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Date 3-1-46

Subject Prelim. Report - Col. River Temperature

Survey at Hanford Engineer Works

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MARCH 1, 1946

PRELIMINARY REPORT
COLUMBIA RIVER TEMPERATURE SURVEY
AT HANFORD ENGINEER WORKS

Introduction

It was agreed during a meeting on July 10, 1945 attended by Major A.A. White, L.R. Donaldson, H. Thayer, E.F. Foster, M.M. Smith, G.T. Cantril, and C.P. Kidder that an investigation should be made by the Technical Department to determine how fast and in what fashion the temperature of the effluent water from the 100 Areas is dissipated in the Columbia River. A preliminary report on this investigation is submitted herewith for review by interested parties.

Summary

Data on the quantities of heat added to the water, on the quantities and temperatures of water returned to the river from the plants, and the known river flows indicate that the three 100 Areas heat the river less than 0.30°C at minimum recorded river flow, and less than 0.01°C at the maximum recorded river flow, after complete mixing with the river. A temperature traverse of the river at B Area on September 14, 1945 made continuously across the river at one foot, five feet, and ten feet depths indicated that all temperature effects attributable to the addition of warm water from a 100 Area had been leveled out to less than 0.2°C after the first 1500 feet of flow. Although the temperature gradients caused by the addition of warm plant water are definite and reproducible within the first 1500 feet, they are minor in comparison with temperature variations observed from hour to hour, and from point to point due to solar heating effects. The sole exception to this generalization is the space within the immediate vicinity of the warm water outlet. Theoretically, it is possible to obtain spot samples of water here 20°C above the river temperature, but these higher temperatures are reduced very rapidly by mixing with river water, and under no conditions form a temperature barrier across the river.

Discussion

The Columbia River normally is at its lowest stage during February, March and April. The spring rise starts in May and the crest is reached usually in June. The flow then drops off gradually for the remainder of the year.

This past year, the crest was reached on June 7, with a flow of 340,000 cu.ft./sec. The lowest flow was 37,000 cu.ft./sec. on February 5 and again on March 5. The lowest flow of which we have a record was 25,500 cu.ft./sec. on January 30, 1931. The highest crest on record was 740,000 cu.ft./sec. in June, 1894.

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For the present operating rates, which probably will be maintained, the three 100 Area plants return to the river a total of 170,000 G.P.H. (378 cu.ft. per sec.) of water heated about 20°C above the river temperature. This quantity of warm water will heat the normal 75,000 cu.ft. per sec. flow of the river a total of

$$\frac{378 \times 20}{75,000} = 0.101^{\circ}\text{C}$$

The minimum recorded flow would be heated 0.30°C and the maximum recorded flow would be heated 0.01°C. The maximum heating effect due to any one area is less than 40% of the above totals for the three 100 Areas.

This survey of temperature in the vicinity of the warm water discharge lines is being made to determine the rapidity and manner in which the warm water mixes with the river, to permit an appraisal of its effect, if any, on fish life in the river.

At each of the three 100 Areas the warm water is introduced into the river through two parallel submerged 42 inch diameter pipes. These pipes are buried in the river bottom and extend out to discharge in the main channel of the river. At B Area, the discharge is about 400 feet out from the south bank; at C Area, the pipes extend out beyond a small island to a point about 1500 feet from the south bank; at V Area the channel is close to the southwest bank, and the discharge is out only about 100 feet from the normal water line on that bank.

Air is entrained with the warm water entering the discharge pipes. The velocity of water in the pipes is not sufficient to keep this air dispersed as small bubbles, and as a result huge air bubbles and surges of water are released alternately from the discharge end. Observations made when the discharge water had coloring matter added to it showed that the air bubbles came to the surface at a steep vertical angle, but that the inertia of the water surges carried the warm water 25 to 30 feet farther out into the river. The resultant alternating surges of warm water out of the discharge pipes result in rapid temperature fluctuations in the immediate vicinity of the discharge, but 200 feet or more downstream, conditions have evened out to such an extent that little fluctuation can be detected.

