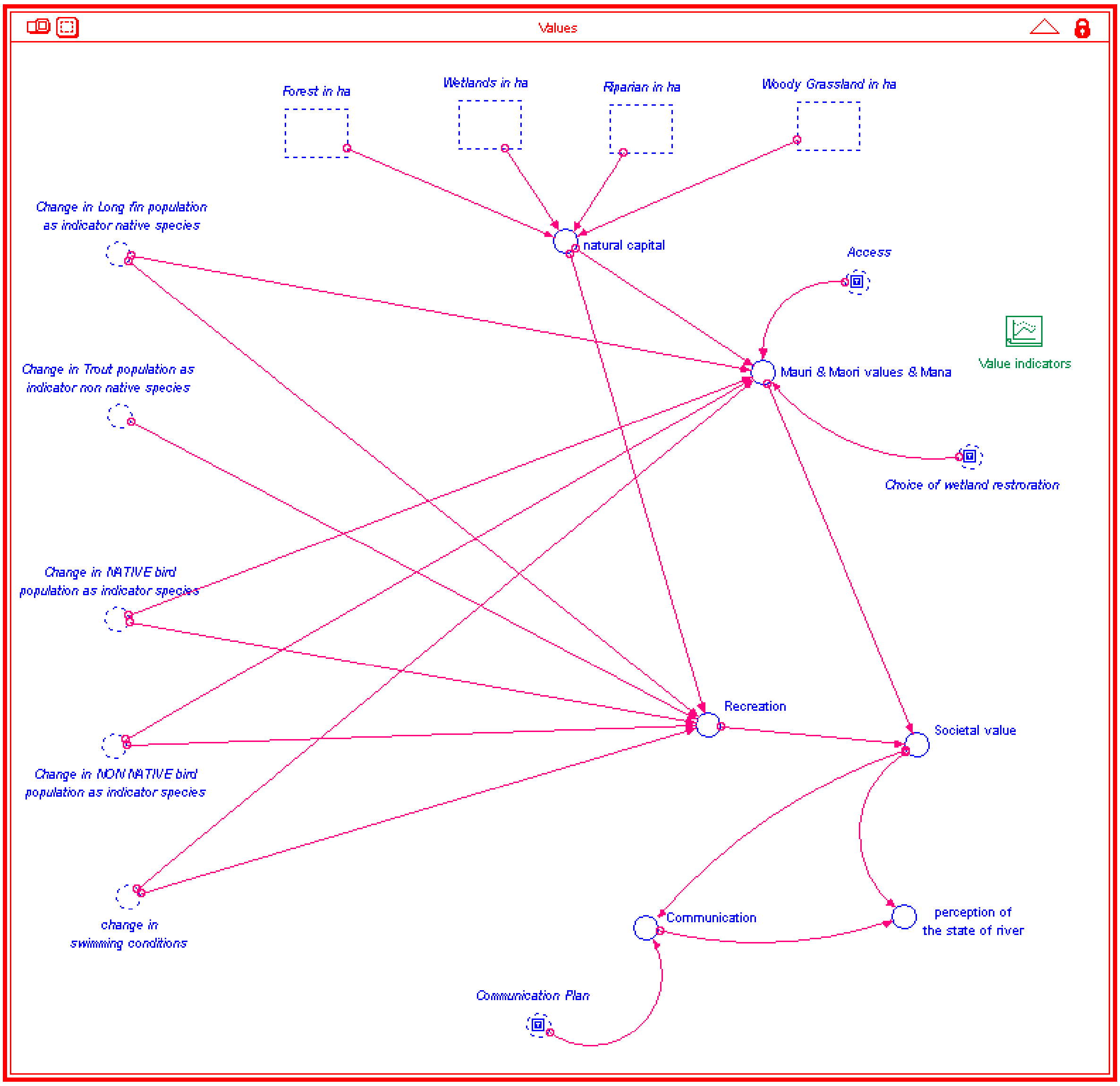


Figure C 29: Values model sector.

Data needs:

- Relationships between different identified values/indicators and changes in catchment landuse and river condition (changes in fish and bird habitat and swimming conditions).

Input data used and calculation procedure:

During the MM workshops, it was discussed that the values could be categorised as 'Mauri, Maori Values and Mana' and 'Recreation' values. These are determined by the natural capital, fish and bird's population and the swimming conditions of the river.

The 'River' module simulates relative changes in swimming conditions; fish (both longfin eel and trout) and bird's (native and non-native) populations (see 'Fish Habitat', 'Birds Habitat' and 'Swimming Conditions' in the 'River' module). The natural capital has a significant influence on 'Mauri, Maori Values and Mana' and 'Recreation' values, and a relative change in natural capital is simulated as follows:

natural_capital =
+(0.50((Wetlands_in_ha/HISTORY(Wetlands_in_ha,TIME=1))-1))*
+(0.30((Riparian_in_ha/HISTORY(Riparian_in_ha,TIME=1))-1))*
+(0.15((Forest_in_ha/HISTORY(Forest_in_ha,TIME=1))-1))*
+(0.05((Woody_Grassland_in_ha/HISTORY(Woody_Grassland_in_ha,TIME=1))-1))*

The weighting factors used in determining a relative change in natural capital are set as 'place holders' at 0.50 for wetlands, 0.30 for riparian, 0.15 for forests and 0.05 for woody grasslands.

The 'Recreation' value is determined as follows:

recreation =
*+(0.40*change_in_swimming_conditions)*
*+(0.15*Change_in_Long_fin_population_as_indicator_native_species)*
*+(0.15*Change_in_Trout_population_as__indicator_non_native_species)*
*+(0.10*Change_in_NATIVE_bird_population_as_indicator_species)*
*+(0.10*Change_in_NON_NATIVE_bird_population_as_indicator_species)*
*+(0.10*natural_capital)*

The 'Mauri, Maori Values and Mana' is determined as follows:

mauri_maori_values_mana =
IF TIME > 2010 AND (Access > 0 AND Choice_of_wetland_restroration > 0) THEN
+0.10
+0.20
*+(0.40*natural_capital)*
*+(0.30*Change_in_Long_fin_population_as_indicator_native_species)*
*+(0.15*Change_in_NATIVE_bird_population_as_indicator_species)*
*+(0.10*Change_in_NON_NATIVE_bird_population_as_indicator_species)*
*+(0.05*change_in_swimming_conditions)*

ELSE IF TIME > 2010 AND Access > 0 THEN
0.10+
*(0.40*natural_capital)+*
*(0.30*Change_in_Long_fin_population_as_indicator_native_species)+*
*(0.15*Change_in_NATIVE_bird_population_as_indicator_species)+*
*(0.10*Change_in_NON_NATIVE_bird_population_as_indicator_species)+*
*(0.05*change_in_swimming_conditions)*
ELSE IF TIME > 2010 AND Choice_of_wetland_restroration > 0 THEN
0.20+
*(0.40*natural_capital)+*
*(0.30*Change_in_Long_fin_population_as_indicator_native_species)+*
*(0.15*Change_in_NATIVE_bird_population_as_indicator_species)+*
*(0.10*Change_in_NON_NATIVE_bird_population_as_indicator_species)+*
*(0.05*change_in_swimming_conditions)*
ELSE
*(0.40*natural_capital)+*
*(0.30*Change_in_Long_fin_population_as_indicator_native_species)+*
*(0.15*Change_in_NATIVE_bird_population_as_indicator_species)+*
*(0.10*Change_in_NON_NATIVE_bird_population_as_indicator_species)+*
*(0.05*change_in_swimming_conditions)*

Table C 13 summarises the weight factors used as ‘place holders’ in determining the ‘Recreation’ and ‘Mauri, Maori Values and Mana’ values based on relative changes in swimming conditions, fish and bird’s populations and natural capital. Note that swimming is given a highest weighting factor in determining the ‘Recreation’ value, while lowest in the ‘Mauri, Maori Values and Mana’ value. More importantly, note the weighting given to ‘Access’ and ‘Choice of wetland restoration’ in the ‘Mauri, Maori Values and Mana’ value to capture the MM workshop discussion that increasing access and choice to restore wetlands enhance the ‘Mauri, Maori Values and Mana’.

