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A FORECAST OF TEMPERATURE CONDITIONS IN THE OXBOW AND LOW HELLS CANYON RESERVOIRS AND IN THE SNAKE RIVER BELOW HELLS CANYON DAM

by

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ABSTRACT

A table is presented of the predicted average annual temperature for discharge water from Oxbow and Low Hells Canyon Dams. Forecast computations are for a median river flow year. The net effect of these two reservoirs on the thermal structure of the river will be small.

INTRODUCTION

This is the fifth report in this series dealing with water temperatures in the Snake River Basin.

Technical Report No. 1. A Preliminary Estimate of Temperature Conditions in Brownlee Reservoir and in the Snake River Below Brownlee Dam. July 18, 1957.

Technical Report No. 2. Evaluation of Snake River Basin Thermograph Program for Reservoir Temperature Studies, September 25, 1957.

Technical Report No. 3. Results of Trip to Snake River on 4 October 1957. October 12, 1957.

Technical Report No. 4. A Second Forecast of Temperature Conditions in the Brownlee Reservoir and in the Snake River Below Brownlee Dam. October 31, 1957.

The present report completes preliminary predictions for water temperature conditions for all three of the Idaho Power Company's plants---Brownlee, Oxbow, and the Low Hells Canyon. It is planned that similar predictions will be completed during the next several months for the two plants which are under consideration by the Pacific Northwest Power Company, Pleasant Valley and Mountain Sheep.

The forecast predictions for each reservoir depend on the accuracy of the forecasts which have been made for upstream reservoirs. With each succeeding reservoir, the range of accuracy necessarily decreases.

However, the relative change which each reservoir contributes to the temperature structure of the river may be forecast with better accuracy than the actual temperature structure itself. This is particularly true for the run-of-the-river plants considered in the present report.

OXBOW RESERVOIR

The projected Oxbow Dam and reservoir is classified as a run-of-the-river plant similar to other low dam and reservoir systems such as Bonneville and Rock Island on the Columbia River.

The planned regulated river flow data for a median flow year for discharge through Brownlee Dam (Idaho Power Company, July 6, 1957) was compared to the predicted average volume of Oxbow Reservoir. It was found that a volume of water equal to the full volume of Oxbow Reservoir would flow through the reservoir on an average of once each 1.3 days during each of the seven months from November through May. During August, the month with the lowest predicted regulated flow, it would take only twice this long, or 2.6 days, to replace the water in the reservoir.

The penstock inlet in Oxbow Dam is to be just above the mid-depth of the reservoir. The top of the inlet is less than 25 feet from the normal pool surface elevation. Less than 6% of the volume of the reservoir is more than 25 feet below the bottom of the penstock entrance.

The relatively shallow depth of 100 feet, and the mid-depth location of the penstock entrance combined with the very rapid rate of flow through the reservoir will produce a turbulent flow regime in the upper 75 feet of the reservoir above an elevation of approximately 1725 feet. This regime in turn will produce an essentially homogenous temperature structure both vertically and horizontally throughout the reservoir above approximately 1725 feet at any given time. It is possible that manipulations of flow through Brownlee may set up small transient gradients at times. A vertical temperature gradient of several degrees may occur in the bottom 4% or 5% of the reservoir below an elevation of approximately 1725 feet.

The predicted water temperatures from Report 4 of this series of reports was used as a starting point in the forecasting computations for Oxbow Reservoir. This prediction was for a median or slightly over a median flow year.

The heat budget which was computed for heat crossing the water surface of Brownlee Reservoir was recomputed to take into account the slight change in latitude between the reservoirs. The cloud cover, wind, and other data were extended back in time in order to have a broader base for determining means for the heat budget. The difference between the predicted surface temperature cycle for Brownlee's Reservoir and the cycle for the water entering Oxbow Reservoir from Brownlee was also taken into account in the new computation.

The mean rate of heating or cooling through the surface of Oxbow Reservoir was computed for each five-day period throughout the year. This heat increment was added to, or subtracted from, the volume of water which would pass through the reservoir each five days. Knowing the temperature of the entering water, the temperature of the water leaving the reservoir was next computed. Then, the predicted temperatures were plotted, taking into account the average time it will take water to pass through the reservoir during each five-day period. This plot gave the forecast temperature of the water leaving the dam. The results are presented in

Table 1. Note that the maximum temperature change between the water below Brownlee Dam and below Oxbow Dam has been forecast at less than half a degree Fahrenheit for any given date.

LOW HELLS CANYON DAM

Low Hells Canyon Dam and Reservoir is also to be a run-of-the-river plant. The designed depth and volume are considerable greater than those for Oxbow. The situation for Low Hells Canyon Reservoir is also more complicated than for Oxbow Reservoir, due to the designed penstock gate house at the surface. The greater depth and volume combined with surface withdrawal should result in some vertical thermal structure in the Low Hells Canyon Reservoir.

