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EFFECT OF HANFORD PLANT OPERATIONS
ON THE TEMPERATURE
OF THE COLUMBIA RIVER
1964 TO PRESENT

R. T. Jaske and M. O. Synoground

November 1970

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DEVELOPMENT REPORT

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EFFECT OF HANFORD PLANT OPERATIONS
ON THE TEMPERATURE OF THE COLUMBIA RIVER
1964 TO PRESENT

By

R. T. Jaske and M. O. Synoground

Water and Land Resources Department
Environmental and Life Sciences Division

November 1970

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ABSTRACT

Compiled and reviewed are significant temperature information and effluent mixing data that have been performed under the study "Effect of Reactor Effluent on the Quality of Columbia River Water," begun in 1962. The report presents basic information needed for a sound view of the temperature modification induced by reactor operation at Hanford and a technical basis for relating these modifications to the ecology. The primary concern here is with physical changes; routine radiological aspects are not included except as they apply to the development of simulation models for effluent transport and dispersion and studies of the mechanics of related food chain transport.

The development of the physical description of the plant effluents includes, among other factors, detailed knowledge of the concentration profiles and travel times of the effluents in the river below the reactors: (1) to determine the extent of interaction between and among operating plants and the city of Richland water plant, (2) to permit prediction of potential exposures from partially diluted effluent to persons downstream, especially in the event of off-standard releases, and (3) to provide a basis for the accurate evaluation and mapping of the extent of zones in which aquatic life might be affected.

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INTRODUCTION

Since the initiation of operations of the Hanford plant in 1944, a continuing program of monitoring of the effects of such operations has been conducted under Atomic Energy Commission sponsorship in order to permit a historical evaluation of those operations on the ecology. A great deal of effort and initiative has been taken to assure that the resulting numerical information and derived judgments represent an objective assessment of the events which have taken place. This report is an attempt to review the salient observations gained from the evaluation programs in relation to other thermal modifications of the Columbia River resulting from the aggregate of man controlled activities.

Effluent cooling water from the Hanford reactors and other production related waste streams (including ground seepage) discharges into the main flow of the Columbia River and changes river water temperatures, chemical characteristics, and content of radionuclides. This study is primarily concerned with the physical changes; routine radiological aspects are not included. However, the existence of radionuclides in the effluents is used indirectly in the development of simulation models for effluent transport and dispersion and studies of the mechanics of related food chain transport. River hydrology and effluent distribution data obtained in this program are used for the radiological assessment of plant emergencies and changes in plant operations.

The information developed by this program is especially valuable in relation to Executive Order 11528 and related legislation involving the establishment of water temperature standards. This covers both increased knowledge of waste inventories and releases and the physical description of waste transport mechanisms.

While prominent importance is given to the measurement, evaluation and prediction of changes in river temperature resulting from plant operation both locally and at distances downstream, other significant chemical parameters are also involved. The development of the physical description of the plant effluents includes, among other factors, detailed knowledge of the concentration profiles and travel times of the effluents in the river below the reactors: (1) to determine the extent of interaction between and among operating plants and the city of Richland water plant, (2) to permit prediction of potential exposures from partially diluted effluent to persons downstream, especially in the event of off-standard releases, and (3) to provide a basis for the accurate evaluation and mapping of the extent of zones in which aquatic life might be affected.

Related progress in mathematical analysis has permitted both better definition of the extent of modification of the river by the heat load from the reactors and improved insight into the distance downstream where significant effects persist. This work is not complete and additional information will be needed from a variety of sources to fully understand and describe the effects of river developments on the water quality. The diurnal, seasonal and hydraulic characteristics of the river, resulting from manipulation of upstream and downstream dams both for power and water quality control purposes, and the effects of impoundments both above and below the Hanford plant are involved. The mixing of the plant effluent with the waters of the Snake River in the McNary reservoir

confuses to a great extent the ability to determine Hanford plant effects by correlation methods alone. Since the annual thermal cycle of the Snake River is decidedly involved in either offsetting or emphasizing plant effects, it is of significance to have the best possible data and techniques for better understanding the regional river systems.

A number of reports directly related to this program are itemized in Section V of this report. This report is a compilation of the more significant temperature information and effluent mixing studies which have been performed under the study "Effects of Reactor Effluent on the Quality of Columbia River Water," Program 02 50 10 10 originally authorized by the AEC-Richland Operations Office in 1962. The report attempts to compile in a single document the basic information needed to obtain a sound perspective view of the temperature modifications induced by reactor operation at Hanford and a technical basis for relating these modifications to the ecology. Readers are urged to examine the original source documents for full treatment of individual topics and interpretation by the original investigators.

PROGRAM DESCRIPTIONDISCUSSION

To evaluate the operations of the Hanford project, commencing in 1958, a system of thermal monitoring stations was installed (Figure 1) with particular emphasis on measurement accuracy. The resulting temperature data have been carefully adjusted with reference to sensor errors and river sampling deviations to reflect the best estimate of the true bulk river temperature at each station. This was necessary to provide a precise background for the development of thermal simulation models⁽¹⁾ capable of predicting temperature and other associated water quality variables to a high degree of accuracy. Although flow through models of this type are capable of accuracies equal to or better than ordinary temperature measurement practice, statistical analyses were conducted to support conclusions derived from the simulation model and for trend analyses related to general environmental modification. These analyses were intended to provide a relatively exact basis for making judgments regarding some of the popular concepts of the effects of dams, and the thermal sink capacity in the Columbia River and its tributaries.

The availability of computerized analytical techniques at the Pacific Northwest Laboratory (Battelle-Northwest) made it possible to utilize existing data in a form never before attempted. The general success of this method of least squares analyses has permitted the generation of a series of least-squares-fitted functional models which form the basis for the conclusions of this presentation.

The need for a reasonably convenient method of making least squares fits of data sets to arbitrary functions has been chronic among experimenters and statisticians everywhere.

FIGURE 1. General Area Covered by Study Program

In particular, the solution originally posed by Gauss appeared promising, but its widespread use was prohibited until automatic computing devices became available.

The problem of least squares usually arises from one of two sources:

1. An experimenter desires to represent a set of data by some function. He is not necessarily interested in what the function is; he merely wants a convenient way to express a mass of information. He may be interested in obtaining a calibration curve for comparing future experiments. He may be interested in forming the curve for the purpose of integrating or differentiating the data in a consistent way. He may want only to draw a smooth curve through the data points. But, in each case, he wants the curve to be the same as that obtained by any other person who is willing to assume the same functional relationship between the experimental variables.
2. An experimenter has a definite function in mind--one whose constants (here called parameters) have a definite physical or theoretical meaning. In this situation, he wants to report not only the "best" values for the parameters, but he also wants to be able to attach a measure of the error inherent in the data and, therefore, in the estimates of the parameters. While it is true that not every investigator can match these ideal conditions, it is also true that proper design assists greatly in minimizing the difficulties inherent in the analysis.

In this research, the function $T = A + B \sin (Cd + D)$ originally used in oceanography and described by Ward⁽²⁾ was adopted because of the excellence of representation of annual temperature data afforded by its use. In the operations research supporting this study, the data points were grouped

by year from January 1 through December 31 using 365 or 366 days per year as appropriate. The data were then analyzed by means of a nonlinear, maximum-likelihood, least-squares-fit routine capable of handling nonlinearities and saddle points reliably. This program, developed by the Applied Physics and Electronics Department of Pacific Northwest Laboratory, is called program MISFIT-LEARN and can be conveniently adapted to a variety of computers such as the IBM 7090 or the larger Univac 1108. LEARN makes use of numeric rounding for accuracy, ill-conditioned matrix inversion logic, and statistical determination of saddle points on the parametric surface. In addition, it contains a two-stage recovery logic. If the usual first order approximation fails, the routine tries the second order terms of the multivariate Taylor expansion. Failing this, the routine branches into a series of approximations best described as "reverse-and-halve the last change" logic. The analysis of the data yields the best-fit parameters and, in addition, produces the root-mean-square error associated with that parameter estimate.

Also included as output is a series of graphs plotted by the CALCOMP plotter from magnetic tapes generated by the computer. These plots include the observed data, the calculated curve, and another pair of curves of plus or minus one standard deviation on each side of the calculated curve. An example is shown in Section IV.

If a function of the form $T = A + B \sin (Cd + D)$ is fitted to annual temperature data, then $C \approx 2\pi/365.25 \approx 0.017$. As an added check on the goodness of fit, this parameter was allowed to vary in each case in order to see what value the computer would calculate. Table 1 shows samples of values of all four parameters for a series of data points from the International border to Bonneville dam for the Calendar Year 1969.

