Before the Commissioners appointed by Canterbury Regional Council

IN THE MATTER OF The Resource Management Act 1991

AND

IN THE MATTER OF 60 water permit applications to take and use water, 30 land use consent applications and 20 discharge permit applications, for agricultural and horticultural activities

Section 42A Officer's Report

Date of Hearing: 21 September 2009

Report of *Dr. Marc Schallenberg*

INTRODUCTION

Background

1. This report forms part of Environment Canterbury's audit of the assessment of environmental effects (AEE) provided by the applicants in support of resource consent applications to take and use water in the upper Waitaki catchment for agricultural and horticultural activities.

2. This report will provide the decision-maker with information and advice related to the actual and potential effects of the proposed activities on cumulative water quality effects. I undertook this audit as an employee of the University of Otago, that has been engaged by Environment Canterbury (ECan) to audit these applications in relation to cumulative water quality effects.

Qualifications

3. I have been a practising limnologist in New Zealand for 16 years. In that time I have personally sampled and studied around 70 lakes, from Northland to Campbell Island. I have worked on Lake Dunstan, a hydro-electric reservoir in Otago which has some similarities to the Lake Benmore. Since 1994, I have been an externally funded limnology research fellow, based in the Zoology Department at the University of Otago. I have published in peer-reviewed journals on topics including effects of land use intensification on lakes, eutrophication, sedimentation, hydrodynamics, algal productivity, climate change impacts on lakes, aquatic microbial ecology, contaminants in aquatic ecosystems, and the environmental histories of lakes. I have been a peer-reviewer for the Intergovernmental Panel on Climate Change (4th Report). I have been an invited keynote speaker at numerous conferences and workshops. I have acted as an expert witness in Environment Court and at Regional Council hearings. I am regularly consulted by Regional Councils, the Department of Conservation, NIWA and a number of community lake-care organisations on technical

matters to do with lakes. I teach 4 university papers in limnology and have supervised 5 PhD students and 6 MSc students. I have examined 5 PhD theses and 1 MSc thesis for universities in New Zealand and elsewhere.

Scope of Report

4. This report is prepared under the provisions of section 42A of the Resource Management Act 1991 (RMA). This section allows a Council officer or Council-appointed consultant to provide a report to the decision-makers on a resource consent application made to the Council, and allows the decision-makers to consider the report at the hearing. Section 41(4) of the RMA allows the decision-makers to request and receive from any person who makes a report under section 42A "any information or advice that is relevant and reasonably necessary to determine the application".

5. This report forms part of a suite of section 42A reports prepared by Environment Canterbury for the above consent applications. All reports should be read together to gain a complete understanding of the audit of the resource consent applications. Full details of the consent applications are provided in Report 1.

6. The scope of this report is to cover the following:

   An audit of the science underpinning predictions of the water quality effects of increasing irrigation in the Mackenzie Basin and, in particular, Lake Benmore, as outlined in the reports listed in section 7, below.

7. To carry out this audit I have considered the following information:

   Cumulative Water Quality Effects of Nutrients from Agricultural Intensification in The Upper Waitaki Catchment: Summary Report (August 2009) and appendices, prepared by GHD for Mackenzie Water Research Limited (henceforth termed, "the MWRL report")

   I am aware that the final MWRL report was made available in late August, but I did not have enough time to adequately review it and meet the deadline for this audit.

8. Any conclusions reached or recommendations made in this report are not binding on the decision-makers. It should not be assumed that the decision-makers will reach the same conclusion having considered all the evidence to be brought before them at the hearing by the applicant and submitters.

Limitations of the calculated nutrient loading rates

9. My colleagues, Dr Clothier, Mr Hanson and Mr Heller, have undertaken an audit of the assessments of nutrient leaching rates, hydrology, hydrogeology, groundwater quality and nutrient loading rates and have identified a number of significant concerns about these matters that also have a bearing on predicting adverse effects on Lake Benmore and other lakes.

10. I have also identified some concerns regarding the nutrient loading rates upon which the lake responses are based. Firstly, it appears that the suggested allowable increases in periphyton biomass in the tributaries (up to 25%; MWRL report) have not been factored into the lake nutrient loading calculations. The "allowable" increase in periphyton biomass represents a conversion of dissolved N and P into particulate

organic N and P and an increase in the organic carbon load to the lakes. This would be input to the lakes during floods which had sufficient energy to remove the periphyton from the river substrates and transport it downstream. Particulate organic nutrients will behave differently to dissolved nutrients, once exported to the lakes.

