# REDUCING NUTRIENT LOSSES TO LAKE REREWHAAKITU

**Bob Longhurst [1], Ian Power [1], Martin Hawke [2], Bob Parker [3]**

[1] *AgResearch Ruakura, Hamilton*
[2] *Bay of Plenty Farm & Pastoral Research, Rotorua*
[3] *Fruition Horticulture, Tauranga*

**Abstract**

Lake Rerewhakaaitu is a mesotrophic shallow lake, unique amongst the Rotorua Lakes, for having a catchment comprising mostly dairy farms. Water quality, as measured by the trophic level index (TLI), has in recent years gone above the Bay of Plenty Regional Council's TLI target of 3.6. Farmers within the catchment are concerned about: 1) the future condition of the lake and 2) possible imposition of constraints on their farming operations. During the past eight years Sustainable Farming Fund projects have been set up to address water quality issues by identifying ways that pastoral management in the catchment could be changed to minimise the environmental impact on the lake, and allow sustainable dairy farming to continue.

In Phase 1 a farmer survey was conducted and OVERSEER® nutrient budgets were compiled for each farm in the lake's catchment. Nitrogen management was the main priority. Phase 2 focused on phosphorus (P) management, identifying the main pollutant form of P so that appropriate on-farm P-mitigations could be demonstrated. In Phase 3 OVERSEER® nutrient budgets were again compiled for each farm and a 'Farm Enviro Walk' undertaken to identify critical source areas for nutrient loss. On-farm mitigations have been identified for farmers to implement. The collective response of farmer mitigations has seen total modelled N and P nutrient loadings from the catchment between 2002/03 and 2009/10 reduced by 18% and 28% respectively.

**Keywords:**
Trophic level index, Olsen P, N leaching, P loss, Tarawera gravels

**Background**

Lake Rerewhakaaitu, in the Rotorua Lakes district, is located at the base of the southern slopes of Mt Tarawera. At an elevation of 435 m asl the shallow 580 ha perched lake has some unique features. Around 80% of the lakes' catchment of 3,816 ha (White et al., 2003) is in dairying. However, most of the farmland groundwater drains to other catchments (e.g., Lake Rotomahana) and surface water only flows out of the lake to the Rangitaiki River during high lake levels.

The tropic level index (TLI) is widely used as an indicator of water quality in New Zealand lakes (Burns et al., 1999). Four parameters (nitrogen, phosphorus, visual clarity and algal biomass (chlorophyll *a*)) are measured to monitor changes in the nutrient (trophic) status of lakes. Lake Rerewhakaaitu was classed as a 'mesotrophic lake' in 2002 as it had a TLI of 3.3 (Gibbons-Davies, 2003). The Bay of Plenty Regional Council (BOPRC) monitors the lakes' water quality, on a monthly basis, for these TLI parameters (BOPRC, 2010). The BOPRC target TLI for Lake Rerewhakaaitu is 3.6 (Figure 1). During 2006/07 the TLI rose above the target 3.6 and peaked at 3.9 during 2008/09 and 2009/10 before declining to 3.7 for 2010/11 (Scholes, pers. comm.).

