POTENTIAL SOURCE OF COOL WATER FOR FISH FACILITIES IN THE COLUMBIA RIVER BASIN

by

George R. Snyder

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INTRODUCTION

In the past decade, fisheries agencies in the Pacific Northwest have stressed the need for supplemental fish production facilities where dams have inundated substantial sections of the natural spawning ground of salmonids.

One of the problems associated with the development of such facilities, particularly in the Columbia River drainage, is that of securing an adequate supply of suitable water for the fish.

The critical stages for fish appear to be the pre-spawning, spawning, and incubation periods, all of which are currently subjected to relatively high water temperatures if the river is the only source of water.

There is a definite need for optimum water temperature production at each hydroelectric dam site. Eight more dams either are planned for, or are being constructed on, the Snake River and two more for the Middle Columbia River. However, at this time the cost of mechanically cooling fish facility water appears to be prohibitive.

The following paper describes an existing nonmechanical cooling system and some physical characteristics of the water found in the system. A discussion of future application of this cooling technique is included.

WATER COOLING SYSTEM

At Chief Joseph Dam on the Columbia River, a unique structure called a relief tunnel today collects and discharges approximately 40 c.f.s. of water at an average temperature of 50° F. In addition, the relief tunnel is strategically located for use as either a hatchery or spawning-channel water supply, or both.

In comparison, Spring Creek Hatchery, the Bureau of Sport Fisheries' most productive salmon hatchery in the Columbia River Basin, discharges 6 to 8 c.f.s. at a constant 46° F. ($\pm$ 0.5° F.). In peak years, the Spring Creek Hatchery "take" exceeds 70 million eggs utilizing this cold water supply.

The Chief Joseph relief tunnel discharges cool water in an appreciable amount all year through a nonmechanical cooling system which purposefully intercepts and delays the groundwater flow. This system, which could benefit fish facilities planning

in that it has potential application to the Snake River drainage, was intended as a protective measure to reduce downstream structural damage.

According to Stinchfield (1958), the water moves into the relief tunnel from river seepage that enters the right bank 2,000 feet upstream from the dam (fig. 1). "Intercepted leakage of relief tunnel water is influenced by reservoir and tailwater levels; leakage has ranged from a maximum of 93 c.f.s. at first filling of the reservoir, to approximately 50 c.f.s. at the present time." An impervious blanket has been installed by the Corps of Engineers which extends 2,000 feet from the dam on the right abutment. The impervious blanket and the relief tunnel protect against excessive abutment seepage in lieu of a positive bedrock cutoff.

COOLING WATER CHARACTERISTICS

Temperature records from Chief Joseph Dam, January 1962 to May 1964, show that the relief tunnel and the Columbia River penstock intake water had about the same annual average temperature (table 1). The 2-year average difference was 1.3° F. However, the relief tunnel water ranged from 45.5° F. to 55.8° F., whereas the Columbia River water ranged from 36.5° F. to 64.4° F. These data are based on weekly comparable temperatures.

Water moves from the river at a permeability rate of 0.324 cm. per sec. to a 1200-foot collection tunnel. Moving from the collection tunnel, this water falls into a 4-foot discharge conduit that leads through the left training wall and enters into the tailrace.

The time lag between the river and the relief tunnel water is 3 to 4 months (fig. 2). This time-lag phenomenon would allow for a higher total quantity of water to be used in a fish facility operation; i.e., cold river water can be added to a warmer relief-tunnel water in February and March, and cold relief-tunnel water can be added to warmer river water during July, August, September, and October. This mixing of river and relief tunnel water could almost double the present average discharge of 40 cubic feet per second while maintaining a constant 50° F. year-round temperature.

FUTURE APPLICATION

In order to consider the potential application of this structure to other sites, answers must be found to the following