Table C 13: Weighting factors for determining the ‘Recreation’ and ‘Mauri, Maori Values and Mana’ for the Manawatū River catchment

Value determinants	Weight factor for	
	Recreation Value	Mauri, Maori Values and Mana
change_in_swimming_conditions	0.40	0.05
Change_in_Long_fin_population_as_indicator_native_species	0.15	0.30
Change_in_Trout_population_as_indicator_non_native_species	0.15	-
Change_in_NATIVE_bird_population_as_indicator_species	0.10	0.15
Change_in_NON_NATIVE_bird_population_as_indicator_species	0.10	0.10
natural_capital	0.10	0.40
Access	-	0.10
Choice_of_wetland_restoration	-	0.20

The ‘societal’ value is determined equally by both the ‘Recreation’ and ‘Mauri, Maori Values and Mana’ values as follows:

societal_value =
*+(0.50*Mauri_&_Maori_values_&_Mana)*
*+(0.50*recreation)*

The ‘societal’ value was discussed to determine the ‘perception of the state of river’. It was also noted and discussed during MM workshops that ‘communication’ (what people hear from media and other sources) plays an important role in determining the ‘perception of the state of river’. To capture this discussion, the ‘perception of the state of river’ is determined as follows:

perception_of_the_state_of_river =
*+(0.80*societal_value)*
*+(0.20*Communication)*
*where, communication = IF TIME > 2010 THEN Communication_Plan*societal_value ELSE 0*

With the inputs described above, Figure C 30 depicts the simulated changes in the ‘Recreation’, ‘Mauri, Maori Values and Mana’ and ‘societal’ value in the Manawatū River catchment from 1990 to 2040. Figure C 30 suggests that, if current practices continued, the all values would keep on decreasing in the Manawatū River catchment. *Note that the model input parameters for determining the value indicators, such as the relationship between changes in different pollutant loadings to changes in swimming conditions and value indicators are in the absence of information ‘place holders’.*

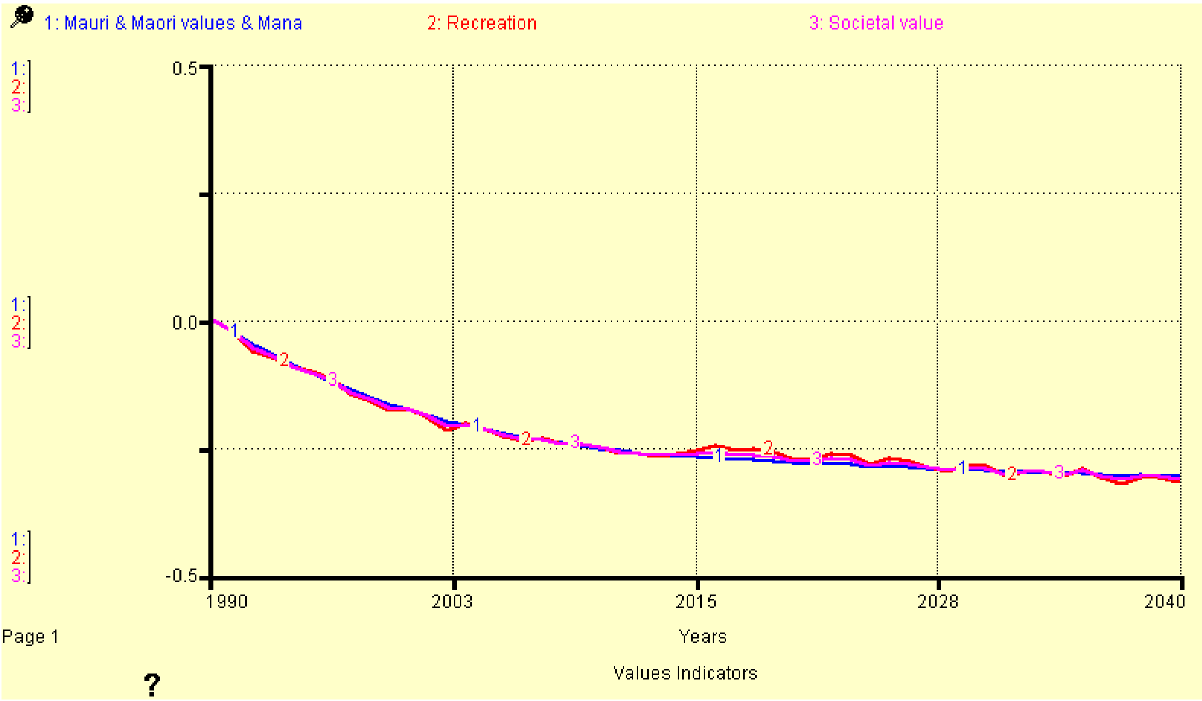


Figure C 30: Simulated changes in value indicators in the Manawatū River catchment from 1990 to 2040. A ‘-ve’ change means decreasing value, and ‘+ve’ means increasing value.

Further developments:

- Understand and develop the cause-effect relationships for different values; what effects what and how!
- Develop and populate the module according to the collected and estimated values and indicators information

Ecosystem Services Module: This module calculates the ecosystem services (ES) values of different landuse, and then adds up to estimate the total ecosystem services values for the Manawatū River catchment.

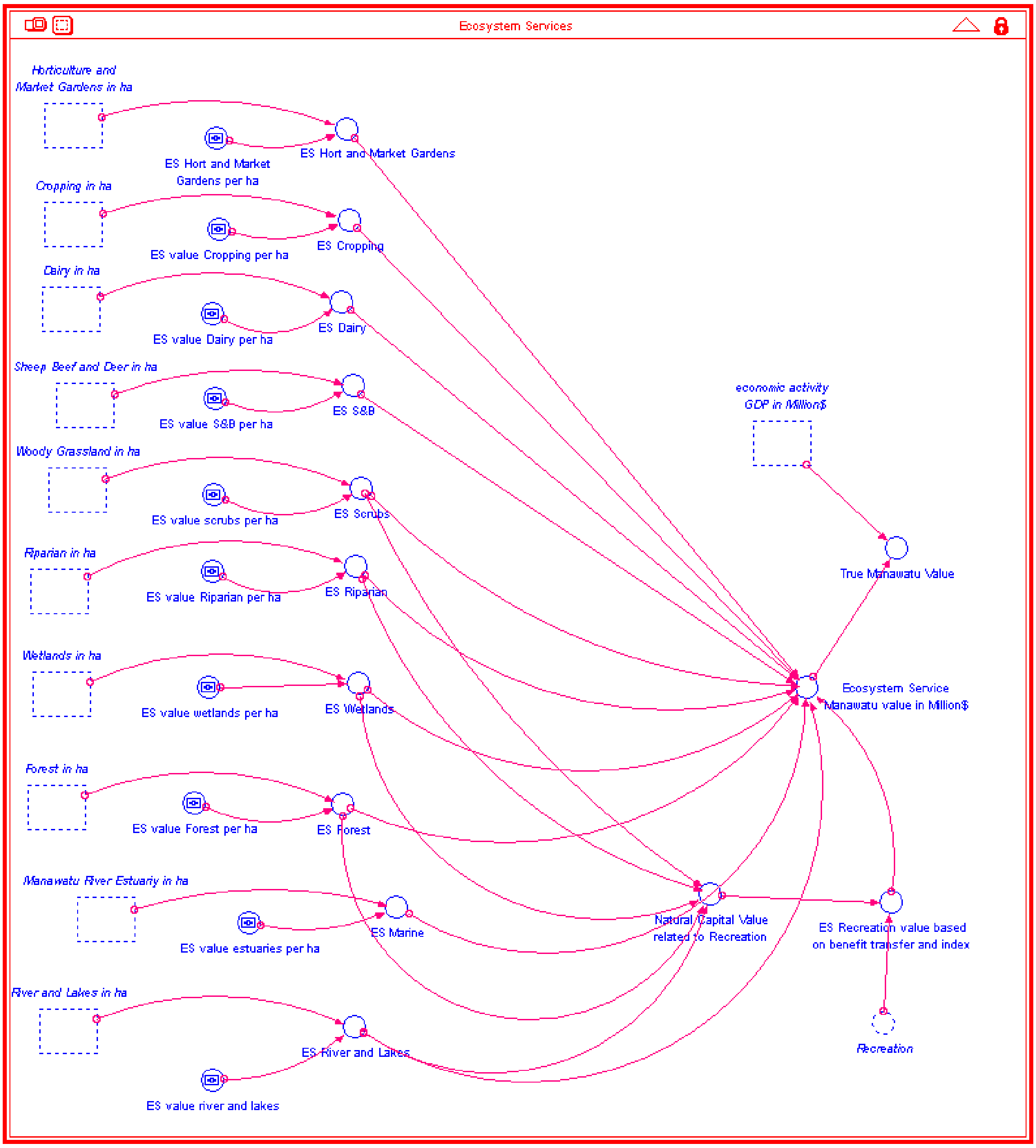


Figure C 31: Ecosystem Services model sector.

Data needs:

- ES values per ha for different land use types in the module

Input data used and calculation procedure:

The ecosystem services value for each landuse is determined by multiplying its area with ecosystem value ($) per ha. The 'Landuse' module simulates the area under different landuse in the catchment from 1990 to 2040, and Table C 14 summarises the ecosystem value ($) per ha used as a 'place holders' for different landuse types in the Manawatū River catchment, the 'placeholder' values are based on Costanza et al 1997.

Table C 14: Ecosystem value per ha used for different landuse types in the Manawatū River catchment.