Two general types of temperature measuring equipment have been developed for surveying these conditions:

For obtaining "spot" samples in the vicinity of the discharge, a 100cc. flask with insulated side walls and quick-opening lid, mounted on a 20 foot pole was used. The temperature of samples obtained with this equipment was read with a glass thermometer with an overall accuracy estimated as better than 1/2°C. Results of a survey made with these facilities April 2, 1945 at 100F Area when the river flow was 43,000 cu.ft. per sec. are reported in Document 3-2401. Several samples as warm as 3.6°C above ambient river water temperature were obtained 50 feet downstream from the discharge. It is difficult to maneuver the boat to stay immediately over the discharge, but it is reasonable to assume that if this were possible, "spot" samples 10 or 1500 above ambient river temperature might be obtained at the instant a surge of water 20°C above ambient temperature left the discharge.

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For exploring over wide areas in which the temperatures are stable for periods of five seconds or longer, a special high-speed response resistance thermometer has been developed. This instrument is described in more detail in the attached discussion. Two other designs were constructed and tested on this survey before this final instrument was perfected. The temperature sensing element is mounted on a torpedo shaped weight or paravane which maintains a constant depth while being towed through the water. This instrument permits temperature readings with an accuracy of better than 0.1°C to be made with a time of response of 3 to 5 seconds. This time of response is sufficiently rapid that surveys can be made as fast as the boat location can be checked. However, when the instrument is used immediately downstream of the discharge, the indicator may oscillate up and back as frequently as 4 or 8 times during a 10 second period. When exposed to temperature fluctuations of this rapidity, the average of the temperatures indicated over a 10 second period probably is an accurate average of the true temperatures, but the maximum and minimum values indicated would not give the true width of variation being experienced. For this reason, the "spot" sample method is considered the more accurate method for determining the limits of temperature variation from second to second in the immediate vicinity of the discharge. The resistance thermometer is more accurate in locating bands of small temperature difference, and in differentiating solar heating effects from effects of the warm water discharge.

Data obtained at A Area with the resistance thermometer September 14, 1948 when the river flow was 77,000 cu.ft. per sec. are given in the attached appendix. Preliminary surveys have also been made at B and F Areas with the resistance thermometer instrument in various stages of development, but these data are not reported because they are not as complete as those obtained at A. However, no conditions differing markedly from A were found at B or F.

With the resistance thermometer, it was possible to trace the slightly warmer water downstream as a definite band in the river. The temperature differences were small, but could be accurately measured, and the findings could be reproduced on check surveys. The band was less than 100 feet wide at a distance 500 feet downstream of the warm water discharge, and the warmest water in the band at that distance was 1.0°C above the ambient main channel temperature several hundred feet farther out in the river. Within the band there appeared to be very complete mixing in a vertical plane. Beyond 500 feet downstream, temperatures at any boat location checked within 0.1°C at 1-foot depth, 5 foot depth and 10 foot depth.

At a distance of 1592 feet downstream of the discharge, the band was about 100 feet wide and the warmest water in the band was 0.4°C above the temperature of the main channel alongside on one traverse, and 0.6°C above ambient main channel temperature when the same traverse was repeated several hours later. (This is considered a good check of results between the two traverses several hours apart).

At a distance of 2753 feet downstream the band was slightly more than 100 feet wide and at the warmest point was 0.3°C above ambient main channel temperature. Downstream 4800 feet or 0.927 miles, the band could still be detected. It was about 200 feet wide but at its warmest point was less than 0.2°C above the ambient temperature of the main channel.

Although the above described temperature effects within the band were definite and reproducible, they were small in comparison with the variations found from hour to hour and from point to point due to solar heating effects.