TABLE 1. Values for CY-1969

	<u>Temp,</u> <u>°C</u>	<u>Model</u> <u>Mean</u> <u>A-°C</u>	<u>Comp.</u> <u>Extreme-</u> <u>B-°C</u>	<u>Daily</u> <u>Shift-C</u> <u>Radians</u>	<u>Peak</u> <u>Shift-D</u> <u>Radians</u>
International Border	T =	9.36	8.14	0.0172	3.97
Grand Coulee	T =	10.09	7.84	0.0172	3.92
Rocky Reach	T =	10.45	8.26	0.0172	3.83
Priest Rapids	T =	10.63	8.24	0.0172	3.94
Richland	T =	11.24	8.39	0.0172	3.94
McNary Dam	T =	11.75	8.69	0.0172	3.97
Bonneville Dam	T =	11.84	9.11	0.0172	4.04

A fuller treatment of the information for the earlier years and specifically those related to the effects of the construction of Grand Coulee Dam is contained in References 3 and 4. The conclusions of this preliminary analysis were:

1. The use of the data plotters with suitable least-squares fitted model functions provides a basis for the processing of significant amounts of stream temperature and other water quality data into promptly available reports with consistent analytical perspective.
2. The erection of low head reservoirs on the main stem of the Columbia River has not produced significant change in the average temperature of the river.
3. The erection of Grand Coulee Dam creating Lake Roosevelt has resulted in a 30-day delay in the transport of water through the reservoir system. This delay and additional delays associated with the expected construction of the Canadian Treaty Dams, when combined, may be significant ecologically.
4. The erection of dams and reservoirs decreases fluctuations in the water temperatures. The ecologic effects of changes

resulting from Columbia River impoundments are not, however, expected to be directly comparable to projects with large storage and relatively small steam flow, such as Lake Mead or some of the TVA impoundments.

Additional computations made during the most recent fiscal year support the conclusions of the preliminary study. Least-squares fitted models have been generated for all of the major projects for which data have been collected over several years. These are detailed in Section IV.

TABLE 2. Comparison of Trends (1935-1969)

	<u>Upper Extreme- Mean - °C</u>	<u>Mean - °C</u>	<u>Lower Extreme- Mean - °C</u>
Rock Island- Rocky Reach	18.0	10.6	2.9
	$\sigma = 0.95$	$\sigma = 0.65$	$\sigma = 0.94$
Bonneville	19.0	11.4	3.8
	$\sigma = 0.88$	$\sigma = 0.81$	$\sigma = 1.06$

Several of the trends observed in comparing the results of extended analyses (Table 2) are of great significance in understanding the overall effects of the combined construction of dams and other industrial plants involving thermal waste discharges. A careful review of the data in Figure 2 which compares the values computed for the A (annual average) and B (computed extremes) terms yields the following observations:

1. The annual mean temperature computed for Rock Island-Rocky Reach for the period 1934 to present shows a slight increase of about 0.2 to 0.4 °C. This is about one-half of a standard deviation for the period studied. The annual mean computed for Bonneville during the period 1939 to present shows a lesser overall effect; however, it reflects a definite upturn for the period 1960 to present after the peak

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FIGURE 2. Computed Temperature Trends (1938-1969)

of 1958. The relationship between the computed means for the two data sets shows a significant departure for the period 1944-1948 and, again, 1950 to present. The combination of AEC operations and the Snake River in adding heat to the river in this reach is apparant.

2. The computed upper and lower extremes with the exception of 1948, the flood year, show a close relationship and consistently rise and fall together. The two groups of data tend to separate in the case of the upper extreme by values about equal to the separation of the means, while the upper extreme of Rock Island continues a steady decrease. During the recent period of 1960 to present both the upper and lower extremes show a sharp tendency to converge on the mean. Again, it is plain that a strong influence has affected the historic trend and sharply reduced the departure from the mean. This timing coincides with the period of greatest dam building activity on the upper Columbia.

To more fully understand the fine structure involved in these differences, additional runs were made in order to add the effects of intermediate projects. Figure 3 illustrates the computed parameters for six projects for which data are available since 1961. Inspection of these data yield further observations:

1. The values for the means and the extremes fall into distinct groups--those above the Hanford Project and those below it. Further, the mean values for Ice Harbor are essentially equal to the McNary values and could account for much of the difference between the upper and lower sets as related to the flow from the Snake River.
2. The values of the means for the period 1960 to present show no significant trend or departure from the group response to individual yearly weather patterns.

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FIGURE 3. Comparative Trends (1960-1969)

3. The upper and lower extremes for both project sets show a common convergence toward the mean. This is more pronounced for the upstream locations than those downstream indicating that a nonweather related influence is overriding the average convergence to a slight extent.
4. The upper and lower computed extremes for the Snake River are significantly higher and lower than the same Columbia River values and similar to the historic values for Bonneville before the erection of Grand Coulee Dam.
5. The data for the projects upriver from Hanford have closely related values with a tendency for a slight reduction in values of the extremes. On the other hand, the McNary and Bonneville data groups show effects peculiar to a cooling trend with the Bonneville Project showing significant lower values for both the annual mean and the lower extremes.

Since these two data groupings would tend to create the impression that the erection of the Columbia River dams have had little or no effect on the water temperature, review of Reference 4 is necessary to visualize the trends. Reference 4 indicates:

1. A sharp and permanent change in the timing of the peak temperature at Rock Island commencing with the filling of Lake Roosevelt in 1941-1942. The permanent change amounts to about 30 days, the average transport time for the mean annual flow through Lake Roosevelt.
2. This sharp and permanent shift is also observed at Bonneville Dam although to a lesser extent. The two projects reveal surprisingly similar shifts in response to annual weather cycles. While the Rock Island peak has stabilized at about September 20, the Bonneville peak has continued to occur later and later as longer and longer flow times result from the addition of upstream projects. The close relationship of McNary and Bonneville indicate little or no cooling takes place in the reach between these projects.

3. The values for the Priest Rapids Project closely resemble peak temperature patterns for Rock Island. The data differences of about 7 to 10 days appear to be related to the travel time through Wanapum and Priest Rapids reservoirs in about the same manner as Grand Coulee.
4. All projects have strong indications of responding in unison to regional weather influences. For example, all projects show early peak arrivals on high temperature years. Clearly, influences beyond the scope of man's activity affect all water temperatures to a surprisingly similar extent.

The only major industrial factor influencing the analysis is the Hanford complex, whose effect upon the system can be modeled in terms of the net difference between existing temperature records at an upstream and a downstream location. Reference is made to two points, one above and the other below the Hanford Complex, and total addition of natural as well as man-made energy is compared. Once again employing the LEARN-LIKELY computer routine (MISFIT) discussed previously, a means of obtaining an unbiased least squares fit to water temperature on an annual basis can be determined.

Between the two points of Priest Rapids and Richland there occurs a singular deviation which is associated with the operation of the Hanford reactors. As mentioned before, the average temperature computed by the program is the first term of the mathematical model $T = A + B \sin (0.0172d + C)$. Summarizing, we are able to calculate the information in Table 3 from unclassified and published river data.

The 19,300 MW from 1966 (see Table 3) was used to estimate the perturbation of the system between Priest Rapids and Richland as a combination of AEC operations and natural weather conditions. Therefore, using the relationship (energy = const $\Delta T \times Q$) the total energy added to a system between the two points is determined as a function of flow and temperature.

TABLE 3. Computed Energy Trends for the Reach Between Priest Rapids and Richland (1965-1969)

<u>Year</u>	<u>Richland $\bar{A}$</u>	<u>Priest R. $\bar{A}$</u>	<u>Diff.</u>	<u>Mean Flow</u>	<u>Equiv. MW</u>
1965	12.12 °C	10.64 °C	1.48 °C	129,000	23,000
1966	12.04 °C	10.65 °C	1.39 °C	115,000	19,300
1967	12.63 °C	11.31 °C	1.32 °C	131,000	20,800
1968	11.70 °C	10.56 °C	1.10 °C	118,500	15,700
1969	11.24 °C	10.63 °C	0.61 °C	134,000	9,680

As a result of the modified hydrology originating with daily flow regulation, this temperature differential in the reach has in the past, before 1968, exceeded the maximum allowable temperature increase recently adopted by the Washington State temperature standards. In these cases the total perturbation of 19,300 MW was reduced to conform to the Washington State standards using the formula

$$\Delta t = \frac{33.95}{T + 9.44} \text{ in } ^\circ\text{C}$$

where Δt = allowable increase

T = final downstream temperature.

The allowable increase will range between 1.15 and 3.60 °C in the river temperature between 0 and 20 °C. Both of these constraints have been represented graphically in Figure 4. As indicated in Figure 4, the allowable system increase is a function of both flow and Priest Rapids temperatures.

The resulting thermal increments were then routed down the river to Bonneville Dam using the COL HEAT simulation model.⁽¹⁾ By superposition, the remaining increment at the dam was determined and plotted on a day by day basis. The remaining increment averaged about 0.2 to 0.3 °C, about 20 to 30% of the energy increment added to the simulation in the Hanford Reach, Figure 5.