11. Secondly, floods are common in the Waitaki Basin (e.g. the Ahuriri inflow to Benmore floods 6.3 times per year; MWRL Appendix Z, page 150). It is unclear whether elevated nutrient loadings during river floods have been adequately predicted for the lakes? Floods may trigger phytoplankton blooms in lakes because they supply pulses of nutrients available to phytoplankton (see section 17).

12. Thirdly, it is not clear from the MWRL report what proportion of gross N loads to the lake have been removed due to assumed denitrification in the catchment. No actual measures of denitrification in the catchment were used to formulate the estimated denitrification rates, which were based on soil maps and the CLUES denitrification multiplier of 0.7 (MWRL Appendix G, page 29). This approach assumes that a proportion of nitrogen passing through wet areas will be removed by denitrification. Unless more authoritative references, or some data on denitrification rates in the catchments, can be provided to show that denitrification, in fact, occurs at the sites where it is predicted to occur and at the predicted rates. In the absence of such reassurances, it would be prudent to assume that no denitrification occurs in this system. Note that attempts to apply denitrification corrections to the groundwater model resulted in "model instability" (MWRL Appendices, p. 16).

13. Finally, it is possible that that nutrient leaching associated with relatively recent irrigation developments in the basin may not yet have fully moved through soil and groundwater systems to appear in surface waters. Such time lags in nutrient transport from the land to surface waters have been shown to occur in lakes which receive a substantial proportion of their nutrient loads via groundwater (e.g. Lake Taupo; Vant & Smith 2004).

CONCLUSIONS

14. **Approach to assessing impacts on the lakes**: The MWRL report attempts to predict the impacts of increased irrigation on the trophic levels of lakes in the Mackenzie Basin. It attempts this by first modelling the N and P loading to the lakes and then estimating the final concentration of N and P in the lakes. The conclusions about the effects of the proposed irrigation are thus based solely on estimated changes in N and P concentrations in the lakes. Below, I outline some of my main concerns about the use of this simplistic approach to assess the likely effects on the lakes. These concerns assume that, as indicated in the MWRL report, individual applicants apply mitigation measures in accordance with those suggested in the MWRL report, to reduce nutrient discharges from specific sites.

15. **Limited scope of assessment of effects on lakes**: The predictions of lake responses are restricted only to predictions of changes to total nitrogen (TN) and total phosphorus (TP) components of the trophic level index (TLI; Burns et al. 1999; Burns and Bryers 2000). The TLI normally incorporates two additional components, chlorophyll *a* and Secchi disc depth, to incorporate effects related to phytoplankton biomass and the light climate, respectively. Thus, the MWRL approach ignores relationships between nutrient inputs and potentially important ecological responses such as: i) changes to the phytoplankton community composition (e.g. potential shifts from diatoms to dinoflagellates or cyanobacteria), ii) the resultant risk of algal blooms (e.g. phytoplankton biomass), and iii) other effects on environmental conditions

related to the life sustaining capacity of the lake (e.g. changes to the dissolved oxygen concentrations of lake water). Furthermore, any of the above direct effects could influence important aspects of the ecology of the lakes, such as salmonid production and aquatic plant growth and distributions.

16. **Over-simplified pressure-response approach**: The TLI calculations in the report assume that the nutrient loads are uniformly diluted by the lake's (or basin's) volume and that no other processes will affect the resultant lake nutrient concentrations. This simplified pressure-response approach ignores chemical, physical and biological processes within the lakes which may modify nutrient concentrations and, hence, the availability of nutrients to algae (e.g. nutrient regeneration and cycling, sediment-water nutrient fluxes, etc.). The influence of such processes on P retention efficiency in a lake may be crudely estimated using a simple empirical model based on the annual mean areal water load (hydraulic input divided by lake area; Kirchner & Dillon 1975). N retention efficiency in lakes is often assumed to be 10-20% lower than P retention efficiency (Jørgensen 1994).

