Water Quality Technical Advisory Group (Rotorua Lakes)

Statement on climate change, lakes and water resources, Rotorua region May 2020.

1. Increases in concentrations of atmospheric carbon dioxide (CO_2) attributable to human activities are almost certainly responsible for increases in temperature from global climate change. The future climate will manifest as rising air temperature and alterations in the timing and distribution of rainfall.

2. Climate models provide the best quantitative tools to predict the extent of climate warming. Air temperature, averaged across a range of models and for seven locations across New Zealand, is projected to increase by 0.7 to 3.7°C by 2110. The variation represents model outputs from four different CO_2 emission pathways.[1]

3. Rotorua is in a region of moderate rainfall, with climate change projections indicating small increases in annual rainfall intensity based on dry regions of New Zealand becoming drier and wet regions becoming wetter. Seasonality of rainfall is expected to change, reinforcing wet seasons (winter-spring) and dry seasons (summer-autumn), and there will be increased frequency of extreme (e.g., 1-in-100 year return period) rainfall events. The frequency of large-scale climate oscillations like the El Niño-Southern Oscillation (ENSO) may be altered by climate warming.

4. Floods in the Bay of Plenty Region may be most damaging when short-term (hour-to-day) extreme rainfall events are interspersed within periods of more prolonged rainfall leading to saturated soil conditions. These events occur in a setting of different phases of the Interdecadal Pacific Oscillation (IPO) and ENSO. For example, coincidence of the La Niña phase of the ESNO, a negative phase of the IPO, and cyclones could lead to extreme storms.

5. Adaptation to climate change requires a *knowledge-to-action* approach that ensures anticipatory implementation of plans and policies that protect natural capital, infrastructure and assets, as well as human life. Government, NGOs and businesses will need to proactively engage with the community, build shared understanding of issues and the need for action, and allocate resources according to identified risks and the range of possible scenarios.

6. Increased flooding risk is one of the most important potential outcomes of climate change. It may compromise flood stopbanks, inundate built infrastructure around lakes and rivers, and cause agricultural economic losses. Washouts have the potential to destroy restoration actions related to establishment and protection of riparian areas, wetlands and detention bunds. Avoiding such occurrences requires strong alignment of preventative actions amongst property owners, businesses, and local and regional government.

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[1] Scenarios are based on the Intergovernmental Panel on Climate Change Fifth Assessment report. Future climate projections across several different models and for seven stations in New Zealand span a wide range of air temperature increases of 0.3–5.0 ^{o}C by 2110 compared with a baseline period of 1995. This variation corresponds to outputs using different representative concentration pathways of CO_2 from several different models. See: https://ccii.org.nz/.

7. Flood mitigation actions may include: optimising grass cover in pastoral systems; establishing well-designed networks of detention bunds and wetlands; provision of forest cover to mitigate rainfall whilst being vigilant with forest harvesting methods and timing; good land use and floodplain management plans including avoiding placement of infrastructure in flood-prone areas; and adoption of green infrastructure (e.g., vegetated swales and stormwater ponds) in preference to hard surfaces. Some of these actions may also be beneficial for water storage provision during drought.

8. Heavy rainfall and associated runoff increase sediment erosion and losses of particulate phosphorus. Their effect on nitrogen delivery is more variable but increased losses are also expected. Complicating factors include: how additional atmospheric CO_2 stimulates plant production and nutrient uptake; increased plant growth and microbial degradation rates from rises in temperature; and interactions of temperature with dissolved organic carbon delivery.

9. The effects of climate change on lake ecosystems may be profound due to increased water temperature and vertical stratification. Shallow polymictic lakes (Rotorua, Rotoehu and Rerewhakaaitu) are most vulnerable because a warmer climate will increase the frequency and duration of intermittent stratification events, which will increase the probability of bottom-water anoxia, nutrient releases from bottom sediments and availability of these nutrients to enhance algal growth upon re-mixing. The deeper monomictic lakes will have longer periods of seasonal stratification, which will also increase the risk of bottom-water anoxia (e.g., Lake Tarawera) or extend the duration of anoxia (e.g., Lake Rotoiti). There is a small probability that some deep lakes may not mix at all in winter, as noted in Lake Taupō in particularly warm winters.

10. Cyanobacteria (blue-green algae) have a number of physiological adaptations that provide them with a competitive advantage over other phytoplankton in a warming climate. For a given nutrient concentration it is likely that there will be increased incidence of blooms and toxin production by cyanobacteria. There are likely to be other 'winners' and 'losers' amongst the flora and fauna of aquatic systems under climate change. Several noxious alien invasive species (catfish, certain weed species, mosquito fish) are native to sub-tropical and tropical regions, and risks of their spread and growth are more likely in a warming climate. Increased surveillance, control and eradication efforts are likely to be necessary for these freshwater invaders. Conversely, habitat of trout, a 'cold-water' fish, may be diminished.

11. The Trophic Level Index (TLI) is used as the primary indicator of water quality for the Rotorua lakes and is linked to Lake Action Plans[2]. Based on model simulations for some lakes, TLI values can be expected to increase by approximately 0.2 units by 2090, more so in polymictic lakes. The Technical Advisory Group recommends a forward-looking approach to adopt emerging science and best-practice frameworks so that nutrient loads are proactively managed as an anticipatory action to ensure that TLI targets are met in the future.

[2] Bay of Plenty Regional Water and Land Plan (2014). Amended as required by National Policy Statement for Freshwater Management 2014.