Towards Design For a Nutrient Trading Programme to Improve Water Quality in Lake Rotorua

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Abstract

This paper explores how to enhance the role for academic research (natural sciences, economics and their integration; and stakeholder management) within the development and implementation of water quality policy in New Zealand. Our focus is on the use of market based instruments and particularly nutrient trading programmes, which are one important part of the potential tool kit to address these issues. We discuss why nutrient trading might be an appropriate instrument for the Lake Rotorua catchment. We survey the existing literature and then outline the outstanding scientific, economic and governance questions that need to be addressed to design an effective trading programme. Finally we discuss how to design a process to address these questions drawing on both technical and practical knowledge through a learning process.

JEL classification
Q53, Q57, Q58, A12

Keywords
water quality, emissions trading, non-point source pollution, nutrients, Rotorua, communication, learning

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1 Aims of and motivation for project

This project has been motivated by the increasing severity and urgency of pressures on water and a shortfall of effective management measures. Protecting the quality of water, protecting groundwater stocks and ensuring efficient use of all water within catchments are important issues all over New Zealand for environmental and economic reasons.

One aim of this work is to enhance the role for academic research (natural sciences, economics and their integration; and stakeholder management) within the development and implementation of water quality policy in New Zealand. Our focus is on the use of market based instruments and particularly nutrient trading programmes. Market based instruments, and specifically tradable allowance regimes, are one important part of the potential tool kit to address these issues. Tradable allowance systems have been used in New Zealand (e.g. fisheries) and could in future also be used more widely (e.g. climate change, biodiversity).

Nutrient trading is part of a suite of possible policies and needs to be embedded in a wider institutional framework. Some policies, such as a non-tradable cap, could be considered precursors to a potential trading regime; they have many common requirements. The most difficult part of establishing a trading regime is defining and creating the property rights to be traded and this must also be addressed in any capped regime. Other policies, such as education or programmes to facilitate the adoption of specific technologies, would be complementary; both programmes will be more effective when done jointly.

We discuss nutrient trading not because we consider it the only option, but because it is a potentially important part of the regulatory toolkit and because many of the issues that must be addressed to implement and effect nutrient trading must also be addressed for other effective regulations. Many of the challenges presented as barriers to using nutrient trading – such as setting a specific monitorable cap on emissions; or determining who should bear the cost of abatement effort – also apply to any other comprehensive regulation; they are simply more transparent in a trading regime. The real trade-off is not between a simple, politically easy non-trading regime and a complex, politically difficult trading regime where the only gains come from tradability. The trade-off is between a clear explicit regulation where goals, rights and obligations are clear and well enforced (and with a potentially high up-front cost to gain this clarity) and a set of regulations where the difficult issues are still unresolved, transaction costs are high because of uncertainty, the environmental goal is both less clear and less likely to be achieved, and any gains that are achieved are likely to be achieved at a relatively high cost. The actual trading is in many ways secondary.

The discussion uses the design of a trading system as a framework to present these wider issues. Thus, most of the technical questions addressed in section 2 have direct relevance beyond nutrient trading.

1.1 Why explore nutrient trading?

For water quality management, a well-designed and operated tradable nutrient regime can have the following benefits:

1. The total level of allowable contamination is set in a political process and then achieved through a cap.

   This has the advantage of certainty in the environmental outcome. It also ensures that consistent monitoring information will be collected and assessed to facilitate future management decisions.

2. That goal is achieved with the maximum possible flexibility.

   This includes flexibility in: where in the catchment the reductions occur; what land uses change; what technologies are used; what management practices change; and when reductions take place. This makes achievement more efficient and also increases the political acceptability of the programme as a whole because it is less prescriptive.

3. Private sector knowledge and innovation are mobilised to help achieve the goal.

   Farmers, foresters and others have a direct interest in finding and implementing methods to reduce nutrient run-off.

4. Complementary policies, such as those to facilitate the adoption of new technology, education or planting riparian boundaries, are more effective

because commercial interests are now more closely aligned with the new initiatives.

Together these mean that the goal is achieved at the lowest cost in both the short and long term. A tradable nutrient regime also offers political benefits:

5. It provides flexibility in how the costs of achieving the goal are spread.

Either allowances can be allocated to groups who seem to face unreasonably high costs, or a flow of income, generated by selling or leasing allowances, can be used to fund policies that compensate vulnerable groups and help them adjust.

6. It allows different groups, including Maori, to be genuinely involved in management decisions on an ongoing basis.

By being owners of part of the allowance pool they have a direct interest in each management decision as well as the resources to express that interest effectively.

1.2 Why do we need to better integrate academic researchers in the development of a nutrient trading regime?

At a textbook level, the design of a tradable nutrient regime is simple: set a cap on emissions; allocate allowances; allow trade; and monitor emissions. In reality, each of these steps is complex and difficult to do well. A poorly designed system that ignores the complexity will not achieve the benefits listed above and may even make the problem worse both environmentally and economically. The complexity arises from both the natural science underlying it and the economics. While the academic researchers cannot offer perfect solutions to any of the issues, the expert understanding of researchers needs to be combined with the pragmatic expertise and local knowledge of stakeholders to make good, genuinely joint decisions under uncertainty.

National consultation on the Water Programme of Action (New Zealand. Ministry for the Environment, 2004), and interviews with stakeholders undertaken for this report, highlight a highly variable understanding of how market based instruments could work, of options around their practical implementation, and of other factors that need to be managed concurrently to allow an effective market to operate. The issue of market based instruments has a political dimension, in part due to concern that the adoption of market based instruments would represent a path to the private ownership of water, and the risk of 'winner takes all' markets. On the other hand, some stakeholders who are proponents of trading believe that 'using markets' is an alternative to regulation rather than a specific form of regulation albeit one with more flexibility.

The potential contribution of market based instruments needs to be explored inside a 'learning environment' where the technical dimensions can be fully analysed, and also where the potential readjustments in relationships among agents and with the resource can be explored without participants representing any group or negotiating on their behalf. In this report, we focus on the technical information needed as an input to that process (key questions), and the principles that will inform the design at several levels, and we propose some specific process design elements of the learning environment.

To implement an effective nutrient trading programme we would need to create a receptive environment in the set-up phase (i.e. before the market is operational) so the policy is politically attractive and all key stakeholders engage constructively to improve the market design.

During the early stages of developing a nutrient trading approach, and particularly before relative allowance allocations are clearly established, significant resources are at stake and large distributional issues must be resolved within the private sector and between private agents and various levels of government. One key concern is to ensure that conflicts over the allocation of costs do not lead to poor decisions on the fundamental architecture of the system.

Positive stakeholder collaboration is also useful after the water management system is created. Because public preferences and scientific knowledge will continue to evolve, adaptive management will be necessary. Adaptive management is much more likely to succeed if stakeholders not only conform to the formal rules but participate constructively in the further development and adaptation of the management system. The incentives for collaboration in this stage are somewhat different from in the initial stage as property rights will have been established (at least in terms of relative cost sharing) and the conflicts of interests between private sector stakeholders and between economic and environmental interests may not be so stark.[1]

Researchers and analysts involved in the establishment of market-based incentives in other areas (e.g. fisheries quotas in New Zealand, sulphur dioxide emissions trading in the U.S.) feel that part of stakeholder resistance to policies comes from lack of understanding of key technical issues, whether they relate to the seriousness of the problem or the real effects of a trading programme. An effective collaborative process should facilitate communication of this scientific and economic information and allow any political negotiations to focus on issues where real conflicts of interest occur. Effective communication can also help to avoid what researchers see as mistakes in policy where technical information is not used or misused and policy decisions are made that have real costs without the real compensating gains that the political stakeholders believe are being achieved.