Landuse Type	Ecosystem Service Value ($) per hectare	Source
Forest	3150	A place holder
Sheep, Beef and Deer	2700	A place holder
Dairy	1796	A place holder
Cropping	852	A place holder
Horticulture and Market Gardens	852	A place holder
Woody Grassland	3083	A place holder
Riparian Planting	5083	A place holder
Wetlands	43,320	A place holder
Rivers and Lakes	8,498	A place holder
Manawatū River Estuary	23,426	A place holder

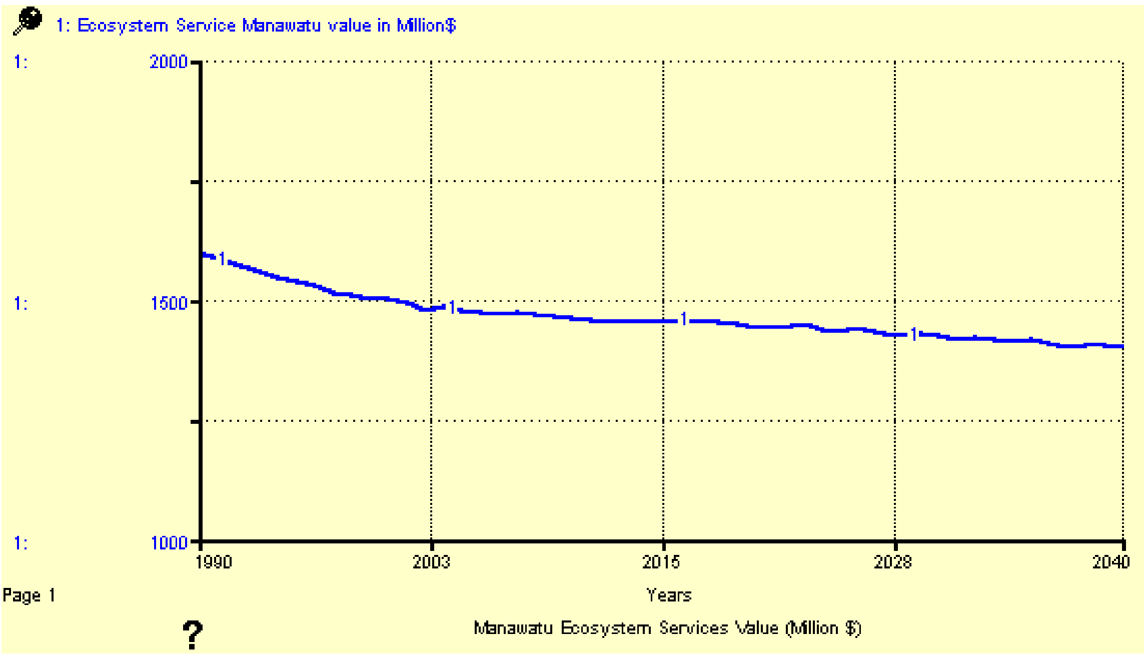


Figure C 32: Manawatū Ecosystem Service Value (1990 – 2040).

With the inputs described above (Table C 14), Figure C 32 suggests that, if current practices continued, the ecosystem services value would keep on decreasing in the Manawatū River catchment. *Note that the model input parameters for ES value simulation, the ES values ($) per ha for different landuse types (Table C 14) are used as 'place holders' in the absence of information, therefore the simulated ecosystem values should be considered as 'place holders' and interpreted carefully.*

Further developments:

- Calibrate the module according to the collected and estimated ES values per ha and information

External factors and pressures Module: This module simulates the impact of external factors and pressures, such as 'Climate change impacts and uncertainties, i.e. % changes in the rainfall' on the catchment water availability and use (see Water Availability and Use Module).

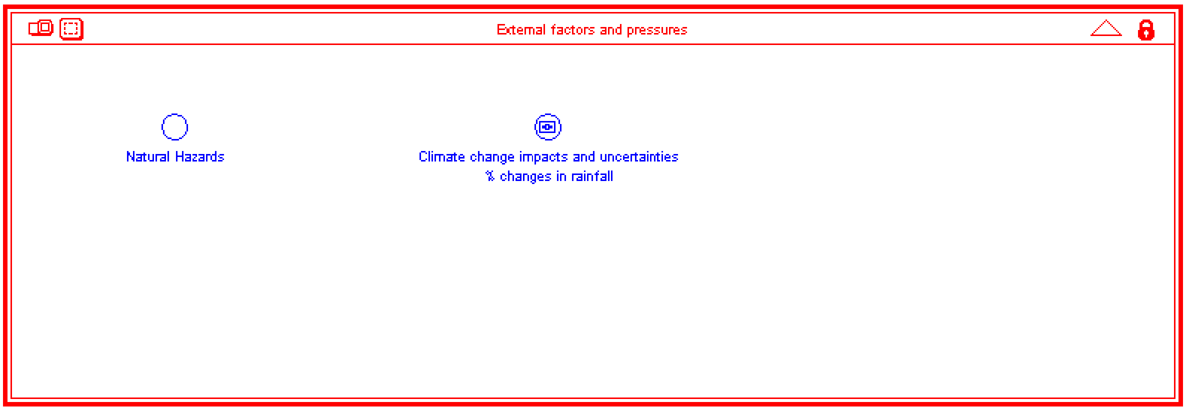


Figure C 33: External factors and pressures model sector.

Further developments:

- Understand and develop the impact links and relationships of external factors and pressures; what effects what and how!
- Develop and populate the module according to the collected and estimated external factors and pressures information.

Economic Module: This module simulates the costs associated with different management actions, and funds available for river enhancement.

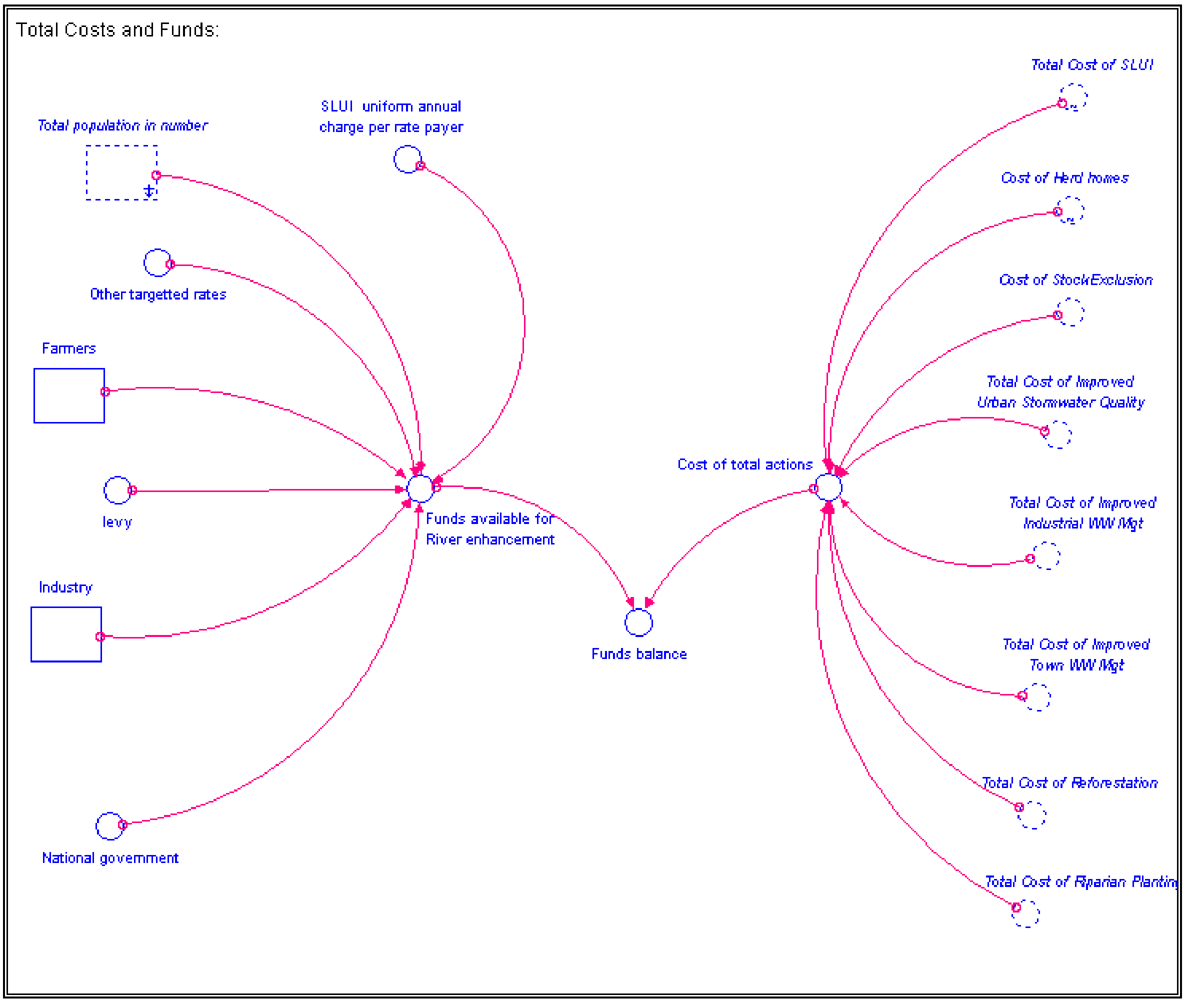


Figure C 34: Total costs and funding model sub-sector.