In a recent study of specific thermal effects of the Hanford plant, which determined the residual fraction of thermal modification remaining from an entire year's operation of the Hanford plant at the Washington-Oregon border,⁽⁵⁾ a similar set of values

FIGURE 4. Addition of Total Energy Between River Mile 396.0 and River Mile 350.0

FIGURE 5. Comparison of Predicted Average Temperatures at Bonneville Dam With and Without the Addition of Energy in the Hanford Reach

was determined. From the report, Reference 5, p. 4:

"River temperature modifications introduced by natural environmental effects and operation of reactors at 1969 power levels would be approximately 65% dissipated at the Washington-Oregon border. The extent of this dissipation is nearly independent of Priest Rapids water temperature and weather conditions affecting the Columbia River between Priest Rapids Dam and the Washington-Oregon border. The numerical values of the remaining increment ranged from essentially zero to a momentary high of 0.5 °C, the average being 0.20 °C for the April through October period used in the study.

"On the basis of the transects taken in the summer and fall of 1969 and using water temperature as a tracer, the McNary reservoir at the Washington-Oregon border is sufficiently well mixed that a single point monitoring station could be appropriately located for the purpose of thermal auditing at that point. Such stratification as exists is very weak, and the isotherms appear to be more subject to modification by flow conditions of the Snake and the Columbia than by heat transfer across the water surface in the reservoir. The study suggests that, on the basis of the samples collected and previous transects made before 1962 (Soldat et al., unpublished), it appears that the day-to-day peaking operations of Ice Harbor Dam in relation to Columbia River peaking operations may bear as important a relationship in creating patches of warmer and cooler water within the reservoir flow system as residual Hanford effects. Additional study is needed to verify this conclusively."

PRINCIPAL OBSERVATIONS BASED ON DATA COLLECTED IN THE PROGRAM

On the basis of the information detailed in the discussion and other related studies reported in Section VI, "References and Bibliography," the following principal observations regarding the temperature regime of the Columbia River and its relationship to operations of the Hanford facility appear appropriate:

1. The erection of hydraulic power dams and reservoirs on the Columbia River has had significant effects on the timing

and extent of annual temperature cycles of the Columbia River. Where annual peak temperatures in the natural, undeveloped river once occurred in mid-August, the construction of reservoirs has altered the timing about in proportion to the increased travel time through the river system. The persistence of this effect verifies earlier predictions of the effect.⁽⁶⁾ Reference 6 summarizes the Columbia River cooling program carried out for AEC between 1958 and 1965. The moving of a relatively identical annual cycle laterally on the time scale creates the appearance of warmer water in later fall months and leads to the conclusion by relatively uninformed observers that dam construction is heating the river system on a general basis. In actuality the reservoir tends to slightly cool the river in more cases than not, and the net effect is the time displacement of a relatively identical thermodynamic history. This is especially true for reservoirs with large ratios of capacity-to-mean flow. Unstratified reservoirs of large capacity such as John Day tend to slightly warm the river in summer due to the increase in travel time and the approach to equilibrium between the river and weather conditions.

2. The erection of hydraulic power dams and reservoirs on the Columbia River has had only a minimal effect on the annual mean temperature of the entire system. This effect is less than 1 °C over the 34 year period from 1936-1970. The extent of this change could easily be attributed to long-term weather changes due to causes beyond the scope of this study.
3. The temperature history of the Columbia River since 1936 suggests that temperatures are related to river management practices to a large extent and that optimization of the total resource must of necessity include consideration of the integrated temperature effects of water storage and management practices. This is especially true of proposed plans to treat the entire main stem as a moving storage

reservoir for the optimization of power production. Such plans when related to other competitive recreational and industrial uses of the river appear to require additional study to determine related water quality modifications.

4. The reach between Priest Rapids and Richland, the last free flowing portion of the river, responds rapidly to changes in weather and thermal modification from industrial effluents as compared to impounded reaches. Conductive heat transfer rates are higher and evaporation rates are lower than in impounded areas. Summertime temperature increases during periods of reactor shutdown are quite high, ranging from 0.5 to as high as 0.75 °C in August and early September. A cooling effect of similar magnitude occurs in the winter months. The mean annual temperature differential for the reach has decreased with reactor shutdowns indicating that the thermal modification of the river on a mean annual basis was directly related to the operation of nuclear facilities. This point and the numerically correlated values reported in this section represent important information to the supporting studies of ecological modification carried out through the period 1964 to present.
5. River temperatures between the Hanford plant and the confluence of the Snake River decrease toward an equilibrium value. Studies of the thermal dissipation of reactor effluent indicate that a majority of the heat is dissipated to the atmosphere before the confluence of the Snake and the Columbia. At the Oregon-Washington border, a fraction ranging from 40% to as low as 5% and averaging 35% remains to be dissipated. On this basis, and assuming the entire thermal modification of the reach between Priest Rapids and Richland to be of industrial origin, it can be stated that the residual effect of the Hanford reach in raising river temperatures below McNary dam in the 1965-69 period was

about equal to the effect of the Snake River. Numerically, the annual mean differential at the confluence of the Snake and Columbia is approximately 0.40°C , ranging from 0.10°C to 0.60°C . Considering the relative flow ratio of 2.0 between the two streams, the mean modification of the Columbia by the Snake would then be about 0.20°C or about the same order of magnitude as the highest differential attributed to the effect of the Hanford reach carried down to the Washington-Oregon border, as reported in BNWL-1345.⁽⁵⁾ On this basis, averaged over long time periods, the annual thermal contribution of the Snake to the Columbia is on the order of 4,000 thermal megawatts. This rate of thermal input is about doubled in the August to September period when the average temperature of the Snake is 2.0 to 2.5°C higher than the Columbia. This situation is expected to materially worsen after Mica Dam is complete since the differential between the Columbia and the Snake after 1975 during August and September is expected to exceed 4.0°C in 9 years out of 10 (Ref. Bib., p. 6.7, March 1, 1969).

6. Columbia River mean annual temperatures continue to rise slightly at all points upstream of the Columbia Gorge. Passage through the Columbia Gorge modifies the water surface to a more natural condition, and heat transfer rates increase due to increased turbulence thus providing greater cooling. From the Bonneville pool to Warrendale (a distance of 10 miles), a substantial difference in annual average temperature is noted based on provisional records of the Bonneville temperatures. It is concluded that the sensor position at Bonneville does not accurately indicate the bulk river temperature since there is no theoretical basis for the extent of temperature differential between Bonneville and Warrendale. This observation is of prime significance in judging the validity of trends which approach the accuracy limits of the data. It is a conclusion of

this study that existing temperature records for Bonneville are not of scientific value in judging temperature conditions on the Columbia River at that point. However, Bonneville temperatures are useful as a basis for observing day-to-day trends for simulation and superposition experiments. Using the existing record, it was determined that the residual thermal differential at Warrendale from the maximum allowable input of thermal energy in the Priest Rapids-Richland reach under existing Washington State standards would be less than 0.20 °C during critical summer months and less than 0.35 °C during winter months. These numerical values indicate that thermal modification in the Priest Rapids-Richland reach is about 80% dissipated at Warrendale, Mile 140, about 200 miles below the Richland sensor. This compares with 65% dissipation at the Washington-Oregon border.

7. Detailed measurements in the Hanford plant effluent mixing zone are described in Appendix C. These reveal that, during the period when all reactors were operating at the Hanford site, the dispersion patterns were such that in the immediate plant area, significant stream cross-section areas of cooler water were available as migration routes for fish. The Ringold area provides a complete mixing zone for full dispersion of materials above that point and represents a location of maximum average stream temperatures related to the operation of reactors. Cross-section temperature measurements made below Ringold during periods of reactor shutdown reveal consistently higher shoreline temperatures than the essentially uniform midstream or thalweg conditions. A temperature rise of from 0.50 to 0.75 °C occurs from natural heating in the Hanford reach during August and September which is high compared to impounded reaches. This is the equivalent of 4000 to 6000 thermal megawatts of energy for flows ranging from

80,000 to 150,000 ft³/sec. The cooling of the river in the Hanford reach is also relatively high compared to the impounded areas. Generally, studies of heat dissipation on the Columbia for thermal effluent and thermal modifications from dam manipulation consistently show that temperature gradients are more conservative in the winter than the summer under average weather conditions. That is, a thermal modification will persist longer in winter than in the summer. This is also shown in the computer simulation of 19,300 thermal megawatts of energy for the Hanford reach in Figure 5 of this discussion.

One of the most significant results of the thermal studies program at Pacific Northwest Laboratory has been the certification of the need for standards of accuracy for stream temperature measurements. Even within a state-of-the-art program, variations in standards exist for reasons of expediency and practicality. It is suggested that the art of stream temperature management will come of age only when an accepted standard of accuracy and sampling frequency is established for all serious researchers, river users and enforcement personnel to have a common basis in discussion of thermal modification of water quality.

SUMMARIES OF DAILY AVERAGE TEMPERATURE

The following tabulations are the daily averages from digitized thermograph records or hourly observations in year, month, day order from Northport (International Border), River Mile 734.1 to River Mile 208.0 below John Day Dam. Included are multiyear averages at Priest Rapids and Grand Coulee on the Columbia River and Ice Harbor on the Snake River.