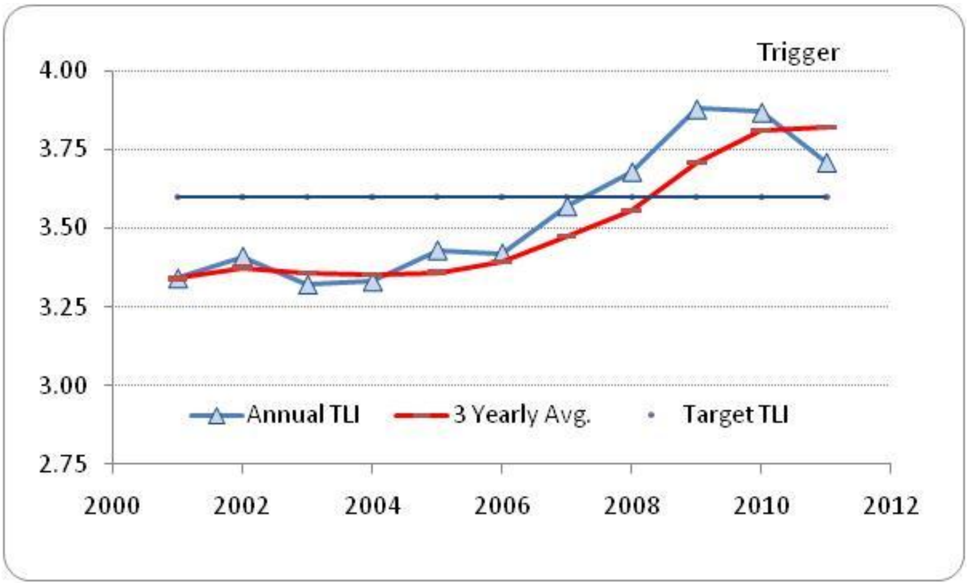


**Figure 1:** Lake Rerewhakaaitu TLI over the past decade.

For some time the Rerewhakaaitu community have been concerned about the declining water quality of the lake. Farmers within the catchment were disturbed about: 1) the future condition of the lake and 2) possible imposition of regulatory constraints on their farming operations. The outcome from these local concerns was that Sustainable Farming Fund (SFF) funding was obtained to set up projects to address the water quality issues by identifying ways that pastoral management in the catchment could be changed to minimise the environmental impact on the lake, while still allowing sustainable dairy farming to continue. The farmers have led a series of projects aimed at identifying, controlling and mitigating nutrient losses from their farms.

The first and second phase of the project focused on nitrogen (N) and phosphorus (P) respectively. After the second phase finished the BOPRC offered the farmers financial and technical support for them to develop and write the Catchment Plan for the lake. A major component of the current third phase is the development of a catchment plan for Lake Rerewhakaaitu due to be completed in 2014. In late 2011 the annual TLI declined, however the 3-year TLI rolling average (Figure 1) exceeded the annual TLI which has triggered the regional water and land Lakes Action Plan process.

This paper reports on some of the significant findings from these projects.

**Aim**

Determine the nutrient losses, identify on-farm mitigations and develop individual nutrient management plans (NMP) for each farm in the lakes' catchment.

**Approach**

<u>Phase 1</u> (2002/2005)

A farmer survey was conducted for the 33 catchment farms and data processed through the OVERSEER® nutrient budget model (Wheeler, 2003). N and P losses were determined for each farm and prevailing farm management practices identified with the focus on N management.

Phase 2 (2006/2009)
This focused on P management with forms and concentrations of P in surface runoff from races and paddocks being measured. On-farm mitigations were demonstrated to farmers that included sediment traps, filter strips (both grass and artificial), and P-socks filled with steel/iron slag or a combination of these mitigations (Longhurst et al., 2009).

Phase 3 (2009/2012)
Farm nutrient budget data was updated for each farm in catchment and processed through OVERSEER®. Farm visits also included a "Farm Enviro Walk" (DairyNZ, 2008) to identify "nutrient hot spots" and possible mitigations were discussed with farmers. From this information an individual farm nutrient management plan (NMP) was developed. This complete, data from each farm was collated to assess the total nutrient losses from the pastoral catchment. A selection of lifestyle blocks was also included to estimate the total nutrient losses from their combined area of 140 ha in the catchment.

**Nutrient losses**
During 2009/10 dairy farms (3,069 ha) comprised 80% of the land use area in the lake's catchment. Dry stock farms, comprising 3% of the catchment, are now increasingly used to winter dairy cows and provide supplementary feed for the surrounding dairy farms. Some farm conversions have occurred during the intervening years increasing the number of dairy farms from 26 to 29. As OVERSEER® had been modeled on the farms at different time periods it presented an opportunity to compare N and P changes since 2003. Tables 1 and 2 summarise these changes.