Data needs:

- Estimated costs associated with different proposed actions
- Estimated fund available or proposed for river enhancement from different sources

Input data used and calculation procedure:

This is a preliminary structure. More work is needed to incorporate and describe the following:

- Cost of Improved Town and Industrial Wastewater Management
- Cost of Improved Urban Stormwater Management
- Fisheries and Tourism (partly done, see below)
- Cost of Reforestation and Riparian Planting
- Cost of Sustainable Landuse Initiative (SLUI) and Sustainable Farm Nutrient Management (SFNM)
- Estimation of Funds available from different sources

Fisheries and Tourism: The following information was requested to be incorporated in the model from Fish and Game Wellington Region:

Market and non-market values for:

1. Angler days – change overtime
2. Trout fish licenses sold
3. $ generated from tourism (Kayaking, rafting, fishing etc)
4. $ generated from recreation use measured by:
   a. Goods sold in hunting, fishing stores
   b. Profitability of tourism ventures

The model structure proposed shows a growing number of trout licenses in proportion to trout population. The average number of angler days per licence is assumed to be inversely related to the trout population (I.e. fewer trout, then people spend more days angling for the same result). The price per license is multiplied with the number of licenses issued for a direct economic value of trout licenses. A multiplier is assumed to reflect the $ value of recreational goods and services for tourism. The recreational value as produced in the model needs to be calibrated with GDP data.

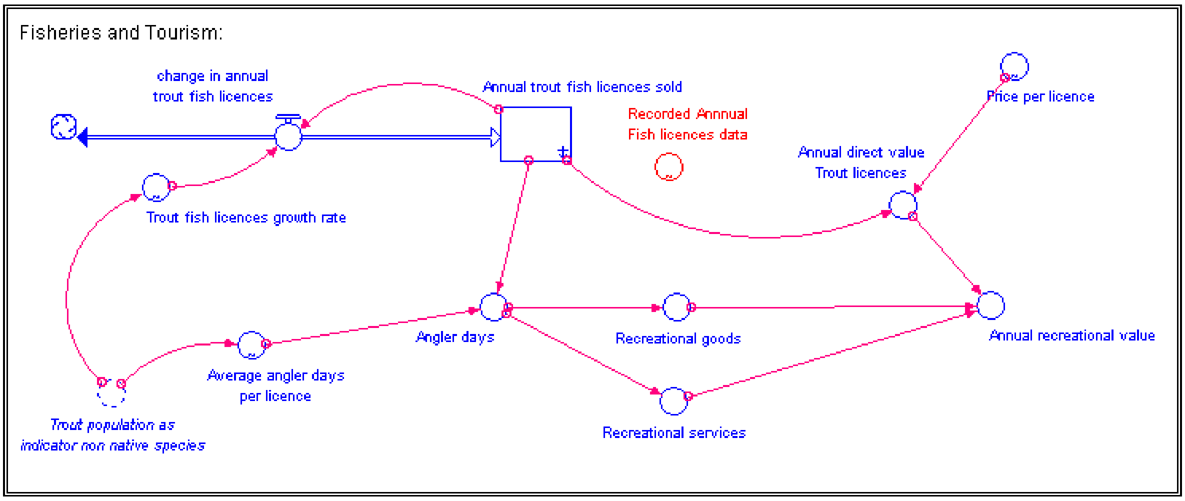


Figure C 35: Fisheries and Tourism model sub-sector

As the angler days increase, the harvest rate of trout will also increase, assuming a non-linear relationship (no data available). This signals a feedback loop and interdependency between trout availability and economic revenue. While there are more licenses sold, there is an increasing pressure on trout population (see Fish Habitat module).

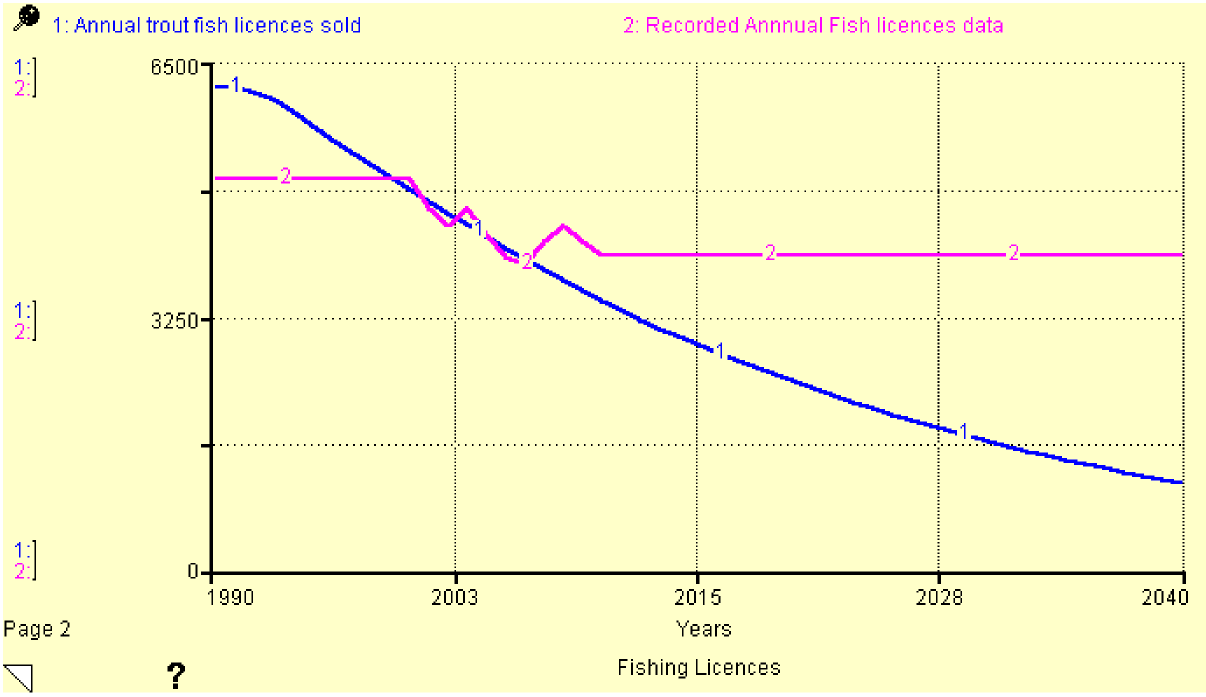


Figure C 36: Calibration of fishing licenses.

Further developments:

- Develop and populate the module according to the collected and estimated costs and funds available information

Actions for Solutions Module:

The actions for solutions are broadly divided into two categories:

1. Actions already underway; simulate possible long term impacts
2. New actions proposed; simulate possible impacts

Data needs:

- Identify the **major actions already underway** in the Manawatū River catchment; and collect their details (what, where, when, and what are the monitored or expected impacts!)
- Identify the **major proposed actions** in the Manawatū River catchment; and estimate their details (what, where, when, and what are their expected impacts!)

Input data used and calculation procedure:

This is a preliminary structure. More work is needed to incorporate and describe the major actions already underway that were discussed and identified during the MM workshops. In the current structure, the module has been designed to simulate the impact of the following actions:

- Wastewater (Town and Industrial) Management Improvement
- Urban Stormwater Management Improvement

- SLUI – Whole Farm Plans – SLUI Experdite
- Farm Nutrient Management Improvement
- Dairy shed Effluent Management – Diary Effluent Compliance Experdite
- Reforestation
- Riparian Planting
- Wetland Restoration
- Access and Communication

Module developments:

- Populate the module with the collected and estimated data
- Further develop the module according to the identified actions to be simulated.

Appendix D Background Information on Actions

The discussion in this Appendix predominantly covers the bolded actions below. These actions were included in the list of key actions and activities to address water quality issues for the MRC in 'OURS. The Manawatū River Leaders' Accord Action Plan' which was signed off on the 22nd of June 2011 (Horizons Regional Council, 2011). The **bolded actions** correspond with actionable scenarios included in the mediated scoping model. In addition, a Cost Benefit Analysis (http://www.ifs.org.nz/assets/Uploads/Cost-Benefit-Analysis-of-Selected-Options-to-Improve-Water-Quality-in-the-Manawatū-River-Catchment.pdf) was prepared for a stakeholder workshop on "Economics of the Manawatū: Whose Bang for Whose Buck?" and refers to similar actions and includes the information in this appendix.

Key Actions

Reduce sediment run-off from erosion prone farmland, the rural road network, and areas of major earthworks through:

- **implementation of the Sustainable Land Use Initiative (SLUI)**
- meeting resource consent conditions, compliance monitoring and enforcement, and
- use of earthworks and road maintenance best management practices.

Reduce the nutrient and bacteria load from point source discharges through:

- **resolution of outstanding resource consent applications**
- ensuring consented conditions, compliance monitoring and enforcement,
- meeting resource consent conditions, compliance monitoring and enforcement, and
- requiring and obtaining resource consents for stormwater discharges

Reduce the run-off of sediment, nutrients and pathogens from intensive land-uses such as dairying, horticulture and cropping through:

- meeting resource consent conditions, compliance monitoring and enforcement, and
- **meeting the Clean Stream Accord targets and successive scheme introduced by the dairy sector, and**
- **adoption of Nutrient Management Plans and promotion of nutrient use efficiency**

Protect areas of habitat for native fish, birds and trout, and enable movement between these areas:

- **fencing and planting streams and bush/wetland areas, and controlling pests**,
- **removing fish barriers (unless there are likely to be negative effects on native fish populations)**
- meeting resource consent conditions, compliance monitoring and enforcement.

