

# IMPROVING NUTRIENT MANAGEMENT FOR DAIRY FACTORY WASTEWATER LAND TREATMENT SYSTEMS

**Jeff Brown**

*Fonterra Environmental Technical Group, Private Bag 11029, Palmerston North*

Email: [jeff.brown@fonterra.com](mailto:jeff.brown@fonterra.com)

## **Abstract**

Fonterra operates land treatment systems to remediate wastewater nutrients at sixteen of its NZ processing sites. Heightened regulatory requirements and increasing public plus customer expectations are resulting in some novel methods to improve nutrient use efficiency. A case study on the recently expanded Pahiatua factory and the measures being undertaken to improve nutrient and water use efficiency in order to secure long term resource consents are outlined. Finally, challenges in complying with Nitrogen Discharge Limits as calculated by Overseer are discussed.

## **1. Introduction**

Nutrient rich wastewater is generated during the processing of milk into powders and other dairy products, mainly through the regular washing of the stainless steel for food hygiene requirements. Milk residues and acid plus alkali cleaning agents are the major chemical components of these wastewaters. Fonterra operate some 26 milk processing facilities around New Zealand (Figure 1). Wastewater treatment systems vary between full biological treatment in large aerated ponds, typically with discharge to surface waters, and land treatment systems (LTS, with and without pre-treatment) involving irrigation on to productive farms. Biological treatment involves high initial capital costs to build the treatment plant and then annual high running costs. However, biologically treated wastewater is of sufficient quality to be directly discharged to surface waters, although this is becoming more difficult to gain resource consents for. Land treatment systems involve less initial capital outlay, although farm purchase and irrigation system installation costs are still significant. LTS may be viewed more favourably by regional councils and they allow the nutrients plus water to be recovered/re-used to a larger extent.

Specific issues relating to LTS for dairy factories are large daily wastewater volumes (2,000-10,000 m<sup>3</sup>/day) from early August right through to May or June. Such volumes make storage difficult and irrigation must occur outside the traditional irrigation period i.e. irrigation is required throughout spring and autumn in addition to summer. Land purchase costs and irrigation infrastructure costing around \$15K/ha mean there is often a trade-off between nitrogen loading rates and the overall size of any irrigation system. Sodium hydroxide based alkaline cleaners result in high wastewater sodium concentrations which require careful management via lime/gypsum additions to the soils to maintain their structure.

## **2. Fonterra Pahiatua factory expansion – Regulatory environment**

The recent expansion of Fonterra's Pahiatua factory in the Manawatu (adding a new 15 T/hour high efficiency milk drier) is a good case study to show how changing public expectations and regulatory environments significantly influenced the resource consenting process and the overall wastewater treatment/nutrient management system installed. The first

milk drier at the Pahiatua factory began operation in 1976. A second drier was added in 1990, but the butter manufacturing plant closed in 1996, and since then the three irrigation farms comprising the LTS had been operating at around half the nitrogen loading limit of 500 kg N/ha/yr of the wastewater irrigation resource consent (# 102907) granted in August 2004.

Recent regulatory changes affecting the factory expansion included Horizons Regional Council One Plan, which emerged from the Environment and High Court appeal processes in 2013. In response to public concerns over surface water quality the One Plan defined numerous targeted ‘Water Management Sub-zones’ (WMS) where significant improvements in water quality are desired over the next two decades. The Mangatainoka sub-catchment to the Manawatu River, in which the Pahiatua factory LTS lies, was one of many such sensitive catchments. Under the One Plan, strict reductions in nitrogen leaching levels are required, with progressive reductions to be achieved over a twenty year period. The degree of decrease required depends on the Land Use Capability (LUC) and whether or not any farming activity fits the definition of ‘intensive agriculture’ which includes dairy farming, cropping and any more intensive irrigated sheep/beef systems.

Under the One Plan Rule 14-2, such farms in a targeted WMS require a ‘consent to farm’ under which changes in management practices resulting in staged decreases in nitrogen leaching rates must be demonstrated. The irrigation farms comprising the Pahiatua factory LTS are run as dairy farms thus they required such consents for the farming activity (restricted discretionary activity) as well as a full discretionary activity resource consent for the ‘discharge of wastewater to land’ under Section 15(1)(b) of the Resource Management Act 1991 and Rule 14-30 ‘Discharges of water or contaminants to land or water not covered by other rules in the Plan or chapter’ of the One Plan.



**Figure 1 Fonterra manufacturing sites in New Zealand with Pahiatua factory site marked.**

Detailed LUC mapping of the three existing plus one new LTS farms and application of the One Plan allocations lead to nitrogen loss targets shown in Table 1. Overseer 6.0 estimations of the predicted leaching as at 2012 during the beginning of the consenting process were between 28-72 kg N/ha/yr, indicating that consenting the status quo would be difficult, even before additional demands were to be placed on the system by the factory expansion.

