Destratification – Fact Sheet

Linking lake restoration with end users for positive environmental outcomes

LERNZ
Lake Ecosystem Restoration New Zealand

Artificial Destratification for Managing Lake Water Quality

During summer, the surface waters of lakes warm and become less dense than the colder bottom waters. This process is known as stratification and prevents surface and bottom water mixing. Stratification can occur intermittently in shallower lakes or for up to 9 months in deeper lakes (Figure 1). Under natural conditions stratification normally breaks down during the winter months when surface temperatures equilibrate with the bottom of the lake.

When lakes become stratified, dissolved oxygen can become depleted in the bottom waters due to bacterial respiration. As oxygen becomes depleted in the lake sediment plant nutrients such as phosphate and ammonium are released into the water column. When stratification breaks down during cooler months, the phosphate and ammonium are mixed through the water column and promote algal growth.

The aim of artificial destratification is to eliminate phosphate and ammonium build up in the hypolimnion and to provide a turbulent mixing environment that is less favourable for cyanobacteria which tend to be buoyant and proliferate under stratified conditions.

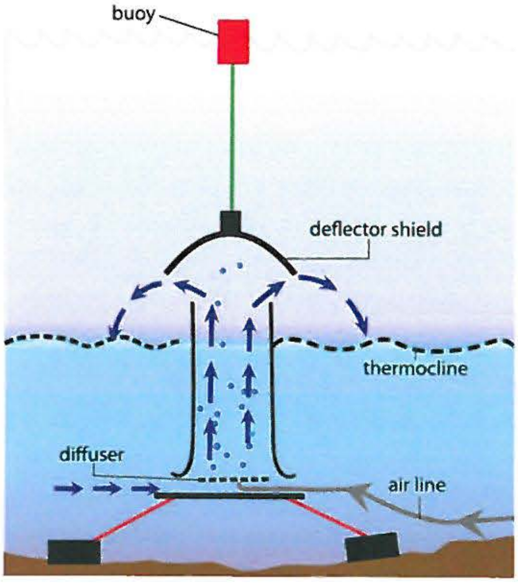
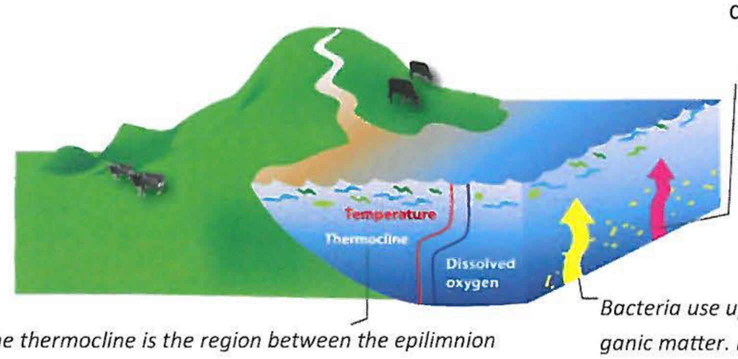


Figure 2. Conceptual diagram of destratification device in operation
Image: Wendy Paul

Aerators and mechanical mixers have been used to artificially break down stratification and oxygenate the hypolimnion (Figure 2). These devices function in two ways: aerators diffuse air into the water column near the sediment to increase dissolved oxygen levels in the hypolimnion. Alternatively, mechanical mixers use impellers to mix water from the epilimnion with water from the hypolimnion breaking down the thermal gradient and allowing mixing.



Phosphate release from the bottom sediments increases when overlying water become deoxygenated.

Bacteria use up oxygen and generate ammonium as they break down organic matter. Dissolved oxygen decreases in the hypolimnion during stratification and it can become anoxic.

The thermocline is the region between the epilimnion and hypolimnion where the temperature undergoes the greatest rate of change.