1. Implementation of the Sustainable Land Use Initiative (SLUI)

As a response to the widespread erosion resulting from the February 2004 floods Horizons Regional Council in 2006/2007 introduced a separate uniform annual rates charge to support sustainable land use in the region. According to Horizons Annual Report (2009-10 p.3) the SLUI programme will take 6-8 years for any actions to have an impact on in-stream water quality. The following table gives the annual revenue and expenditure for SLUI operations in the total region.

Table D 1: SLUI Funding and Expenditure

Year	Rates Revenue	Expenditure	Rates Balance	SLUI Balance*
Annual report 2006/07	$474,000	$993,000	$-519,000	$-519,000
Annual report 2007/08	$1,390,000	$941,000	$- 70,000	$- 70,000
Annual report 2008/09	$1,856,000	$985,000	$801,000	$1,390,000*
Annual report 2009/10	$2,592,000	$1,952,000	$640,000	$2,030,000*
Total	$6,312,000	$4,871,000	$852,000	$2,831,000

Source: Horizons Regional Council Annual Plans (various years)

* Includes additional funding from central government. The surplus has been invested in land leases and the cashflow surplus will be used to fund future SLUI work.

The 2009-10 Horizons Annual report said the SLUI programme covered 300 farmers and was providing whole farm plans for over 200,000ha in the Horizons region. Given that farmers are expected to pay a third of the costs between 2006 and 2010 the total SLUI budget is approximately $6.5m ($4.871m *1.33%).

The 10-year budget for Horizons shows substantial investment plans in SLUI (Table D 1)

	Total	2012-13	2013-14	2014-15	2015-16	2016-17	2017-18	2018-19	2019-20	2020-21	2021-22
Total Budget	537,476	46,183	48,787	51,105	51,886	53,118	54,582	55,531	57,132	58,816	60,336
SLUI	53,830	4,656	4,778	5,147	5,607	5,607	5,607	5,607	5,607	5,607	5,607

Source: Horizons 10-year Budget

With the SLUI programme farmers are provided with whole farm management plans. They are encouraged to intensify production on land that is less steep and fence off and plant erosion prone areas. This can be with poplar and willow poles for gully and slope stabilisation, plantation forestry or regenerating scrub.

Table D 2: Typical establishment costs for plantation radiata pine (winter 2000)

Site preparation

- Spraying weeds, $70-150 /ha
- *Clearing scrub, $500 -1000/ha – not needed for grazed land*
- Controlling pests, $2-20/ha

Plants

- Seedlings, $210-260 per 1000
- Cuttings, $500-700 per 1000

Planting

- Contract labour $220-320 /ha

Post-plant spraying

- $150-250 /ha

Stockproof fence

- $4000 / km or $4 per metre (HRC)
- Perimeter of sq ha =.04 kms

Bulldozing access track

- $800/km or $0.80 per metre

Source: (Taranaki Regional Council, n.d.)

Applying the upper limits = (150+20+700+320+250+($4000*.04)+($800 *.04) this gives a $1,632 per ha planting cost.

The Whatawhata Integrated Catchment Management study cited in the WRISS produced costs similar to this. Afforestation of 160 ha into mostly pine, riparian management of 20 kilometres of stream network, restoration/extension of five hectares of native forest, and intensification on remaining pastoral land had a net cost of $260,000 in the first year (spread over 160 ha this is $1625/ha). Total establishment costs were $600,000 over a 10 year period for establishing land use changes for the 296 ha property (NIWA, 2010; p.135). The loss of income from stock was compensated in the short term from better farm management and intensification of remaining land area. However, additional returns were not sufficient to cover the capital investment cost required for the forestry.

The WRISS estimated a cost of $91m to plant 68,000 ha of steep hill country which is $1338/ha (NIWA, 2010; Table 5.8, p.139)

Establishment of a forestry block on a SLUI farm in the MRC is estimated at $1,750 - $2020 / ha (LandVision Ltd 2008).

Expected Benefits from SLUI

The CBA cover s a period of 20 years and does not include some of the additional benefits that accrue from pine afforestation. These include improved water infiltration and carbon credits and the returns from harvesting.

Tree plantations greater than one hectare have the potential to earn landowners income through the Emissions Trading Scheme (ETS). According to Chris Kelly (CEO Landcorp) if land can carry only two or three stock units per hectare forestry planting under the ETS is an effective alternative land use (Carpinter 23 July 2011). MAF uses a NZU value of $NZ 25 for emission trading calculations (MAF, 2010a). At $25/su net income at a stocking rate of 7 su/ha[10] this is a return of $175 per hectare. With no discounting in 30 years this is equal to $5,250 in income.

The following information has been sourced from the MAF publication "Introduction to Forestry in the Emissions Trading Scheme" (MAF, 2010a).

For a radiata pine forest harvested after 30 years and then replanted the first crop retains about 220 tonnes per ha of carbon on site after harvesting so 220 units (NZU is a tonne of carbon dioxide equivalent of emissions or removals) could be traded without the requirement to pay units at the time of harvest (this is a one off gain MAF (2010a, p.7). At the present price of $25 per hectare this is $5625.

Under the Kyoto Protocol, only new forests established after 31 December 1989 are eligible to earn carbon units (NZU or carbon credits). These are called Kyoto Protocol-compliant forests or post-1989 forests. These forests can earn units for increases in carbon stocks from 1 January 2008. However, if the carbon in the forest decreases, or the forest is withdrawn from the ETS, then units must be surrendered. Participation in the ETS for forest owners with post-1989 forest land is voluntary.

Forest land is an area of land of at least 1 hectare with forest species that have, or are likely to have:

- tree crown cover of more than 30 percent on each hectare; and
- an average crown cover width of at least 30 metres.

Landowners complete an emissions return that reconciles the change in carbon stocks in the registered forest area using specified methods. They then either:

- receive NZUs for increases in carbon in their forests; or
- are liable to surrender NZUs (or pay cash) for decreases in carbon in their forests from harvesting or natural causes.

Post 1989 forest land is eligible to earn NZU for carbon sequestered from 1 January 2013. Landowners who complete emissions returns can receive NZU for increases in carbon in their forests. They are also liable to surrender NZU for decreases from harvesting or natural causes. The amount of carbon stored in a forest varies depending on the age, the species, and the site. An average radiata pine forest absorbs approximately 800 tonnes carbon dioxide equivalent per hectare over 30 years, equivalent to approximately 2.5 tonnes per tree. "Temporarily unstocked" forest land is an area temporarily not meeting the definition of forest land because of human actions or natural events such as harvesting or storm damage. Shelterbelts and riparian strips less than 30 metres wide are not forest land. Also, if land management practices (for example, grazing, clearing) suppress regeneration so the crown cover threshold is not expected to be achieved, the land is non-forest land.

SLUI impacts for the region are calculated (by John Dymond, Landcare Research) and represented in Table D 3*.*

[10] The average stocking rate on steep hill country sheep-beef farms is 8 su/ha (NIWA, 2010; Appendix 9, Table 2). The stocking rate used by Horizons for the Whole Farm Plan in the Manawatū Catchment is 6.66 su/ha (LandVision Ltd, 2008, 71).

Table D 3: SLUI projected impacts

Zone	Area (ha)	2002 erosion (t/km2/yr)	Target erosion (t/km2/yr)	Target % reduction	2002 sediment yield (t/yr)	Target sediment yield (t/yr)	Proportion implemented by 2020	Average maturity by 2020	2020 sediment yield	2020 % reduction
Upper Tamaki	3275	538	539	0	17630	17658	0.75	0.65	17644	0
Oroua	90301	346	263	24	312893	237812	0.75	0.65	276291	12
Coastal Manawatū	56970	114	114	0	64689	64722	0.75	0.65	64705	0
Upper Kumeti	1237	200	200	0	2481	2477	0.75	0.65	2479	0
Tamaki - Hopelands	33807	340	264	22	114804	89263	0.75	0.65	102353	11
Middle Manawatū (mainly Pohangina)	72362	490	350	29	354825	253435	0.75	0.65	305397	14
Northern Coastal	11919	226	161	29	26877	19180	0.75	0.65	23125	14
Lower Manawatū	49009	104	104	0	50868	50857	0.75	0.65	50863	0
Weber - Tamaki	16516	911	822	10	150416	135806	0.75	0.65	143293	5
Hopelands - Tiraumea	4158	472	357	24	19608	14851	0.75	0.65	17289	12
Upper Manawatū	71834	893	681	24	641691	489337	0.75	0.65	567419	12
Upper Gorge	52632	327	323	1	171955	170013	0.75	0.65	171008	1
Mangatainoka	49223	531	506	5	261431	249142	0.75	0.65	255440	2
Tiraumea	88151	1065	633	41	938887	558345	0.75	0.65	753373	20
Manawatū Catchment	**601394**	**6557**	**5319**	**208**	**3129056**	**2352897**	**0.75**		**2750679**	**12**

SLUI sediment yield targets (pers. com. John Dymond).