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The ambient water temperature in the main channel increased 0.7°C between 8:30 A.M. and 3:30 P.M. At 8:30 A.M. the more slowly moving water next to the bank was 0.1 to 0.2°C cooler than the main channel, but as the day progressed, it heated rapidly so that by 3:30 P.M. the water next to the banks was 1.0 to 2.0°C warmer than the main channel at that time. That is, the normal profile of the temperatures across the river inverted between early morning and mid-afternoon. In some places, the mid-afternoon temperatures were 2.0°C warmer than at the same spot in the morning.

The existence of these rapid temperature changes due to solar heating effects demonstrates the utility of this temperature measuring device which permits rapid traverses to be made. Without it, it would be very difficult to pick out a temperature band only 0.2 to 0.4°C warmer than an ambient temperature varying 0.7°C during the day.

In making the temperature traverses, two range flags were placed on the bank of each station where a traverse was desired. The boat was maneuvered up or downstream as necessary to keep these two flags in line. The distance of the boat from the bank was determined by means of a transit on the bank sighting on a stadia rod on the boat. The desired measurement was set on the stadia rod and a flagman by the transit signalled the boat in or out as necessary to obtain the desired location.

Soundings for river depth were taken at 100 foot intervals along the range lines. These soundings were tied in with the river elevation as measured at the area pump house, so that the same soundings can be revised as necessary to compensate for changes in river elevation.

In making the temperature traverses, readings were taken in a continuous traverse across the river at one foot depth, then back at 5 foot depth, and then across again at 10 foot depth when necessary. Readings were taken at 100 foot intervals if the readings were constant or proceeding uniformly up or uniformly down. When fluctuations occurred between readings, the maximum or minimum temperature was noted also.

Graphs showing the elevation of the Columbia River during the high and low months of the year 1945, together with a graphical and tabular presentation of the data obtained during this river temperature survey are given as the attached Appendix A, B and C.

C. P. KIDDER, ASST. CHIEF SUPERV.
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R. H. Osterloh
100 Technical

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Appendix A - Sheet 1

Columbia River Temperature Survey

100 B Area

September 14, 1948

Measurements made in line with upstr. warm water discharge pipe

Distance out from R.M. on South Bank	River Depth*	Temperatures - °C			
		← 9:15 to 9:25 AM →		← 2:25 to 2:55 PM →	
- Feet -	- Feet -	1 ft. Deep	5 ft. Deep	1 ft. Deep	5 ft. Deep
100	5.3	17.6	17.6	18.8-	18.6
200	11.0	17.7	17.7	18.4-	18.4
300	12.3	17.7	17.7	18.4-	18.3+
400	12.4	17.7	17.7	18.3	18.3
500	13.1	17.7	17.7	18.3	18.3-
600	16.3	17.7	17.7	18.3	18.2+
700	19.9	17.7	17.7	18.3-	18.2+
800	17.4	17.7	17.7	18.3-	18.2+
900	16.3	17.7	17.7	18.3-	18.2+
1000	14.7	17.7	17.7	18.3	18.2+
1100	12.8	17.7	17.7	18.4-	18.3
1200	10.8	17.7	17.7-	18.6	18.4
1300	10.6	17.8+	17.8	19.0	18.7
1400	6.8	17.4+	--	19.4	--
1500	Opposite Bank	--	--	--	--

* River Elevation 537.2 feet above mean sea level at 100 B Pump House. River Flow 77,000 C.F.S.

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Appendix A - Cont'd.