1.3 Why Study Nutrient Trading in Lake Rotorua?

The Rotorua lakes region presents a case study area in which to develop generalisable results that can inform similar processes in other regions in the future. It is one of the first in a large number of catchments nationally that face similar issues (Environment Waikato has already created a form of trading programme for Lake Taupo). A lot of work is already going on relating to water quality in the Rotorua region and potentially a nutrient trading system could be set up in the Lake Rotorua catchment.

[1] Though restrictions on land and water use will impose costs on some stakeholders, many of the same stakeholders also have an interest in the protection of water quality, because of its positive effects on local land values. Both the absolute and the relative costs of regulation will be important to these stakeholders. They may be willing to bear higher costs when those costs are partially offset by land values, and when they know that others will bear their share also. Those who own 'allowances' (rights to apply nutrients) might also support (or not oppose) more stringent targets because more stringent targets will raise the value of the allowances that remain. Thus they may oppose the regulation during the set up of the system, but become supporters or at least less active opponents once it is operational. This effect has been seen in the case of the New Zealand Fisheries Individual Tradable Quota system where the contest over allocation of initial quota was ferocious and drawn out (nearly 20 years until all challenges were resolved), but over time fishers have come to support the system and reduce their resistance to more stringent quota limits. This support has reduced the enforcement challenge for many stocks because fishermen monitor each other. There are some crucial exceptions to this positive outcome which are also instructional (e.g. arguably orange roughy where private interests are not aligned with sustainability and stocks have been allowed to collapse). This effect arises because fishers are the primary beneficiaries of stock protection. This positive effect is likely to be weaker in the case of water quality because landowners within the catchment receive only a small percentage of the total gains from improved water quality.

Nutrient trading systems are a potentially valuable tool in the Lake Rotorua catchment partly because there is a large number of players and many potential abatement options, many of which are still in development and for which the relative values are both uncertain and highly variable across players. This complexity means that private players have large amounts of 'private information' about their best abatement strategies (i.e. information not available to the regulator). An efficient water quality policy needs to use this information and conventional non-market forms of regulation will not easily elicit it.

The physical characteristics of the lake and, in particular, its naturally high productivity resulting from a large catchment area (including a large area of agricultural land) relative to lake volume also suggest that a land use management strategy that focuses on managing nutrient loads would be appropriate and that innovative management is required. This strategy could possibly be complemented by other interventions.

Although monitoring nutrient application and understanding its ultimate effects on water quality are complex and require the use of models based on simple observable data, once these models are accepted (and they are needed for any regulation based on players' effectiveness at improving water quality, i.e. 'performance based' rather than direct input controls) no extra data are required for trading. Thus, the administrative burden on government and private players needs not be high.

The major barrier to most trading systems is the need to explicitly define and allocate property rights, in this case to nutrient applications. All regulations implicitly define these rights, but under many regulations they may be perceived as less permanent or their non-transparency may allow them to be ignored. In the case of water quality in Lake Rotorua, many of the issues relating to property rights definition are already resolved through the existing RMA process though some important ones are outstanding.

Finally, creating property rights and a trading mechanism is a costly process (in both political and economic terms). It is worthwhile where the gains from efficient water quality management are likely to be high. Lake Rotorua is likely to meet this criterion. Water quality issues are already causing serious environmental and economic cost and continuing development in the catchment is unlikely to lead to water quality improvements on its own but rather the reverse. Thus the level of effort to enhance and protect water quality is likely to rise and the value from making that effort efficient will also rise. A trading market can facilitate an efficient mitigation effort both because mitigation efforts are done in the most effective way at each point in time and because the market creates incentives to find and adopt new technologies and land management methods.

Lake Rotorua is probably the only part of the Rotorua Lakes region where trading would work well at least in the short term. In the longer term, if the problem becomes more acute requiring more intensive action, if the trading programme is working well, and if transfers of water/nutrients between lakes become a more serious issue, the trading programme could be extended.

Nutrient trading programmes would be a complement and a supplement to ongoing Rotorua lakes efforts. They cannot be developed in isolation, so it is critical to involve key stakeholders who are already involved and affected by water quality management efforts. Ongoing efforts to develop and apply technology or to develop cooperation to change land management practices through other programmes may facilitate the operation of a nutrient trading programme.

In the other direction, a trading programme can help to verify that the system as a whole is working because it, by design, must cover and monitor all nutrient flows. It can thus coordinate different efforts and help evaluate them. As an example, one stakeholder raised that in the Lake Taupo case, the government paid for riparian boundaries along all streams leading into Taupo when the problem of excess nutrients was first identified. This lowered nutrient inputs effectively in the short term, but couldn't fully solve the long-term problem and, because it was a one-off effort, it did not generate ongoing monitoring and evaluation of progress. A trading programme would require this periodic monitoring and evaluation as an integral part of its operation.

A trading programme also provides incentives and, potentially, capital to facilitate the adoption of technology and practices that are piloted in other programmes thus making their broader application much easier.

1.4 Existing work relevant to nutrient trading in Lake Rotorua

Environment Bay of Plenty and many others have been working on the quality of the lakes in the Rotorua region for many years. They have a well advanced technical and consultation process for water quality management in general. The many reports they have commissioned are available online at www.envbop.govt.nz/Water/Lakes/Technical-Reports.asp. These have been carried out by the University of Waikato, NIWA and a range of other statutory bodies, research agencies, consultants and non-governmental groups and are critical to understanding the physical/biological, institutional, social and economic context that is relevant to nutrient trading.

The April 2006 report of the Office of the Parliamentary Commissioner for the Environment "Restoring the Rotorua Lakes" provides an excellent synoptic review of the issues of water quality in the Rotorua Lakes, including nutrient sources and the "lag time" issue. It also provides an overview of action already underway to improve water quality, including reference to the Rotorua Lakes Protection and Restoration Programme, RMA statutory plans, the role of the Ministry for the Environment, Treaty Settlement, community initiatives and research.

The Ministry for Agriculture and Forestry has funded a series of projects that explore different abatement options within the Rotorua Lakes region. The lake and catchment environment of Lake Taupo is one of the most technically studied regions of New Zealand, and some of this material is directly relevant to Lake Rotorua.

Some of this literature is referenced in the text below. It, and the insights of the analysts, stakeholders and researchers involved in creating it, will all form the starting point for exploring the specific technical challenges associated with a nutrient trading programme.

2 Specific needs for academic/technical input

Below, we outline the key natural, economic and social science issues relating to creating an effective nutrient trading system and specifically for creating one for Lake Rotorua. Most of these questions are also salient for other regulatory options. These are issues that should be addressed jointly and collaboratively by stakeholders. They all have a purely technical element, but also need to involve local knowledge and political judgement to create a technically and politically effective and sustainable management system.

The technical aim of the engagement would be to ensure that stakeholders understand the nexus of economic, policy and natural science issues as much as possible and, where they cannot understand them, trust the technical experts/process well enough to separate technical from political issues and narrow the range of issues on which negotiation is needed.

The technical issues can never be resolved with complete certainty. Lack of information should not necessarily mean lack of action however. What is needed is an informed judgement that we know enough that we can take actions now that are better than the status quo. We can then seek more information both from fundamental research and by evaluating the effects of our actions and use this information to improve our decisions over time. This is the essence of adaptive management.

When we discuss some of these issues with stakeholders we will benefit from existing detailed local technical research. In other cases, we can draw on experience from similar issues elsewhere in New Zealand (e.g. catchments with similar hydrology, trading rules and governance processes design in the NZ Fisheries Individual Transferable Quota system) or abroad (e.g. Australian water management including water trading, similar environmental markets). In still other cases, we will either require some dedicated research or will need to handle them as inherent uncertainties.

