

IN THE MATTER OF the Resource Management Act 1991

AND

IN THE MATTER OF resource consent applications lodged for the water take consents in relation to the Waitaki Basin under section 120 of the Resource Management Act 1991

EVIDENCE OF MELISSA CLARE ROBSON

Qualifications and Experience

1. My name is Melissa Clare Robson and I am an environmental scientist.
2. I have been in a senior environmental scientist role in the Waterways and Coastal Group of GHD Limited for 18 months. I hold a Bachelor of Science (Honours) in Tropical Environmental Science conferred by the University of Aberdeen, a Masters of Science in Integrated Water Management and Advanced Irrigation conferred by Cranfield Institute of Water Management at Silsoe, and a Doctorate in Plant and Soil Science conferred by the University of Aberdeen, the Aberdeen Centre for Organic Agriculture and the Scottish Agricultural College.
3. I have completed the UK Fertiliser Advisers Certification & Training Scheme (FACTS): An independent, non-statutory certification scheme for advisers in plant nutrient management. I have also completed the Fertiliser and Lime Research Centre Intermediate Sustainable Nutrient Management Course and am in the process of completing the Advanced course.
4. I have 10 years of post graduate experience and since 2004 have been working specifically to reduce diffuse pollution from agriculture both in a regulatory role and through voluntary schemes. In 2004 – 2005 I worked as an Agricultural Environment Officer for the Environment Agency working specifically with farmers to reduce nitrate losses and meet regulations with respect to nitrate losses, groundwater protection, slurry, silage and fuel oil, pesticide use and containment and general pollution prevention. During this time I conducted a catchment campaign aimed at reducing nutrient pollution from dairy farmers.
5. At the same time I began working on the Environment Agency's 'Landcare' project. This project was initiated to address the degradation from diffuse agricultural sources that was evident in the Avon Catchment, a chalk stream system regarded as one of the finest in

Europe and one that is subject to numerous sites of special scientific interest, special areas of conservation and other designations for both flora and fauna characteristic of this low nutrient environment. The chalk aquifer underlying the catchment is a key water source in the area and supplies water to the cities of Bournemouth and Bath.

6. From 2005 to 2008 I worked full time on the Landcare project, determining and addressing diffuse pollution problems in the catchment and providing on farm advice and direction on methods, options and planning mechanisms to reduce farm losses. In 2006 the Landcare project format was adopted and rolled out as part of a UK-wide project to address diffuse pollution from agriculture as part of the England Catchment Sensitive Farming Delivery Initiative. This initiative is now a principal tool to address diffuse water pollution from agriculture used to deliver water quality improvements required under the European Union Water Framework Directive.
7. Since February 2008 I have worked in New Zealand, predominantly on the Upper Waitaki Water Quality Study to assess the cumulative effects of increased nutrients on water quality from agricultural intensification. I have worked as the project leader for on-farm mitigation strategies to reduce soil and nutrient losses and developing farm management planning strategies to achieve environmental targets.
8. I have been involved with the Water Quality Study (WQS) since February 2008. I prepared the summary report for the WQS and was a part of the GHD led team assembled to undertake the WQS. I have written the mitigation toolkit with assistance from Laura Buckthought¹, from GHD Ltd. This toolkit is designed to illustrate that the nutrient thresholds set in the WQS can be met through on-farm mitigation, to offer land managers guidance for formulating a Farm Environmental Management Plan to deliver nutrient mitigation required by the WQS, and to provide a suite of options for reducing diffuse pollution from site specific environmental risks identified on their farms.

Scope of my evidence

9. I have been asked by MWRL to prepare and present evidence on the mitigation toolkit introduced by the Water Quality Study. The evidence covers the following sections:
 - (a) A background to the mitigation toolkit;

¹ Environmental scientist with GHD Ltd. BSc Hons Environmental Science. Honours thesis on nitrate pollution of the Ashburton River.

- (b) A description of the mitigation toolkit;
 - (c) How to build a Farm Environmental Management Plan;
 - (d) How the mitigation measures included in the toolkit were chosen;
 - (e) A description of the mitigation measures, their previous use and reported efficacy; and,
 - (f) A worked example of building a Farm Environmental Management Plan.
10. I confirm that I have visited the Waitaki region on eight occasions.
11. I confirm that I have read the Code of Conduct for expert witnesses contained in the Environment Court Practice note and that I have complied with it in the preparation of my statement of evidence. I agree to comply with it when presenting this evidence before this Committee. I confirm that the evidence I present is within my area of expertise and I am not aware of any material facts that may alter or detract from the opinions I express.

Background to mitigations toolkit

12. The mitigations toolkit was developed as the final chapter to the WQS. As a part of the WQS, nutrient loads under current and predicted land use were derived, as were the nutrient loads that the receiving environments at specified monitoring points could tolerate without suffering significant adverse effects. As the predicted nutrient loads may cause adverse environmental effects in some receiving environments, on-farm mitigation will be required.
13. Farm management planning and the use of best management practices and mitigation methods are commonly used to reduce diffuse pollution from farms, and have been trialled internationally and in New Zealand both as voluntary measures and through regulation. Diffuse pollution, as the name suggests, does not come from a single traceable source. In many cases the impacts are both temporally and spatially distanced from the source. This makes measurement from and traceability to an individual property difficult. For this reason, instead of measuring the losses, the emphasis is placed on the implementation of techniques that are known to reduce the contaminant. It is a collection of these techniques that makes up the mitigations tool kit. Also, for this reason, the monitoring points for the WQS are located in the lower reaches or outlets of sub-catchments, thereby capturing as much of the generated load as possible that passes through the surface water system.

Description of mitigations toolkit

14. The toolkit is divided into three principal sections:
 - (a) a description of nutrient loss pathways from farms in general and in the Upper Waitaki Catchment in particular;
 - (b) a framework to translate the required nutrient mitigation targets set in the WQS and other site specific environmental issues identified into a Farm Environmental Management Plan (FEMP); and
 - (c) a section that describes each of the mitigation measures in detail with reference to implementation, efficacy, limitations to use and impact on other pollutants. In addition, a brief suggestion of how to monitoring the measure is given.
15. The development of a FEMP is also divided into three sections. The first section describes some mandatory good agricultural practices that need to be implemented across the farm, and include the base assumptions of the OVERSEER model². This helps to validate the use of the model on the property. In this study, the OVERSEER model has been fundamental in deriving nutrient losses in the catchment. It follows therefore to use the same model to illustrate the achievement of the requirement mitigations. In addition, the OVERSEER model is in a constant state of development and improvement for both the underlying models and mitigation strategies. The justification for the use of OVERSEER as the most appropriate model is given in evidence presented for this hearing by V. Snow and R. Monaghan.
16. The second section is the construction of a representative farm model in OVERSEER and the cross checking of the WQS modelled outputs from the farm and the results from the representative farm model, and the confirmation of the required mitigation. Once the mitigation requirements have been established, the proposed farm practices can be altered and modelled to give the required mitigation for the sub-catchment and receiving environment. The changes in farm practice will be noted separately to be included in the FEMP.
17. The third section is the completion of an on-farm environmental risk assessment (FERA), and the choosing of management options or techniques to mitigate these specific risks.

² In the future, should an alternative model be used, the assumptions for that model would need to be specified in this good agricultural practice section.

The site-specific environmental risks on the farm include both the physical characteristics of the farm as well as the farming system and how the farm is managed. These site specific issues may not be reflected in a modelled nutrient budget on the irrigated areas, but will need to be addressed.

18. The collation of mitigations and best management practices into toolkits to address specific environmental problems exists both in New Zealand and internationally (e.g. Cuttle *et al.*, 2006; McKergow *et al.*, 2008; Monaghan, 2009). This toolkit draws on work done in New Zealand as well from international research and evidence, and although farming styles and techniques vary across New Zealand and internationally, the principles of mitigation nutrient loss; decreasing the source of nutrients, reducing the transport of nutrients and attenuating nutrients in transport, are universally applicable.
19. A central tenet of this process is proportionality: The requirements to effect a low nutrient reduction are less onerous than those for a high nutrient reduction. In this way excessive planning and mitigation for minor issues is avoided and in areas where more environmental protection is required, larger scale or more numerous strategies are required. In OVERSEER, a small mitigation requirement may be achieved with relatively small changes to farm management, however, large mitigation requirements may require farm system changes. However, even when the receiving environment mitigation requirement is low or zero, the initial section detailing good agricultural practices are still mandatory, and the FERA still needs to be completed and the identified issues addressed.

Stage 1 - Mandatory good agricultural practices (MGAPs)

20. The mandatory good agricultural practices adopted in this study are:
 - (a) Fertilisers applied according to the code of practice for fertiliser use. This is a basic assumption in OVERSEER. The fertiliser users' code of practice (FERT Research, 2002) aims to ensure that where fertilisers are used that they are used safely, responsibly and effectively and in a way that avoids, remedies or mitigates any adverse environmental effects. The code of practice includes guidance on fertiliser use, application, storage, transport, handling and disposal.
 - (b) Using a recommendation system for fertiliser, whereby the amount of fertiliser applied has been determined through a recognised system, e.g. a nutrient budget or a crop calculator. Planning fertiliser applications to all crops, determining crop

requirement and accounting for soil nutrients and organic nutrient supplies, all reduce the risks of applying excessive fertiliser above the crop requirement. This maximises the economic return from the use of fertilisers and reduces the risk of causing nutrient pollution of the environment (MAFF, 2000).