Columbia River Temperature Survey

100 S Area

September 14, 1948

Measurements 580 Feet Downstream of Warm Water Discharge Pipe

Distance Out from B.M. on South Bank	River Depth	Temperatures - °C			
		← 9:45 to 10:05 AM →		← 2:25 to 2:40 PM →	
- Feet -	- Feet -	1 ft. Deep	5 ft. Deep	1 ft. Deep	5 ft. Deep
100	11.2	17.6	17.7	19.3	19.0
200	12.1	17.7	17.7+	18.5	18.8
300	14.3	17.7	17.7	18.3+	18.8
400	16.0	17.7	17.7	18.5	18.3
500	22.4	18.5	18.7	max. 19.2	19.2
600	20.3	17.7	17.7	18.5	18.8
700	17.3	17.7	17.7	18.3-	18.2+
800	12.0	17.7	17.7	18.2+	18.2+
900	↓	—	—	18.2+	18.2+
1000	↓	17.7	17.7	18.2+	18.3-
1100	Less than 6.0	—	—	—	18.3
1200	and too swift	17.7	17.7	18.4-	18.4
1300	for soundings	17.7	—	—	18.6
1400	↓	—	—	18.6	19.3
1450	Opposite Bank	—	—	19.6	—

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Appendix A - Cont'd.

Columbia River Temperature Survey

100-B Area

September 14, 1948

Measurements 1502 Feet Downstream of warm water discharge pipe

Distance out from B.M. on South Bank	River Depth*	Temperatures - °C			
		← 10:15 to 10:35 AM →		← 1:55 to 2:04 PM →	
		1 ft deep	5 ft deep	1 ft deep	5 ft deep
- Feet -	- Feet -				
100	6.8	17.6	17.8-	18.7	18.6
200	12.0	17.8	17.8	18.3+	18.5
300	19.0	17.8	18.1	18.6	18.3
		Max. 18.3 →	18.2 →		18.6 →
400	22.8	18.1	17.8	18.4	18.6
500	21.0	17.7	17.8	18.2	18.2
600	17.4	17.7	17.7+	18.2	18.2-
700	12.9	17.7	17.7+	18.2	18.2-
800	10.0	17.7+	17.7+	18.2	18.2
900	Shallow	17.7+	17.7+	18.2	18.2+
1000	and	17.8-	17.7	18.2+	18.3-
	Swift			18.5	18.5
1200	Est. 4.0	17.8-	17.7	18.4-	18.4
1400		17.8-		18.6	18.2

* River Elevation 387.9 feet above mean sea level at 100-B Pump House. River Flow 77,000 C.F.S.

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Appendix A - Cont'd.

Columbia River Temperature Survey

100 B Area

September 14, 1945

Measurements made 2735 feet downstream of warm water discharge pipe

Distance out from D.K. on South Bank	River Depth	Temperatures - °			
		10:50 to 11:05 AM		2:10 to 2:15 PM	
- Feet -	- Feet -	1 ft. Deep	5 ft. Deep	1 ft. Deep	5 ft. Deep
100	6.3	17.8	17.9	18.8	18.7
200	17.0	17.8	17.8	18.3	18.5
300	21.0	18.0	18.0	18.3	18.2
400	21.0	17.8	17.8	18.2	18.2
500	17.0	17.8	17.8	18.2	18.2
600	16.8	17.8	17.8	18.3	18.2
700	7.8	17.8	17.8	18.4	18.3
800	6.0	17.8	17.8	18.5	18.4
900	5.8	17.9		18.5	

1300 Opposite Shore

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Appendix A - Cont'd.

Columbia River Temperature Survey

100 ft Area

September 14, 1946

Measurements made 4890 feet downstream of warm water discharge pipe

Distance out
from H.M. on
South Bank

Temperatures -°C
11:20 to 11:30 AM

- Feet -

1 ft. Deep

5 ft. Deep

100	18.0	18.0 17.9
200	17.9	17.9
300	18.0+	18.0
400	17.8	17.9
500	17.8	17.8
600	17.8	17.8
700	17.8+	17.8-
800	17.9	18.0-
900	18.0+	18.0
1000	18.3	
1050	Opposite Bank	

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APPENDIX B

COLUMBIA RIVER TEMPERATURE SURVEY
IN CONNECTION WITH WARM WATER DISCHARGE FROM

100 B AREA

SEPTEMBER 14, 1945

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