The daily averages of the maximum and minimum hourly temperature in degrees centigrade observed each day for a period of 20 years, 1947 through 1967 are shown in Tables 4 and Table 5. Temperatures measured at Rock Island, about 56 miles above Priest Rapids, were used for the years prior to 1960.

These data have been adjusted to account for sensor position error and instrument readout error. They represent the best estimate of the actual mean water temperature for the stated period as was technically feasible for the time period involved.

INSTRUMENTATION ACCURACY

Sensor and Instrument Error Estimates

Northport ±0.75 °C	Foxboro thermograph located on bridge pier of Highway 25, and serviced under a Battelle-Northwest/AEC contract. The instrument is affected by ore trucks using the bridge and by water level fluctuations from dam regulation both above and below the instrument site. Usable accuracy is maintained by comparison to a weekly check made with a certified thermometer and a daily measurement made by United States Geological Survey (USGS).
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Grand Coulee ±0.35 °C	Foxboro thermograph located on a bridge pier where the highway crosses the river below the dam. Accuracy maintained by periodic checks with an Atkins thermometer.
Priest Rapids ±0.20 °C	Leeds and Northrup thermograph and river stage recorder at the USGS gage site below Priest Rapids dam. Historically the most reliable instrument in our reporting network with 0.20 °C error margin from both river sensor and recorder. Serviced and checked by AEC contractor and Grant County PUD. Periodic boat surveys made.
Richland ±0.30 °C	Foxboro thermograph at River Mile 338.0. Accuracy of instrument maintained by periodic checks with Atkins thermometer. Upstream islands deter uniform mixing. Monthly boat surveys made.
Pasco ±0.30 °C	Foxboro thermograph (prior to 1969) accuracy maintained by periodic calibration in Battelle-Northwest Instrument Shop. (Readings in 1969 not reliable.)
Umatilla ±0.20 °C	Foxboro thermograph accuracy maintained by weekly check with certified Atkins thermometer and shop calibration when needed.
Biggs-John Day ±0.25 °C	Foxboro thermograph checked periodically with Atkins thermometer.

* The Atkins RTD thermometer has a certified accuracy of $\pm 0.01^{\circ}\text{C}$ with a precision of $\pm 0.005^{\circ}\text{C}$ when tested in a stirred calibration facility.

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
NORTHPORT, DEGREES CENTIGRADE

1966	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	4.20	3.00	4.20	5.10	6.10	8.40	12.90	15.80	15.50	15.90	11.00	6.80
2	4.10	3.10	4.20	5.20	6.40	8.60	13.00	16.30	15.60	15.70	10.80	6.70
3	4.00	3.00	4.20	5.20	6.80	8.90	12.90	16.40	15.60	15.80	10.60	6.60
4	3.90	3.10	4.20	5.30	7.20	9.10	13.00	16.40	16.00	15.50	10.40	6.50
5	3.80	3.10	4.10	5.30	7.60	9.30	12.90	16.20	16.40	15.20	10.50	6.40
6	3.80	3.10	4.10	5.40	7.80	9.60	13.00	16.40	16.50	14.90	10.30	6.40
7	3.70	3.20	4.10	5.50	7.90	9.80	13.10	16.40	16.70	14.90	10.00	6.40
8	3.60	3.30	4.10	5.50	7.70	10.00	13.70	16.70	16.70	14.80	9.90	6.40
9	3.50	3.40	4.10	5.60	7.80	10.20	13.80	16.70	16.70	14.80	9.70	6.30
10	3.50	3.50	4.10	5.70	7.80	10.60	13.90	16.70	16.80	14.60	9.50	6.10
11	3.40	3.50	4.10	5.60	7.40	10.70	13.90	16.70	17.30	13.40	9.20	5.60
12	3.40	3.60	4.10	5.30	7.50	10.70	14.00	16.60	17.20	13.00	8.90	5.50
13	3.30	3.60	4.10	5.00	7.10	10.60	13.90	16.70	17.20	13.40	8.70	5.50
14	3.30	3.60	4.10	4.90	6.80	10.30	13.90	16.40	17.10	13.10	8.40	5.40
15	3.20	3.50	4.20	4.90	6.40	10.50	14.00	16.20	17.00	13.20	8.20	5.40
16	3.20	3.50	4.30	5.40	6.10	10.90	14.40	16.10	17.00	13.20	8.20	5.50
17	3.20	3.50	4.40	5.20	5.90	11.30	14.50	16.00	16.90	13.20	8.10	5.60
18	3.20	3.40	4.40	5.00	5.90	11.70	14.50	15.90	16.80	13.00	8.10	5.60
19	3.10	3.40	4.50	4.80	6.40	11.90	14.60	16.10	16.80	12.80	8.10	5.70
20	3.10	3.50	4.60	4.60	6.80	12.10	14.50	16.10	16.60	12.40	7.90	5.70
21	3.10	3.50	4.60	4.70	6.80	12.00	14.50	16.10	16.40	12.10	7.80	5.70
22	3.10	3.60	4.70	4.80	7.00	11.90	15.00	16.20	16.30	11.90	7.90	5.60
23	3.10	3.70	4.80	5.00	7.90	11.90	15.00	16.20	16.40	11.60	7.90	5.60
24	3.10	3.80	4.90	5.30	7.30	12.00	14.80	16.30	16.50	11.60	7.70	5.60
25	3.10	3.90	5.00	5.40	7.50	12.10	14.80	16.30	16.40	11.50	7.50	5.50
26	3.00	4.10	5.00	5.60	7.80	12.40	14.60	16.30	16.40	11.40	7.40	5.20
27	3.10	4.20	4.90	5.50	8.20	12.20	14.80	16.30	16.40	11.30	7.30	4.90
28	3.00	4.20	4.90	5.50	9.50	12.40	15.40	16.30	16.30	11.20	7.10	4.80
29	3.10		5.00	5.80	8.70	12.60	15.70	16.30	16.30	11.30	7.00	4.80
30	3.20		5.00	5.90	8.60	12.80	15.50	16.00	16.10	11.20	6.90	4.30
31	3.10		5.10		8.10		15.50	15.50		11.10		4.10

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
NORTHPORT, DEGREES CENTIGRADE

1967	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	4.10	3.40	3.90	5.30	7.40	9.80	13.10	15.20	16.40	15.50	9.10	5.50
2	4.00	3.30	4.10	5.50	7.50	9.80	13.60	15.60	16.70	15.20	8.90	5.40
3	3.80	3.20	4.10	6.00	7.70	9.80	13.80	15.80	16.70	14.90	8.80	5.40
4	3.60	3.20	4.10	6.30	7.80	10.10	13.60	15.90	16.60	14.70	8.70	5.30
5	3.40	3.20	4.10	6.40	7.90	10.30	13.60	15.90	16.70	14.30	8.70	5.20
6	3.30	3.60	4.20	6.50	8.30	10.40	13.70	15.70	16.70	13.90	8.60	5.10
7	3.20	3.60	4.20	6.90	8.30	10.70	13.80	15.50	16.50	13.90	8.50	5.00
8	3.00	3.60	4.20	7.00	8.10	10.80	13.80	15.30	16.10	13.70	8.50	4.80
9	3.00	3.60	4.20	7.10	7.90	10.70	13.90	15.60	16.30	13.50	8.40	4.60
10	3.00	3.70	4.20	7.00	7.90	10.80	14.20	16.00	16.50	13.50	8.30	4.30
11	3.00	3.70	4.30	7.00	7.60	11.00	14.00	16.50	16.30	13.40	8.20	4.00
12	2.90	3.60	4.30	7.00	7.40	11.00	14.20	16.80	15.90	13.20	8.10	3.80
13	2.90	3.70	4.20	7.00	7.70	11.00	14.30	17.00	15.70	13.20	8.00	3.60
14	3.00	3.70	4.20	6.90	8.20	11.30	14.40	16.80	15.70	13.20	8.00	3.40
15	3.00	3.70	4.20	7.00	8.50	11.40	14.40	17.10	15.90	13.00	7.90	3.30
16	3.20	3.70	4.20	6.90	8.80	11.70	14.40	17.10	16.20	12.70	7.80	3.20
17	3.30	3.70	4.20	6.80	8.70	11.90	14.40	17.20	16.30	12.50	7.70	3.10
18	3.30	3.70	4.20	6.90	8.60	12.30	14.10	17.10	16.10	12.20	7.50	3.00
19	3.30	3.70	4.20	6.90	9.20	12.70	13.50	17.20	16.10	12.00	7.30	3.00
20	3.40	3.70	4.30	6.90	9.70	13.00	13.40	17.20	16.00	11.80	7.20	2.90
21	3.40	3.40	4.30	7.10	9.70	12.80	13.50	17.10	16.10	11.70	7.00	2.80
22	3.40	3.40	4.30	7.30	9.60	12.60	13.90	17.00	16.10	11.50	6.90	2.90
23	3.40	3.40	4.60	7.50	9.90	12.20	14.30	16.90	16.00	11.20	6.70	3.00
24	3.40	3.40	4.80	7.40	10.00	12.10	14.60	17.20	15.90	10.90	6.60	3.00
25	3.40	3.40	4.90	7.30	9.90	12.00	14.80	17.30	15.80	10.60	6.40	3.10
26	3.40	3.40	5.00	7.20	9.80	12.40	15.10	17.20	15.70	10.30	6.30	3.20
27	3.40	3.90	5.10	7.10	9.80	12.50	15.90	17.20	15.60	10.00	6.10	3.30
28	3.40	3.90	5.10	7.00	9.70	12.70	15.90	16.90	15.70	9.90	5.90	3.40
29	3.40		5.10	7.10	9.70	12.80	15.70	16.70	15.70	9.50	5.80	3.40
30	3.40		5.10	7.20	9.50	12.90	15.20	16.50	15.70	9.40	5.60	3.50
31	3.40		5.10		9.50		15.30	16.40		9.20		3.60