Issues to take into Account with SLUI

Fencing water ways without riparian planting helps reduce sediment and phosphorous loading into waterways but does not reduce nitrogen run-off sufficiently to prevent nutrient loading of waters or provide shade to lower water temperatures. Without stock to eat watercress, celeric and other vegetation in waterways plant growth accelerates to the point they have the ability to block waterways in high rainfall periods. This causes flooding and can result in the formation of new waterways which in turn require fencing off. Alternatives include (1) riparian planting to reduce the nitrogen run-off and in time provide shade which will prevent some weed growth (2) harvesting the nutrient rich plants for use.

Another issue in the MRC is the spread of 'Old Mans Beard' through fenced off riparian areas. At the moment stock grazing reduces the rate at which this weed is spreading through both agricultural and bush areas.

2. Resolution of outstanding resource consent applications

There are 20 sewage plants and 5 major industrial discharges into the Manawatū River. Horizons has a monitoring programme and regularly tests water quality at 60 sites. This testing has identified major problem sites in order as (i) Feilding WWTP (also ammonia is an issue), (ii) Dannevirke (has spent $4m but there are still leaks draining into river) (iii) Pahiatua WWTP (iv) Kimbolton sewage outflow (Jon Roygard pers. comm, 7 July, 2011). There are also other resource consents that are overdue for renewal. Data has been collected to construct a cost curve for the following major dischargers:

Table D 4: WWTP Infrastructure Upgrades Required and Cost Estimates

Rank	Where	Upgrade needed	Volume discharge per year	$	Source
1	Feilding	Upgrade of Feilding WWTP	24000 m^3	$4.8m	MDC LTCCP 2009-2019
		WWTP Sludge processing and disposal		$3 m	MDC LTCCP 2009-2019
2	Dannevirke	Plant membrane and screen	6370 m^3	$1.047m	TDC LTCCP
3	Pahiatua	Effluent quality	4600 m^3 (est)	$1.7m	TDC AR 2009/10
2	Kimbolton	WWTP plant upgrade	216 m^3	$300,000	MDC LTCCP 2009-2019
4	Longburn	Pipe to PNCC	144 m^3	$300,000	MDC LTCCP 2009-2019
5	Eketahuna	Effluent quality	216 m^3 (est)	$930,000	TDC AR 2009/10
6	Ashhurst	Oxidation ponds	4600 m^3	$2.1 m	Forum letter
7	Fonterra (Pah)	Wastewater disposal	2250 m^3	$1m	
8	Fonterra (Long)	Wastewater disposal	6000 m^3	$2m	Dom Post
9	DB Breweries Ltd	Wastewater and cooling water			
	PNCC	Land disposal	46000 m^3	$100m	Forum letter

The benefits of improvements to WWTP are difficult to quantify and not all investments listed will improve water discharge quality to the river. New technology options to remove pollutants from wastewater are being trialled and are under continual review. For small scale plants such as Pahiatua (population 2559) Eketahuna (population 456) or Ashhurst (population 2526) the use of andesitic tephra sub-soils to remove DRP from domestic wastewater is a possibility. "Hanly et al., (2011) estimated the tephra filter size required for a WWTP servicing a community the size of Taihape (population 1788) with an average daily wastewater volume of 928 m^3 and average DRP concentration of 3.3 g P/m^3. Based on results from the Liesch (2010) study, a tephra (Okato tephra) filter volume of 232 m^3 is estimated to have the potential to remove a total of 1,670 kg P from wastewater, at 97% removal efficiency. This would treat about 18 months of wastewater discharge from Taihape's WWTP. If DRP removal was only required during the summer and early autumn months (i.e. five months per year), then the longevity of the filter could be extended to about 3.5 years." (Hanly et al., 2011, p.5)

Transport costs are the main cost component of the tephra subsoils option. Hanly et al (2011) estimated cartage from the north-western Taranaki region to Taihape distance of 250 km would be about $11,600 (based on $0.20/tonne/km to transport 232 m^3 (i.e. 232 tonnes, assuming an as-received wet weight of 1 tonne/m^3). Excavation cost for 232 m^3 would be $2,320 ($10/m^3).

Using a local tephra subsoil with a lower P adsorption capacity would substantially reduce cartage costs. Therefore, the trade-off between cartage distance and the P adsorption capacity of the subsoil needs to be considered when assessing the feasibility of tephra soil filters.

3. Meeting the Clean Stream Accord targets and successive scheme introduced by the dairy sector, and Adoption of Nutrient Management Plans and promotion of nutrient use efficiency

Actions such as the Clean Stream Accord targets, fencing and planting streams, bush/wetland area restoration, controlling pests, and adoption of a Nutrient Management Plans to promote efficient use of nutrients are all directed at reducing the impact of land uses in the Manawatū Catchment on waterways. The WRISS looked at similar water quality issues in the Waikato region to those for the Manawatū Catchment and recommended the following initiatives:

(i) On Farm Nutrient Management Plans

Reduced nitrogen outcomes are more likely to be achieved if dairy farm operations can be made more profitable at the same time. For this reason Dewes (2011) recommends a whole of farm approach focussing on:

- Increasing the tonnes of home grown feed so farms supply 55-85% of total feed
- Getting the stocking rate for the farm "right"
- Increasing efficiencies (labour, nutrients, feed)

Potential nutrient management tools for reducing Nitrogen loss and the modelled volumes that can be achieved are set out in the following table.

Table D 5: Potential Nutrient Management Tools for Reducing Nitrogen Loss and Modelled Results

Tool	System Changes	N Loss Reduction Modelled
Lower overall or no winter N use	Change to high growth times of year. Lower overall & more strategic usage	↓10-20%
Better effluent capture and recirculation	(up to 50% of farm area). Collected from feed pads, stored & use on summer re grazable crops such as chicory, plantain & over sown with winter ryegrasses. *No mineralisation period*. N & P use, costs	↓10-15%
"Right" stocking rate	Following self analysis of historical data, match cow requirements to pasture harvested. Aim for improved intakes, productivity similar. Best tool to use when stocking rate is "above optimum" for farm. (10-15%)	↓3-20%
DCD – Nitrogen Inhibitor	Sprayed on pastures at optimum times, can result in 5% increase in pasture growth – winter. Not yet proven for widespread use in North Island.	↓0-10%
Winter grazing off	If whole herd is grazed off 4-6 weeks. Can be most profitable way to reduce N leaching, but unlikely to be an option in sensitive catchments.	↓15-25%
Infrastructure improvements	Options such as: Feed Pads, Wintering Pads, Standing Cows off Autumn/Winter. Assumes Effluent is captured and reused at optimal times.	↓3-15%
Higher per cow production	↑ Milk solids/cow 8-10%, with low protein supplement, alternative feeding strategies, good infrastructure.	↓3-10%

(Source: Dewes, 2011)

(ii) Lower overall or no winter N use

Nitrogen fertiliser application has to be closely matched with the ability of plants to take it up. Cow urine patches apply the rate of 1000 kgs/ha of N soil for the area they cover. The typical application rate for fertiliser is 30 kgs/ha. The volume and intensity of urine is of most concern in summer and autumn. These are the key times for limiting N leaching as N breaks down quicker when the temperature is less than 10 degrees (M. Hedley, pers. comm. 15 July, 2011).

(iii) Better effluent capture and recirculation

Dairy farmers can pay between $100,000 and $200,000 for a dairy effluent spraying system (Galloway, 2011b). There are also interest costs, maintenance, power costs and labour costs. This investment, however, allows effluent to be used as a fertiliser and can save the average dairy farmer up to $20,000 per year. Farmers typically irrigate about 2-3% of land but can increase this with additional storage capacity. Effluent irrigation provides a savings in fertiliser costs of approximately $6,000 per ha/year (provided at the IFS workshop).

The requirement not to dispose of cow shed effluent into water ways was resisted by farmers when first imposed by regional councils. It has since been shown that good management systems and the ability to irrigate in dry periods boost profitability. The ability to irrigate at the end of the summer provides additional feed at a time when cows have to be in good condition for mating. It also reduces groundwater and surface water takes when rivers are likely to have low flows. Some farmers are increasing storage capacity beyond the minimum required for effluent management (www.fonterra.com) to provide additional irrigation. As fertiliser costs increase and greater international demand makes sourcing fertiliser more difficult and costly this represents closing the loop for farmers. Such self-sufficiency provides resilience to farmers as well as saving money.

High quality effluent management systems are promoted by the dairy industry[11] with the Farm Dairy Effluent Design Code of Practice and Design Standards, the AgITO effluent management training programme, Smart Water on Dairy Farms project, trials with Irrigation NZ and DairyNZ to provide tools to enable farmers to optimise water application, the Farm-Enviro-Walk, and the Effluent Improvement Plan (Dairy Sector, 2011). Fonterra have sanctions in place including non-pick up of milk for failure to comply with Effluent Improvement Plans. Good effluent management practice is encouraged with the provision of one-on-one advice to any supplier requiring it. Repeated poor performance is penalised with milk pay-out deductions (between $1500/$3000 during the 2010 season) (Dairy Sector, 2011).