- (c) Accounting for all sources of nutrients. This includes imported sources as well as soil reservoirs and entails regular soil testing. This is an important factor in more intensive systems that produce effluent and/or manures or where manures or organic material is imported onto the farm. The re-application of organic manures to land is often thought of as a disposal of a waste product, and the available nutrients within the organic manures are not accounted for. The use of an integrated nutrient budgeting tool such as OVERSEER automatically accounts for nutrients supplied in organic manures.
- (d) Calibrate and optimise fertiliser spreaders at least annually. The even application of fertiliser is an assumption of the OVERSEER model as included in the fertiliser code of practice. Fertiliser spreaders should be tested and calibrated in-house at least annually.
- (e) Calibrate and optimise irrigators annually. The even application of water and or effluent is an assumption of the OVERSEER model. Irrigators should be tested and calibrated in-house annually and every 5 years by an independent auditor according to the code of practice for irrigation evaluation (Irrigation New Zealand).
- (f) Good design of irrigation systems. Irrigation design will match soil properties and low application amounts on shallower soil to prevent summer drainage.
- (g) Robust irrigation scheduling. Good irrigation scheduling to prevent summer drainage.
- (h) Record crop, cultivation, nutrient inputs and yields on paddocks. Maintaining good crop input records is important for:
 - (i) The calculation of cumulative annual organic fertiliser applications and also their contribution to long term nutrient supply;
 - (ii) The determination of realistic crop yields that are used to determine crop requirements;

- (iii) Providing accurate inputs to the OVERSEER nutrient budgeting model that is being used here as a proxy for measuring diffuse nutrient losses.

21. The implementation of these practices established a commitment to a good base level of practice. It also, by including the base assumptions of the OVERSEER model that the inputs to the farming system are made using good practice, means that the consequent farm modelling can be viewed with more confidence. These should be included as conditions of consent, see paragraph 22. On the larger, more intensive properties, two additional MGAPs have been adopted, these are management of supplements and feeding out and winter grazing management. These activities are still recognised as potential issues on the farms with smaller scale development, and will be identified and addressed through the Farm Environmental Risk Assessment process.

22. Conditions of Consent for MGAP

Nutrient Budgeting

A nutrient budgeting tool will be used to determine fertiliser requirements and inputs from non-fertiliser sources of nutrients;

Records shall be maintained throughout the year of the farm management practices and associated data that will be used as input to the approved method of nutrient budgeting;

A nutrient budget is prepared annually for the property.

Fertiliser Application

Fertiliser shall be applied in accordance with The Code of Practice for Nutrient Management (With Emphasis on Fertiliser Use) NZFMRA 07.

Fertiliser spreaders should be tested and calibrated in-house at least annually and every 5 years by an independent auditor.

Irrigation Application

All new irrigation infrastructures shall be designed and accredited by a qualified professional, and installed in accordance with the accredited design. The design shall take into account the specific requirements of the property's soil types.

If a consent holder is using existing irrigation infrastructure they shall obtain an evaluation report prepared by a certified irrigation evaluator. The evaluation shall determine the system's current performance in accordance with the Code of Practice for Irrigation Evaluation 2005 by a qualified irrigation auditor. This report shall be obtained within 3 months of the first exercise of the consent. Any recommendations identified in the report shall implement within 12 months from the date of receipt of the report. A copy of the report shall be given to the Canterbury Regional Council: attention the Compliance and Enforcement Manager.

All irrigation infrastructure shall be tested and calibrated in-house at least annually and then every 5 years in accordance with the Code of Practice for Irrigation Evaluation 2005 by a qualified irrigation auditor. Any recommendations identified shall be implemented within 12 months from the date of receipt of the report. A copy of the report shall be given to the Canterbury Regional Council: attention the Compliance and Enforcement Manager (K Johnston, Pers Comm. 2009).

Stage 2 – OVERSEER and delivering the Water Quality Study mitigation requirements

23. The use of OVERSEER as a proxy measure for nutrient losses from farms for managing nutrients at a catchment scale has a precedent both in Environment Waikato's proposed rule changes for nutrient regulation around Lake Taupo where OVERSEER farm nutrient plans form the basis for allocating N credits to farms around the lake (Environment Waikato), and in Horizons Regional Council's proposed 'One Plan', where OVERSEER nutrient budgets will be used to assess compliance with permitted losses in designated nitrate sensitive rivers and streams (Horizons Regional Council).
24. Protocols for the use of OVERSEER in this were published by Manderson and Mackay (A Manderson, *pers comm.* July 2009) for Horizons Regional Council. Where these protocols pertain to the creation of an on farm nutrient budget, in using a common database for rainfall and only using certified OVERSEER practitioners, they have been observed in the preparation of the Farm Environmental Management Plans. The adherence to these protocols is important to ensure the quality of the plans. It should be a condition of consent that, for auditing purposes, OVERSEER is run by an certified practitioner.
25. Once a robust OVERSEER model is created for individual farms (for both current and proposed practices), the actual mitigation for each farm can be calculated. Required changes to farm management practices or farm systems are modelled and refinements made until the required mitigation is achieved. The outputs from the OVERSEER nutrient budget can be used to audit the required nutrient reduction.

Stage 3 – Farm environmental Risk Assessment and the Mitigations toolkit

26. All farms are unique and will have environmental problems unique to them as well. Site specific environmental issues may not be reflected in a modelled nutrient budget, but will still need to be addressed.

27. In order to address site specific issues on a farm, the mitigations toolkit described a process by which environmental issues could be identified, through a Farm Environmental Risk Assessment (FERA) and solutions chosen.
28. A FERA examines the physical characteristics of the farm, the potential receiving environments and risks associated with current and proposed farm practices. An example of a FERA can be found in Appendix A.
29. Once a FERA has been completed, the table of site specific mitigations is consulted and appropriate mitigation tool is selected. The toolkit provides information on how the mitigation option works, its likely efficacy and a suggestion on how to monitor.

How mitigation options were chosen

30. In the initial stage, a list of mitigation measures was drawn from personal experience of techniques used to reduce diffuse pollution from agriculture. This list was further developed through a literature search for both New Zealand and international examples. Once this list had been completed, several filters were applied to make the list applicable to the Upper Waitaki. These filters are described below.
 - (a) Mitigation measures can be divided into three groups; source, pathway and receptor. The focus of the toolkit is on source and pathway measures as the emphasis of the toolkit is on farm control of nutrients
 - (b) The contaminants of concern identified and studied in the WQS were nitrogen and phosphorus and mitigation options specifically aimed at controlling these were targeted.
 - (c) Inherent factors such as local climate were taken into account to exclude some mitigation measures.
 - (d) The tool kit was designed for both new applicants and renewals, therefore measures to optimise current farming and different irrigation systems were included.
 - (e) A range of farming systems are proposed including dairy farming. Additional measures have been included in the toolkit to deal with issues specific to dairy farming.

Mitigation options

31. The mitigation options have been categorised into groups by the source of the loss, and their main mechanisms of mitigation described. Examples are given of where the measures have been advised and used elsewhere to reduce diffuse pollution from agriculture and their reported efficacy. Where techniques have wide usage, both elsewhere in New Zealand and internationally, this increases the confidence in the robustness of the measures and their potential for reducing the same types of issues in the Upper Waitaki Catchment. This is especially the case in areas where diffuse pollution has long been identified as a cause of water quality issues and has been the focus of research. The efficacy of many of these management techniques depends on how they are implemented and managed and individual farm conditions, therefore on farm monitoring is required to check how the measures are working.

Soil mitigation options

32. Soil erosion involves the upheaval and transport of soil from the system mainly as a result of runoff where water picks up soil particles and transports them to a watercourse, or wind, which picks up particles and deposits them elsewhere. Soil erosion is the major pathway for sediment and phosphorus ('P') pollution of surface waters (Humphrey *et al.*, undated).
33. The soil mitigation options in the toolkit are; 'minimise soil erosion', 'reduce compaction in soils', 'catch cropping', 'timeliness of cultivation' and 'no winter grazing of forage crops'. These management options aim to reduce soil loss and runoff through improving the soil physical condition both at the surface and at depth.
34. The mechanisms are:
 - (a) To identify and remove soil compaction both on the surface and at depth. Where soils are compacted, the pores through which water moves, are compressed and therefore the soil holds less water (and air) and conducts the water down the profile more slowly. This decreases the amount of water that the soil can hold before becoming saturated and increases the risk of the infiltration capacity being exceeded by rainfall and leading to surface runoff or ponding. In addition, compacted soils can depress plant root and shoot growth and can lead to the formation of anaerobic soil conditions.

- (b) To reduce practices known to impair soil physical condition. Practices that impair soil physical condition include grazing forage crops over winter, grazing pasture over winter, or leaving soil exposed over winter and spring, allowing soil organic matter levels to decline, trafficking the soil in poor conditions. These practices either expose the soil to damaging forces, such as physical break up of stable soil aggregates through raindrop action, machinery or animal hooves, so reduces the ability of the soil to withstand these forces, such as the decline of soil organic matter, and,
- (c) To implement practices known to improve soil physical condition or protect the soil. Practices that are known to improve soil physical condition include the maintenance or build up of soil organic matter, the use of cover cropping and undersowing, and the establishment of good ground cover. These practices either protect the soils from damaging forces, such as through cover cropping and undersowing, or increases the soil's ability to withstand damaging forces through building soil organic matter.