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
NORTHPORT, DEGREES CENTIGRADE

1968	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	3.30	1.50	4.20	6.30	8.10	9.00	12.30	15.70	15.90	14.30	9.60	5.70
2	3.20	1.40	4.30	6.40	8.00	8.40	12.40	15.70	15.90	13.90	9.40	5.50
3	3.10	1.40	4.40	6.40	8.20	7.90	12.50	15.80	16.30	13.90	9.40	5.50
4	3.10	1.50	4.50	6.40	8.40	8.70	12.80	15.80	16.50	13.70	9.40	5.20
5	3.00	1.50	4.60	6.50	8.40	9.10	13.00	15.80	16.80	13.50	9.00	4.90
6	2.90	1.60	4.70	6.50	8.30	9.80	13.30	15.20	16.90	13.30	8.80	4.70
7	2.80	1.70	4.80	6.60	8.00	10.20	13.50	15.10	16.70	13.00	8.60	4.60
8	2.70	1.70	4.90	6.60	7.90	10.60	14.20	15.30	16.60	12.70	8.30	4.60
9	2.60	1.80	5.00	6.50	8.00	11.00	14.30	16.30	16.40	12.60	8.20	4.60
10	2.50	1.90	5.00	6.40	8.50	11.40	14.00	16.80	15.90	12.60	8.10	4.60
11	2.50	2.00	5.10	6.50	8.70	10.80	13.80	16.80	15.80	12.20	7.80	4.50
12	2.50	2.10	5.10	6.20	8.70	10.60	13.40	16.50	15.80	11.80	7.60	4.40
13	2.50	2.20	5.20	6.40	8.90	10.60	13.10	16.60	16.20	11.60	7.50	4.20
14	2.50	2.30	5.20	6.60	9.00	10.80	13.50	16.60	16.40	11.50	7.40	4.10
15	2.50	2.40	5.20	6.40	9.30	10.80	13.40	16.40	16.10	11.40	7.20	4.10
16	2.50	2.50	5.20	6.10	9.90	11.50	13.70	16.00	15.60	11.10	6.90	4.20
17	2.50	2.60	5.30	5.40	9.80	11.30	14.20	16.20	15.30	11.00	6.70	4.00
18	2.50	2.70	5.30	5.40	9.60	11.50	14.80	16.00	15.10	11.00	6.60	3.90
19	2.40	2.80	5.30	5.60	9.80	12.10	14.90	16.10	15.30	10.90	6.60	3.80
20	2.40	2.90	5.40	5.90	9.80	12.30	15.00	16.00	15.10	10.80	6.60	3.50
21	2.40	3.10	5.40	6.40	9.60	12.50	15.00	15.80	14.90	10.50	6.60	3.40
22	2.40	3.20	5.50	6.30	9.50	12.50	14.90	15.90	14.80	10.50	6.70	3.10
23	2.30	3.30	5.50	6.50	9.50	12.10	14.90	15.60	14.80	10.40	6.80	3.00
24	2.30	3.40	5.60	6.50	9.60	12.30	14.70	15.60	14.80	10.40	6.60	2.90
25	2.30	3.50	5.90	6.80	9.00	12.50	14.90	15.50	14.60	10.40	6.40	3.20
26	2.20	3.70	5.90	6.90	9.10	12.70	15.30	15.30	14.50	10.30	6.40	3.30
27	2.10	3.80	6.00	6.90	8.90	13.10	15.20	15.30	14.50	10.00	6.20	2.80
28	2.00	3.90	6.10	7.20	8.50	13.70	15.70	15.20	14.40	9.80	6.10	2.40
29	1.80	4.10	6.20	7.70	8.30	13.50	15.60	15.50	14.40	9.70	6.00	2.00
30	1.70		6.20	8.20	8.80	13.40	15.90	15.70	14.40	10.00	5.60	1.60
31	1.60		6.30		8.70		16.00	15.90		9.80		1.40

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
NORTHPORT, DEGREES CENTIGRADE

1969	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	1.40	.80	1.90	5.40	7.40	10.00	13.80	17.80	18.10	15.40	10.00	7.10
2	1.40	.80	2.10	5.50	7.30	10.90	14.30	17.90	18.30	15.10	9.90	7.00
3	1.50	.90	2.30	5.50	7.10	10.90	14.30	17.90	18.30	14.80	9.80	7.10
4	1.60	.90	2.40	5.40	7.30	12.20	14.50	17.50	18.30	14.60	9.70	7.20
5	1.60	.70	2.50	5.60	8.00	12.40	14.20	17.10	18.10	14.30	9.70	7.20
6	1.70	.70	2.70	5.40	8.50	12.70	13.70	17.00	17.80	14.10	9.60	7.10
7	1.70	.40	2.80	5.50	9.20	12.80	13.90	17.20	17.80	14.00	9.30	7.00
8	1.60	.50	2.70	5.30	9.30	12.90	14.00	17.70	17.70	14.10	9.20	6.60
9	1.40	.50	2.40	5.40	9.50	13.10	14.30	18.40	17.70	14.10	8.90	6.40
10	1.60	.60	2.50	5.60	9.60	13.40	14.70	18.30	17.60	13.80	8.70	6.20
11	1.70	.80	2.50	5.60	9.60	13.60	14.60	18.10	17.80	13.60	8.60	5.90
12	1.60	.90	2.60	5.60	9.70	13.60	14.30	18.00	17.90	13.50	8.60	5.60
13	1.40	1.00	2.80	5.60	9.90	12.80	14.40	18.30	18.00	13.20	8.70	5.40
14	1.30	1.00	3.00	5.60	9.80	12.40	14.90	18.60	17.60	12.90	8.70	5.40
15	1.20	1.10	3.10	5.60	9.60	12.40	15.40	18.80	17.00	12.70	8.70	5.30
16	1.00	1.00	3.20	5.80	9.50	12.60	16.00	18.90	17.10	12.40	8.60	5.30
17	1.00	1.10	3.30	5.80	9.30	13.00	16.20	19.00	17.10	12.10	8.60	5.30
18	.80	1.20	3.40	5.90	9.30	13.80	16.40	19.10	17.10	11.80	8.60	5.40
19	.80	1.20	3.40	5.60	9.50	14.50	16.50	18.40	17.00	11.50	8.60	5.40
20	.80	1.30	3.60	6.10	9.80	14.60	16.50	18.10	16.80	11.30	8.60	5.40
21	.70	1.40	3.70	6.60	9.80	14.70	16.50	18.20	16.10	11.10	8.50	5.40
22	.70	1.40	3.60	6.80	9.70	15.00	16.90	18.20	16.10	10.90	8.10	5.30
23	.70	1.40	3.80	7.10	10.00	15.20	17.40	18.60	15.90	10.60	8.10	5.30
24	.70	1.50	3.70	6.80	10.20	14.80	17.80	18.90	15.40	10.60	8.00	5.30
25	.70	1.60	3.90	6.60	10.20	14.60	17.70	18.60	15.40	10.60	7.90	5.40
26	.80	1.70	4.10	6.80	10.40	14.70	17.50	17.80	15.50	10.60	7.80	5.40
27	.80	1.90	4.30	7.10	10.10	14.30	17.70	17.80	15.40	10.50	7.70	5.40
28	.80	1.80	4.50	7.10	9.80	13.40	17.30	17.70	15.30	10.30	7.60	5.20
29	.80		4.60	7.30	9.50	13.20	16.80	17.40	15.40	10.30	7.50	4.90
30	.80		4.80	7.40	9.30	13.50	17.50	17.90	15.50	10.40	7.30	4.70
31	.80		4.90		9.30		16.00	17.90		10.20		4.70

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
GRAND COULEE, DEGREES CE., TIGRADE