2.1 Key natural science questions: protecting water quality under uncertainty

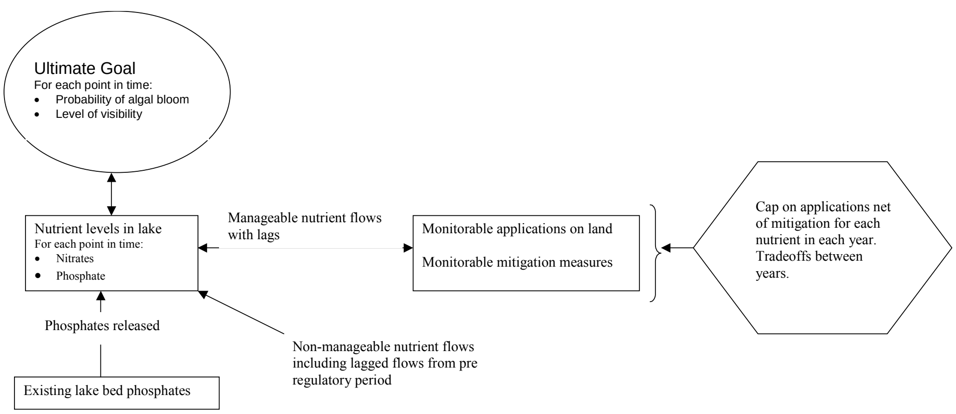
Two regulatory decisions are heavily dependent on natural science input.

1. How stringent should the nutrient target(s) be in the next 10 years over the catchment as a whole?

Figure 1 outlines the different steps in relating ultimate environmental goals to caps on monitorable, manageable applications of specific nutrients (net of mitigation actions) at specific points in time and vice versa. Each of these arrows and boxes involves a body of science knowledge and some uncertainty. We need to use as much knowledge as possible about how reductions in applications of each nutrient will contribute to our ultimate goal when we decide how intensively to target each manageable nutrient and when. The effects of reductions in nitrate applications on algal blooms will depend on how much of this nitrate reaches the lake and when, the likely levels of phosphate and uncontrollable nitrates in the lake, and how the two nutrients interact.

This question is not at all specific to nutrient trading but must be resolved clearly (even if in an interim way) before allowances can be defined (allowances to do what, when?), and the allowance cap can be set.

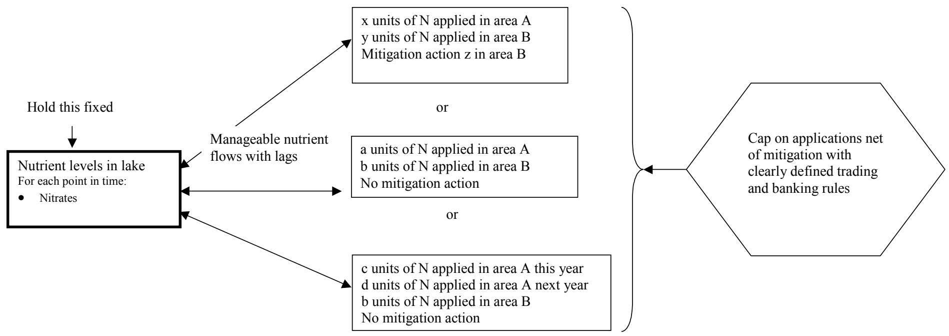
Figure 1 Linking environmental goals to nutrient caps



2. How should we create rules that allow land-use/management change (e.g. intensifying dairy) in one place to be offset by other land-use/management changes (e.g. using EcoN or allowing native reversion) in another place or at another time?

The environmental goal could be achieved in a number of ways. When deciding how to weight different management efforts in a non-trading system or how to set trading rules - how changes in one activity can be offset by changes in another - the science needs to be used to establish which changes in application/mitigation patterns across space and time will lead to more or less equal environmental outcomes.

Figure 2 Science required to establish scientifically robust tradeoffs / trading rules: nitrates



Again this involves intensive science input: measurement of the net nitrate and phosphate flows from each activity, as well as a spatial and temporal understanding of catchment-wide surface and groundwater dynamics.

This section aims to begin to explore two questions in relation to these critical regulatory decisions:

A. What existing scientific/technical knowledge do we need to effectively communicate to stakeholders involved in designing a nutrient trading programme?

- This is potentially a trade-off between 'What do we know enough about to communicate effectively and clearly' and 'What is really key scientific information without which they may make terrible mistakes'. The latter may be complex and uncertain and hence difficult to communicate easily.

B. What new scientific research should stakeholders consider commissioning as part of a 'joint fact finding' process to help them make better decisions?

The answer to this probably takes into account where there is most uncertainty; where the uncertainty is most important for policy; and where we might actually be able to reduce uncertainty.

This section does not try to provide answers to the critical questions. It provides some basic background but primarily aims to outline the natural science issues that the learning and policy development process will need to consider.

Many groups are already addressing the scientific issues in the Lake Rotorua context. In particular Environment Bay of Plenty, the Rotorua District Council and Te Arawa Maori Trust Board have created a Technical Advisory Group (TAG) to assess technical aspects of lakes research. We will focus on the application of existing science to our issues, as well as identifying any necessary extensions or new interpretations of existing research that arise specifically as a result of a trading programme. The scientists involved in our process are also involved in the Technical Advisory Group. As we design and develop the learning process, the scientists and other participants will decide which questions to focus on and where to seek new research.

What would be technically ideal, would be a dynamic spatial stochastic model of the catchment and lake that includes data on all historical nutrients in groundwater and links these and current land use and management to various measures of the probability of certain water quality states and adverse events. This would allow us to simulate baseline water quality as well as water quality under a number of different mitigation scenarios. This science-based model could then be linked to economic models of the costs of low water quality and spatial, dynamic, stochastic models of the costs of changing land use and management in specific places and at specific times, or implementing direct mitigation strategies. This would inform a process that would allow us to set targets efficiently and design an optimal trading programme. In the absence of such a model we need to explore each dimension of the issue and use judgement where research is weak and modelling does not allow us to link components.

2.1.1 How stringent should the nutrient target(s) be in the next 10 years over the catchment as a whole?

2.1.1.a What are the consequences of lake water nutrient levels?

This is a central question when choosing the ultimate environmental goal. The key problems for the public are nuisance algal blooms and reductions in water clarity, while there are also concerns that the trout fishery might ultimately be impacted by severe eutrophication. No unique water quality indicator adequately predicts all of these changes. In addition, the science can tell us something about indicators of physical damage but these are only one aspect of determining the loss of value to humans. This is a key contribution to the problem of deciding an appropriate ultimate environmental goal.

> *Water quality status of the Rotorua lakes may be examined from a number of different perspectives; through water clarity measurements or trophic level indices, which combine information on nutrients, phytoplankton concentrations and water clarity, and, for deeper lakes, depletion rates of dissolved oxygen in bottom waters in association with stratification. In addition, LakeSpy may be used as an indicator of health of benthic plant communities, specifically macrophytes. Together, these indices provide an indication of trends in water quality;* (Hamilton, 2006)
>
> *... there were substantial decreases in both water clarity and invasive macrophyte beds [in Lake Rotorua] through the 1970s.* (Hamilton, 2006)
>
> *Several indices have been used in this paper to denote long-term trends in water quality in the major Rotorua lakes. Across all of the water quality indices selected, only Lake Rotoma and, arguably, lakes Rotomahana and Rotorua appear to be stable.* (Hamilton, 2006)

Damage is not likely to respond linearly to nutrient levels either in a physical sense or in terms of how humans perceive the damage.