Dairy farm compliance rates with effluent disposal have increased significantly and it should be recognised many of the technologies and practices introduced have produced sustainability gains. As the price of fertiliser has increased farmers have shifted from regarding effluent as a ‘waste’ to regarding it as an ‘asset’. However, managing effluent requires skills, training and capital investment.

[11] The Fonterra website actively promotes good effluent management. (http://www.fonterra.com/wps/wcm/connect/fonterracom/fonterra.com/Our+Business/Sustainability/Fonterra+farmers+doing+the+right+thing+for+the+environment/Taranaki%20Sustainability%20video)

The industry is responding by providing training programmes and standards for equipment. Determining the pond size required has been assisted with the effluent pond calculator developed by Massey University. Leaky effluent ponds remain a problem with this being the source of an estimated 10% of N loss in the Manawatū Catchment (Workshop 3 notes). Generally, 50-60% more grass is produced on areas that spray effluent. The expected payback period for effluent storage and spraying equipment is 6 years but there can also be additional advantages. For Nicky and Andrew Watts effluent capture and controlled spraying has increased the soils ability to hold water by 5-6% on their Canterbury farm so less irrigation is required. Over the last 3 years since putting in their effluent system the farm has reduced the cost of N fertiliser by 37% per ha, decreased animal health costs by 20%, increased pasture harvest by 10%, and increased in milk solids production by 10% (www.Fonterra.com). This is a positive feedback loop for farmers. By improving environmental outcomes farmers improve on-farm resilience.

(iv) "Right" stocking rate

The right stocking rate is when leaching (N, P, pathogens) does not show up in groundwater and waterways. The right stocking rate varies from farm to farm due to variation in soil type, slope, sun-shine, wind and rainfall. The Overseer model has been developed to assist farmers determine the appropriate stocking rate to maximise feed production and minimise leaching. The correct carrying capacity for a farm is determined by multiple factors in addition to natural elements. These include at a minimum: the amount of supplementary feed grown, the ability to stand cows off pasture during wet periods, storage capacity for effluent and irrigation and management skills.

(v) DCD – Nitrogen Inhibitor

Trials have shown under ideal conditions nitrogen inhibitors applied to urine patches can increase pasture growth while lowering nitrous oxide emissions and nitrate leaching to waterways. The effectiveness of nitrogen inhibitors on typical farms and in different climatic conditions is still uncertain. According to MAF (2010b, p.12) "Nitrification inhibitors slow down the conversion of ammonium in the soil to nitrate. The ammonium comes from animal urine and nitrogen fertiliser applied to pasture. This slower process benefits both the farmer and the environment by reducing nitrate leaching into waterways and the production of nitrous oxide. It has the added benefit of improving pasture growth in spring by retaining more available nitrogen in the soil, for grass growth. This will enable farmers to reduce fertiliser inputs while maintaining or increasing farm productivity."

(vi) Winter grazing off

Winter grazing off can be either completely removing cows from a dairy farm over the winter or reducing the time on pasture. Farmers currently cope with wet conditions by standing cows off grass on pads or tracks for up to 20 hours a day in extreme conditions. This is possible when quality feed is available. Research by Christensen et al. (2012) into "duration controlled grazing" indicates cows eat all they need in 4 hours periods in paddocks (day and night) and N leaching rates can be reduced by as much as 50% when cows have stand-off periods. If the cows excrete on surfaces where waste can be captured excreta can be applied to the grazed pasture to maintain nutrient balance and hence pasture production.

(vii) Infrastructure improvements

Standing cows off grass has additional associated costs such as concrete feeding pads or herdhome construction. Some farmers have constructed feedpads that allow cows to be off pasture in the wet but cows cannot stand for long periods on concrete as this results in lameness. Removing cows from pasture has the additional advantages of preventing pugging, protecting grass growth and enabling cows to be fed supplements more efficiently. For example, magnesium which is important for metabolism can be provided in lower volumes than when spread on grass in the wet or put in troughs that overflow (Galloway, 2011a).

Herdhomes are more advanced structures that provide shelter in summer and winter and are suited for cows to be in for more extensive time periods without lameness. The capital cost of herdfarms estimated at $1350/cow (NIWA, 2010; Appendix 9, Table 4) makes this option prohibitive for the majority of farmers. A higher milk-solids price ~ $8/kg might make herd homes more feasible.

(viii) Higher per cow production

The quantity and mix of diet is important for milk-solids production. There is a need to match a cow's protein intake with cows protein requirements. A 100% grass diet provides around 25% crude protein all year round whereas cows only require 16-17%. A higher protein level results in a higher N intake than needed and a greater quantity of N excreted.

Table D 6: Urinary N excretion in NZ dairy cows

	Pasture only diet	**Pasture +25% maize silage**	**Pasture + 45% maize silage**
Mean dietary protein	26%	22%	17.5%
Dietary N intake (g/day)	711	594	478
Urine N(g) excreted per day	403	294	179
Energy cost in managing extra urea (litres lost per cow per day)	9.8 Megajoules (2 litres of milk lost)	5.9 MJ (1 litre of milk lost)	2 MJ (0.5 litre)

Source: J Burke (2009) cited in Dewes, 2011

4. Fencing and planting streams and bush/wetland areas, and controlling pests

In addition to improving water quality fencing off stream will have benefits such as reduced stock loss, easier management and better stock health due to higher quality water supply in troughs.

Horizons have used the Tararua area as a pilot scheme for subsidised fencing near waterways. In total 84 farmers in the district received $315,000 financial help from Horizons. Fencing stretching 160 kilometres had been erected (Waterhouse, 2011). This gives an estimated cost of fencing for Horizons of $1,968 per kilometre. Individual farmers got a 50% subsidy and groups of four or more farmers were offered a 75% subsidy. Assuming most subsidies went to individual farmers the actual cost of fencing per km is $3,936 (say $4,000/km). If both sides of a waterway need to be fenced this would equate to $8,000/km of stream.

Troughs to replace the water supply are estimated to cost $250 each and 8 are required per km of stream (NIWA, 2010; Appendix 11, Table 5). Total cost is therefore $10,000/km.

Due to terrain fencing costs are higher for Sheep and Beef farmers than dairy farmers.

Estimated Cost of Riparian Planting all REC Order 1-7 waterways in the MRC

An estimate for the cost of riparian planting waterways in the MRC for 5 metre native vegetation buffers has been made using GIS data (Ministry for the Environment, 2011) and costs as in Table D 7 from the WRISS (NIWA, 2010; Appendix 11, Table 5). The length of waterways in each of the 7 REC classifications in the MRC was estimated first. The polygons with a cow density of >13847 in the MRC were identified and these assumed to be the intensive dairying areas. The length of streams in these areas was summed. The remaining pastoral areas were assumed to be mainly sheep and beef and the length of streams in these areas summed. Approximately 39% of the streams were in the dairying areas and the 61% in sheep and beef areas. The total length was divided between Dairying and Sheep and Beef farming on the basis of this ratio.

Table D 7: Estimated Costs for Riparian Planting

Description of action	Costs	Comments
5 m wide native revegetation buffer for **dry stock** farm streams currently having grass riparian vegetation	**$58,500**/km for post and batten fences ($18/m = $36k/km stream) + 8 troughs ($250 ea) per km stream + native PB2 grade plants @ 2,500 stems/ha ($5 planted) + maintenance to year 3 ($8k/ha)	Minimum width buffers for aesthetics requiring more ongoing vegetation maintenance and weeding than 10 m wide buffers. Post and batten fences needed to exclude sheep.
5 m wide native revegetation buffer for **dairy** farm streams currently having grass riparian vegetation	**$32,500**/km for 3 wire electric fences ($5/m = $10k/km stream) + 8 troughs ($250 ea) per km stream + native PB2 grade plants @ 2,500 stems/ha ($5 planted) + maintenance to year 3 ($8k/ha)	Minimum width buffers for aesthetics requiring more ongoing vegetation maintenance and weeding than 10 m wide buffers. Electric fences needed to exclude cows.
10 m wide native revegetation buffer for **dry stock** farm streams currently having grass riparian vegetation	**$79,000**/km for post and batten fences ($18/m = $36k/km stream) + 8 troughs ($250 ea) per km stream + native PB2 grade plants @ 2,500 stems/ha ($5 planted) + maintenance to year 3 ($8k/ha)	Optimal compromise width buffers for aesthetics. Post and batten fences needed to exclude sheep. Wider buffers particularly beneficial on larger streams.
10 m wide native revegetation buffer for **dairy** farm streams currently having grass riparian vegetation	**$53,000**/km for 3 wire electric fences ($5/m = $10k/km stream) + 8 troughs ($250 ea) per km stream + native PB2 grade plants @ 2500 stems/ha ($5 planted) + maintenance to year 3 ($8k/ha)	Optimal compromise width buffers for aesthetics. Electric fences needed to exclude cows. Wider buffers particularly beneficial on larger streams.
Willow removal then fencing and native revegetation as above	Appropriate options above **+ $14,000/km** along 1st-2nd order streams **or + $24,000/km** along ≥3rd order streams	Willow removal is cheaper per km along small streams where machinery can operate from one bank (estimates pers. comm. Bruce Peploe EW).