Examples of previous use

- 35. Reduction of soil erosion from erodible land under pasture is the most important BMP identified for managing P losses from agricultural land in the Upper Manawatu catchment (Parfitt *et al*, 2007) and have been included in Horizons Regional Council's developing policy 'framework for managing non-point source and point source nutrient contributions to water quality' (Roygard and McArthur, 2008).
- 36. All of the soil mitigation measures identified are options in the soil management plans used in the England Catchment Sensitive Farming Delivery Initiative to deliver national water quality improvements in areas impacted by diffuse pollution from agriculture.
- 37. Checking the condition of soils, recognising soil loss and damage, and cover cropping are recognised as best farming practices for soil management in Best Farming Practice: Profit for change (Information sheets IS 2.2.1, IS 2.2.2, IS 2.3.3 and IS 2.4) (ADAS and West Country Rivers Trust).
- 38. Soil erosion plans, incorporation of organic matter, and cover crops are identified as practical best management practices for reducing diffuse pollution to rivers designated as Special Areas of Conservation (Hilton *et al.*, 2003).

39. The US EPA 'National Management Measures for the Control of Non-Point Pollution' identifies ensuring optimum water infiltration by minimising soil compaction as a key management measures for reducing pollution through grazing management.

Effectiveness

40. Cuttle *et al.* (2006) reported estimated reductions in P loss of 1.11 kg/ha in the affected areas for measures such as decreased soil compaction in grassland, maintenance or increase of soil organic matter levels, reduced tillage, covers crops and contour cultivation.
41. Withers *et al.* (1997) found that poor timeliness of cultivations resulting in late cultivation in poorer conditions increased overland flow by up to five times and increased suspended sediment and phosphorus mobilisation by an order of magnitude.
42. Where ground cover falls below 70 % runoff and erosion by water and wind increase dramatically. Basher (1996) found average soil losses from the Upper Waitaki Basin were 25 mm over a 40 year period and that areas with full vegetation showed no signs of loss.
43. Grazing of crops over winter was found to increase P losses by 250 % and sediment losses by 25 % compared with un-grazed winter crops (Houlbrooke and McDowell, 2008).
44. Decreases in N leaching have been estimated at 0-5 kg/ha for reduced cultivation and 5-15 kg/ha for cover cropping (Cuttle *et al.*, 2006).
45. Nil effect was reported by Cuttle *et al.*, 2006, for decreasing soil compaction, however in severely compacted areas the improved soil physical condition is likely to improve plant growth and increase N uptake, thereby reducing losses.
46. Building up organic matter will provide additional capacity in the soil for N storage (Schipper *et al.*, 200), however with greater organic matter contents, there will be more mineralisation (Brady, 1990).
47. 'No winter grazing of forage crops' was modelled using lysimeter experiments to reduce winter nitrate loss by over 90 % in a simulation of cattle grazed over winter and 60 % for sheep (Houlbrook and McDowell, 2008).

Effluent mitigation options

48. Farm effluent contains significant concentrations of plant nutrients, particularly N and P, and organic matter. Although their application to land has, in many cases, been shown to result in significant increases in plant yields and improvements in soil physical conditions and chemical fertility (Cameron *et al.*, 1997), without proper management losses of nutrients during collection, storage and application will occur. Whilst land treatment of effluent represents a large improvement in the loss of nutrients in comparison to direct discharge, there is room for improvement as currently 2-20% of N and P applied as effluent is lost (Houlbrooke *et al.*, 2004).
49. The effluent management options in the toolkit are; 'minimise effluent produced' 'improve effluent storage', 'manage effluent application rate and timing', and "no effluent in high risk places'. These management options aim to reduce effluent produced and minimise losses associated with collection, storage and application of effluent.
50. The mechanisms are:
- (a) To reduce the amount of contaminated water produced in the farm yard. Reducing the volume of dirty water produced will make more efficient use of the existing storage volumes and reduce likelihood of exceeding storage capacity and having to irrigate in poor conditions that runs the risk of leaching or runoff. Technologies that reduce the volumes of effluent produced at the milking shed are likely to greatly reduce the frequency of unwanted discharges of effluent to water (Mongahan *et al.*, 2007).
 - (b) Reduce the amount of clean water draining to effluent storage facility. Allowing 'clean' water into the effluent system unnecessarily increases the volume of effluent that will be collected, stored and applied to land. Reductions can be made by separating clean and dirty water and ensuring that clean water is either collected and reused or is diverted and not allowed to drain to effluent stores. Clean water includes roof water and water that falls on unstocked or 'clean' yards.
 - (c) To reduce application rates. Research has shown that the rate at which effluent is applied has a significant impact on the extent of leaching. Concentrations of N and P in drainage and runoff increases as rates and concentration of effluent increases (Melland *et al.*, 2007). Jacobs and Ward (2006) found that annual effluent applications up to 200 kg N and 44 kg P applied in small doses over the dry season did not markedly increase nutrient losses compared to no application

as the pasture used the available nutrients. The low application rates increases the contact time in the soil and hence the soil has a greater capacity to 'treat' the effluent (Houlbrook *et al.*, 2004), and

- (d) To manage timing and placement of effluent applications to reduce losses. Applying effluent at a time or in a place where it is unlikely that the available nutrients will be taken up by a plant wastes resources and increases the environmental risks. However, agricultural activities, such as milking in dairy farming systems, cannot be put on hold due to bad weather, and consequently, effluent is still produced. In the autumn and winter months, soil moisture deficits are low or zero and where effluent is applied to the land at this time, the risk of leaching and nutrient runoff is high. In order to manage the timing of effluent application the farm needs to have sufficient effluent storage capacity over the high risk months. Once the storage capacity is in place, a system of irrigation can operate where effluent is applied at less than the soil moisture deficits during the growing season, maximising the opportunity for the nutrients to be taken up from the soil once applied. Effluent applied at any time of the year to areas where there is unlikely to be plant uptake, or in hydrologically connected areas is likely to increase the risk of nutrient loss. Examples of high risk places are hill slopes or depressions/channels in the ground that provide a 'pathway' from the land to a waterway, water courses, riparian margins, bores and springs non-productive areas e.g. tracks. Other high-risk places may include areas of free-draining soils that are at/near field capacity, or clayey soils that are dry and prone to cracking.

Examples of previous use

- 51. All of the effluent mitigation and management techniques identified are in the Dixel and Environment Canterbury publication; 'A Guide to Managing Dairy Effluent', issued to help dairy farmers improve performance on their farms and reduce their impact on the environment.
- 52. The irrigation of effluent according to 'deferred irrigation' criteria and applying effluent at a low rate are recommended as best management practice for reducing phosphorus losses from agricultural land in the Manawatu catchment (Parfitt *et al.*, 2007) and have been included in Horizons Regional Council's developing policy 'framework for managing non-point source and point source nutrient contributions to water quality' (Roygard and McArthur, 2008).

53. The US EPA 'National Management Measures for the Control of Non-Point Pollution' identifies diversion of clean water, prevention of point source discharges from yard area, and provision of adequate storage as key management measures for reducing pollution from animal feeding operations.
54. Provision of adequate manure storage, 'closed period' for manure spreading and planning for exclusion of high risk areas are measures enforced under the Nitrates Directive in the UK for the reduction of nitrate pollution in ground and surface waters.
55. Clean water separation and dirty water minimisation are recognised as best farming practices for soil management in Best Farming Practice: Profit for change (Information sheets IS 1.2.4 and IS 1.3.5) (ADAS and West Country Rivers Trust).

Efficacy of measure

56. Parfitt *et al.* (2007) reported that deferred irrigation and low rate applications could reduce farm P losses by 1 kg/ha.
57. Effluent storage and low rate application should be considered as best management practice (Houlebrook *et al.*, 2006) for land vulnerable to leaching losses.
58. Giason *et al.* (2003) reported that installing at least three months storage was the most cost effective control of diffuse P losses.
59. Pennsylvania State University (1992, cited in the US EPA manual) found that animal waste management systems, including collecting storing and disposing of effluent could remove 90 % total phosphorus, 80 % of total nitrogen in effluent losses.

Stock loss mitigation options

60. Losses from grassland systems are greater in the presence of animals than from fertiliser alone (Monaghan *et al.*, 2003), and N excreted by animals, particularly urine, is the most important determinant of N loss (Monaghan *et al.*, 2007) in stocked systems. Grazing animals return 75-90% of ingested herbage N through dung and urine (Di and Cameron, 2004) and the quantities of N that are deposited greatly exceed the immediate plant requirements in the area of the urine patch, at applications equivalent to 300 – 600 kg N/ha even up to 1000 kg N/ha (e.g. Haynes and Williams, 1993; Di and Cameron, 2004), and leaves the excess N subject to leaching losses (de Klein and Ledgard, 2001).

61. The stock loss mitigation options in the toolkit are 'nitrification and urease inhibitors', 'reduce dietary N and P intake', 'Nil and restricted grazing', 'reduced stocking rates', and 'change animal type'. These management options all aim to reduce nutrient losses from grazing animals.
62. The mechanisms are:
- (a) To reduce the nutrient concentrations in excreta. The N and P contents of the stock feed are greater than that required by the animal. The primary way to reduce the amount of nutrients excreted by animals is to decrease the amount that is consumed and increase the efficiency of utilisation of the dietary nutrients (US EPA, undated). Practices that reduce nutrient contents in excreta include using feed concentrates with lower nutrient concentrations, batch feeding stock according to requirements and dietary amendments.
 - (b) To retard nitrogen transformations into species vulnerable to losses. Amendments can be added to the soil that slow down nitrogen cycle transformations into species that are vulnerable to losses. These amendments are either urease inhibitors or nitrification inhibitors.
 - (c) Urease inhibitors - Over 80 % of the N fertiliser used in New Zealand is urea (Blennerhassett *et al.*, 2007). However, the traditionally expected responses of 10-15 kg DM/kg N from urea is based on only partial utilisation of the applied fertiliser. Urea is rapidly converted to ammonium and then can either be lost to the atmosphere, nitrified to nitrate, bound by soil or taken up by plants. By slowing down the process of hydrolysis through application of urease inhibitors, direct losses of fertiliser are reduced and more fertiliser N is available to the plant (Watson, 2000).
 - (d) N excreted by animals and in particular urine, is the most important determinant of N loss (Monaghan *et al.*, 2007) in stocked systems. The quantities of N that are deposited greatly exceed the immediate plant requirements in the area of the urine patch (Di and Cameron, 2004), leaving the excess N subject to leaching losses (de Klein and Ledgard, 2001). Urea in urine patches undergoes a series of transformations through ammonia to ammonium to nitrite and into nitrate. The negatively charged nitrate ion is not held within the soil and is vulnerable to be leached when drainage occurs.