1964	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	8.70	7.00	4.00	4.70	6.50	11.70	11.40	15.20	15.80	16.00	13.70	10.80
2	8.60	6.50	4.10	4.80	6.50	11.70	11.50	15.20	15.80	15.90	13.80	10.80
3	8.50	6.60	4.10	4.80	6.50	11.80	11.70	15.10	15.90	15.90	13.70	10.50
4	8.50	6.60	4.10	4.70	6.70	11.80	11.80	15.10	15.80	15.90	13.70	10.40
5	8.40	6.40	4.00	4.70	6.80	11.80	11.90	15.20	15.90	15.80	13.50	10.20
6	8.40	6.20	4.00	4.80	6.70	11.60	12.00	15.30	15.90	15.70	13.40	10.20
7	8.40	6.00	4.00	4.90	6.70	11.50	12.10	15.50	15.90	15.70	13.30	10.10
8	8.20	6.00	4.00	4.80	6.90	11.10	12.30	15.30	15.90	15.60	13.20	10.00
9	8.10	6.00	4.00	4.80	7.30	11.00	12.40	15.30	16.00	15.60	13.10	9.90
10	8.00	5.90	3.80	4.90	7.30	11.00	12.60	15.40	16.00	15.50	13.00	9.80
11	7.80	5.80	3.90	5.00	7.40	11.20	12.60	15.60	16.10	15.40	12.90	9.50
12	7.70	5.70	3.80	5.10	7.80	11.30	12.90	15.70	16.00	15.40	12.80	9.40
13	7.80	4.90	4.00	5.20	7.70	11.50	13.40	15.90	16.10	15.50	12.70	9.30
14	7.80	4.80	4.20	5.20	8.00	11.70	13.30	16.00	16.10	15.50	12.70	9.40
15	7.80	5.00	4.20	5.30	8.20	11.70	13.70	16.30	16.10	15.40	12.50	9.40
16	7.70	4.90	4.20	5.30	8.20	11.70	13.90	16.20	16.10	15.30	12.50	9.10
17	8.00	4.90	4.20	5.40	8.30	11.70	14.10	16.20	16.30	15.20	12.30	8.90
18	7.80	4.80	4.20	5.50	8.70	11.60	14.20	16.20	16.10	15.10	12.30	8.70
19	7.60	4.60	4.00	5.60	8.90	11.40	14.20	15.80	16.10	15.00	12.10	8.50
20	7.80	4.60	4.30	5.60	9.10	11.50	14.20	15.70	16.20	14.90	12.00	8.40
21	7.70	4.60	4.40	5.70	9.20	11.40	14.50	15.70	16.10	14.90	11.90	8.40
22	7.60	4.50	4.50	5.70	9.60	11.40	14.60	15.90	16.20	14.80	11.80	8.20
23	7.30	4.40	4.30	5.70	9.80	11.30	14.70	15.80	16.20	14.60	11.70	8.10
24	7.50	4.40	4.20	5.80	10.00	11.30	14.90	15.90	16.30	14.50	11.70	7.90
25	7.40	4.30	4.20	5.80	10.30	11.20	14.90	15.80	16.40	14.40	11.50	7.80
26	7.30	4.20	4.20	6.00	10.90	11.30	14.90	15.80	16.30	14.30	11.30	7.60
27	7.30	4.10	4.30	6.10	11.00	11.20	15.00	15.80	16.20	14.20	11.20	7.60
28	7.30	4.00	4.40	6.30	11.20	11.40	15.10	15.70	16.20	14.20	11.10	7.50
29	7.40	4.00	4.50	6.40	11.30	11.40	15.10	15.80	16.20	14.10	11.00	7.40
30	7.20		4.50	6.50	11.50	11.30	15.10	15.70	16.10	13.90	11.00	7.30
31	7.10		4.50		11.60	11.30	15.10	15.70	15.70	13.90		7.10

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
GRAND COULEE, DEGREES CELSIUS

1965	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	6.90	3.60	3.10	3.50	6.60	10.60	13.40	16.60	17.90	16.90	14.90	11.80
2	6.80	3.70	3.00	3.40	7.20	10.60	13.60	16.80	18.00	16.80	14.70	11.70
3	6.70	3.90	3.00	3.70	7.50	10.60	13.70	16.80	18.00	16.60	14.60	11.50
4	6.70	3.30	2.90	3.70	7.70	10.80	13.70	16.70	18.00	16.70	14.50	11.40
5	6.50	2.80	2.80	3.80	7.80	10.90	13.90	16.60	18.00	16.50	14.40	11.30
6	6.40	3.20	3.00	3.60	7.90	11.00	14.00	16.50	18.00	16.40	14.30	11.30
7	6.40	3.50	3.00	4.00	8.00	11.10	14.10	16.90	18.10	16.40	14.20	11.00
8	6.40	3.60	3.00	4.10	8.20	11.60	13.80	17.10	18.10	16.40	14.10	10.90
9	6.30	3.40	3.00	4.20	8.40	11.70	14.00	16.60	18.10	16.20	14.00	10.80
10	6.00	3.10	3.00	4.30	9.60	11.90	14.20	16.20	18.10	16.10	13.90	10.70
11	5.90	3.30	3.00	4.30	8.60	11.90	14.00	16.40	18.10	16.10	13.80	10.50
12	5.70	3.10	3.20	4.40	8.80	11.90	14.10	16.60	18.20	16.10	13.80	10.40
13	5.60	2.70	3.10	4.40	8.90	12.00	14.30	16.50	18.20	16.00	13.70	10.40
14	5.40	2.70	3.10	4.50	9.00	12.10	14.60	16.40	18.00	15.90	13.60	10.30
15	5.40	2.90	3.10	4.60	9.10	12.20	14.40	16.50	18.10	15.80	13.50	10.20
16	5.30	2.70	3.20	4.60	9.20	12.30	14.40	16.80	18.00	15.70	13.30	9.90
17	5.10	2.60	3.20	5.20	9.20	12.70	14.70	16.70	18.10	15.80	13.20	9.80
18	5.10	2.60	3.10	5.20	9.30	12.70	14.40	16.90	18.10	15.80	13.00	9.60
19	4.90	2.80	3.20	5.30	9.40	12.80	14.50	16.90	18.00	15.70	13.10	9.80
20	4.70	3.00	3.20	5.70	9.30	13.00	14.80	16.90	17.90	15.70	13.00	9.80
21	4.60	3.00	3.10	5.50	9.20	13.10	14.80	16.90	17.90	15.60	12.80	9.60
22	4.60	2.90	3.20	5.50	9.20	13.20	15.00	16.80	17.80	15.60	12.80	9.50
23	4.50	3.10	3.20	5.80	9.20	13.10	15.20	16.80	17.80	15.50	12.60	9.40
24	4.60	3.30	3.10	6.00	9.50	13.10	15.30	16.90	17.70	15.40	12.50	9.60
25	4.30	3.30	3.20	6.00	9.70	13.30	15.40	17.00	17.60	15.30	12.40	9.50
26	4.00	3.20	3.20	6.00	10.10	13.20	14.60	17.20	17.50	15.30	12.40	9.00
27	4.00	3.50	3.20	6.00	10.30	13.00	14.90	17.50	17.40	15.20	12.30	9.00
28	3.90	3.00	3.30	6.40	10.30	13.10	15.30	17.60	17.30	15.20	12.20	9.20
29	3.20		3.30	6.50	10.40	13.10	16.00	17.50	17.20	15.10	12.10	8.60
30	3.20		3.40	6.50	10.30	13.20	16.40	17.60	17.10	15.10	12.00	8.50
31	3.70		3.50		10.50		16.50	17.80		14.90		8.40

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
GRAND COULEE, DEGREES CENTIGRADE

