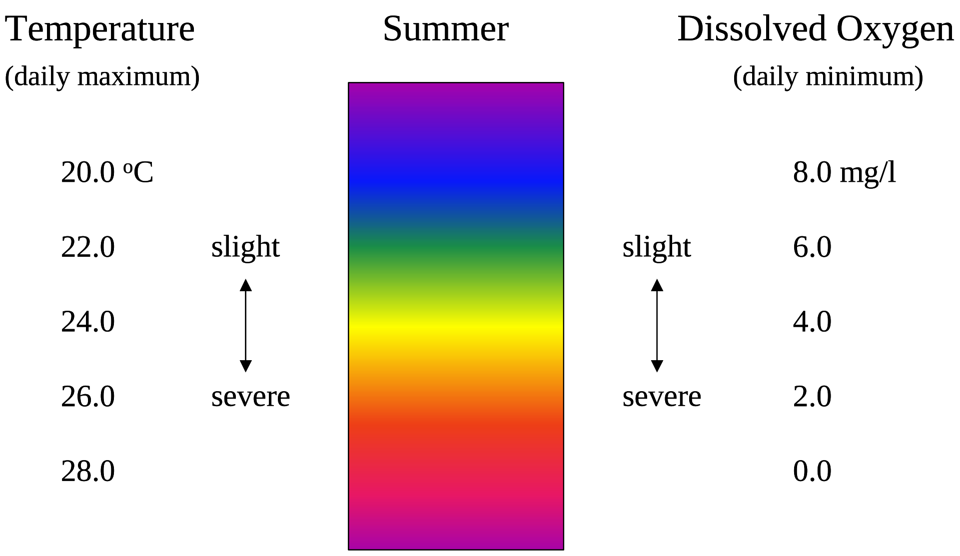
Maxted, J.R., McCready, C.H., and Scarsbrook, M.R. 2005. Effects of small ponds on stream water quality and macroinvertebrate communities. *New Zealand Journal of Marine and Freshwater Research 39*:1069-1084.

The Water Resources, Environmental Services, and Environmental Research sections of the Auckland Regional Council conducted research on the water quality (WQ) conditions in small ponds (rural and native forest catchments) and their effects on stream WQ and biota. The work has been published in a scientific journal (see above citation). The abstract can be viewed from the following web site. Subscribers to the journal may download the paper from this web site, and all other may view the paper from libraries (including the ARC library; 21 Pitt Street, Auckland) or by contacting the authors.

http://www.rsnz.org/publish/nzjmfr/2005/087.php

The work identified temperature and dissolved oxygen as key stressors affected streams with on-line ponds, and elevated temperatures persisted for hundred of metres downstream of ponds. The following illustration summarises the temperature and dissolved oxygen thresholds used in the data analysis.



above **slight** - no adverse effects
below **slight** - beginning of adverse effects, generally reduced growth and reproduction
between **slight and severe** – variable effects depending on the species sensitivity, exposure history and presence of other stressors
below **severe** – mortality of sensitive species and some tolerant species

