HWP Waitohi Irrigation and Hydro Scheme

Additional Ecological Information

Aquatic Ecology Responses

Prepared for

Hurunui Water Project Limited

by

Boffa Miskell Limited

Boffa Miskell

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Introduction

Following the applications of the HWP Irrigation and Hydro Waitohi Scheme, Environment Canterbury has raised several issues related to the applications. Several of the issues relate to potential water quality and ecological effects. The following were identified as not being addressed in the application:

- The effect of water quality as a result of the inundation of farmland and vegetation.
- The effect of temperature on water quality from both the turbines and storage lakes (i.e. stratification over summer).

In this brief report the following is included in relation to each of the issues:

- a brief introduction as to what the issue is;
- a description of what has been typically done in New Zealand; and
- the rationale and considerations given to those aspects and reasons why it is considered the potential for adverse effects is low.

Lake stratification potential and Water temperature discharging from the the proposed Waitohi reservoirs.

The thermal stratification of lakes refers to a change in the temperature at different depths in the lake, and is due to the change in water's density with temperature. Cold water is denser than warm water and the epilimnion generally consists of water that is not as dense as the water in the hypolimnion.

In temperate regions where lake water warms up and cools through the seasons, a cyclical pattern of overturn occurs that is repeated from year to year as the cold dense water at the top of the lake sinks. This process occurs more slowly in deeper water and as a result, a thermal bar may form.

The accumulation of dissolved carbon dioxide, lower dissolved oxygen and particular types of bacteria (especially cyano-bactera) can potentially be dangerous because under certain conditions a large quantity of carbon dioxide or water without oxygen may quickly leave the lake and affect aquatic life downstream.

Stratification in proposed Waitohi Reservoirs

The constructed lakes on the Waitohi will likely be classified as type 3 lakes in terms of the lake environmental classification scheme of Snelder (2006) 1– i.e. small lakes in cool southern areas (the Hurricane Gully lake may classify as type 4 (medium sized in cool location)).

Lakes that are deep enough to undergo full seasonal stratification (monomictic lakes) are almost exclusively in classes 4, 5 and 7. (Snelder 2006). The few large, coastal lakes in class 6 are too shallow

[1] Snelder AH. 2006. Definition of a multivariate classification of New Zealand lakes. *NIWA Client Report CHC2006-084*.

and have too great a fetch to stratify seasonally, and most of the small lakes in classes 1 to 3 are too small for seasonal stratification. Such is expected to be the case in regard to the smaller Waitohi examples (Inches Road and Lower Gorge 1 Dams).

Furthermore, the upper two and larger inundation lakes (Hurricane Gully and Seven Hills) are likely to be too variable in their level as the regular draw downs and resultant water movement will reduce the potential for stratification.

However, brief intermittent stratification (polymixis) may be common in these larger lakes in winter, sometimes diurnally or sometimes irregularly, depending on solar radiation, wind and air temperature.

The Waitohi lakes are of areas and depths as follows:

Lake	Surface Area (ha)	Depth	Magnitude of draw downs (% of depth)	Chance of temperature stratification
Hurricane	787	100	50%	medium, short term
Seven hills	64	40	50%	low
Inches Road	36	30	75% (stage 1), less than 10% stage 2	low
Lower Gorge	6	20	minor	none

The primary potential issue is the discharge of deoxygenated or super carbondioxide waters, and possible cyano-bacteria laden waters into the lower Waitohi. Even if stratification occurs for a length of time to allow such water conditions to occur which is considered highly unlikely the released water will come from the "top" layer of three of the lakes. The exception is for the Inches road reservoir where in stage one the draw down is most of the lake and so the intake is near the bottom, and in stage two there will be three levels of intake. In general however, water is discharged from the lowest reservoir, from the "top", having passed through the other reservoirs (and so being mixed) and therefore the system is unlikely to discharge stratification caused poor quality water to the river.

So stratification is unlikely, serious adverse water quality related to stratification is unlikely and any discharge of stratified water to the lower Waitohi is highly unlikely.

Temperature differences in discharged water.

The potential issue:

There is, depending on solar radiation, wind, lake depth, stratification and "storage" period, a condition whereby lake waters are warmer in winter than nearby flowing (river) water, and cooler in summer than flowing river water. Releases of differential water temperature from a lake or storage reservoir to an independent waterway can result in adverse aquatic community responses. The temperature difference needs to be measureable and biologically relevant (3-5 degrees). Some overseas research has alluded to benthic community affects by confusing their migration and breeding cycles with changes in temperature e.g. Lehmkuhl (1972). In that research they found that

the kinds and numbers of ephemeroptera and other insects in the Saskatchewan River were greatly reduced downstream of a dam. That effect was attributed to changes in river temperatures caused by the reservoir. The river is warmed in winter and cooled in summer; consequently, mayflies and other insects with strict thermal requirements did not hatch and grow successfully.

This effect has not been recorded or reported in the New Zealand literature despite there now being roughly 32 hydropower and 10 water storage dams/reservoirs/lakes around the Country.

Applications for the Arnold, Coleridge, Waitaki, and Clyde dams did not address discharge temperature to the receiving river. The Wairau Hydroelectric Power application very briefly examined canal / power station discharge of water temperature differences to the lower (receiving) Wairau (Evidence of Dr Hudson[2]). His analysis was that water temperature varied seasonally, daily, and during the day. The natural seasonal range is almost 20ºC and the daily range is often 5 to 7ºC. Water temperatures are highly related to cloud cover and solar radiation, not stream flow per se. He predicted that the effects of the HEPS in a worst case summer was to increase the mean daily water temperature <0.7 ºC and the maximum daily water temperature by 1.7 ºC in the lower river.