1966	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	8.00	4.80	3.10	4.20	7.60	10.40	12.60	14.90	15.90	16.50	15.50	11.20
2	8.10	4.70	3.10	4.40	7.70	10.40	12.70	15.00	16.00	16.50	15.30	11.40
3	8.20	4.60	3.10	4.60	7.80	10.40	12.80	15.10	16.10	16.70	15.30	11.30
4	8.00	4.50	3.00	4.60	7.90	10.40	12.90	15.20	16.20	16.70	15.10	11.20
5	7.70	4.40	3.00	4.70	8.00	10.45	12.95	15.45	16.30	16.70	14.90	11.20
6	7.60	4.40	3.00	4.80	8.20	10.60	12.90	15.80	16.20	16.80	14.70	10.90
7	7.50	4.30	2.90	4.80	8.20	10.80	13.00	16.10	16.30	16.70	14.60	10.80
8	7.40	4.20	2.90	5.00	8.40	10.90	13.10	16.25	16.30	16.70	14.50	10.50
9	7.30	4.10	2.90	5.00	8.40	11.15	13.20	15.70	16.30	16.80	14.40	10.60
10	7.20	3.80	3.00	5.00	8.40	11.30	13.30	15.90	16.30	16.90	14.20	10.50
11	7.10	3.50	3.00	5.20	8.70	11.30	13.30	15.90	16.30	16.90	14.10	10.30
12	6.90	3.30	3.00	5.20	9.00	11.30	13.60	16.10	16.40	16.80	13.90	10.30
13	6.80	3.50	3.00	5.30	8.90	11.30	14.00	16.10	16.40	16.80	13.70	10.10
14	6.80	3.30	3.10	5.70	9.30	11.20	14.00	16.30	16.50	16.80	13.70	9.90
15	6.60	3.20	3.10	5.60	9.50	11.10	14.00	15.90	16.50	16.80	13.60	9.90
16	6.40	3.30	3.10	5.60	9.60	11.05	14.10	15.40	16.60	16.80	13.40	9.90
17	6.40	3.10	3.20	5.60	9.60	11.10	14.30	15.40	16.50	16.80	13.20	9.70
18	6.20	3.00	3.20	5.70	9.90	10.80	14.60	15.50	16.50	16.70	13.20	9.50
19	6.00	3.00	3.30	6.30	10.10	10.90	14.45	15.80	16.50	16.60	13.10	9.40
20	6.00	3.00	3.30	6.40	10.30	11.10	14.40	15.80	16.50	16.60	12.90	9.30
21	6.00	2.80	3.30	6.50	10.20	11.30	14.65	15.80	16.50	16.40	12.80	9.10
22	5.80	2.80	3.40	6.40	10.20	11.50	14.90	15.80	16.50	16.30	12.70	9.00
23	5.80	2.90	3.50	6.50	10.40	11.60	14.95	15.70	16.50	16.10	12.50	8.90
24	5.60	3.00	3.50	6.70	10.60	11.70	14.90	15.70	16.50	16.10	12.40	8.80
25	5.50	3.00	3.60	6.80	10.70	11.75	14.70	15.75	16.60	16.00	12.30	8.60
26	5.40	3.00	3.70	6.60	10.80	11.80	14.90	15.80	16.60	15.90	12.10	8.50
27	5.30	3.10	3.90	6.70	10.50	11.90	15.20	15.70	16.50	15.90	12.00	8.50
28	5.30	3.00	4.00	7.30	10.40	12.00	15.30	15.70	16.60	15.90	11.90	8.50
29	5.10		4.10	7.60	10.60	12.10	15.30	15.75	16.60	15.80	11.60	8.60
30	5.00		4.10	7.60	10.60	12.30	15.20	15.80	16.60	15.70	11.30	8.40
31	4.90		4.20		10.60		14.80	15.90		15.60		8.30

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
GRAND COULEE, DEGREES CENTIGRADE

1967	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	8.20	5.70	3.90	4.70	6.90	11.50	13.70	15.70	16.70	18.60	15.90	11.10
2	8.00	5.50	3.80	4.40	7.00	11.90	13.60	15.70	16.60	18.60	15.40	11.30
3	8.10	5.50	3.80	4.60	7.40	11.90	13.70	16.20	16.60	18.50	15.40	10.90
4	8.00	5.50	3.80	4.50	7.30	11.90	13.50	16.30	16.70	18.50	15.50	11.30
5	7.90	5.40	3.90	4.70	7.20	11.80	13.60	16.50	16.90	18.50	15.60	10.30
6	7.70	5.30	3.80	4.70	7.20	11.90	13.60	16.60	16.70	18.70	14.90	10.10
7	7.70	5.20	3.80	4.70	7.10	11.90	13.60	15.50	16.90	18.40	14.60	10.50
8	7.70	5.20	3.80	4.60	7.30	11.80	13.90	15.40	17.20	18.40	14.80	10.10
9	7.50	5.30	3.80	4.80	7.50	11.70	13.90	15.50	17.50	18.30	14.80	10.10
10	7.40	5.10	3.70	5.00	7.70	11.50	13.90	16.50	17.40	18.30	14.90	9.90
11	7.30	4.90	3.70	5.00	7.90	11.40	14.00	16.70	17.30	18.40	14.80	9.60
12	7.20	4.80	3.60	5.20	7.90	11.70	14.10	16.70	17.30	18.30	14.60	9.70
13	7.20	4.70	3.80	5.30	8.00	11.70	14.20	17.00	17.40	18.30	14.30	9.50
14	7.10	4.60	3.80	5.20	8.10	11.70	14.30	17.00	17.30	17.90	14.20	9.50
15	7.00	4.60	3.80	5.30	8.00	11.80	14.50	17.30	17.40	18.10	14.00	9.40
16	6.90	4.40	3.80	5.80	8.40	12.00	14.60	17.40	17.50	18.10	13.60	9.00
17	6.90	4.40	3.90	5.70	8.70	12.10	14.70	17.40	17.60	18.40	13.40	8.80
18	6.70	4.40	3.80	6.20	8.60	12.10	14.60	16.90	17.80	18.20	13.30	8.90
19	6.70	4.30	3.80	6.20	8.70	12.20	14.80	16.40	17.80	18.00	13.20	8.70
20	6.50	4.30	3.90	6.10	8.90	12.40	14.90	16.80	17.70	17.90	12.80	8.60
21	6.80	4.20	4.00	5.90	9.00	12.40	14.90	16.50	17.70	17.60	12.70	8.30
22	6.80	4.10	4.00	5.90	9.10	12.50	14.90	16.70	17.80	17.60	12.60	8.30
23	6.60	4.10	3.90	5.80	9.30	12.70	15.10	16.40	17.90	16.90	12.30	8.20
24	6.60	4.00	3.90	6.00	9.40	12.80	15.50	16.40	17.90	16.90	12.10	7.80
25	6.30	4.00	4.00	6.40	9.70	12.90	15.40	16.40	18.00	16.90	12.10	7.70
26	6.20	3.90	4.00	6.30	10.30	13.20	15.60	16.40	17.90	16.90	11.80	7.60
27	6.10	3.90	4.00	6.40	10.40	13.30	15.60	16.70	17.90	16.90	11.30	7.30
28	5.80	3.90	4.10	6.70	10.80	13.50	15.80	16.60	18.50	16.70	11.50	7.20
29	5.80		4.20	6.80	11.00	13.80	15.80	16.90	18.70	16.20	11.80	7.00
30	5.80		4.20	6.80	11.30	13.80	15.50	16.90	18.80	16.30	11.40	6.70
31	5.70		4.30		11.40		15.40	16.80		16.10		6.60

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
GRAND COULEE, DEGREES CENTIGRADE

1908	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	6.40	3.50	2.70	4.90	7.50	11.90	13.80	16.30	17.10	16.90	14.50	10.60
2	6.60	3.40	2.70	4.90	7.50	12.00	13.90	16.40	16.70	16.80	14.40	10.40
3	6.10	3.30	2.80	5.10	7.50	11.90	14.00	16.50	16.50	16.90	14.30	10.20
4	6.10	3.30	2.80	5.20	7.70	11.90	14.10	16.40	16.50	16.80	14.10	10.20
5	6.30	3.30	2.80	5.30	7.70	12.10	14.20	16.40	16.70	16.90	14.10	10.00
6	6.50	3.20	2.80	5.50	7.70	12.20	14.40	16.00	16.60	16.80	13.90	9.90
7	6.60	3.30	2.80	5.60	7.70	12.40	14.30	16.20	16.60	16.90	13.70	9.90
8	6.60	3.30	2.80	5.70	8.00	12.40	14.70	16.10	16.70	16.80	13.60	9.90
9	6.70	3.20	2.80	5.80	8.10	12.30	14.60	16.30	16.70	16.80	13.50	9.80
10	6.10	2.90	2.90	5.80	8.20	12.30	14.80	16.40	16.90	16.60	13.40	9.70
11	6.30	2.90	2.90	5.70	8.40	12.20	14.80	15.90	16.80	16.60	13.30	9.50
12	6.20	3.00	3.00	5.60	8.50	12.10	14.80	15.40	16.90	16.50	13.00	9.30
13	6.30	2.70	3.10	5.70	8.70	12.10	14.90	15.90	16.80	16.40	12.80	9.10
14	6.10	2.70	3.30	6.00	9.10	12.00	14.90	15.90	16.80	16.30	12.80	9.10
15	5.90	2.80	3.40	6.10	9.10	12.00	15.00	16.40	16.90	16.20	12.70	9.10
16	5.90	2.80	3.40	6.10	9.30	12.00	15.00	16.40	16.90	16.10	12.50	8.90
17	5.80	2.70	3.50	6.30	9.60	12.00	15.20	16.50	16.80	15.90	12.40	8.70
18	5.80	2.70	3.60	6.40	9.80	12.30	15.40	16.40	16.80	15.80	12.30	8.60
19	5.80	2.50	3.70	6.50	9.90	12.40	15.40	15.90	16.80	15.80	12.20	8.50
20	5.80	2.40	3.80	6.60	10.10	12.50	15.40	16.10	16.80	15.70	12.00	8.40
21	5.40	2.50	3.90	6.70	10.00	12.60	15.60	16.10	16.90	15.70	12.10	8.30
22	5.40	2.50	3.90	6.80	10.20	12.60	15.30	16.90	16.80	15.60	11.70	8.20
23	5.80	2.50	4.10	7.00	10.40	12.80	15.30	16.80	16.90	15.50	11.50	8.10
24	5.90	2.60	4.10	6.90	10.60	13.10	15.10	16.70	16.90	15.50	11.40	8.10
25	5.50	2.60	4.10	7.00	10.90	13.00	15.20	16.80	16.90	15.40	11.40	8.00
26	5.00	2.60	4.20	7.00	11.00	12.90	15.20	17.10	17.10	15.30	11.30	7.80
27	4.80	2.60	4.30	7.20	11.30	12.80	15.80	17.10	16.90	15.20	11.10	7.60
28	4.60	2.60	4.40	7.40	11.60	13.10	15.00	16.90	16.90	15.00	11.00	7.50
29	4.30	2.70	4.50	7.60	11.60	13.40	15.30	16.80	17.00	14.80	10.90	7.40
30	4.10		4.60	7.70	11.70	13.50	15.50	16.70	17.00	14.70	10.70	7.10
31	3.40		4.80		11.80		16.10	17.00		14.60		6.90