- (e) Nitrification inhibitors retard the transformation of ammonium into nitrate. Slowing this conversion allows time for ammonium uptake by plants, or for binding onto soil components (Anon, 2005), and as ammonium is positively charged, it is not so readily leached from the soil profile as nitrate (NO_3^-), and,
- (f) To reduce the deposition of excreta on the soil surface. Manure and urine deposition can be reduced in three ways; by reducing the number of animals, by reducing the time that the animals spend on the paddocks, and by changing animal type to ones associated with lower losses. Practices that reduce deposition include nil and restricted grazing, reduced stocking rates and changing stock type. These practices reduce the number and frequency of urine patches and the nitrogen loading per urine patch and by these means, reduce the excess N available to be leached.

Examples of previous use

- 63. The US EPA 'National Management Measures for the Control of Non-Point Pollution' identifies manipulating the frequency, duration and season of grazing as a key management measures for managing water quality.

Efficacy of measures

- 64. Studies have shown that the urine-N in the soil at the start of the drainage season is directly related to the time of year that urine was deposited (Cuttle and Bourne, 1993), with 5-13% remaining from spring and early summer deposition and 30-50% from late summer deposition. The greatest losses are from overwintering stock in part, due to deposition of much excretal N onto grazed land when corresponding uptake is low (Monaghan *et al.*, 2004). Monaghan *et al.* (2004) found that in the South Island catchments, stock wintering made up a disproportionately large contribution to N emission of up to 60% of total N leaching. Restricted and zero grazing systems reduce N leaching losses through zero winter grazing and reduced or zero grazing throughout the rest of the year, thereby greatly reducing or eliminating the 'patchy over-application' of N in dung and urine patches especially when crop uptake is low.
- 65. Ledgard and Meneer, (2005) reported that reducing stocking rate by 20 % (from 2 cows/ha producing 600 kg Milk Solids/ha with no additional fertiliser use) would result in about a 50% reduction in N leaching (from 49 kg N/ha to 25 kg N/ha). Hugin *et al.* (1995) found 27 kg/ha N lost from extensively grazed pastures in Germany compared with 87 kg N/ha

from intensively grazed sites. Cuttle *et al.* (2006) reported estimated decreases in N leaching of 10–25 kg N/ha (from 30-50 kg N/ha) for a 20% reduction in dairy numbers and 3-5 kg N/ha for the same reduction in beef numbers. Schepers and Francis (1982) measured 40% less P loss from pastures when cattle were not grazing compared to when they were stocked, and heavily grazed pastures were found to lose twice as much P as lightly stocked (Heathwaite *et al.*, 1990).

66. Betteridge *et al.* (2005) reported that all sheep or deer systems reduced first year N leaching by around 50% in comparison to cattle systems in the Taupo catchment. Ledgard and Meneer (2005) reported changing animal type to have a medium to large potential impact on N leaching. However, deer through fence-line running and wallowing behaviour, cause higher sediment and P losses than other stock classes (Snow *et al.*, 2008).
67. Research has found that nitrification inhibitors applied on to a grazed pastures can significantly reduce N leaching compared to non-treated pasture (e.g. Ballance, undated; Di and Cameron, 2004; Bryant *et al.*, 2007; Cameron *et al.*, 2007).
68. Ramakrishnan *et al.* (2006) examined the use of urease inhibitor combined with nitrification inhibitors. They found that the urease inhibitor (Agrotain) was effective at slowing the hydrolysis of urea to ammonium and the combination of the treatments significantly reduced soil nitrate concentrations at the Ashburton site from 157 mg/l in the urine to 65 and 47 mg/l for the lower and higher rates of application respectively. Zaman and Blennerhassett (2008) found that the use of urease inhibitor combined with nitrification inhibitors reduced N leaching by up to 60% from urine patches compared to urine alone.

Fertiliser mitigation options

69. The essence of good nutrient management and fertiliser use is to ensure that the necessary quantities of the essential crop nutrient are available when required for uptake by the crop, and that losses to the environment are minimised. The application of a nutrient as a fertiliser is normally justified where the supply from all the other sources is expected to be insufficient to meet the crop requirement. Two fundamental principles of good nutrient management; using a recommendation system for fertiliser and accounting for all nutrient sources are included as mandatory good agricultural practices.
70. The fertiliser mitigation options in the toolkit are, 'no fertiliser at high risk times or places', 'reduction of P soil concentration', 'split nitrogen applications', 'fertigation' and 'the use of slowly available phosphate fertiliser (such as reactive phosphate rock, RPR)'. These

management options aim to apply the appropriate amount of fertiliser to the crop at the optimum time and in a way that ensures minimum losses.

71. The mechanisms are:
- (a) Minimising fertiliser losses. Applying fertiliser at a time, or in a place when it is unlikely to be taken up by the plant or at rates greater than can be taken up by the pasture at that time will increase the risk of nutrient loss. Practices that minimise fertiliser losses include no fertiliser at high risk times or places, split N applications, reduction of P soil concentration, the use of RPR, fertigation and the application of fertiliser in accordance with the fertiliser code of practice.

Examples of previous use

72. The use of RPR rather than more soluble P fertiliser and ensuring soil P levels remain within agronomic optimum range were identified as best management practices for managing phosphorus losses from agricultural land in the Upper Manawatu catchment (Parfitt *et al*, 2007) and have been included in Horizons Regional Council's developing policy 'framework for managing non-point source and point source nutrient contributions to water quality' (Roygard and McArthur, 2008).
73. Soil testing and crediting other nitrogen sources are two methods recommended by farmers as practical ways to protect surface water quality (Hirschi *et al.*, 1997) in a US publication aimed at practical ways for farmers to protect surface waters.
74. Accounting for the nutrients in organic manures is recognised as best farming practices for nutrient management in Best Farming Practice: Profit for change (Information sheets IS 1.3.3 and IS 1.3.4) (ADAS and West Country Rivers Trust).
75. Nutrient management including using a recommendation system and accounting for other nutrient sources, and reducing P index to agronomic optimum were both considered as practical methods of reduce diffuse P pollution from agricultural land in a UK pilot study of nutrient source control options and costs (Hilton *et al.*, undated).
76. The US EPA 'National Management Measures for the Control of Non-Point Pollution' identifies soil testing, determining crop requirements, accounting for other nutrient sources and timing of application to minimise losses as key management measures for managing water quality.

77. Nutrient management plans, including producing a nutrient budget, accounting for inputs from other sources soil testing and applying fertilisers according to the code of practice for fertiliser use have been made conditions to the permitted activity of fertiliser application by Environment Waikato (Kaufler, 2007).
78. Crop nutrient management planning, including determining crop requirements and identifying other sources of nutrients has been identified as an effective BMP for controlling diffuse pollution in Scotland (Vinten *et al.*, 2005).

Efficacy of measures

79. Over a 32 day trial, P losses in superphosphate treated plots were over 30 times greater than those from slow release phosphorus fertiliser (RPR) treated plots. (Nguyen *et al.*, 2002) .Weatherley *et al.* (2007) also found that the use of less soluble partly acidulate phosphate rock (PAPR) fertiliser resulted in lower P concentration in runoff from pastures than more soluble fertilisers such as superphosphate.
80. Fertigation (the application of liquid fertiliser with the irrigation water) and irrigation based on soil moisture content was reported to result in nitrate leaching to below 1% of the applied N from Bermudagrass turf (Snyder *et al.*, 1984).
81. Simple farm gate nutrient budgets, where nutrients entering the farm are balanced with those being removed, were used with success in the 'Green Dairy' project in the UK leading to moderate reductions in fertiliser usage with no yield penalties (Jewkes and Scholefield, 2008).
82. Langland and Fischel (1996) found that the base flow concentrations of nitrate, ammonia, organic N, Total P, dissolved P and orthophosphate decreased in small catchments in the US where Nutrient Management Plans had been implemented. The plans had lead to a 14% reduction in P use and a 57% reduction in N use. Pennsylvania State also found that where implemented, Nutrient Management Plans resulted in a reduction in the use of N and P, in their case, by 16.8 kg and 37 kg/ha respectively (US EPA, undated).

Irrigation water mitigation options

83. A well-designed and managed irrigation system will reduce waste of irrigation water, improve water use efficiency and reduce the total pollutant discharge from an irrigations system. Any irrigation management system should aim to minimise water loss to deep percolation and runoff, minimise any soil erosion, and reduce water loss to evaporation. Large amounts of nitrate can be leached beneath the root zone of shallow rooted crops

where either fertiliser or irrigation is applied in excess of crop requirements (Francis *et al.*, 2006).