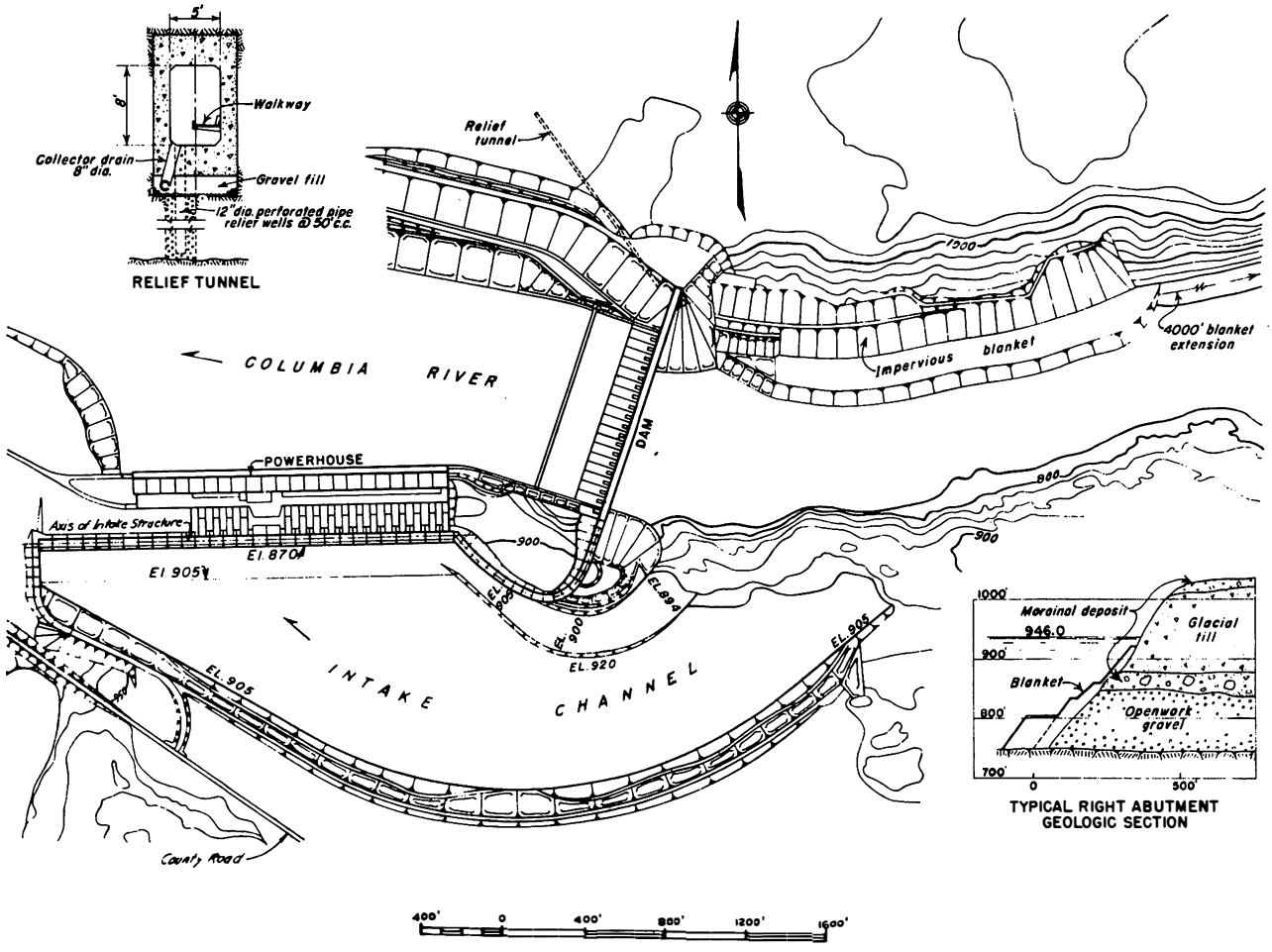

Figure 1.--General layout of Chief Joseph Dam with details of impervious blanket and relief tunnel required to control seepage in the right abutment.

Table 1.--Chief Joseph Dam "relief tunnel", average monthly temperature and discharge for 1962-1963.

Date	Average tunnel discharge	Average tunnel water temperature[1]	Average Columbia River temperature[2]
1962	c.f.s.	°F.	°F.
January	41.8	48.2	53.2
February	39.1	55.8	37.4
March	39.6	54.0	36.5
April	39.3	49.0	41.0
May	39.1	48.0	47.5
June	41.5	45.5	53.6
July	42.5	46.4	57.6
August	41.9	46.4	61.5
September	40.0	48.6	62.6
October	39.2	50.0	61.2
November	41.7	53.2	56.5
December	41.1	53.6	57.4
1963			
January	39.7	55.4	43.7
February	39.5	54.9	38.3
March	38.2	53.1	37.8
April	37.2	51.8	42.4
May	37.9	48.2	49.1
June	40.89	46.8	55.4
July	38.9	46.4	60.1
August	38.7	46.8	62.6
September	38.2	48.6	64.4
October	38.9	51.3	63.0
November	39.1	54.9	58.3
December	40.3	55.0	50.7
Averages			
1962	40.6	49.8	51.6
1963	38.9	51.4	52.2
2-year	39.8	50.6	51.9

1/ Water analysis of the relief tunnel water has been carried out by Douglas County Public Utilities District, according to George Atwood, Plant Superintendent, and has been found to be pure and usable for drinking purposes.

2/ Penstock intake.