**Table 1. Individual property nitrogen leaching targets required accordant to Horizons Regional Council One Plan**

	Fonterra Tui	Fonterra O'Brien	Private Farm 1	Private Farm 2
<b>Irrigated (ha)</b>	<b>99</b>	<b>140</b>	<b>70</b>	<b>80</b>
Productive (ha)	103	149	84	100
<b>Horizons Regional Council One Plan designated nitrogen leaching rates (kg N/ha/yr)</b>				
<b>Year 1</b>	26	26	26	28
<b>Year 5</b>	24	24	24	25
<b>Year 10</b>	21	22	21	24
<b>Year 20</b>	20	21	20	23

### 3. Analysis of wastewater treatment and nutrient management options

Initial options considered to reduce the nutrient loadings from the expanded Pahiatua factory to the environment were:

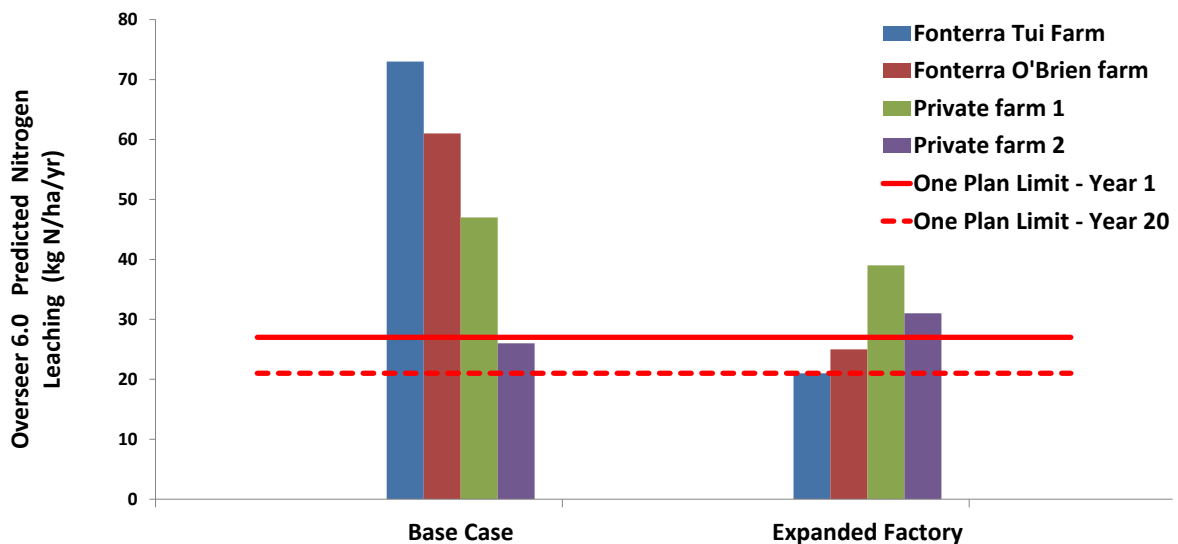
1. Dissolved Air Flotation treatment to reduce gross fats and protein residues plus a greatly expanded irrigation area.
2. Biological treatment of the additional wastewater loads resulting from the new drier expansion, together with an expanded irrigation area.
3. Full biological treatment of all wastewaters and discharge into the Mangatainoka River.
4. Full biological treatment of all wastewaters, treated effluent storage of 100,000 m<sup>3</sup> to avoid irrigation during extremely wet periods and final 'polishing' of treated effluent irrigation using the existing LTS.

Option 1 was discounted as more than 500 ha of new irrigation would have been required in order for nitrogen loadings to be low enough to likely meet the 10 year One Plan targets. Access or purchase of such a large amount of land would have been unlikely in the catchment. Option 2 would have involved a small treatment plant, but the extra irrigation land still required was also likely prohibitive. Option 3 with full biological treatment and direct discharge of treated wastewater to the river would have resulted in only minor nitrogen effects on the river but was discounted based on predicted increases in phosphorus loadings. Option 4 had the major capital cost of a full treatment plant (\$15M) plus dam storage, but it would have resulted in nitrogen loadings to the LTS farms dropping from around the existing 250 kg N/ha/yr down to around 65 kg N/ha/yr due to the high efficiency of the treatment plant at eliminating nitrogen. At such low nitrogen loadings the existing dairy farms would not have been able to sustain average production without the addition of urea or similar artificial fertiliser.