> *It is important to use these measurements to forecast when there may be abrupt and sometimes catastrophic changes in lake water quality and biodiversity as a result of increased stresses imposed by additional nutrients and invasive species.* (Hamilton, 2006)

Key outstanding questions are:

- What is the current status of water quality in the Rotorua lakes and how great is the difference between this state and a relatively unimpacted state?
- How accurately can we forecast the extent of change of water quality in Lake Rotorua?
- How can we link nutrient levels to water quality measures and the probability of extreme events such as algal blooms?

2.1.1.b Are any damages persistent or even irreversible (i.e. do they depend on past as well as current nutrient levels)?

This is important because it determines whether the ultimate goal can be defined as a long term nutrient level only (with many possible paths to that goal) or if we need to be concerned about the path, and particularly with peaks in the path, even if they are short lived. The simple answer is that the path matters.

> *The costs of restoration amplify greatly once lake degradation exceeds a 'tipping point', when the lake switches into a low-water clarity state often characterised by loss of weed beds in shallow lakes or increased blue-green algae (cyanobacteria) populations in deep lakes.* (Hamilton, 2006)
>
> *In addition there may be a strong hysteresis in the recovery path once the tipping point has been exceeded (Harris, 1999).* (Hamilton, 2006)

> *There may have to be quite severe management actions taken in the degraded lakes in order to achieve restoration. These actions may involve attempting to limit nutrient exports from the land, but may also include inflow diversions, flocculating and sedimenting out nutrients from the water column, dredging sediments or attempting to re-aerate bottom waters. Preliminary analyses indicate that the costs of these measures may be 1 to 2 orders of magnitude greater, in terms of mass of nutrients removed per dollar expended, than the costs of land-based applications of the nutrients in the form of fertiliser. This analysis serves to demonstrate the importance of retaining nutrients on the land and targeting lake restoration measures to arrest degradation before the tipping point characterised by rapid degradation.* (Hamilton, 2006)

The critical questions are:

- How close is Lake Rotorua to the tipping point? David Hamilton and Paul Dell consider that Rotorua has already had a tipping point.
- What levels of reductions in manageable nutrient flows would it take to avoid reaching the tipping point given the lags in groundwater flows on the one hand and the potential to control lake bed sediment releases on the other?

2.1.1.c What nutrients should a trading programme aim to control?

There is no point controlling one nutrient if increased levels of the other combined with baseline levels will still lead to acute water quality problems. If controlling one of the nutrients would be hard and small changes in its flows would have little effect in the short term, however, it may not be such a priority for control.

Either phosphorus (P) or nitrogen (N) may be the limiting nutrient for phytoplankton growth in Lake Rotorua, depending on location and time. Currently N is considered to be limiting most of the time. Not only are absolute levels of these nutrients important, but also the ratio between them, which can be used to infer which nutrient is limiting phytoplankton growth. In addition, low ratios of nitrogen to phosphorus have been associated with increased incidence of nitrogen-fixing blue-green algae (cyanobacteria), many species of which form blooms at high concentrations. Blooms of blue-green algae can have adverse impacts on lake amenity, including formation of surface scums, toxin production and effects on fisheries.

In order to assess which nutrient to control, we need to understand:

- Are there different optimal strategies for control of N versus P in the catchment?

- What are the implications of targeting management of a single nutrient (either nitrogen or phosphorus) and making that nutrient the primary control on phytoplankton growth?
  - What would happen if we only controlled N in the short term?
  - Can we effectively control P outside the trading programme?
- To what extent will nutrient controls on land be confounded by lake bed releases of nutrients from an abundant historical store?

2.1.1.d How much of each nutrient is flowing into Lake Rotorua and how do they reach the lake?

This helps us understand the levels of baseline or uncontrollable nutrients in the lake in the future; the environmental effects of changes in manageable nutrients will depend heavily on this. It also helps us to understand the timing with which nutrients applied in the future will affect the lake. In particular it helps us understand the likely effect of having tight targets in the short run but more flexibility in the long term in contrast to a slow starting programme with tighter future targets.

Nitrogen

Most nitrogen enters the lake through groundwater either directly (about 15-20%) or indirectly through nine major streams.

> *The nitrogen loading to Lake Rotorua prior to major landuse development in the catchment in the 1950's was calculated to be 60 t/year. This has slowly increased to a present nitrogen load of 420 t/y, delayed by long travel times of the groundwater. The nitrogen loading is expected to further increase to 532 t/y in 50 years (25% increase from current), 572 t/y in 100 years (35% increase from current), and to 619 t/y at steady-state (47% increase from current).* (Morgenstern et al.)

This forecast assumes a specific path of land use and management.

> *About 75% of the groundwater-derived nitrogen loading at steady-state enters Lake Rotorua via the nine major streams, and about 20% enters the Lake from direct groundwater inflow via the lake bed. The loading estimate for the direct groundwater has the largest relative uncertainty because very limited age and chemistry data are available. Lake side springs and minor streams together contribute only about 5% of the total nitrogen load to Lake Rotorua.* (Morgenstern et al.)

> *Groundwater that feeds streams and springs in the Lake Rotorua catchment has mean residence times of water in the aquifer of 15 to 130 years. These long residence times result in*

considerable lags of nitrogen loading to the lake from historical agricultural and urban development in the catchment. Currently observed increases in nitrogen loading in surface and groundwater are mostly due to the delayed impact of catchment development that occurred around 55 years ago. Further increases in nitrogen are expected as detailed above. (Morgenstern et al.)

This means that efforts to reduce the amount of nitrogen that enters groundwater and hence the lake will take effect very slowly and that the problem is likely to worsen before it improves. The groundwater estimates are still quite uncertain. The following question is still the subject of active research:

- What are the groundwater residence times and how do they vary across the catchment?

We also need to know

- What are the historical applications of manageable nitrates that are still flowing through?

2.1.1.e Phosphorus

In contrast, P appears to be stable.

In marked contrast to nitrate, there is no evidence of a trend in baseflow soluble phosphorus concentrations in the major streams of the Rotorua catchment. Stream phosphorus loads currently comply with the target load for streams. Sewage phosphorus loads were high during the 1980s but currently comply with the assigned target load. (Environment Bay of Plenty. Technical Advisory Group, 2004)

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No changes are expected in phosphorus loads via groundwater as long as landuse-derived P continues to be absorbed by the volcanic soils in the catchment. (Morgenstern et al)

Controlling P is not subject to the lags related to groundwater.

- How does P get into the lake now?

2.1.1.f Once nutrients reach the lake, how long do they stay there?

Again, this helps us to understand the baseline levels of nutrients and also how the effects of manageable nutrients will play out over time.

The mean residence time for water in the lake is only about 1.5 years. This doesn't mean however that if nutrient flows were immediately altered to pre-development levels, nutrient levels in the lake would return to pre-development levels in 1.5 years. The key factor influencing the rate of recovery is nutrient release from sediment in the lake bed. Deoxygenation caused in part by eutrophication releases more nutrients from sediment creating a negative feedback with increasing supply from the catchment.

The duration of intermittent stratification events, when water stops mixing vertically, is sufficiently long in Lake Rotorua to effect occasional periods of deoxygenation of bottom waters (Rutherford et al., 1996). Furthermore, these deoxygenation events contribute significant inputs of ammonium and phosphate to the water column, that in years of prolonged stratification (i.e. weeks) may produce internal nutrient loads comparable to those arising as point and diffuse sources from the lake catchment (Burger et al., this volume). (Hamilton, 2003)

Thus any trading programme to reduce land use and land management sources of N and P could possibly be complemented by efforts to manage and control lake bed sediments. These efforts will be contingent upon the following knowledge:

- How effectively can lake bed sediment nutrients be controlled in the large area of Lake Rotorua?
- What is the likely effect of efforts to control lake bed sediments relative to efforts to control nutrient inflows? Are there different levels of risk in the two strategies?