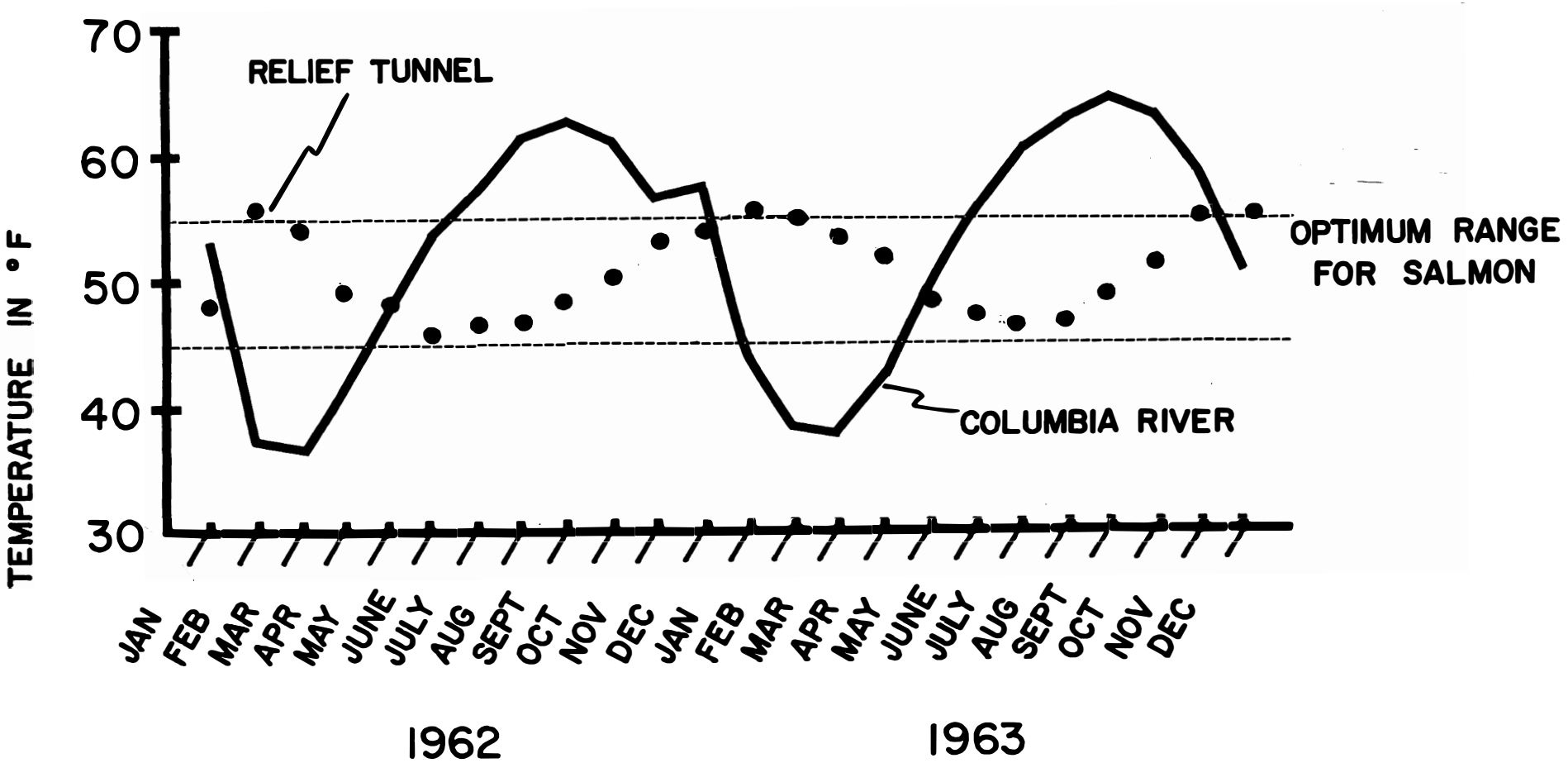

Figure 2.--Average monthly water temperatures, Chief Joseph Dam, 1962-1963.

questions: (1) What specific geologic structure is producing this cool temperature and uniform flow condition? (2) Does this structure have application to other hydroelectric sites or is it unique to Chief Joseph Dam? (3) Is it possible to predict the temperature and flow characteristics of such a relief tunnel at other sites?

LITERATURE CITED

Stinchfield, William S.
1958. Chief Joseph Dam. Reprint of an article prepared for the 6th International Congress on Large Dams. U.S. Army Corps of Engineers, Seattle District, p. 1-4.

ADDENDUM

Ice Harbor Dam, Snake River Mouth, Average Monthly Water Temperatures, May 1962 - April 1964.

Month	Average Snake River water temperature 1962 °F.	1963 °F.	1964 °F.
January		37.5	38.6
February		38.1	38.0
March		44.2	40.8
April		49.6	47.5
May	53.9	55.0	
June	59.2	60.6	
July	69.3	68.3	
August	73.5	73.3	
September	68.3	69.5	
October	58.8	63.3	
November	50.5	50.2	
December	44.7	41.3	
Average	59.8	54.3	41.2

24-month average 53.9° F.

Possible tunnel water range, 49.1 -- 57.9° F.