84. The irrigation water management options in the toolkit are, 'irrigation scheduling³', 'pond and spray border dyke systems⁴', 'laser level existing border dykes' and 'border dyke irrigation management', 'changing to a more efficient irrigation system'. These management options aim to determine and apply the optimum amount of irrigation water to the crops while minimising losses.
85. Mechanisms include:
- (a) Determining the exact amount of water to apply to a crop. The application of water to meet the soil's moisture deficit and no more will result in less drainage and therefore less leaching. Nitrate, while it remains in the soil profile will be able to be taken up by plants, and
 - (b) Minimising irrigation water losses. Due to inefficiencies in the delivery of irrigation water, (for example runoff, wind drift, evaporation and deep percolation losses) the amount of water needed for irrigation is greater than the consumptive use. The aim of irrigation best management practices is to minimise the irrigation of water over and above that needed for consumptive use. This excess water, lost either as drainage or runoff, can carry significant loads of nutrients. Practices to minimise irrigation water losses include catching and reusing irrigation runoff, improved management of border dyke systems and changing to more efficient irrigation system. In the Upper Waitaki Catchment, the target application efficiency of 80% is specified in the Waitaki Allocation Plan.

Examples of previous use

86. The US EPA 'National Management Measures for the Control of Non-Point Pollution' identifies the matching of timing and amount of irrigation water to crop needs as the key management measures for reducing pollution through irrigation water management. The importance of efficient application of irrigation water and use of run off or tailgate losses are also highlighted.

³ The process used by irrigation system managers to determine the correct frequency and duration of watering.

⁴ Where runoff losses from border dyke irrigation systems is collected and used to irrigate another area.

87. Irrigation scheduling is a management option available in the soil management plans used in the England Catchment Sensitive Farming Delivery Initiative, to reduce excessive or mis-timed irrigation and subsequent runoff.

Effectiveness

88. Irrigation scheduling that maintains soil water at or near field capacity has been found to significantly enhance the yield and N uptake of crops (Home *et al*, 2001). The increased uptake of N by the crop leaves less in the soil profile and therefore vulnerable to leaching.
89. When used with fertigation, irrigation based on soil moisture content was reported to result in nitrate leaching to below 1% of the applied N from Bermudagrass turf (Snyder *et al.*, 1984).
90. Houlebrook *et al* (2008) found that the collection of runoff losses prevented annual losses of 9 kg P/ha and 32 kg N/ha from the border dyke systems being lost to the wider environment. Houlebrook *et al.* (2008) also found that wider, laser levelled border dykes reduced the tailgate or runoff losses significantly and the P losses by 80 %, and that restricted and managed border dyke watering times could result in a reduction of N and P losses by 0.9 and 1.4 kg/ha respectively.

Runoff mitigation options

91. Runoff is water travelling over land surfaces. It can carry large loads of dissolved and particulate matter. As water runs overland it picks up loose or eroded material and any manure and fertiliser not incorporated. Where flows or velocities increase, runoff can also be an erosive force itself. Soil erosion, as stated previously, is the major pathway for sediment and phosphorus pollution of surface waters.
92. Runoff mitigation options in the toolkit are; 'riparian margins', 'in-field buffer strips', 'restricting livestock access to watercourses', 'constructed wetlands', 'swales', 'sediment traps' and 'track and cattle track management'. These options are all pathway mitigations aimed at reducing the load of nutrients arriving at receiving environments once they have been generated.
93. The mechanisms include:
- a) Attenuating runoff to allow for infiltration, uptake or denitrification. Attenuation is the permanent loss or temporary storage of nutrients, sediment or microbes during the transport

process between where they are generated and where they impact on water quality (McKergow *et al.* 2008). Practices that attenuate runoff waters for long enough can reduce the nutrient loads of the runoff waters. Options such as buffer strips intended for N reductions rely predominantly on denitrification to remove nitrate (Howard-Williams *et al.*, 1986; Cooper 1990). The pollutant removal mechanism for P and sediment, is predominantly through infiltration, deposition, filtration, absorption and adsorption, and

- b) Removal or diversion of runoff waters. Practices that divert or collect runoff prevent those nutrients reaching a receiving environment. Diversion options such as track management divert water and allow infiltration of runoff waters in safe areas. Containment options such as sediment traps also capture runoff however must be regularly dug out to maintain optimum storage capacity.

Examples of previous use

- 94. In catchments draining to Lakes Rotorua and Rotoiti, 80% of the stream margins draining pastoral land were taken out of production and planted with trees and shrubs. This led to a significant reduction in loads of suspended solids and P (Cooper *et al.*, 1992). Riparian plantings have also been used as a strategy to manage elevated N and P levels in Lake Kapoai, Northland (Fertresearch, 2003). In-field grass strips are being trialled in the Rotorua catchment and initial results show that they can reduce sediment and phosphorus loads in runoff (McKergow *et al.*, 2007).
- 95. The moving of tracks that link to streams and riparian planting and fencing were identified as best management practices for managing phosphorus losses from agricultural land in the Upper Manawatu catchment (Parfitt *et al.*, 2007) and have been included in Horizons Regional Council's developing policy 'framework for managing non-point source and point source nutrient contributions to water quality' (Roygard and McArthur, 2008).
- 96. Riparian buffer zones, wetlands, sediment retention basins, swales, water diversions and in-field grass strips were all considered as practical methods of reduce diffuse P pollution from agricultural land in a UK pilot study of nutrient source control options and costs (Hilton *et al.*, undated).
- 97. Track management, sediments traps and swales were used effectively to reduce surface runoff and reducing sediment and phosphorus pollution of surface waters and funded under the England Catchment Sensitive Farming Delivery Initiative.

98. Creating and managing wetlands and track management to reduce runoff are recognised as best farming practices for nutrient management in Best Farming Practice: Profit for change (Information sheets 2.10.2 and 3.2.1) (ADAS and West Country Rivers Trust, undated).
99. Installing swales, planting vegetated filter strips, using buffer strips and installing sediment control basins are four methods recommended by US farmers as practical ways to protect surface water (Hirschi *et al* 1997).

Effectiveness

100. Buffer strips ranging in widths from 5 – 50 m, have been found to be effective in reducing sediments and removing nutrients. If anaerobicity is maintained in the riparian margins, significant amounts of the nitrate can be removed through denitrification (Ettema *et al.*, 1999; Schoonover and Williard, 2003), and narrower strips are sufficient for nitrate removal (Haycock and Burt, 1991). Phosphorus and sediment reductions of over 90 % have been reported depending on buffer width and flow velocities.
101. The moving of tracks that link to streams were modelled to reduce losses from dairy farms by 0.1 kgP/ha (Parfitt *et al*, 2007).
102. Cuttle *et al.* (2006) reported estimated decreases in P losses at 1.63 kg P/ha of riparian buffer strip and 2.17 kg P/ha of infield buffer strip. Cuttle *et al.* (2006) estimated little direct reduction of N leaching, but some reductions, between 1-5 kg/ha for each ha of buffer strip, were gained by default of land being taken out of fertilized production and the possibility of denitrification at sites with appropriate soil conditions.
103. Chavan and Dennett (2008) Nguyen *et al.* (1999) and Sukias *et al.* (2006) all reported N removal efficiencies of between 45 and 87 % for constructed wetlands. Nguyen *et al.* (1999) and Hawkins (undated) reported P removal efficiencies of between 27 and 57. Cuttle *et al.* (2006) reported estimated reductions in P loss of 1.53 kg/ha in the areas draining to the wetland.
104. Average pollutant removal efficiencies reported for the test swales vary from 14 to 99% for total suspended solids, chemical oxygen demand, total nitrogen, and total phosphorus (Yu, *et al.*, 2001). The wide range of performance results indicates the importance of such design parameters as length, longitudinal slope, and the presence of check dams. The

Scottish Environmental Protection Agency (SEPA) (undated) report 30 -80% removal of suspended solids and 15-45% removal of N and P using swales.

105. All of the measures listed are reported to have medium to high applicability for use in New Zealand in a toolkit prepared for reducing runoff (McKergow *et al.*, 2008).

Will the Toolkit work?

106. The combination of a validated nutrient budgeting model and a suite of well used and practical mitigation tools are used to ensure that both the mitigation requirement and site specific environmental risks are addressed in the FEMP. A worked example for Glen Eyrie Downs Station follows to show the steps of putting together a FEMP. Glen Eyrie Downs was chosen as an example as it has intensive land use planned and it is in an area where some of the highest nutrient mitigation is required.

107. Step 1 - Mandatory good agricultural practices, table 1, are committed to.

Table 1. Mandatory good agricultural practices

| Mandatory good agricultural practices |
|---|
| Fertilisers applied according to code of practice for fertiliser use |
| Use a fertiliser recommendation system and account for all sources of nutrients including applied effluents and soil reservoirs accounted for |
| Fertiliser application applied evenly |
| Irrigation and effluent applied evenly |
| Crop, cultivation, nutrient inputs and yield records kept per farm management unit |
| Good design of irrigation systems |
| Robust irrigation scheduling |
| Supplement and feeding out management |
| Winter grazing management |

108. Step 2 – Current and proposed farm systems are described and modelled and mitigation requirements derived. In relation to the current farming system, approximately 1200 ha

have been cleared from a heavy infestation of wilding pine, and the remaining farm area cleared from poor quality pasture and is now cropped by Bio Fuels NZ. The proposed farm system is a conventional irrigated dairy at 3.5 dairy cows/ha, with stock over-wintered on farm and during the winter period stock are grazed for approximately 5 hours per day with the remainder of the time on a wintering pad. Approximately 2,068 ha of irrigation is proposed on a property of 2,200 ha.