The reservoir was divided into 50-foot layers from the surface downward, similar to those used in the computation for Brownlee (Report 4). After some trial to determine possible withdrawal rates from the layers, the following arbitrary picture was examined. 75% of the draw was assigned to the surface 50 feet. Draw from the other layers was taken as proportional to the reciprocal of the mean distance from the center of the layer to the center of the surface layer times the mean area of the layer. (This is almost identical to the arbitrary system used for computation on Brownlee Reservoir at minimum pool elevation where 77% of the draw was assigned to the top 56-foot layer.) According to this arbitrary estimate, 75% of the discharge would be drawn from the surface layer; 21.6% from the next layer; and only 3.1 and .3% respectively from the next two layers.

Considering the regulated flow rate of the river and the volume of each layer, it was found that for the seven months from November through May, the top layer would be replaced 1.16 times (116%); the second layer

70%; and third and fourth layers 35% and 26% during each five-day period. For the low flow month of August, 61% of the top layer would be replaced each five days and 37%, 18%, 13%, of the other three layers.

With this arbitrary assignment of discharge from the various layers, only 3.4% of the discharge comes from the bottom two layers (100 feet) and thus the temperature of the bottom half of the reservoir could not materially affect the discharge temperature. The top two layers with 96.6% of the discharge would be replaced from .37 times to 1.16 times each five days with an average replacement time of approximately 7 days. The above indicates a rapid rate of turnover in the surface layers which would control the outflow temperature. Assignment of higher rates of withdrawal from the bottom 100 feet, to say 20% of the total withdrawal, would mean that these bottom waters would be replaced in an average time of less than a week.

No consistant combination of estimated withdrawal rates from different depths changes the fact that any depth that furnishes enough water to effect the outfall temperature will have its waters rapidly replaced with new water coming in at the top of the reservoir.

For this reason, detailed computation with set withdrawal rates from each layer was not carried out. Instead, the following two sets of computations were carried out:

1. A turbulent regime was considered with thorough mixing throughout the reservoir. The heating or cooling through the surface was applied to all the water passing through the reservoir. The travel time was computed on the basis of the volume of the reservoir at normal pool elevation and the predicted regulated river flow through Brownlee Dam. The temperature of the outflowing water was computed on these assumptions.

2. In the second approach, it was considered that turbulence extended down to 50 feet below the surface and that all withdrawal was from this top 50 feet. All heat exchanged with the atmosphere was considered to flow into or out of the top 50 feet. Next, the temperature of the outflowing water was computed on these assumptions.

The resulting two sets of forecast temperatures were compared for each five days for the whole year. The maximum temperature difference between the two sets of computations was 0.7°F. This indicates that the surface layer practically controls the temperature changes in the reservoir. The mean values between those of the two predictions were computed and placed in Table 1 as the predicted temperatures for the water leaving the dam. No consistent method of computation based of different possible withdrawal regimes could change the predicted temperatures by as much as a whole degree. By a consistent withdrawal regime, it is meant that if a given percentage is taken from a given depth at one time, it must also be taken from the depth at all other times during the period of computation.

LOW HELLS CANYON TEMPERATURE DEPTH PROFILES

Computations were not made to forecast the temperature depth profile for Low Hells Canyon Reservoir. The surface temperatures should be close to the predicted temperatures for water leaving the reservoir (Table 1). From similarity to Brownlee, Owyhee, and Grand Coulee Reservoirs, the water column will probably be isothermal from the surface to the bottom from October 1 through February. The surface layer should be nearly isothermal down to 50 feet for the rest of the year. A gradual 5 to 10°F gradient should extend from the 50-foot level to the bottom. This gradient below 50 feet will vary greatly from year to year, depending on the river flow. It will be most marked during years with relatively low flow during the critical months of April, May, and June

Date	Below Brownlee	Below Oxbow	Below Hells Canyon
Jan. 1	39.0°F	38.7°F	38.5°F
11	39.0	38.8	38.0
21	39.0	38.8	38.2
Feb. 1	39.0	38.9	38.5
11	39.0	39.0	38.8
21	39.0	39.0	39.1
Mar. 1	39.4	39.4	39.4
11	40.0	40.1	40.2
21	42.3	42.0	41.8
Apr. 1	44.9	44.7	44.2
11	48.1	47.9	47.5
21	50.7	50.6	50.3
May 1	53.3	53.2	53.2
11	55.0	55.0	55.3
21	57.0	56.9	57.2
Jun. 1	59.6	59.6	59.7
11	61.5	61.6	61.9
21	63.5	63.6	63.8
Jul. 1	65.6	65.8	65.8
11	67.1	67.3	67.4
21	68.3	68.4	68.4
Aug. 1	69.3	69.2	69.2
11	70.2	70.0	69.4
21	70.7	70.4	69.9
Sep. 1	70.6	70.3	69.8
11	69.9	69.6	69.3
21	68.5	68.4	68.3
Oct. 1	66.1	66.0	66.0
11	62.8	63.0	63.4
21	60.6	60.6	60.3
Nov. 1	57.2	57.2	57.5
11	54.3	54.2	54.3
21	51.2	51.2	51.3
Dec. 1	48.1	48.2	48.2
11	45.1	45.1	45.3
21	42.0	42.2	42.5

Table 1.

Predicted water temperatures below Brownlee, Oxbow, and Low Hells Canyon Dams for a median flow year.