17. **Temporal resolution is insufficient to assess the likelihood of important lake effects**: Throughout the MWRL report, annual means are relied upon to predict lake responses. However, biological responses, such as algal growth rates, can be rapid (e.g. cell doubling times can often be between 2-10 days in lakes; Padisák 2004) and blooms may be related to prior flood events (Mihaljevic et al. 2009; M. Schallenberg, pers. observation). Thus, an annual mean water residence time or annual mean nutrient load will not necessarily accurately predict the likelihood of algal blooms occurring in the rivers or lakes. A modelling approach using a monthly modelling time step for drivers of ecological functioning (e.g. water residence time, nutrient loads) as well as ecological responses (e.g., chlorophyll *a* concentrations, periphyton biomass, etc) would be more informative and appropriate.

18. **Predictions ignore effects on ecological variability**: It is a general rule in ecology that population variability increases as the mean population size increases (McArdle et al. 1990). This is why environmental data must often be log-transformed before statistical analyses are carried out. Thus, the risk of key effects thresholds being breached increases exponentially with increasing nutrient loads (i.e. biological productivity). Consequently, as the nutrient loading of the lakes increases, the temporal variability in ecological responses (e.g. algal biomass) will also increase, augmenting the risk of algal blooms in a multiplicative way. A risk analysis approach accounting for increasing variability in key effects with increasing irrigation, would be an appropriate way to address this issue.

19. **Climate change**: No mention is made in the MWRL report of the potential impacts of climate change on the ecology of the lakes and rivers under the various irrigation scenarios. While climate change affects on lakes are multitudinous, merely the warming of the climate can cause effects in lakes similar to eutrophication (Schindler 2001). According to predicted effects of global climate change on the Waitaki Lakes catchment (MfE 2008), the lakes will be situated in an increasingly warm and wet climate, and will also receive increasing amounts of discharge from snow and ice melt and rainfall in the Southern Alps. The climate is also predicted to become less stable and storminess will increase. Thus, climate change will probably increase inflow volumes, lake temperatures and nutrient loads (floods and storms transport a large proportion of nutrients). A careful quantitative analysis is required to determine whether such changes in environmental variables will increase, nutrient concentrations and algal biomass in the lakes and oxygen depletion in the bottom waters of Lake Benmore, but my view is that they will increase. Such climate change-

driven alterations to the lakes would also potentially interact with impacts on the lakes related to the proposed irrigation developments. Therefore, a quantitative assessment of the potential for climate change to exacerbate negative effects of irrigation on the lakes should be undertaken. Again, such an assessment would most appropriately be addressed in the context of a risk analysis.

20. **Analysis of risks**: Given the uncertainties regarding effects of the proposed irrigation scheme on the water quality, ecology and life sustaining capacity of the lower Waitaki lakes, a risk assessment should be carried which:

i) increases the scope of lake impacts examined as outlined above,

ii) examines impacts and risks on monthly time steps,

iii) acknowledges that, as the nutrient loading increases, the biological variability and risk of algal blooms will increase disproportionately, and

iv) which considers how climate change may exacerbate the impacts of the irrigation development on the lakes.

The risk assessment should also account for the very limited background data and ecological knowledge about the system, the lack of data available to validate models, and the lack of accounting for relevant ecological processes in the lakes and rivers.

21. **Adaptive management as a precautionary approach to dealing with uncertainties**: The uncertainties about the ecological impacts on Lake Benmore and other affected lakes are unacceptably high. No adaptive management approach has been proposed in the MWRL report. A major and significant reduction in these uncertainties is required.

22. **Summary**: Few background data are available and the level of analysis of potential impacts on the lakes is insufficient to allow me to judge whether the provided assessment of effects on Lake Benmore and other Waitaki lakes is reliable. On the basis of the information that I currently have there is a significant risk that the adverse effects could be greater than predicted in the MWRL report. They are certainly likely to be more widespread than impacts on TN and TP. Among the direct potential adverse effects are: the development of nuisance algal blooms, unfavourable changes in the dominant species of algae, and reductions in the oxygen content of the bottom waters and these impacts could potentially be exacerbated by climate change. Ultimately, such impacts could indirectly affect the salmonid fishery (a key ecosystem service) and the distribution and proliferation of aquatic plants (e.g., *Lagarosiphon major*, a potential threat to ecosystem services and biodiversity). A comprehensive assessment of such risks would require a more in depth analysis of the present state of the lakes and future scenarios than the current analyses presented in the MWRL reports provide.

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