109. The mitigation requirements set out in the water quality study are shown in Appendix B. In the area of the farm in the Quail Burn sub-catchment, the Lake Benmore mitigation requirement is the most stringent for N and P. In the area of the farm in the Wairepo Creek sub-catchment, the groundwater mitigations are the most stringent for both N and P. In any sub-catchment, the most stringent mitigation requirements should be adopted for each area.
110. The high degree of mitigation requirement required on this farm, and the high proportion of the farm which is proposed to be irrigated will require a change in farm system from that initially proposed. In discussions with the land owner, a greater degree of restricted grazing was proposed through the use of cubicle stables.
111. Step 3 – The management option or suite of options chosen are modelled using OVERSEER. In this case the OVERSEER model (proposed system without mitigations) was used and increasingly restricted grazing is imposed until the mitigation requirement was met (ensuring that the inputs remain feasible and reasonable). For this example, the mitigation requirement was met with a system of 8 months nil grazing and 4 months restricted grazing, the removal of some organic manure from the farm, the implementation of riparian buffer strips, the importation of additional dry matter, the capping of the soil P concentration and a restriction of total N applied.
112. Step 4 – Issues in the FERA identified. A FERA has been conducted on site and examples of the site specific issues identified are shown in Table 2 below. The full FERA can be found in Appendix 3.
113. Step 5 – Appropriate mitigation options chosen for site specific issues identified in the FERA. Once the site specific risks were identified, the ‘site specific risk’ table was consulted and an appropriate mitigation tool chosen. Examples of the measures chosen for each risk identified are shown in Table 2 below.

Table 2. Examples of issues identified in the Farm Environmental Risk Assessment and management options chosen to mitigate them.

| Site specific issues identified in the FERA | Mitigation/management options |
|--|---|
| <p>The FERA highlighted potential soil issues arising from the vulnerable nature of the soils to erosion, the grazing of stock over winter and the possibility of trafficking soils when wet.</p> | <p>Proposed irrigation and consequent full ground cover to protect the soil from erosion.</p> <p>The housing of stock over the winter period to remove potential for soil damage from grazing stock in adverse conditions.</p> <p>No trafficking of soils when wet, and as this is not always possible, the annual monitoring and identification of soil compaction and documented remedial actions taken.</p> |
| <p>The FERA highlighted potential stock issues arising from the non exclusion of stock from watercourses, the non-control of dietary N and P, and the grazing of stock over winter with no provision for reducing these losses</p> | <p>The exclusion of stock from watercourses by planting and fencing riparian margins.</p> <p>Phase feeding of herd; feeding of animals according to their requirements and management of N and P intakes through their levels in supplementary feeds.</p> <p>The housing of stock over the winter period will mitigate winter stock nutrient losses.</p> |
| <p>The FERA highlighted potential fertiliser issues arising from more than 50 kg fertiliser N being applied in a single application, N applications occurring in autumn and winter, fertiliser spreaders not being calibrated and no suitable storage and filling area has not been identified</p> | <p>No N fertiliser to be applied in autumn and winter.</p> <p>N fertiliser applications to be split to under 50 kg N/ application.</p> <p>Slowly available phosphorus fertiliser such as RPR to be used.</p> <p>Fertiliser spreaders to be calibrated annually and optimised, or with change of fertiliser, whichever is the more frequent.</p> <p>Fertiliser will be stored in a covered area.</p> <p>The identified fertiliser filling area will be at least 50 m from a watercourse of spring or bore and will have no drains that discharge to clean water or that can discharge straight to ground.</p> <p>If liquid fertiliser used, fertiliser will be stored in</p> |

| | |
|--|--|
| | a bunded tank and also protected from vehicle movements. |
|--|--|

114. Step 6 – Draw up list of options chosen along with monitoring and auditing strategies. A list was compiled of the mandatory good agricultural practices, the farm changes modelled in OVERSEER and the mitigation options chosen to address site specific environmental issues. Each of the options should be presented with a method for monitoring the implementation (an independent method if possible). Some examples from this list are shown in Table 3 below.

Table 3. Examples of management and mitigation measures and their monitoring and auditing for Glen Eyrie Downs Station

| Management techniques | Monitoring | Auditing |
|---|--|---|
| Apply fertiliser according to code of practice | | Self certification. |
| Use of recommended fertiliser system | Use of annual nutrient budget and professional crop recommendations. | Submission of proof of annual nutrient budget and examples of corresponding crop records. |
| Integrating organic and inorganic nutrient supplies | Testing of effluents and recording of annual cumulative application. Use in nutrient budget. | Submission of examples of corresponding crop records with cumulative effluent applications and effluent test results. |
| Test and calibrate fertiliser spreaders annually | Test and calibrate fertiliser spreaders and retain test results. | Submission of results of testing and calibration. |
| Test and calibrate irrigators annually | Test and calibrate fertiliser spreaders and retain test results. | Submission of results of testing and calibration. |
| Nil grazing for 8 months | Field records showing when nil grazing starts and ends. | Signed field records. |
| Restricted grazing for 4 months | Field records showing when restricted grazing starts and ends. | Signed field records. |
| Cap on imported N fertiliser | | Proof of fertiliser purchase. Submission of nutrient budget. |
| Export of solid manure fraction | Testing of effluents and recording of annual cumulative application, and calculation of nutrients to be removed. | Submission of examples of cumulative effluent applications and effluent test results. Receipt from accepting farmer. |
| Fencing and planting of riparian buffer strips | Annual wet weather survey, where efficacy of pathway mitigations are reviewed. | Photographic evidence of buffer strips. Submission of wet weather survey and recommendations if issues found. |

115. Monitoring and auditing of the FEMP are as important as the plan itself. Monitoring includes not only the implementation monitoring detailed above in table 3, but also environmental monitoring. Table 4 below shows examples from the overall monitoring plan for Glen Eyrie Downs and includes triggers and contingency plans should the triggers be exceeded.

Table 4. Examples from environmental monitoring plan for Glen Eyrie Downs showing location, frequency and parameters

| | | Location | Frequency | Measured parameters to include | Triggers | Contingency plan if triggers are exceeded |
|----------|---------------------------------|--|---|---|---|--|
| Soil | Soil nutrient testing | All blocks in rotation | 1 in 3 years | Standard suite of soil nutrients, pH C, N and organic matter | Olsen P of 23 | Reduce or stop addition of P fertiliser to area and monitor. |
| Soil | Soil compaction survey | All blocks | Annually | Surface and subsoil compaction | Compaction, surface capping | Remove compaction with appropriate tool |
| Soil | Wet weather survey | All blocks | Annually | Runoff from tracks and centre pivot tracks and overland flow through riparian margins | Runoff occurring | Immediately review current runoff mitigation options for pivot tracks. Introduce further runoff removal infrastructure. Runoff through riparian margins should be attenuated through placement of temporary barriers or detention pits for larger volumes until source of runoff can be identified and addressed. |
| Effluent | Cumulative effluent application | All blocks receiving effluent | Record each time effluent is applied | Application depth | 200 kg/ha effluent N including solid fraction | Store solid fraction until exportation can be arranged. Export enough of solid fraction to maintain application at less than 200 kg. |
| Water | Groundwater quality | On farm bore | 2 x per year at mid depth of aquifer | Total Nitrogen, nitrate, ammonia, total Kjeldahl nitrogen, total phosphorus, dissolved reactive phosphorus. | > 1 mg/l nitrate-N | If comparative groundwater analysis from upstream and downstream indicates an exceedence of 1 mg/l due to on farm activities, the N application to land should be reduced or stock withheld for longer until a root cause analysis can be conducted. |
| Water | Surface water quality | Entry and exit of Wairepo Creek and Serpentine Creek and main tributary on property boundaries | Monthly for first couple of years to establish patterns | Total Nitrogen, nitrate, ammonia, total Kjeldahl nitrogen, total phosphorus, dissolved reactive phosphorus, suspended solids. | No significant decrease in water quality | If comparative surface water analysis indicates a decrease in surface water quality, the degraded determinands should be identified as these will indicate the likely cause of the contamination, while a full root cause analysis is undertaken. If the determinands suggest effluent, then effluent irrigation should cease on the implicated pivots. If the analyses indicate stock encroachment, the stock should be withheld from the connected paddocks. |
| Water | Irrigation application | | Annually in house and 1 in 5 years by an independent | Application uniformity | >80 % | Optimisation of the irrigator performance will be performed at the time of testing. |

| | Location | Frequency | Measured parameters to include | Triggers | Contingency plan if triggers are exceeded | |
|---------|--------------|------------|--------------------------------|----------------|---|---|
| Pasture | Ground cover | All blocks | 2 x per year | % Ground cover | >80 % | Soil nutrient and compaction testing should be performed to identify possible causes. |

116. The auditing process allows both the farm operator to illustrate and other interested parties to have confidence that the management practices and mitigation measures planned for the farm are being implemented. In addition, the audit lays out the mechanism for adaptive management of the property should the chosen mitigation or management not perform to expectations. An annual audit is proposed requiring both in-house and external input. Table 5 below shows some examples of the proposed contents of an annual audit report for Glen Eyrie Downs and action in case of non compliance.