Nitrogen
A slight reduction in farm N surplus has occurred between years 2002/2003 and 2009/2010 largely due to a substitution of supplementary feed for fertiliser N inputs (Table 1). While the nitrogen conversion efficiency (N in product/N in inputs) remains similar the modeled amount of N leached has reduced by 18% and total N lost from dairying in the catchment has reduced by 21.5t N/yr (Table 1). Feed N is more likely to be evenly spread over pasture via the effluent system compared to fertiliser N recycled through cow urine. Other factors such as reducing fertiliser N inputs during the high-risk May-July period have also helped lower N leaching.

**Table 1:** Nitrogen report for dairy milking platforms.

| Year | Farm N surplus (kg/ha) | Nitrogen conversion efficiency (%) | Nitrogen leached (kg/ha) | Catchment N Loss (t N/yr) |
|---|---|---|---|---|
| 2002/03 | 157 | 29 | 38 | 116.6 |
| 2009/10 | 151 | 28 | 31 | 95.1 |

Phosphorus
Farm P surplus has declined by 15% between 2002/03 and 2009/10 (Table 2) largely due to decreased fertiliser P inputs. Modeled farm P loss has reduced by 28% from 2.9 to 2.1 kg P/ha, a saving of some 2.5t of P in 2009/2010 over the land in dairy within the catchment.
Average soil Olsen P levels have reduced from 65 to 58 µg/ml (Table 2) but these levels still remain above the target range of 35-45 for pumice soils (Roberts & Morton, 2004). A more recent review of fertiliser P research in New Zealand has indicated that the critical target

level for pumice soils should be closer to 50 (43-61 µg/ml soil) to achieve 97% relative pasture production (Edmeades *et al*., 2006).

Olsen P levels on the Rotomahana mud, Kaharoa ash and Taupo pumice soils averaged 31, 33, and 43 respectively. These are within the target range. However, farmers on the Matahina and Tarawera gravels continue to maintain very high Olsen P soil levels (average 71 and 90 µg/ml respectively). The farmers "divide test by 3 approach" is based on the belief that soil Olsen P values should be divided by 3 to obtain the "real" value. Rajendram et al., (2011) reported that Olsen P concentrations for Tarawera and Matahina gravel soils decrease when the gravel is included in the laboratory testing procedure and better agreement with the advised range of Olsen P (35-45 µg/ml) for Pumice soils is seen if gravel is retained when testing for Olsen P. They recommended that field representative samples should be collected and that laboratories should include the proportion of gravel in the fraction measured particularly in high gravel soils.

**Table 2:** Phosphorus report for dairy milking platforms

| Season | Farm P surplus (kg/ha) | Farm P loss (kg/ha) | Catchment P Loss (t P/yr) | Soil Olsen P (µg/ml) |
|---|---|---|---|---|
| 2002/03 | 47 | 2.9 | 8.9 | 65 |
| 2009/10 | 40 | 2.1 | 6.4 | 58 |

**How farmer acceptance has changed**

During the course of the project the acceptance to reduce N and P losses has changed for the positive. These changes are summarised below:

1) OVERSEER®
    - Farmers were initially were uncertain about OVERSEER® and the benefits of nutrient budgeting
    - Now accept that the model is sound and based on good science
    - Now use modelled outputs to better manage farm nutrients

2) Mitigations
    Many options have been implemented on farms:
    - Average size of effluent blocks have been enlarged from 11% to 16% of farm area
    - Average N fertiliser and P fertiliser inputs have been reduced
    - Less N and P fertiliser is now applied during high-risk periods
    - Reduced or nil N and P fertiliser applied to effluent block areas
    - On average, soil Olsen P levels have reduced
    - Streams have been fenced

3) Common themes
    - Greater use made of standing cows off soils when wet
    - Higher use of feed supplements (maize silage and PKE), less fertiliser inputs
    - Revival in planting lucerne to provide summer feed particularly on drought prone Tarawera and Matahina gravel soils
    - Farmers aiming to maintain current milk solids production

Nutrient budgets for the 2011/2012 year will be updated to assess the impact of the farmer agreed mitigations on N and P reductions. The success of the project has been the close interaction between the farmers and the science providers through frank discussions, regular newsletters and farmer meetings.

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