2.1.2 From what type of activities and from where in the catchment are manageable nutrients coming now and in the future?

What activities important to include; what basis cap is determined on; what sort of trading might be valuable; what might happen to prices of nutrients in future?

> *...nutrients arising from agriculture have contributed most to human-induced nutrient loads to lakes in New Zealand (Ministry for the Environment, 1997), though contributions from septic tanks and stormwater are significant. Removal of the natural vegetation cover and destruction of the mechanisms that conserve nutrients in natural ecosystems, together with fertiliser applications, can greatly increase export of nutrients associated with agricultural development (Moss, 1998). The relationships between agricultural development in catchments and eutrophication of lakes have been demonstrated locally (McColl, 1972; Malthus and Mitchell, 1988) and globally (Foy and Withers, 1995).* (Hamilton, 2004)

Not only have nutrient flows increased, particularly from agriculture, but also mechanisms that conserve nutrients in natural ecosystems have decreased. AgResearch has some good information on nutrient leaching from different types of land uses (www.envbop.govt.nz/water/media/pdf/land use.pdf). They also discuss the issues of spatial variation in nutrient leaching. A presentation put together by NIWA scientist Kit Rutherford (Rutherford, 2004) also discusses the processes associated with nutrient loss from catchments. Because groundwater flows vary spatially, nutrients applied in different parts of the catchment will have different effects on the time path of damage.

Sewage was a major contributor in Lake Rotorua but this problem was dealt with in 1991 when sewage was diverted. It could potentially be a problem when sewage is applied to land if P is not adequately absorbed or nitrates are leached. Natural nitrogen flows are very low relative to human induced flows so it appears that most baseline flows could potentially be controlled.

The critical questions are:

- Should we include activities other than land use in a trading programme?
- Should we include protection and restoration of natural mechanisms to conserve nutrients as well as applications of nutrients in the trading programme?
- How do we vary the way we treat monitorable nutrient applications (or nutrient leaching if we model that directly) across the catchment to address spatial variation in leaching and time taken to flow to the lake.
- What percentage of P in stream inflows is controllable, particularly given the dominance of stormflows in contributing P loads to lakes?

2.1.3 What are short term mitigation options?

If short term mitigation options can be used to lower nutrient levels immediately and avoid the peak flows from historical emissions we can focus our land use regulation on longer term solutions. If we can use short term measures to avoid reaching a tipping point, we can encourage 'banking' or increased short term reductions but not require stringent short term targets for land based flows.

The potential for short term solutions such as chemical treatment, diversion of flows, and changes in management of surface water is discussed in a Ministry for the Environment commissioned report (Hamilton, 2003). Several of the potential options outlined in this report have been discussed by the TAG group and discarded (e.g. use of herbicides for algal bloom control). Chemical control in a lake the size of Lake Rotorua is probably risky and would require comprehensive planning and preparatory studies prior to application.

- Should we consider any short term mitigation options in Lake Rotorua?
- What impact could they have on nutrient levels and water quality?

2.1.4 What are technological options for mitigation and abatement?

One of the major benefits of a nutrient trading regime rather than a non-tradable regime is that we do not need specific information on how reductions are to be achieved. When monitoring of the behaviour that leads to reductions is costly, however, information on key options that landowners are likely to choose is useful. Landowners can be rewarded with allowances only for actions that are included in the monitoring system. Thus if we believe that many dairy farmers could choose to install feeding pads we will want to require reporting of the existence (or non-existence) of a feeding pad. In contrast, if only one landowner is likely to enhance a wetland as a mitigation measure it is probably not worth designing a wetland mitigation measurement system just for this one use. The availability of options also gives some idea of the cost of meeting any target level of nutrient applications and so is a key input to the decision on how stringently to set the target.

Many options are available and some are under active research and evaluation through processes such as the Sustainable Farming Fund. Some of these options are summarised in Menneer et al (2004).

2.2 Key economic/social science questions: Challenges for market-based-instrument design

In economic terms, the first task for any stakeholder collaboration to develop a nutrient trading market is to ensure that all participants understand the basic structure and functioning of a trading programme. This should be presented in a simplified text book form with a clear understanding that the real life complexities will be discussed later. This stage would allow agreement on common terminology for the later more complex discussions.

Here we outline the key design questions that need to be tailored to any specific case. Some of these issues have already been explored for Lake Rotorua by Nimmo Bell in reports commissioned by EBOP (Bell and Butcher, 2003, Bell et al, 2004 and Bell and Yap, 2004). Preliminary answers to some are embedded in existing regulations such as Rule 11. Other questions were explored in the similar case of Lake Taupo in Bennett et al (2006). Many are intrinsic to design of any good regulation – not just a trading programme – so have been extensively considered by existing stakeholders. For other questions we can draw on research from other catchments or even abroad. The 'answers' to these will draw on the key science questions addressed above. Here we focus on the implications for regulatory design. As the discussions progress, participants will identify new issues, and reprioritise and redefine the existing ones. We group the questions in 7 categories:

1. Defining and setting the manageable nutrient targets
2. Monitoring of activities and coverage of sources/sinks
3. Social, local-economic, or non-water-environmental impacts of programme
4. Defining trading rules
5. Initial allocation of allowances
6. Funding
7. Governance

2.2.1 Target setting – what level of water quality are we seeking and when?

2.2.1.a Definition of target

The damages we are concerned about come from the quality of water in the lake. In contrast, the costs of regulation depend on exactly what is regulated. Because the impact of behaviour on water quality cannot be directly observed, we need to find proxies and monitor these (discussed further below). The target should be defined in terms of water quality in particular places and times first. The link between that and monitored activity, e.g. manageable nitrate applications, needs to be explicitly modelled even if those models involve significant uncertainty. The first critical decisions then are whether to target only nitrogen or also phosphorus and then, which model of the link between monitorable land use and management and water quality to initially use: these are primarily natural science questions as discussed above.

2.2.1.b Level of target

In a technically ideal world, the target setting process would be informed (but not determined) by a detailed dynamic cost-benefit analysis that would take into account levels of damage from poor water quality along different 'paths' (nutrient levels over time) and the costs of controlling nutrients to the level below business-as-usual of those different paths. The analysis would find the optimal path using a societal discount rate and would take uncertainty into account explicitly including society's risk aversion.

In reality we do not have the information to do this. Even if we had an enormous research budget, we could not accurately assess society's preferences over different pollution paths or the costs of achieving those paths let alone assess 'societal' risk preferences. Instead, we must use research budgets carefully to understand the scale and key dimensions of tradeoffs and then use expert and local knowledge to reach an informed negotiated judgement.

To assess the cost of damage we need to consider the following socio-economic/cultural questions together with the scientific questions discussed above:

- What types of damage do people care most about? E.g. visibility, smell, hazardous algal blooms that prevent water sports, potability of water, protection of native habitat.
- What is the scale of the economic cost of environmental damage dollars and how sensitive is it to the pollution level?
- How do people trade-off current damage with future damage?
- To what extent does culture influence views of the need for action?
- What outcomes are people most fearful of? Are there critical thresholds in damage?
- How does this translate to economic costs through loss of tourism or trade advantages from our 'clean green' image?