In the Waitohi

For this scheme the dam engineers (Rileys) have advised that the effects of the turbines on the temperature are minor in comparison to the natural variations within the reservoir. An estimate of around 0.5^0C increase is predicted (Riley associates pers com) for the Hurricane Gully turbines and less for the turbines on the smaller dams.

The engineers have also advised that it is possible to include an intake that takes water from different levels to control temperatures, assuming that the lakes form any sort of stratification (which seems unlikely). From an ecological perspective we do not consider that such an approach will be required.

We state this because pertinent to the Waitohi situation is that the lower Waitohi River (the receiving environment), will be totally reliant on a constant release from the reservoirs (the minimal flow regime of at least 250L/S). That water, released as it is from the dams through the release mechanism) be it the turbines or from the dam, will already be, and by default reflect, the lakes water temperature (plus or minus half a degree). The differential therefore should be very small to nothing and the responses seen in the USA examples not witnessed.

We also note that (as recorded by Stevenson, Wilks & Hayward 2010[3]), hill-lower rivers have a temperature range from 0.2 to 24 degrees (Celsius). Also water temperatures in un-shaded shallow streams may rise to nearly 30°C in the peak of summer (MfE). We consider that the lower Waitohi (given measurements we made via temperature logger in the South Branch last summer), with such low flows as do currently persist will often be at this upper range (and greater) through summer. It is more likely cooler lake water in summer periods which is both consistently discharged via the

[2] Dr Henry Hudson 2007. Statement of Evidence in regard to the Trustpower Wairau HEPS.
[3] "An over view of the state and trends in water quality of Canterburies rivers and streams". Ecan Technical Report R10/117. Michele Stevenson, Taryn Wilks, Shirley Hayward November 2010, ECAN

residual flow but also for long periods for irrigation purposes (irrigation releases being larger than the 250L/s) will be beneficial rather than adverse.

We note that this is the case on Lake Sumner, a direct lake to river release, and the upper Hurunui remains a great fishery and habitat.

The NRRP addresses water quality for artificial lakes:

Objective WQL 1.2(3) sets minimum water quality outcomes for artificial lakes to ensure that these lakes do not become nutrient enriched, causing excessive algal growths or generating toxic contaminants. An artificial lake is one that has been created by human action and the surface area of water exceeds eight hectares at its minimum water level. Artificial lakes are created and managed for specific purposes.

They may be created on dryland sites, in valleys where there are ephemeral streams, or on permanently flowing rivers. These lakes may undergo significant physical and chemical changes after establishment as the lake evolves to an equilibrium state. This establishment phase may take several years or longer if there are significant areas of organic-rich soils that have been inundated.

Seasonal processes, such as temperature stratification, may also occur in areas sheltered from significant wind mixing. Sometimes, this stratification and subsequent lack of mixing of lake water may lead to the depletion of oxygen or anoxia in the cold, bottom-water zone (hypolimnion) of the lake, and the generation of toxic contaminants and soluble nutrients.

Objective WQL1.2 Natural and artificial lakes:

(1) For high country lakes,

(a) where the water quality is in a natural state, it is to be maintained in that state; and

(b) where the water quality is not in a natural state, the water quality is to be maintained or improved so that:

(i) it is suitable for contact recreation;

(ii) it is suitable as a habitat for indigenous species and salmonids;

(iii) it provides for Ngai Tahu cultural values, including mahinga kai;

(iv) the average annual phytoplankton biomass does not exceed five milligrams of chlorophyll a per cubic metre; and,

(v) there is no conspicuous change to the visual clarity of the lake.

It is our estimation, given the current rationale and knowledge of the reservoir operation and the quality of the receiving environment that WQL1.2 can and will be meet by the proposal

The effect of water quality as a result of the inundation of farmland and vegetation.

We have undertaken a literature review of this issue. Despite a number of quite prominent damming projects and the "drowning" of forests in both New Zealand (e.g. Manapouri) and Australia and the USA no reported research discusses or has measured the resultant water quality issues relating to the breakdown of drowned vegetation.

The breakdown of the grasses, shrubs and herbs present (some 900 ha) will result, as it must, in the release of carbon, Nitrogen, Phosphates and other minerals and more minor compounds. That will occur over a period of some time, Bassett et.al. 2010[4], suggests that that period would be greater than 10 weeks (based on results from *Isolepis* p*rolifer* and *Schoenoplectus tabernaemontani)*, and given the extent of fibre etc more like 4-7 months.

During this time some forms of littoral aquatic plant communities will be beginning to form and will begin to absorb this increasing nutrient, where it is available.

Much of the nutrient however, will adhere to and be kept at the bottom of the lake and will not be suspended into the "active" upper layers.

It is our opinion that the majority of nutrient resultant of the vegetation decay will be sequestered in developing lake vegetation, adhered to the substrate and little over long periods will be discharged to the Lower Waitohi.

We do not, in relation to the proposal to form four reservoirs, consider, also noting the existing nutrient issues in the low Waitohi, that it is likely that a biologically significant release of nutrients will occur because of the grassland / shrubland decay on the lake bottoms.

One option to limit this potential would be to burn off the vegetation to be inundated and to clear any large ash piles.

However, as noted we have searched the NZ Journal of Ecology and NZ journal of Marine and Freshwater Research, as well as other academic publication areas and have not revealed any New Zealand (or international) research on this phenomenon.

[4] Basset, I; Beggs, J; Paynter, Q. 2010 ; *New Zealand Journal of Ecology* (2010) 34(3): 324-331 © New Zealand Ecological Society.