Table 5. Examples from proposed annual audit report for Glen Eyrie Downs

| Audit measures | Action in the case of non-compliance |
|---|---|
| Additional auditing that must be done externally | |
| Check the clean and dirty water separation methods in and around the cubicle stables, parlour and yards, plus photographs | If any contamination of clean water is found all water should be directed to effluent store until problem is found and effective separation is verified |
| Check for evidence of direct discharges from the cubicle stables, parlour and yard area | Any direct discharge must be stopped immediately. Temporary barriers such as straw bales may be used to take up any discharges until permanent structures are in place |
| Riparian margins should be checked for signs of overland runoff through the margin. | Where there is evidence of runoff through the riparian margin, temporary barriers or detention pits should be dug (not in the riparian margin) to attenuate runoff while the source of the runoff is investigated and the integrity of the dense vegetation is inspected. |
| Check the storage of silage for visible signs of discharge and destination of silage liquor | All liquid should drain into effluent storage. Any discharge must be stopped immediately. Temporary barriers such as straw bales may be used to take up any discharges until permanent structures are in place |
| Annual audit of OVERSEER nutrient budget and report based on previous 3 years. Submission of compliance with thresholds | Should the OVERSEER report show losses exceeding the threshold, further mitigations should be adopted to effect a reduction in nutrient loss to below thresholds. |
| Fertiliser spreader and irrigation testing and calibration 1 in 5 years by independent auditor | Spreaders and irrigators not performing should be recalibrated |
| Additional auditing that can be done either externally or internally | |
| Submission and brief interpretation of soil, effluent, water quality, supplement and machinery calibration tests | Where triggers have been exceeded, immediate contingency plans should have been put in place and a root cause analysis conducted. The results of which should be presented here. |
| Annual soil compaction survey, submission broad findings and | Where poor soil structure is found and cause assessed, the remedials should be implemented and followed up in the |

| Audit measures | Action in the case of non-compliance |
|--|--|
| remedials | next audit |
| Annual wet weather survey, submission broad findings and remedials | Where runoff is found and cause assessed, the remedials should be implemented and followed up in the next audit |
| Auditing that must be done internally | |
| Self certification for application of fertiliser according to code of practice | Any failures in observing the code of practice for applying fertiliser should be rectified and followed up in the next audit |
| Submission of proof of 'approved handler' status | Inappropriate handling of chemicals should cease until an approved handler is in place |

117. This implementation monitoring, along with environmental monitoring (soil and water analyses), should be collated, interpreted and presented in an annual audit report and submitted to the relevant authorities, in this case ECan and Mackenzie Irrigation Company/ Upper Waitaki Water Quality Trust.

Expert caucusing

118. On 22 July 2009, I attended a caucus with ECan and Meridian experts. Also present was Val Snow, John Bright and Brian Coffey. The principal concern raised with regard to the mitigation and Farm Environmental Management Planning part of the WQS was how could there be confidence in the landowners meeting the mitigation requirements set out in the WQS. It was confirmed that each of the farmers had a threshold of N and P that included their mitigation requirements, and that meeting these thresholds would be a conditions of consent.
119. Concerns were raised on the farm systems modelling used to underpin the WQS and also used in the development of the Farm Environmental Management Plans. Dr Val Snow will address these concerns in her evidence.
120. In addition concern has been raised outside the caucus questioning of whether mitigation techniques that have been principally researched and documented overseas can be used in the Upper Waitaki. I have addressed this in a statement at the start of my evidence.

Conclusion

121. The efficacy of all management plans is to a great extent, dependent on their implementation. The principal risk of management plans is that, once written, they are not

used or implemented. In this case, regardless of how technically competent a plan is, it will not be effective. Therefore a plan needs to be not only technically competent, but it needs to be implemented, monitored and impartially audited.

122. In my opinion the variable successes of BMPs in reducing diffuse pollution is often not a reflection on the practice in question, but that the practice is implemented incorrectly or not at all. To counter this, robust monitoring and auditing processes are essential, the results of which shape the FEMP into the future.

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Appendix A

Identification of farm environment risks

The exercise of identifying specific environmental risks on the farm can either be undertaken by an experienced independent consultant, or the farmer can complete and have it audited by an experienced independent consultant.

The purpose of the exercise is to identify areas of environmental risk on the farm and in the farm practice. Some risks pertain to inherent risks on the farm, i.e. the natural environment or conditions, and some risks arise from the way the farm is managed. Additionally, some risks may be answered immediately, such as 'Are soils left bare over winter?' whereas others such as 'are the compacted consolidated or capped soils?' a cursory investigation will be needed to answer.

The questions listed here are an illustration of the type of information that is needed to assess the environmental risks of the farm, and is not comprehensive. For all risks, the relevant locations should be marked on a farm map.

Soil

Below are some examples of questions to ascertain whether there are inherent or managed soil risks on your farm.

| Some example questions on soil health | Notes/description |
|---|--------------------------|
| Previous incidence of soil erosion or wash? | |
| Are there compacted, consolidated or capped soils? | |
| Is the soil trafficked when wet? | |
| Are there slaking or highly erodible soils present on farm? | |
| If arable or fodder crops are grown, are measures taken to conserve or build soil organic matter on arable land? | |
| If these crops are grazed over winter, are remedial measures in place after winter grazed crops? | |
| Is stock over wintered outside? | |
| Other soil issues or incidences? Please describe | |
| If you have answered yes to any red questions or no to any blue questions, then there are inherent or managed soils risks on the farm | |

Cropping

Below are some examples of questions to ascertain whether there are inherent or managed cropping risks on your farm

| Some example questions on cropping | Notes/description |
|--|-------------------|
| Is inversion tillage used? | |
| Are soils left bare over winter? | |
| If arable or fodder crops are grown, are measures taken to conserve or build soil organic matter on arable land? | |
| Are remedial measures in place after winter grazed crops? | |
| Is there a possibility of run off from winter grazed crops reaching a water course? | |
| Other cropping issues or incidences? Please describe | |
| If you have answered yes to any red questions or no to any blue questions, then there are inherent or managed cropping risks on the farm | |

Effluent/Infrastructure

Below are some examples of questions to ascertain whether there are inherent or managed effluent risks on your farm.

| Some example questions on effluent | Notes/description |
|---|-------------------|
| Do you produce effluent? | |
| Do you have less than 4 weeks storage of effluent? | |
| Is your effluent storage facility fully sealed? | |
| Do you separate clean and dirty water in the yard? | |
| Do any direct discharges occur off the yard? | |
| Do you spread effluent by a travelling irrigator? If not, how | |
| What rate do you apply effluent at? | |
| What depth of effluent do you typically apply? | |
| Do you use soil moisture deficits to decide on application depth? | |

| Some example questions on effluent | Notes/description |
|--|-------------------|
| How do you determine application depth? | |
| Do you apply more than 150 kg N/ha/yr of effluent N? | |
| If silage is made on farm, is effluent collected and spread to land? | |
| Are there any direct discharges from silage pit? | |
| Other effluent issues or incidences? Please describe | |
| If you have answered yes to any red questions or no to any blue questions, then there are inherent or managed effluent risks on the farm | |

Fertiliser

Below are some examples of questions to ascertain whether there are inherent or managed fertiliser risks on your farm.

| Some guideline questions for fertiliser | Notes/description |
|--|-------------------|
| Do you apply more than 50 kg N per application? | |
| Do you apply N fertiliser during later autumn and winter? | |
| Do you apply P fertiliser within 3 weeks of irrigation? | |
| Do you regularly soil test? | |
| Do you have Olsen P levels over 30 ? | |
| Are fertilisers ever applied within 20 m of a watercourse or borehole? | |
| Are fertiliser spreaders calibrated regularly? | |
| Are spreaders calibrated to each fertiliser type? | |
| Are there 'no-fertiliser' areas on farm? | |
| Other fertiliser issues or incidences? Please describe | |
| If you have answered yes to any red questions or no to any blue questions, then there are inherent or managed fertiliser risks on the farm | |

Water

Below are some examples of questions to ascertain whether there are inherent or managed water risks on your farm.

| Some guideline questions for water | Notes/description |
|---|--------------------------|
| Is your water metered? | |
| Do you compare annual water usages? | |
| Do you collect rainwater? | |
| Do your stock drink from watercourses? | |
| Do you sample other than metered water to check for suitability for use? | |
| Do you use irrigation scheduling? | |
| Do you measure soil moisture deficit? | |
| Do you use surface irrigation (border dyke, wild flood) | |
| Do you collect wipeoff losses? | |
| Are these wipeoff losses discharged to a watercourse | |
| Are your borders laser levelled? | |
| If you have spray irrigation, do you practice fertigation? | |
| Is clean water yards collected separately and discharged or used? | |
| Are back siphoning prevention measures in place? | |
| Other water issues or incidences? Please describe | |
| If you have answered yes to any red questions or no to any blue questions, then there are inherent or managed water risks on the farm | |

Chemicals

Below are some examples of questions to ascertain whether there are chemical risks on your farm.

| Some guideline questions for chemical usage | Notes/description |
|--|--------------------------|
| Are sprayers filled on a concrete or impermeable pad? Or in the field? | |

Some guideline questions for chemical usage

Notes/description

Does this pad drain to sealed tank?

Are contents of sealed tank spread to land?

Are tank washings resprayed to fields? If not how disposed of?

Is the sprayer stored under cover?

When sprayer is washed down, where do washings drain to?

Are any measures in place to prevent drips and spills?

Are chemicals stored in a secure place?

How are containers and foil caps disposed of?

Are there 'no spray' areas located on the farm?

Are back siphoning prevention measures in place?

Is there an emergency procedure in case of chemical spillage?

Are the services of a professional crop adviser employed?

Are sheep dipped or drenched?

If dipped, how is dip disposed of?

Are recently treated sheep prevented from entering a watercourse?

Are washings collected from yard where treatment occurs?