To assess the cost of controlling pollution to given levels, we need to address the following questions:

- What would happen to land use and hence nutrient application if there were no regulation?
- What are the current costs of controlling nitrogen application? E.g. how valuable is marginal fertiliser use? How much does it cost to change the timing of fertiliser use if that could help?

- How much would short term mitigation measures (such as adding chemicals to the lake) cost?
- How much will it cost to reduce nutrients quickly rather than slowly? E.g. How many fixed capital assets will be affected by a move to lower nitrogen use? – e.g. age and value of milking sheds on marginal dairy land; how many new technologies are currently in development?
- How sensitive is the cost of control to the level of control at a point in time and over time? Are there thresholds where control suddenly gets much more expensive?

The problem of definition and level of target must be resolved before the programme can begin. It must also however be updated regularly to reflect changes in preferences and new information. This requires the establishment of a governance process that can oversee research and make these decisions in an acceptable way. The design of this governance process is part of the initial programme design and is discussed below.

2.2.2 Monitoring and coverage

2.2.2.a Monitoring

There are two motivations for monitoring. The first is to ensure compliance with the regulation and achievement of the defined cap. The second is to evaluate the effectiveness of the regulation in reducing inputs of nutrients to the lake and ultimately water quality. Here we focus only on the first type of monitoring. The second will be a critical input to the governance process and ongoing reassessment of the cap.

An effective, efficient monitoring system is required for any cap on nutrients – not only for trading. It is a critical element of an effective trading system. The ideal monitoring system would include contributions of every human behaviour (primarily land use and land management practices) to the path of nutrients, and hence ultimately damage probabilities, in critical locations – i.e. parts of the lake where damage is most likely.

In reality this is impossible, so we need to use a model that relates behaviours that we can observe and verify to contributions to damage. This is an issue on which the collaboration between natural and economic sciences is critical to find an appropriate trade-off between the value of more accurate information and the cost of collecting that information. Critical questions involving economic information include:

- How much of the flow of nutrients in the catchment is affected by a particular type of potentially monitorable behaviour? For example if the potential behaviour is protection of existing wetlands, how much wetland area is there and what effect does it have on lake quality?

- How sensitive to the incentives from the trading programme is behaviour on activities relating to each potentially observable characteristic? These include positive incentives to abate an activity if the characteristics it affects are included in the monitoring, and perverse incentives to increase this activity instead of another monitored one if the characteristics this activity affects are excluded. Using the wetlands example again: 'Are the existing wetlands under threat and could this threat be significantly reduced under the regulation?' 'If the nutrient implications of clearing forested areas to increase dairy land are included in the programme while wetlands are unregulated so they can be drained, is there a real risk that farmers will drain wetlands rather than clearing forest in response to the policy?

2.2.2.b Coverage

All sources of nutrients, controlled and uncontrolled, need to be included in some way for evaluation and updating the total target (in an analogous way, to set commercial fish catch limits optimally, recreational fishing of those stocks must be estimated). The key issue is which sources/actors the programme should require to monitor and take responsibility for nutrient applications directly. If a set of sources is excluded from the system in the way that recreational fishers are excluded from the fisheries ITQ system, the other actors share the responsibility for covering any increase in their nutrient applications so that the cap as a whole is not breached. An alternative strategy would be to have the regional or local council directly responsible for applications by uncovered sources. In deciding which sources to cover, the trade-off is between those sources' abilities to respond to the regulatory incentives (positively to inclusion or negatively to exclusion) and the cost of inclusion (these abilities and costs may relate to size or activity type). Thus the key questions here are:

- Which sources should be monitored directly and made responsible for applications?
- Who should bear responsibility for applications by uncovered sources?

As with the target, the rules for monitoring and the level of coverage can and should be reassessed over time through a governance process that should be defined in the initial set-up.

2.2.3 Social, local-economic, or non-water-environmental impacts of programme

Ideally a trading programme will have one ultimate goal (water quality).[2] If stakeholders want to address more than one goal through one programme, they need to clearly understand the tradeoffs. Stakeholders are often concerned that a trading programme will have unintended social impacts (e.g. the closure of small farms) or impacts on other environmental issues (e.g. on biodiversity).

In some situations side effects are a real problem. For example, a programme that rewards carbon sequestration in plantation forests, but does not take account of biodiversity can lead to significant losses of biodiversity for relatively small carbon gains.

This can be a problem even without trading. For example a farmer may reduce nutrient loads to meet her cap by converting half her farm to plantation forest and thus also reducing local employment. With trading because the possibility for land use and management change is much greater (which is the source of the benefits) the side effects can also be greater. Stakeholders must remember that the side effects of a trading programme may also be positive, so restrictions may not only damage the water quality programme but also may lead to the loss of other side benefits of behavioural change aimed at water quality improvement, such as biodiversity protection. Local economic gains in one area

[2] There will be important instrumental goals relating to how that is achieved. For example, a good programme will achieve the goal at the lowest economic cost and with the best cultural impact possible – i.e. maximising opportunities for sustainable land use – and will involve the greatest possible local collaboration in management and decision-making.

from trading restrictions will be more than offset by economic losses elsewhere. Rather than limiting transferability of allowances, stakeholders should consider achieving these other goals through the existing RMA mechanisms. The application of the RMA might need to be adjusted with a trading programme because new issues are likely to arise, or existing issues may become more important. Thus key questions are:

- Is the extra goal a legitimate aim for policy – would it be supported by the electorate if stated directly?
- Can the goal be adequately managed through the RMA or other existing instruments?
- Is restricting or altering the trading programme an effective way to achieve the extra stated goal?
- What is the cost in terms of the primary goal of achieving the secondary goal?

2.2.4 Trading rules

2.2.4.a What can be traded?

This is defined entirely by monitoring rules and allowance holdings, and any RMA-related restrictions on land use and management change as discussed above. If a landowner changes his behaviour and the monitoring rules mean that his new behaviour is related to lower measured manageable nutrient applications he will have excess allowances and will be able to sell them.

2.2.4.b Administration of trading

Any cap system, with or without trading must record individual landowners' allowable cap and monitored/modelled levels of nutrient applications. This system can deal with ownership of allowances at each point in time as well as any banking of allowances for future use. A trading programme is even more dependent on the integrity of this system because mistakes can lead to illegitimate trades. Also, as much information should be made easily available from the system to facilitate buyers and sellers' search for trading partners. This registry system is very similar to a simple bank or stock registry and could be modelled on the fisheries ITQ system. Various software packages are available for this function. Stakeholders need to be comfortable with the operation of the system to reassure themselves about the simplicity of trading as well as the environmental integrity of this aspect of the system. They could work through this using simulated games on existing software and with simple proposed versions for registry and trading templates. The key questions here are:

- What exact form of registry and trading software should be implemented?
- What information in the registry system should be made publicly available (and to whom)?

An issue that needs to be resolved nationally is the ability of Regional Councils to create a simple trading programme under the RMA. Currently, allowances must be linked to land and transfers must happen through RMA processes which makes them more complex and uncertain than necessary and may significantly reduce the effectiveness of the market. The key question here is:

- What legal form should trading take under the RMA?

2.2.5 Initial allocation

This is the most politically contentious issue. It involves allocation between government and private actors, as well as allocation between private actors. We discuss it after many other issues because debates about initial allocation should be informed as much as possible by understanding and agreement on the shape of the programme as a whole. What we would be seeking here at a technical level would be common understanding of some underlying processes and principles rather than agreement on relative allocations. The key questions for discussion are:

- What are the effects of allocation – wealth, efficiency, psychology?
- Who will bear costs of water quality improvement?
- Who benefits from water quality improvement?
- Who has historically contributed to damage?

