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WATER TEMPERTURE CHANGES IN THE PROPOSED LAKE TEKAPO TO OPIHI RIVER CANAL AND THE EFFECT ON OPIHI RIVER WATER TEMPERATURES AND TROUT STOCKS

by

I.G. Jowett

Report to: Davie, Lovell-Smith

Freshwater Fisheries Centre

MAF Fisheries

PO Box 8324

CHRISTCHURCH

Servicing freshwater fisheries and aquaculture

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Enquiries to: The Librarian
Freshwater Fisheries Centre
PO Box 8324
Riccarton, Christchurch
New Zealand

Water temperature changes in the proposed Lake Tekapo to Opihi River canal and the effect on Opihi River water temperatures and trout stocks

Prepared by Ian Jowett
Freshwater Fisheries Centre
P O Box 8324
Christchurch
30 July 1990

Introduction

The proposal to divert water from Lake Tekapo to the Opihi River will alter water temperatures in the Opihi River. This study estimates the water temperature changes which would occur in the canal between Lake Tekapo and the Opihi River, the resultant water temperature when mixed with Opihi River water, and the possible effect on trout stocks.

Water temperatures vary diurnally, with a maximum in late afternoon and a minimum in early morning. The average daily water temperature is usually assumed to be the mean of the daily maximum and minimum. This study considers only average daily water temperatures in the summer months (December to March) for two sets of meteorological conditions - monthly average and average monthly maximum. This gives some idea of the sensitivity of water temperature to meteorological conditions.

Method

Mathematical modelling of water temperaure is based on well-known physical principles. This study used a water temperature model developed by the Cooperative Instream Flow Group (Theurer 1982) to calculate changes in daily mean water temperature from meteorological conditions, canal geometry and flow, and water temperatures at Lake Tekapo.

Data

- Lake Tekapo water temperature

Studies of water quality made by the chemistry division of the DSIR state that deep lake water temperatures vary from 12.0 to 13.1°C and that temperatures in shallow beach areas vary from 7.3 to 17.1°C. This study uses water temperatures recorded at the outlet to Lake Tekapo as most representative of the water temperature in the proposed canal. A sine curve was fitted to 27 water temperatures recorded throughout the year and temperatures estimated for December to March according to the formula:

$$T_i = \text{mean} + \text{amplitude} * \sin(2\pi t_i + 1.23)$$

where T_i is the water temperature at time t_i with $0 < t_i < 1$, with zero at the beginning of January and 1 at the end of December (Mosley 1982).

- Canal geometry and flow

The proposed geometry of the canal is a 3 m wide base with 2.5:1 batters and a water depth of 1.5 m at the maximum flow of 6 m^3/s. This gives a water surface width of 10.5 m and a mean water velocity of 0.6 m/s. The time taken for water to flow from the inlet at Lake Tekapo through the 19.4 km of canal to the Opihi River will be about 9 hours.

- Meteorological data

Meteorological data have been recorded at Lake Tekapo since 1925 and summaries of these data are available (e.g. N. Z. Meteorological Service miscellaneous publications 143, 177, and 115(17)). Meteorological data for Fairlie differed little from that of Lake Tekapo so unmodified Lake Tekapo data were considered to represent meteorological conditions along the canal line from Tekapo to the Opihi River. Wind data were taken from Fairlie records as none were available for Lake Tekapo and solar radiation was taken from records for Mt John. Table 1 lists the assumed meteorological conditions along the canal line for the months December to March.

Table 1. Summary of meteorological data.

	Dec.	*Jan.*	*Feb.*	*Mar.*
Average air temperature	13.5	14.8	14.8	12.9
Average maximum air temperature	26.6	28.4	28.1	25.8
Average maximum daily mean air temperature	20.5	21.9	21.4	19.6
Average ground temperature at 0.35 m	16	17	17	16
Mean sunshine hours	243	256	221	206
% possible sunshine	52	57	59	56
Average relative humidity %	59	58	63	70
Mean wind velocity (m/s)	1.60	1.71	1.66	1.28
Average daily solar radiation (MJ/m^2)	25.2	24.7	22.0	16.2

- Opihi River water temperatures

Water temperatures recorded at the Rockwood Bridge were analysed in the same manner as the Lake Tekapo temperatures to estimate mean monthly water temperatures from December to March.

Results

- Canal water temperatures

Under average meteorological conditions (Table 1), water temperatures in the canal increased by about 3°C from 14°C to 17°C as the water flowed from Lake Tekapo to the Opihi River. Under more extreme summer conditions, such as when air temperatures rose to the average monthly maximum, water temperatures increased another degree; to about 18°C (Table 2).

Table 2. Normal and maximum water temperature changes in the canal.

	Dec.	*Jan.*	*Feb.*	*Mar.*
Canal flow (m^3/s)	4.5	6.0	6.0	5.0
Canal water temperature at Lake Tekapo	13.9	14.4	14.1	13.1
Canal water temperature at Opihi under normal conditions	17.8	17.5	16.8	15.1
Canal water temperature at Opihi under maximum conditions	19.2	18.5	18.0	16.1

- Shading

Under conditions of high solar radiation such as occurs in the MacKenzie country, water temperature changes are influenced by the amount of shade. In this analysis, it was assumed that there would be little shading, so that temperature increases are relatively large. Canal bank shading would reduce the increase in water temperature by about 1°C.

- Opihi River water temperatures

The water temperature of the Opihi River after the Lake Tekapo water had mixed varied between 15°C and 17°C over the summer months, very little different to normal Opihi River water temperatures (Table 3). However, Opihi River water temperature during periods of low flow would be higher than at normal flow and addition of Lake Tekapo water would reduce water temperatures during this period. As water flows down the Opihi River, temperatures increase due to heating from solar radiation etc. so that the effects of any reduction in temperature caused by the diversion would gradually decrease.

Table 3. Opihi River flows (m^3/s) and water temperatures (°C).				
	Dec.	*Jan.*	*Feb.*	*Mar.*
Canal				
flow	4.5	6	6	5
water temperature	17.8	17.5	16.8	15.1
Opihi River (natural)				
flow	4.89	5.93	4.63	5.10
water temperature	16.5	17.6	17.0	15.0
Opihi River (augmented)				
flow	9.4	11.9	10.6	10.1
water temperature	17.1	17.6	16.9	15.0

- Effect on trout stocks

The estimated water temperature of the augmented river varies very little from existing normal summer water temperatures at normal flow. However, at low flows, water temperatures in the Opihi River would exceed those of the canal water and the addition of canal water would effectively reduce water temperatures to about 18°C. This would be beneficial to trout stocks. At water temperatures above about 20°C trout stop feeding. In the Opihi River, the MAF Fisheries drift diving survey noted that trout had congregated in the one large deep scour pool in the section of river surveyed. This congregation was assumed to be a response to high water temperatures and low flow. Increased flow and lower water temperature would encourage trout to utilise more of the river and maintain better condition through increased feeding. Angling opportunities would increase correspondingly.

References

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