Source: NIWA, 2010; Appendix 11, Table 5

Table D 8: Estimated Costs for Riparian Planting Dairy and Sheep and Beef Farms in the MRC

REC	Length (kms)	Length (kms) in dairy 39%	Length (kms) in Sheep & Beef 61%	Total cost for Dairy @$32,500/km $m	Total cost for Sheep & Beef @$58,500/km $m	Total Fencing costs $m
Order 7	56	22	34	1	2	3
Order 6	142	55	86	2	5	7
Order 5	253	98	154	3	9	12
Order 4	521	203	318	7	19	25
Order 3	885	345	540	11	32	43
Order 2	1862	726	1136	24	66	90
Order 1	3715	1449	2266	47	133	180
Total	7433	2899	4535	94	265	359

Note: In Table D 8 no adjustment has been made for areas already fenced off.

Cost curves for planting from biggest waterways (Order 7) to smallest waterways (Order 1) for both dairy and sheep and beef farming areas are shown in Figure D 1.

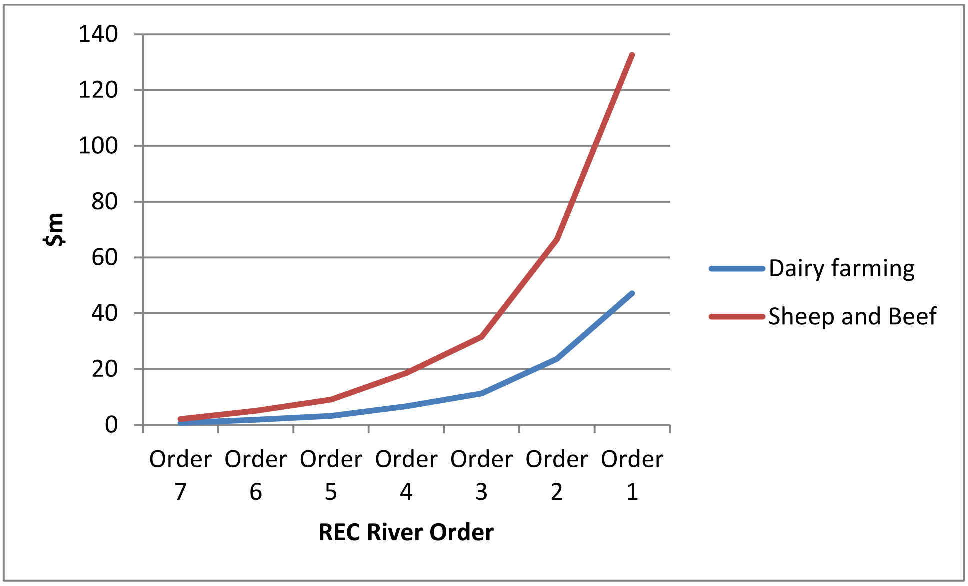


Figure D 1: Estimated direct costs (fencing, planting, maintenance) of riparian vegetation for all REC streams on dairying and sheep and beef farms

Plant costs and variety needs to be considered for riparian strips. Just fencing off will not have significant aesthetic or biodiversity benefits and, without careful weed control, is likely to result in a proliferation of weed species such as blackberry. The riparian planting of well-selected plants[12] can have additional benefit such as protecting honey bees. The bee is estimated to contribute $3 billion to the annual GDP by pollinating horticultural and specialty agricultural crops (Federated Farmers, 2009). Livestock production also benefits indirectly through the pollination of clover which is a nitrogen regeneration source for the pastoral land. Lack of flowering plants, disease and pests (e.g., varroa mite) have resulted in a decline in bee numbers and an under-performing of pollination services. Pollination, a free ecosystem service provided by nature, is difficult to value for the Manawatū Catchment but is a factor that needs to be considered. Planting bee friendly trees and shrubs along waterway margins, windbreaks, field edges, under pivots and roadsides has long-term

[12] Some plants that flower well and are a source of pollen are also aggressive environmental weeds.

benefits as “in terms of the food we eat, about a third of the calories and three-quarters of the diversity rely on bees for pollination” (Federated Farmers, 2009).

Wetland Planting

Wetlands have soils, substrates and vegetation that have developed under conditions of waterlogging and restricted aeration. The efficiency of a wetland is determined by characteristics such as water dispersion, flow paths, depths, residence times, and vegetation characteristics. Approximately 97% of the original wetland cover of the Manawatū has been converted to urban use or farmland by draining. Wetlands provide multiple ecosystem services such as gas regulation, disturbance regulation, water regulation, water supply, waste treatment, wildlife habitat, enhanced biodiversity, recreational opportunities, landscape and amenity values and cultural needs. These services, provided free by nature, have been lost as a result of the draining of wetlands. Planted wetlands try to replicate processes that occur naturally in swamps, fens and marshes.

The following information has been extracted from (McKergow, Tanner et al. 2007, p.44).

“Wetlands are important nitrate and sediment attenuation tools. Wetlands can provide suitable conditions for deposition of sediment and particulate nutrients. The dominant nutrient processes in wetlands are denitrification, plant uptake, deposition, adsorption and mineralisation. Of these processes only denitrification represents permanent removal of nutrients from a wetland. The other nutrient processes are temporary stores, which can be re-released back to through-flowing waters. Plant uptake is a temporary nutrient store as unless aging plant material is removed from the system (e.g., by biomass harvesting, stock grazing etc.) a large proportion will eventually be converted back into soluble, bioavailable forms … Adsorption of phosphorus to inorganic sediments may be reversed under anaerobic conditions and fine particles that sorb onto vegetation and detritus may re-mobilise when they dry and/or during subsequent high flows. In practice, a small proportion (~5-10%) of the N and P taken up and cycled by plants is retained as long-lived humic compounds in accumulated sediments, or released in soluble humic forms with low bioavailability. “

Costs for constructing and operating wetlands are relatively low if suitable land is available and natural landscape features such as depressions utilised. Costs and benefits are determined by the size of the wetland. “To achieve 50-60% nitrate and TN removal, constructed wetlands generally need to cover 2-3% of the catchment from which they receive drainage water. Smaller wetlands (1% of catchment area) will generally remove ~30% of nitrogen, while larger wetlands (5% of catchment area) can achieve 70% nitrogen removal or greater. In practice, treatment performance will vary with year-to-year differences in the timing and magnitude of run-off events, which affect hydraulic retention times, inter-event duration and the seasonal timing of loadings in relation to microbial denitrification activity, and plant growth and senescence (Tanner et al. 2005a; Tanner et al. 2005b; Tanner et al,. 2005c)” (McKergow, Tanner et al., 2007, p.44).

The following costs in Table D 9 are for a constructed wetland where there are natural depressions, gullies and wet areas that intercept surface run-off and springflows and are able to be modified to form wetlands. The wetland covers 2.5% of the contributing catchment and the expected benefits are (1) a reduction of ~80% of the sediment load in surface run-off, (2) a ~ 60% (likely range 40-80%) reduction in N and (3) ~ 60-80% reduction in particulate P (dissolved P retention is not high). A significant reduction in sediment associated EColi is likely but no data is available to quantify this.

Table D 9: Costs for constructed wetland where there are natural wet areas

Activity	Costs	Assumptions	Data Source
Fencing	50m/ha @ $4 per metre =$200	Assumes wetland sized to treat run-off from 5 ha sub-catchment. Fencing on all sides assuming 9:1 length: width ratio, fence erected 1.5m from wetland water edge	McKergow et al. (2007, p.40), HRC fencing cost$4000 per km
Set up costs	$1625/ha	Double handling of topsoil etc. expected to increase costs somewhat for larger dimension wetlands, whilst fixed costs likely to be greater for smaller wetlands.	McKergow et al. (2007, p.40),
Land production loss (Dairy)	$1,467/ha/annum	Based on dairy free drain $1,467 per ha; values from Appendix 9: Farms	WRISS (NIWA, 2010; Appendix 12 (2010, p.31)
Land production loss (Sheep and Beef)	$323/ha/annum	Based on catchment in sheep and beef Class 4, $323 per ha; values from Appendix 9: Farms	WRISS (NIWA, 2010; Appendix 12 (2010, p.27)
	$175/ha/annum	Based on MRC whole farm plan	LandVisions 2008 p.71
Maintenance	$25/ha/annum	Based on cost for established wetland of one weed spray and one further inspection per year	McKergow et al. (2007, p.40),

Land production loss costs will vary. In many situations the opportunity cost of the land utilised will be low as it would be boggy for certain times of the year. Benefits such as reduced stock loss can compensate for loss of productive capacity.

Planting wetlands with flax provides a food source for both bees and native birds which provide the pollination services required by agriculture. When constructing wetlands using small impoundments care is needed as this can impact on downstream habitat by changing and fragmenting stream flow regimes, and modifying physico-chemistry which can effect macroinvertebrate communities downstream (McKergow, Tanner et al., 2007).

List of figures

List of tables

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