The following additional option was evaluated and became the preferred option for the consenting process:

5. Combination of wastewater treatment and changes to the existing farming systems, involving:
  - a. Treatment and reuse of the new drier ‘condensate’ to reduce overall increases in wastewater volumes
  - b. Full biological treatment of all factory wastewaters
  - c. Storage of treated wastewater for 100,000 m<sup>3</sup>
  - d. Expansion of irrigation area on the three existing LTS farms by around 60 ha
  - e. Replacement of the older travelling irrigators with low-rate fixed in-ground sprinklers
  - f. Addition of 80 ha extra irrigation land on an adjoining property
  - g. Integration of dairyshed effluent irrigation into the overall LTS irrigation system on the Fonterra owned Tui and O’Brien farms
  - h. Addition of excess biosolids from the treatment plant to hold nitrogen loadings at 250 kg N/ha/yr to maintain existing farm productivity
  - i. Reducing overall nitrogen leaching losses by installation of cow-houses on the two Fonterra owned farms
  - j. Implementation of ‘duration controlled grazing’ (2 x 4 hour grazing periods) for the full milking season

The predicted (Overseer 6.0) combined annual nitrogen losses from the four farms comprising the expanded LTS decreased by 48% to 28 kg N/ha/yr as a result of the above changes (Figure 2).



**Figure 2. Predicted nitrogen leaching losses for the Fonterra Pahiatua land treatment farms as assessed in 2013 using Overseer 6.0**

#### **4. Outcome of consent process**

After a full council hearing, Horizons Regional Council granted a thirty five year resource consent for the treated wastewater irrigation (# 106632/1, 106633/1, 106634/1, 106635/1).

Conditions specific to nitrogen management in the new consent included:

1. Nitrogen loading limit of 250 kg N/ha/yr from all sources
2. Combined average annual nitrogen leaching rate (calculated by Overseer) across the four LTS farms of 28 kg N/ha/yr calculated as a five year rolling average.

Subsequent to the consent being granted and while the new factory and wastewater treatment system were being built, it was decided to implement an 'extensive' dairying system to reduce the capital expenditure associated with the proposed changes on the two Fonterra farms. These changes involved halving cow numbers to around 1.6 cows/ha and removing surplus grass as 'Cut and Carry' silage to be exported from the farms. The proposed changes were shown to be able to comply with the nutrient loss target (2 above) while still utilising the existing milking sheds and other dairying infrastructure on the farms.

This modification to the proposed farming system did not require a resource consent variation as it still met the target required. The farming system modifications have been made and the irrigation now installed. All systems are operating according to plan.

#### **5. Issues associated with the use of the Overseer model and the One Plan**

An issue with having nutrient loss targets written into the wastewater irrigation consent conditions is that version changes of the Overseer model mean that there is a risk of non-compliance resulting from significant calculation changes in leaching estimates (for the same input parameters). The changes in the irrigation sub-routines within Overseer resulted in major increases when the original files, created in version 6.0 were updated in version 6.2. Fortunately the resource consent allowed for review if this occurred. Significant work was required to update the original Overseer files so that they were applicable to the new model and associated changes to the data input standards. A request to change the consented nitrogen leaching limit was granted by Horizons Regional Council and it now sits at 33 kg N/ha/yr. The recent change to version 6.2.1 within the Overseer model had little effect, however the potential remains that the consent limit must be reviewed every time Overseer is updated to take account of the latest science.

A similar process is now occurring for the applications for the 'farming consents' for the four LTS farms. The consenting process is different from that for the wastewater irrigation consent in that there is 'farm-upwards' focus, although it is for exactly the same operation for both the farms and the wastewater irrigation. The base year for assessment also changes from an average of 2010/11 and 2011/12 seasons for the wastewater irrigation consent to the 2012/13 season for the farming consents. In addition, any farm run-offs must be included whereas they were not for the irrigation consent. In order to avoid duplicity, there is a need to ensure consistency of monitoring requirements between the two sets of consents, as the wastewater irrigation consent already requires intensive soil, surface water and groundwater sampling. Finally, there will likely be a discrepancy regarding consent terms, as Horizons have indicated a consent term of 15-20 years whereas that for the irrigation consent is 35 years.

## **6. Conclusion**

‘Step change’ improvements in nutrient management have been undertaken as part of the Fonterra Pahiatua factory expansion in order to meet regulatory requirements and public expectations. The improvements, focussing around full biological wastewater treatment and a low stocking rate dairy plus Cut and Carry farming system on the two Fonterra owned LTS farms, should see a decrease of over 40% in nitrogen losses. Changes to the Overseer model, by which compliance with the nitrogen leaching limit within the consent are calculated, must be assessed whenever the model is updated to take account of the latest science. Horizons One Plan requires ‘farming consents’ in addition to the treated wastewater irrigation consents which also cover the farming systems. These consents are now being processed.