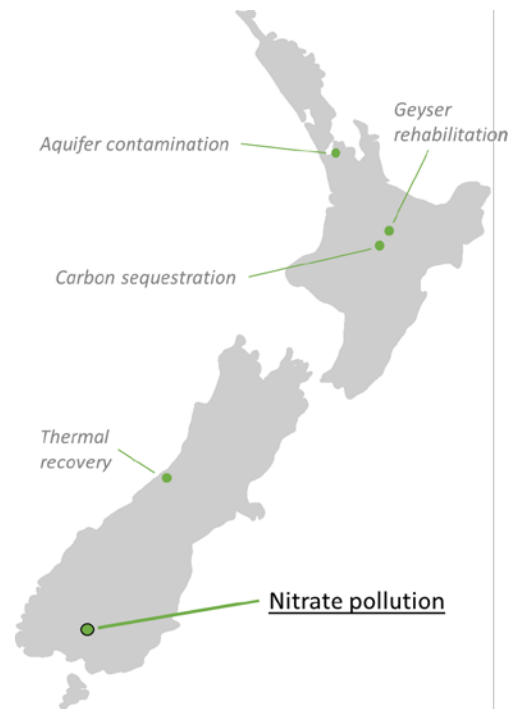


Nitrate leaching into Southland aquifers

Groundwater aquifers are massive volumes of porous rock from which we source freshwater for drinking or irrigation. This water is replaced over many millennia by the infiltration of rainwater and its slow percolation down pressure gradients towards the ocean. In their undisturbed state, the water in shallow aquifers has a low concentration of nitrate because this is filtered from the percolating rainwater by microbes in the soil. However, when there is intensive dairy farming, the rate of surface nitrate release (from fertilisers and cow pee) can overwhelm the microbes and leach into aquifers. Fortunately, most farmers carefully manage their stock to avoid such leaching.



In Southland, there are now 20 times more dairy cattle than there were 30 years ago. In some places, nitrate concentrations are climbing to harmful levels for both ecosystems and human consumption. If all farming practices were to cease, an aquifer will slowly recover: this is because fresh water entering at the high-pressure boundary of the aquifer will flush out the contaminated water at the low-pressure end. However, torpedoing the primary export industry and employer in Southland is unlikely to go down well with the electorate, so compromise and coexistence are the orders of the day. There are two interventions that can reduce nitrate leaching. First, modified farming practices like stocking away from waterways and redirection of runoff to active carbon sinks (wood chip layers) can cut the surface nitrate source. Second, a program of managed aquifer recharge (MAR), where freshwater is injected "upstream" to raise the high-pressure boundary, can increase nitrate flushing AND reduce new nitrate leaching from the surface.

Environment Southland are reviewing Dairy NZ's groundwater consent for a demonstration farm they own near Edendale. This farm is used for testing new agricultural practices and monitoring their environmental effects. For instance, in 2010 an extensive active carbon sink was installed on site, which Dairy NZ claim has led to reduced nitrate levels in groundwater. In the new consent, the applicant proposes to use MAR to further improve aquifer quality. The application is tentatively supported by Ngāi Tahu who hold a financial interest in several dairy farms, although they are concerned by displacement of nitrate into the nearby Maitai River from which their people harvest mahinga kai. You have been retained by Dairy NZ to conduct a computer modelling analysis of the nitrate leaching, addressing *both* the effectiveness of the 2010 intervention and the design of the proposed MAR program.

To support your study, the following data have been made available to you:

- Annual dairy cattle numbers in Southland, which is the best proxy measure available for nitrate release.
- Quarterly nitrate concentration measurements from a bore on the Edendale farm.
- Local groundwater reports indicating that the total pressure drop across the Edendale aquifer is about 0.1 MPa. Furthermore, nitrate transport across the soil layer appears to be driven by a 0.05 MPa surface overpressure (relative to the aquifer) with an unknown transit time. This means that there is a delay between changes in the nitrate source at the surface and nitrate input into the aquifer. Pressure effects are felt almost immediately.

Project expectations:

You should undertake a computer modelling study that will assist decision-making during the resource consent hearing, in particular addressing the noted concerns of other stakeholders where they are relevant to the study. The model you develop should be defensible, reflective of reality, and take appropriate account of uncertainty. You will be required to communicate the model findings in both oral and written formats.

Recommended literature:

Schipper, Louis A., S. C. Cameron, and Sören Warneke. (2010). Nitrate removal from three different effluents using large-scale denitrification beds. *Ecological Engineering* 36, 1552-1557.

Thomas N. (2012). Edendale Groundwater Model. *Pattle Delamore Partners Ltd, Report prepared for Environment Southland.*

Wilson et al. (2014). Estimating Time Lags for Nitrate Response in Shallow Southland Groundwater. *Lincoln Agritech Tech Rep, 2014-03.*