Other chemical issues or incidences? Please describe

If you have answered yes to any red questions or no to any blue questions, then there are chemical risks on the farm

Biodiversity/natural features

Below are some examples of questions to ascertain whether there are inherent or managed biodiversity risks on your farm.

| Some guideline questions for biodiversity | Notes/description |
|--|-------------------|
| Are there any special areas or species of interest or conservation on the farm? | |
| Are there any water or wetland features on the farm? | |
| Are these features actively protected? | |
| Are surface water features protected from stock access? | |
| Is there evidence of bankside erosion | |
| Other biodiversity issues? Please describe | |
| If you have answered yes to any red questions or no to any blue questions, then there are biodiversity risks on the farm | |

Stock nutrient losses

Below are some examples of questions to ascertain whether there are inherent or managed stock nutrient loss risks on your farm.

| Some guideline questions for stock nutrient loss | Notes/description |
|--|-------------------|
| If stock over wintered outside on the farm, are strategies in place to reduce winter nutrient losses? | |
| Are measures taken to control dietary intakes of N and P? (Intensive beef and dairy) | |
| Are stock restricted from entering watercourses? | |
| Are troughs rotated/moved during winter in hydrologically connected fields? | |
| Other stock nutrient issues or incidences? Please describe | |
| If you have answered yes to any red questions or no to any blue questions, then there are stock nutrient risks on the farm | |

Track management and runoff

Below are some examples of questions to ascertain whether there are track management and runoff risks on your farm.

Some guideline questions for track management and runoff

Notes/description

Are there tracks in hydrologically connected areas?

Do any tracks run through streams?

Do any tracks directly runoff to a water course

Are devices in place for removing and/or treating contaminated water from tracks?

Are tracks for stock specifically maintained?

Do stock regularly pass through water courses?

Are there any sloping fields adjacent or hydrologically connected to a water course?

Any previous runoff or soil wash?

If arable or fodder crops are grown, are measures taken to conserve or build soil organic matter on arable land?

Are remedial measures in place after winter grazed crops?

Is there a possibility of run off from winter grazed crops reaching a water course?

If you have answered yes to any red questions or no to any blue questions, then there are runoff risks on the farm

Appendix B

Worked example of mitigation requirements for Glen Eyrie Downs

| Farm | Surface water sub-catchment | Secondary surface water sub-catchment | Groundwater sub-catchment | Lake Sub-catchment | Proposed whole farm N loss from WQS | Proposed whole farm P loss/ha from WQS | Stream mitigation required for periphyton kg/ha irrigated land | | Secondary stream mitigation required for periphyton kg/ha irrigated land | | Stream mitigation required for ANZECC kg/ha irrigated land | | Secondary stream mitigation required for ANZECC kg/ha irrigated land | | Groundwater mitigation required kg/ha irrigated land | | Lake mitigation required kg/ha irrigated land | |
|------|-----------------------------|---------------------------------------|---------------------------|--------------------|-------------------------------------|--|--|------|--|------|--|------|--|---|--|------|---|------|
| | | | | | | | N | P | N | P | N | P | N | P | N | P | N | P |
| GED | Quail Burn | Ahuriri | Quail Burn | Ahuriri Arm | 72054 | 3792 | 0.4 | -0.3 | 1.1 | -0.9 | 2.3 | -0.5 | 0 | 0 | 0 | 0 | -10.7 | -1.1 |
| GED | Wairepo | NA | Wairepo | Northern Arm | 72054 | 3792 | 0 | 0 | 0 | 0 | -1.9 | -1 | 0 | 0 | -16.4 | -0.7 | 0 | 0 |

Table continued

| Stream mitigation required for periphyton kg/farm | | Secondary stream mitigation required for periphyton kg/farm | | Stream mitigation required for ANZECC kg/farm | | Secondary stream mitigation required ANZECC kg/farm | | GWR mitigation required kg/farm | | Lake mitigation required kg/farm | | Stream mitigation threshold for periphyton kg/year | | Secondary stream mitigation threshold for periphyton kg/year | | Stream mitigation threshold for ANZECC kg/year | | Secondary stream mitigation threshold for ANZECC kg/year | | Groundwater mitigation required threshold kg/year | | Lake mitigation required threshold kg/year | | Overall Farm thresholds for WQS mitigation kg/year | |
|---|------|---|-------|---|-------|---|---|---------------------------------|-------|----------------------------------|-------|--|------|--|------|--|------|--|------|---|------|--|------|--|------|
| N | P | N | P | N | P | N | P | N | P | N | P | N | P | N | P | N | P | N | P | N | P | N | P | N | P |
| 827 | -620 | 2275 | -1861 | 4756 | -1034 | 0 | 0 | 0 | 0 | -22024 | -2171 | 72881 | 3172 | 74329 | 1931 | 76810 | 2758 | 72054 | 3792 | 72054 | 3792 | 50030 | 1621 | 50030 | 1621 |
| 0 | 0 | 0 | 0 | -3929 | -2068 | 0 | 0 | -33915 | -1448 | 0 | 0 | 72054 | 3792 | 72054 | 3792 | 74122 | 1724 | 72054 | 3792 | 38139 | 2344 | 72054 | 3792 | 38139 | 1724 |

Appendix 3

Farm Environmental Risk Assessment for Glen Eyrie Downs

| Some example questions on soil health | Notes/description |
|--|---|
| Are there compacted, consolidated or capped soils? | Yes. In recently cultivated and currently exposed soils, there is visible running together of surface, and variable compaction found between 0 and 10 cm and between 30 and 40 cm where soils were deeper (>60 cm). |
| Is the soil trafficked when wet? | Paddocks may be trafficked when wet, although this will avoided as much as possible as wet conditions would also decrease silage quality |
| Are there slaking or easily erodible soils present on farm? | Yes |
| Is stock over wintered outside? | Yes |
| Is inversion tillage used? | Inversion tillage may be used to establish pastures |
| Other soil issues or incidences? Please describe | Exposed soils exhibited frost heave to approximately 5 cm, and in un-vegetated area, there will be a high risk of loss by erosion in these areas once the soil dries |
| Do you produce effluent? | Farm will produce effluent |
| Do you separate clean and dirty water in the yard? | To be determined so NO |
| What rate do you apply effluent at? | To be determined |
| What depth of effluent do you typically apply? | Depends on SMD |
| Do you apply more than 150 kg N/ha/yr of effluent N? | More than 150 kg of organic manure N will be applied |
| If silage is made on farm, is effluent collected and spread to land? | To be determined so NO |
| Are there any direct discharges from silage pit? | To be determined so YES |
| Do you apply more than 50 kg N per application? | To be determined so YES |
| Do you apply N fertiliser during later autumn and winter? | To be determined so YES |
| Do you apply P fertiliser within 3 weeks of irrigation? | No surface irrigation used |
| Do you have Olsen P levels over 30 ? | Not currently but will include in FERA as it may be likely |
| Are fertilisers ever applied within 20 m of a watercourse or borehole? | No |
| Are fertiliser spreaders calibrated regularly? | To be determined so NO |
| Are spreaders calibrated to each fertiliser type? | To be determined so NO |
| If fertigation is practiced, do centre pivots run over water courses? | No |
| Are there 'no-fertiliser' areas on farm? | Yes there will be – Riparian margins |
| Other fertiliser issues or incidences? Please describe | Verify storage and filling areas |
| Do your stock drink from watercourses? | Stock will be able to drink from watercourses |
| If you have spray irrigation, do you practice fertigation? | To be determined |
| Is clean water yards collected separately and discharged or used? | To be determined |
| Are back siphoning prevention measures in place? | To be determined |
| Are sprayers filled on a concrete or impermeable pad? Or in the field? | To be determined |
| Does this pad drain to sealed tank? | To be determined |
| Are contents of sealed tank spread to land? | To be determined |
| Are tank washings re-sprayed to fields? If not how disposed of? | To be determined |

| | |
|---|---|
| Is the sprayer stored under cover? | To be determined |
| When sprayer is washed down, where do washings drain to? | To be determined |
| Are any measures in place to prevent drips and spills? | To be determined |
| Are chemicals stored in a secure place? | To be determined |
| How are containers and foil caps disposed of? | To be determined |
| Are there 'no spray' areas located on the farm? | To be determined |
| Are back siphoning prevention measures in place? | To be determined |
| Is there an emergency procedure in case of chemical spillage? | To be determined |
| Are the services of a professional crop adviser employed? | To be determined |
| Are there any special areas or species of interest or conservation on the farm? | There is a small area (10.6 ha) of conservation land to the north of the Six Mile Creek on the northern boundary of the farm. This is designated for conservation of native vegetation and is fenced. However it is currently infested with wilding pine. Within the boundary of the property is a Department of Conservation wetland (401.5 ha). This wetland is bounded almost entirely by the Glen Eyrie property. This wetland area is protected as a habitat for Black Stilts. |
| Are there any water or wetland features on the farm? | There are three water courses that cross the property, 'Six Mile Creek, Wairepo Creek and Serpentine Creek. There are two ponds and an old pond flat on the eastern side of the property and a swamp (15.7 ha) on the northern side. The soils on the property are associated with poorly drained riparian margins. Within the boundary of the property is a Department of Conservation wetland (401.5 ha). This wetland is bounded almost entirely by the Glen Eyrie property. There are currently no natural water or wetland features on the property. |
| Are these features actively protected? | The DOC wetland is protected by fencing. The watercourse are to be protected through riparian planting |
| Are surface water features protected from stock access? | No |
| If stock over wintered outside on the farm, are strategies in place to reduce winter nutrient losses? | No |
| Are measures taken to control dietary intakes of N and P? (Intensive beef and dairy) | To be determined so No |
| Are stock restricted from entering watercourses? | No |
| Are troughs rotated/moved during winter in hydrologically connected fields? | To be determined so No |
| Are there tracks in hydrologically connected areas? | Yes |
| Do any tracks run through streams? | Yes |
| Do any tracks directly runoff to a water course | Yes |
| Are devices in place for removing and/or treating contaminated water from tracks? | No |
| Are tracks for stock specifically maintained? | To be determined so no |
| Do stock regularly pass through water courses? | Yes, through irrigation race |
| Are there any sloping fields adjacent or hydrologically connected to a water course? | Yes |
| Is there a possibility of run off from winter grazed crops reaching a water course? | No crops, but from pasture |