This issue has been extensively discussed in the Rotorua Lakes area and some principles have already been established. The discussion could build on those understandings and existing data and analysis and see if additional research can help move the debate forward.

2.2.6 Funding

A trading system needs funding for three distinct tasks. The first arises during initial implementation. Setting up a regulatory system, including trading, is a costly process in itself. Often to resolve the initial allocation issue and get sufficient stakeholder buy-in to the programme, it is useful to have some funding available to buy back some nutrient applications so that the initial target can be met with relatively little cost to individuals. This approach was used relatively successfully in the fisheries ITQ situation where some stocks were over fished and the total allowable catch set was lower than existing catch. Voluntary buy backs avoided either cutting everyone's catch or requiring decisions about who would be excluded from the fishery. This was funded by central government. Similarly, for the Lake Taupo case, a fund has been established to ease the initial introduction of the nutrient cap.

Funding is also required to support recurrent administration costs and the cost of research to support the evaluation and hence evolution of the system. To decide how these should be funded, stakeholders need to consider who benefits from the operation of the existing system and who benefits from system improvements – they are not necessarily the same groups. These are the obvious candidates to fund these activities. The amount and sources of funding will be likely to have material effects on how decisions about the future evolution of the system are made.

2.2.7 Governance

No regulation is perfect when first created. This is particularly true of environmental regulations that need to deal with changing social and environmental circumstances and new knowledge about human-environment interactions. Therefore, environmental governance structures should allow the evolution of the regulatory system to occur in an effective, fair and efficient way. Without this, the system will not adapt to change, and will be vulnerable to collapse in a crisis. This approach has been called adaptive management, and is widely used for management of complex natural-human systems in environmentally sensitive areas.

When the nutrient trading system is first created, the initial rules will be set, as discussed above. In addition, a 'constitution', which provides a framework for review and updating of the rules, needs to be created. The 'constitution' needs to define who participates in making decisions, how decisions are made, how the system is monitored and evaluated, which aspects of the system can change without a 'law' change (a rule or the equivalent for a Regional Council), what structure is placed on the changes.

2.2.7.a Monitoring and Research

A process for monitoring various aspects of the system, including water quality, nutrient flows and regulatory functioning, and for commissioning and reviewing research to provide a sound technical basis for programme review needs to be established.

The key questions here are:

- How can nutrient producers and other interested parties best engage with the regulatory authority and each other to monitor the implementation of the system and ensure that it is meeting agreed goals?
- What technical information and expertise will be most relevant to governance (and who will decide what research to commission and from whom?)
- How can technical information and expertise best be integrated in the governance process?

To ensure responsiveness to changing local environmental conditions (positive or negative), the governance structure and process needs to incorporate technical knowledge and expertise in a way that is credible – and is seen to be credible by expert, government and citizen stakeholders. The governance system must communicate and incorporate the scientific information in an effective and trusted way to avoid manipulation of science or simple misunderstanding. Stakeholders must feel that although the science is uncertain, the current state of knowledge is being presented and applied in an unbiased way.

2.2.7.b *Which aspects of the system can change without a 'law' change (or the equivalent for a Regional Council), and what limits are placed on how they change?*

Stakeholders' interests are not necessarily consistent over time. While it may be better for the group as a whole to agree in advance not to change certain aspects of the rules over time, it may be in individual stakeholders' interests to later challenge that. For example, all stakeholders are better off ex ante agreeing on relative allowance allocations once and for all when the programme is established. However, some will turn out to have more bargaining power in later periods and would then like to renegotiate the allocations. Renegotiation is costly, encourages the redirection of effort toward political ends rather than improvements in water quality, and anticipation of renegotiation creates uncertainty, so it is better to avoid it if possible.

Thus the institutions of the nutrient trading system would ideally restrict future changes. The 'constitution' could define the principles by which potential changes will be assessed, and restrict the forms of change by clearly defining the parameters that need to be reassessed. For example, allowances could be defined as shares of the total nutrient target so that as that target is reassessed, individual allowance holdings are automatically changed.

The question of what should be able to be updated and how, can be asked for each of the aspects of the system discussed above in 2.2. One particularly complex case is that of updating the model used to define allowable changes in management practices and trades.

Updating monitoring model

The monitoring model will need to be updated repeatedly to allow new mitigation options and incorporate new information on existing options. Landowners should be protected from risks arising from scientific uncertainty that they do not understand. At the same time however, they should be encouraged to use their private information on new mitigation options that are likely to be included in the near future, and should be prevented from exploiting information about shortcomings in the model that will soon be addressed. For example, even if EcoN is not initially included in the monitoring model because of technical constraints, landowners should not be discouraged from using it. Conversely, if the model over-rewards conversions from dairy to forestry, and this is commonly known and hence a change in the model is anticipated, such conversions should not be encouraged.

When deciding how to respond to these issues, the following questions arise:

- Who should bear the risk of changes in the monitoring model? The way each landowner's allowance need is adjusted and the target is changed in response to monitoring model changes, determines who bears the risk in the monitoring system.
- How is the need for allowances adjusted for each landowner as the monitoring model is updated?
- Do landowners' pre-existing land practices affect the measured emissions that they need to match with allowances when those land practices are added to the monitoring model, or do the measurement changes apply only to changes in land practices going forward? Are relative allowances for different management strategies that have already been implemented affected by changes in scientific information that lead to a realisation that the nutrient impacts of current strategies have been over- or under-estimated?
- When a new, highly uncertain management option is added to the model, should transfers of allowances be limited to temporary transfers to avoid exploitation of errors that landowners know will later be corrected?

2.2.7.c Process for making decisions over time

To ensure continuing public support for environmental management, it needs to represent--and be seen to represent—the interests of key stakeholders in a fair way. The decision making process will be partly determined by existing institutional structures including the Resource Management Act framework, but a lot of flexibility remains. Decisions on the process will need to consider questions such as the timing of reviews, who is involved in reviews in what roles, how agendas are set, what resources are available to participants. Stakeholders must perceive that they have voice and influence in decision making, and that the decision making process is fair. Otherwise, it is unlikely that they will support its decisions.

3 Next steps

3.1 Alignment on purpose and approach

Key technical questions relevant to implementing a market based approach have been explored above. This section outlines ways that Rotorua Lakes stakeholders might jointly explore the use of market based instruments for nutrient management in the Rotorua Lakes.

3.1.1 Forming a Nutrient Trading Learning Group

Motu, with support from Environment Bay of Plenty, the Ministry for the Environment and the Ministry of Agriculture and Forestry have convened a small focused group of experienced stakeholders and technical experts to develop a proposed structure for a nutrient trading programme that will address water quality issues in Lake Rotorua. After each meeting, material will be made available to stimulate discussion and feedback so that preliminary results can be fed into the wider water quality policy development process. The final output will be a concrete nutrient trading design proposal and set of backing documents by 30 April 2008. In the longer term, we hope this proposal will form a template for trading programmes in other catchments.

The work will build on the extensive scientific and regulatory design work already done in the catchment and take account of existing regulatory structures. The group will develop working documents on each key design issue, meet bi-monthly to discuss these drafts and then revise them for more general release. The process is not intended to reach political agreement but to: clearly outline the issues at stake; present the current state of knowledge; and propose technical solutions to the challenges that arise where they are possible.

The group was established in February 2007. It will meet bi-monthly for 16 months. This group is aligned with a proposal being submitted to the Foundation for Research Science and Technology to do more technical research on these issues but is not dependent on that new research. The first 16 months will be based primarily on existing knowledge but will also identify research needs. That research could be incorporated in a second phase.