Figure 1. Lake stratification leads to oxygen depletion and release of nutrients from lake sediments.
Image: Wendy Paul

Artificial Mixing of Lake Rotoehu

Lake Rotoehu is comparatively shallow, with a mean depth of 8.2 m. During periods of low wind it becomes stratified and oxygen becomes depleted in the bottom waters. Since the 1990s, the lake has changed from mesotrophic (moderately productive) to eutrophic as nutrient inputs have increased with a shift to greater pastoral area in the catchment. With increased nutrient levels, cyanobacteria (blue-green algae) have become the dominant phytoplankton group during the summer resulting in lowered water clarity and potentially toxic algal blooms forming.

During the summers of 2012-13 and 2013-14 two artificial mixing devices were installed in Lake Rotoehu (Figure 3) in an attempt to prevent lake stratification formation. These devices, designed by Hans Burggraaf (Page Macrae Engineering) (Figure 4), utilise a novel approach whereby compressed air is used to entrain water from the hypolimnion and draw it to the surface. Unlike traditional aeration devices that attempt to oxygenate the hypolimnion, this new approach draws cooler hypolimnetic water to the surface where it mixes with warmer surface waters preventing the formation of different thermal layers. The advantage of this approach is that the majority of the compressed air can be recycled, reducing energy costs.

LERNZ researchers, collaborating with the Bay of Plenty Regional Council, NIWA and Tottori University in Japan carried out lake modelling and monitoring studies in support of this project. Modelling results provided support for site selection, capacity and design of the mixing devices (Figure 5). Extensive monitoring of the lake's physicochemical parameters and plankton communities was conducted between December 2011 and June 2015. It was concluded that the mixing devices were effective in drawing hypolimnetic water to the surface, resulting in localised homogenisation of the lakes' thermal layers.

Figure 3. A section of a destratification device prior to installation in Lake Rotoehu. Image: Andy Bruere

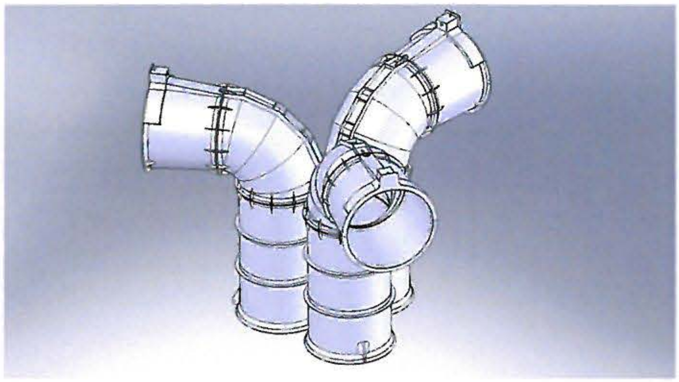


Figure 4. Plan diagram of a destratification device installed in Lake Rotoehu. Image: Hans Burggraaf

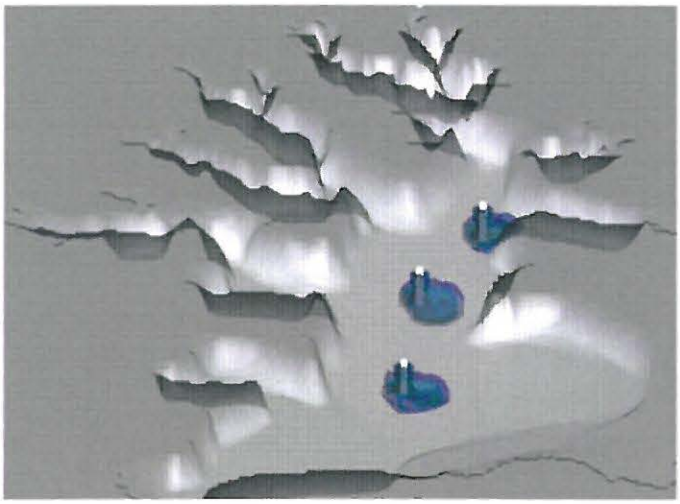


Figure 5. Model output showing three destratification devices in Lake Rotoehu Image: Kohji Muraoka