

## **Attachment 4: Excerpt from NIWA report**

site in the Lower Benmore basin, where a model prediction of cold temperatures in the shallow areas of the Ahuriri Arm in August results in an underflow that maintains too-cold deep bottom temperatures for the rest of the year in the Benmore basin (RMSE 0.9°C, NRMSE 13%). The predicted profiles of dissolved oxygen are similarly good (RMSE 0.3-0.6 mg/L in surface waters, NRMSE 3-7%; RMSE 0.7-1.4 mg/L in bottom waters, NRMSE 6-17%), although there is a tendency to overestimate dissolved oxygen concentrations. The match between the measured chl *a* and predicted profiles is not as close as for temperature and dissolved oxygen, but this is not unexpected given similar findings in other model applications and the complexity of the processes involved. RMSE values from the time series are 0.2-0.5 µg/L in surface waters (NRMSE 28-30%) and 0.08-0.61 µg/L in bottom waters (NRMSE 46-104%); there was no tendency to consistently overestimate or underestimate the concentrations.

There are no measured profiles for TN and TP; only the time-series plots are available to give visual assessments (Appendix C, Figures C.4 – C.9). RMSE for TN are 21-71 µg/L, NRMSE 28-67%, with a tendency for the model to underestimate concentrations at most sites and most depths. RMSE for TP are 3-19 µg/L, NRMSE 59-152%, with a tendency for the model to overestimate TP in the deeper waters at the Benmore and Haldon sites, but underestimate TP at all depths at the Ahuriri site.

Because these error measures are based on a small number of data points they are sensitive to the possibility of being biased by relatively extreme events. For example, on 21 January 2009, the sample collected from 15 m at the Ahuriri site was unusually turbid with visibly high concentrations of suspended solids. Analytical results returned very high values of TN and TP for the sample. If the result from this single sample is removed from the error analysis, the RMSE for TN at this site and depth is reduced from 54 to 31 µg/L (NRMSE from 43 to 24%) and for TP from 12 to 4 µg/L (NRMSE from 96 to 29%). In this regard it is also of interest to compare the RMSE values of all variables at all sites and depths with the naturally observed variability in measured values, a measure of which is the standard deviation. Standard deviations for the samples are shown in Table F.1, and they are of similar magnitudes to the RMSE values.

Examination of the time series for chl *a* and for nutrient species (Appendix C, Figures C.4 – C.9) also gives us reason to consider that the model is performing well in terms of predicting patterns for all these variables. The most notable discrepancy is that for dissolved organic carbon (DOC), for which the measured in-lake values are consistently higher than the modelled values. DOC concentrations were not increased in the inflows as part of the scenarios, and we deliberately avoided adjusting model parameters for in-lake DOC following the advice of Dr C Howard-Williams, who felt that further attention is needed to confirm the laboratory analyses of DOC in these