3.1.2 Learning Group participants and goals

The learning group's membership encompasses the main stakeholder groups with an interest in nutrient management. It also includes technical experts jointly acceptable to the stakeholders, who support the group's work by assessing and developing nutrient trading options. The group's goal is to learn about nutrient trading and assess whether and how trading could be useful for Rotorua Lakes land management and environmental protection.

As a whole, the group includes members spanning the following categories:

- Technical specialities
  - Economic skills (deep understanding of market based instruments)
  - Scientific skills
- Agency perspectives
  - Local government
  - Central government
- Rural land uses
  - Farming (dairy and non-dairy)
  - Forestry
  - Lifestyle
- Civil and cultural
  - Maori
  - Rural
  - Environmental

3.2 Learning into the future

The PCE report on the Rotorua Lakes uses the phrase, "The Ultimate Endurance Challenge'. A fundamental value of taking the learning process seriously at this stage is the capacity it builds in the local and regional community (and in the national community) for dealing with a complex issue in a deeply informed way, while also learning to think about it in a way that includes the community. The future is uncertain, but a capacity to listen deeply to one another is at the heart of a sustainable future.

Appendix 1: People consulted in the development of this report

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Annex: Design of a Learning Process

The composition of a learning group

There were two options for a technical learning group. One was for it to focus on scientific, economic and policy technical skills. These people would have a similar way of relating to technical material. The other option was to include people in the learning process who represent perspectives of all the elements who will be involved in the future implementation of a nutrient trading regime, if adopted. There were sound reasons to consider the latter, other than on the grounds of "representation of the interests of the stakeholders". The latter is not the intention of a learning process – and the issue of representation, in its own right, should be managed external to the technical learning process.

The reason for including a range of perspectives in the technical working group is two-fold. First, people think differently. Technical people use an empirical approach. People from business use a commercial perspective, and others see the world through a cultural lens. These different views will challenge each other and lead to deeper exploration of the issues. Second, at the next stage of the process, when the technical group engages other regional stakeholders, people communicate most clearly with others who use a similar language and rationality. Because eventually, the intention is to "ripple out" the learning, the technical group should be designed with this capacity in mind.

Key differences in perspectives between respondents

Technical knowledge of the lakes and catchment, management options and challenges, and many of the issues of water management identified in the national consultation round and interviews are equally well understood by some respondents at the national, the regional and the local levels. In other words, the knowledge (and wisdom!) is not limited to either a national or a local level. There is a broadly shared commitment to the lakes and their management, and to social, economic, cultural and environmental well-being, at all levels. Furthermore, some distinct perspectives and inspiring examples of leadership can be found in individuals. It is also possible to detect frustration, stubbornness, resignation and deep fear in individuals across all levels. We also detected misunderstanding between individuals.

On reflection, the most distinctive consistent difference between respondents have been categorised into four primary perspectives, below (based on cultural theory, Thompson, 1988). The perspectives have a sound basis in theory, and have arisen framed in relatively similar ways in reviews of other water programmes globally. The distinctions are proposed as working hypotheses.

It is useful to consider that everyone takes all of these perspectives as part of their total world view. Respondents are not regarded as exclusively belonging to one or other perspective. However, for the purpose here, and specifically for the purpose of the design of an agency, technical and community engagement and learning process, this distinction is useful:

1) Agency perspective.
   When operating from an *agency* perspective, people focus on the authority, accountability, policy instruments, planning processes and formal organisation and legislation. Their focus in on *decisions*. For example, EBOP staff spoke in detail about the Regional Council's approach to planning and managing the catchments and water bodies, and the structure of working and technical groups.

2) Technical perspective.
   When operating from a *technical* perspective, people focus on formal scientific (or economic) evidence, models, and frameworks. Their approach is based on empiricism, (observations of what is deemed *real*) viewed through disciplinary frameworks of reference. They will seek for *truth*. For example, scientists (both university and agency-based) spoke in depth about the scientific evidence and the models of water bodies.

3) Cultural/Sector perspective.
   When operating from a *cultural* or *sectoral* perspective, people focus on the accepted consensus within their primary cultural or sectoral identity group. This could be within a local Maori network, or within a network of farmers, local tourist operators, beach owners or staff of the regional council. This perspective uses primarily the rationality of hermeneutics - how *persuasive* a view point is, rather than whether it is the *truth* in scientific terms).

4) Individual perspective.

   Everyone has an individual perspective, but some individuals are more easily seen through this frame than through an agency, technical or cultural frame. Individual farmers, land owners, or other businesses may come into this category. Their views on the world are based largely on the world view they hold as an individual, and the process by which they distinguish what is appropriate might be called *truthfulness*. The frame of reference will be *true to myself* as distinct from a statutory, technical or group point of reference. For example, other farmers and agricultural consultants in the catchment spoke from their own perspectives about water quality issues in the lakes catchment.

Purpose and process of a learning group

The learning group is not a policy development or a design group. Its intention is to 'get its (collective) head' around some complex technical issues and follow these logically through, exploring them from different technical perspectives, then from the "four perspectives" described earlier (organisational, technical, cultural and individual), and then to contribute back to a wider group from the emergent systems view.

The focus of the learning group is both to learn for itself and also to learn 'for the system'. The group becomes a resource for the rest of the community, as a group of people who can speak about the 'business of nutrient trading' from every key perspective that is held in the catchment – and in language that makes sense to each of those perspectives. So, it is not a technical sub-committee of a policy organisation, neither is it a group that represents a range of positions and interests.

The process for learning in this way is being used globally in a small number of leading programmes focussed on whole-system transformation, including the Global Sustainable Food Lab facilitated by the Sustainability Institute in collaboration with MIT.

The learning group will be trained and coached in the fundamentals and disciplines of team learning, which should include training in systems thinking, mental models and learning in a multi-perspective setting.

Four Stages of a learning process

Early in the process, the group will sort out the key issues that it needs to start exploring, and then collaborate within itself and with external people to gather facts, build models, and explore their application. The process would be one of 'discovery based planning'.

The first stage of a learning process is to suspend judgement while exploring the useful perspectives of each of the participants. This would include a primer on the catchment technical perspectives (science, economics). In this stage, the group focuses on listening to each of the participants fully – to identify all the issues which they see from their perspective. This helps to reveal both the theoretical perspectives that the participants employ, and their cultural perspectives, concerns and values – many of which are so familiar to us they are in our "blind spot".

The second stage is to "dive deep" into the system from one perspective at a time, for example, lakes ecology, or the economics and practicality of farming, or the theory and practice of developing nutrient trading mechanisms. These could involve

- Technical presentations and joint application of technical ideas to specific questions
- Visits from people with an external perspective (e.g. who have worked on the fisheries ITQ system)
- "Learning journeys" to visit places or people in the catchment to learn to see the world through their eyes. Learning journeys are not field trips, but ways of bringing close focus on specific aspects of the system. In global experience, it is through this process that some of the most unexpected insights, and later, innovations, in complex settings emerge.

Reflecting on each, the group gets to see what the perspective provides, and what it misses out.

The third stage, after creating scenarios, is to explore the impact of these scenarios on different groups in the catchment. And lastly, the process explores the way the scenarios would affect individuals, or how individuals would need to change in order to operate well in that scenario.

The learning group itself, in this last stage, would reflect on what it has learned and working together, will create “teaching tools” to share what they have learned with the ‘folks back home’ – people who see the world they do. As a communications discipline, participants would draft communiqués for one another’s audience, to see if they could explain what they see, ‘cross culturally’.

The learning group would go through this learning cycle as many times as is practical and as it takes to surface a ‘systems view’.

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