Mechanisms elevating temperatures in ponds

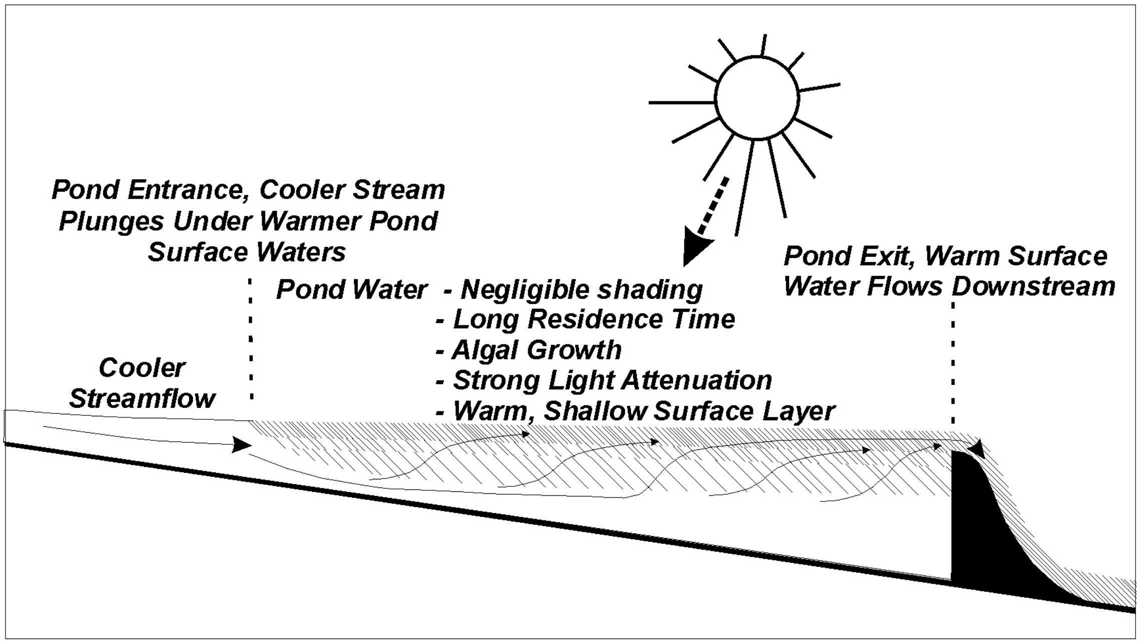
Dr. Robert Spigel, National Institute of Water and Atmospheric Research (NIWA, Christchurch) prepared the following analysis of the mechanisms that promote the heating of water in ponds.

While no systematic measurements were made of either water clarity or thermal stratification during this study, the reasons for elevated water temperatures are straightforward and well supported by classic text-book and research references in the limnological literature. The following explanation provides a context in which to view the more detailed results on water chemistry and biology presented in the paper (Maxted et al., 2005).

The hypothesised heating process is summarized in the sketch in the Figure below. Initially cool stream water plunges under warmer pond surface waters as the stream enters the pond, as a result of the increased water density associated with cooler water temperature (see, e.g., Wetzel 2001 p. 122, Fischer et al 1979, p. 209). As this inflow inserts itself at depth, it pushes the water above it upward, with the topmost layers forming the outflow over the dam crest. Incoming solar radiation, unhindered by any of the topographic or vegetation shading characteristic of the stream channel, is rapidly attenuated by dissolved and suspended substances in the pond water, thereby focusing the gain in thermal energy over a shallow depth and leading to a rapid rate of temperature rise, and hence a high daily maximum temperature excess in the pond over that of the inflowing stream. It is this warm surface water that supplies water for the downstream flow.

Empirical support for the above explanation includes the presence of thermal stratification (a shallow layer of warm water at the surface overlying cooler water at depth) always observed when retrieving and replacing datasondes and thermistors in the ponds, indicating that a thermocline existed above 0.5 m. If the average daily total incoming solar flux of 24.5 MJ $m^{-2}day^{-1}$ (NZ Meteorological Service 1983, Climate Station C74082, Auckland Airport; data for January) were distributed over a 0.5 m thick layer of water the temperature rise over a 12-hour period would be 11.7 ºC (see, e.g., Rutherford et al. 1999, equation B1). Accounting for energy losses due to evaporative and sensible heat transfer and back-radiation from the water surface would bring this figure well within the range of temperature changes observed in this study. Moreover, the presence of relatively high concentrations of dissolved humic substances (that lend Auckland stream water a brownish-yellowish color, even in protected bush catchments), high concentrations of chlorophyll and other suspended particulate matter found in the ponds, and plentiful solar radiation all combine to make the shallow heating that was observed inevitable (Davies-Colley et al., 1993; Kirk, 1994; Mazumder and Taylor, 1994).

Conceptual model of pond heating



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