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
GRAND COULEE, DEGREES CENTIGRADE

1969	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	6.00	.90	.60	5.10	7.30	10.90	14.50	16.00	16.80	17.60	14.40	10.80
2	5.30	1.00	.60	5.10	7.20	11.00	14.60	16.30	16.80	17.50	14.30	10.60
3	5.10	1.10	.70	5.20	7.20	11.20	14.60	16.20	16.90	17.40	14.20	10.60
4	5.00	1.20	.70	5.10	7.20	11.30	14.60	15.80	17.00	17.30	14.00	10.40
5	4.90	1.00	.80	5.20	7.30	11.40	14.70	15.60	17.00	17.30	13.90	10.20
6	4.70	.60	.80	5.30	7.40	11.50	14.90	15.50	16.80	17.20	13.70	10.20
7	4.50	.50	.80	5.50	7.60	12.10	14.70	15.80	16.90	17.20	13.60	10.10
8	4.30	1.10	.90	5.80	7.70	12.00	15.00	16.00	17.00	17.20	13.50	9.90
9	4.30	1.00	1.00	5.90	7.90	12.00	15.00	16.20	17.00	17.10	13.30	9.70
10	4.00	.80	1.10	6.00	8.10	12.40	15.00	15.70	17.10	17.00	12.80	9.60
11	4.00	.80	1.20	6.00	8.50	12.40	14.60	15.70	17.10	16.90	12.60	9.40
12	3.90	.70	1.50	6.10	9.10	12.70	14.50	15.60	17.20	16.80	12.60	9.30
13	4.00	.60	1.70	6.10	9.60	12.70	14.50	15.20	17.20	16.80	12.40	9.10
14	3.90	.60	1.70	6.10	10.10	12.70	14.50	15.10	17.30	16.80	12.30	9.10
15	3.80	.60	1.90	6.10	10.20	12.90	14.50	15.60	17.30	16.60	12.00	8.90
16	3.50	.70	2.00	6.20	10.40	13.10	14.70	15.60	17.60	16.50	11.90	8.60
17	3.20	.70	2.20	6.30	10.50	13.40	15.00	15.70	17.60	16.40	12.30	8.50
18	2.70	.50	2.40	6.30	10.70	13.50	15.00	16.30	17.60	16.30	12.30	8.40
19	2.70	.50	2.50	6.40	10.90	13.60	15.10	15.50	17.50	16.20	12.30	8.30
20	2.50	.50	2.70	6.40	10.90	13.80	15.20	15.80	17.50	16.10	12.30	8.10
21	2.30	.30	2.90	6.50	10.80	13.60	14.70	15.80	17.50	16.00	12.00	8.00
22	2.00	.30	3.00	6.50	10.70	13.70	14.80	16.00	17.60	15.90	11.90	7.90
23	1.70	.40	3.10	6.60	10.60	14.20	14.50	16.00	17.50	15.70	12.00	7.80
24	1.50	.40	3.20	6.70	10.50	14.50	14.50	16.00	17.50	15.60	11.70	7.60
25	1.30	.40	3.40	6.80	10.50	14.50	14.40	16.50	17.50	15.50	11.60	7.50
26	1.20	.50	3.70	6.90	10.60	14.50	14.70	16.90	17.60	15.40	11.40	7.30
27	1.10	.50	4.00	7.10	10.70	14.50	15.50	16.70	17.60	15.20	11.30	7.10
28	1.00	.50	4.30	7.30	10.80	14.40	15.30	17.10	17.60	15.00	11.10	7.10
29	.90		4.50	7.50	10.90	14.30	15.20	17.30	17.60	14.80	11.00	7.30
30	.90		4.80	7.40	10.80	14.40	15.40	16.80	17.60	14.60	10.90	7.10
31	.90		5.00		10.90		15.60	16.70		14.50		6.90

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
ROCKY REACH, DEGREES CENTIGRADE

1964	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	7.75	5.70	4.00	4.85	7.20	11.60	13.00	16.25	16.00	15.80	13.20	9.60
2	7.85	5.65	4.00	5.00	7.30	11.70	13.00	16.15	16.10	15.30	13.20	9.60
3	8.00	5.80	4.10	4.10	7.30	11.70	13.00	16.10	16.10	15.25	12.90	9.80
4	7.60	5.60	4.10	5.30	7.40	11.70	13.20	16.10	16.10	15.20	12.80	9.80
5	6.40	5.50	4.00	5.45	7.50	11.60	13.40	16.10	16.30	15.20	12.70	9.70
6	6.30	5.50	4.00	5.60	7.70	11.70	13.60	16.10	16.45	15.20	12.50	9.70
7	7.00	5.50	3.90	5.80	7.85	11.60	13.90	16.30	16.50	15.20	12.50	9.60
8	6.75	5.40	3.90	5.90	7.90	11.40	14.10	16.40	16.30	15.30	12.30	9.30
9	6.60	5.20	3.90	5.60	7.90	11.30	14.20	16.40	16.20	15.30	12.00	9.10
10	6.50	5.30	3.90	5.80	8.10	11.50	14.20	16.80	16.10	15.40	12.00	9.00
11	6.30	5.15	3.90	6.00	8.00	11.80	14.30	16.70	16.10	15.40	12.05	8.80
12	6.10	5.10	3.90	6.10	8.10	12.10	14.60	16.60	16.00	15.30	11.75	8.50
13	6.20	5.00	4.00	6.10	8.20	12.30	14.80	16.60	16.00	15.40	11.70	8.30
14	6.20	4.90	4.10	6.05	8.20	12.50	14.70	16.50	16.10	15.30	11.50	8.05
15	6.20	4.80	4.30	6.10	8.50	12.70	14.70	16.70	16.10	15.10	11.30	7.60
16	6.00	4.90	4.30	6.10	8.90	12.70	14.80	16.80	16.30	14.90	11.20	7.00
17	6.10	4.90	4.30	6.20	9.10	12.50	14.70	16.90	16.40	14.70	11.10	6.50
18	6.50	5.00	4.35	6.20	9.60	12.40	14.70	17.00	16.20	14.50	11.00	5.30
19	6.10	5.00	4.30	6.10	10.00	12.30	15.05	17.10	16.20	14.40	10.90	5.40
20	6.00	5.00	4.20	6.25	9.90	12.40	15.10	17.20	16.00	14.30	10.70	5.70
21	5.80	5.10	4.20	5.40	9.90	12.70	15.10	17.20	15.90	14.20	10.70	4.80
22	5.85	5.00	4.20	5.30	9.90	12.90	15.20	17.30	15.80	14.20	10.70	5.70
23	6.30	4.80	4.20	5.20	9.90	13.10	15.20	17.30	15.95	14.10	10.60	6.00
24	5.90	4.60	4.10	5.30	9.95	13.05	15.40	17.00	15.90	14.20	10.60	6.00
25	5.60	4.50	4.10	5.45	10.50	12.90	15.70	16.80	16.20	14.10	10.60	5.85
26	5.70	4.40	4.10	6.65	10.75	13.00	16.00	16.70	16.20	13.90	10.30	5.60
27	5.60	4.10	4.25	6.70	10.90	12.90	16.10	16.30	16.10	13.60	10.20	5.60
28	5.70	4.05	4.40	6.85	11.30	12.80	16.20	16.30	16.20	13.50	9.90	5.50
29	5.70	4.00	4.50	6.90	11.40	12.80	16.30	16.20	16.20	13.20	9.75	5.70
30	5.70	4.60	4.60	7.00	11.60	12.90	16.55	16.10	16.10	13.30	9.70	5.80
31	5.70	5.70	4.90	11.70	11.80	16.40	16.15	16.15	13.30	13.30	5.80	5.80

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
ROCKY REACH, DEGREES CELSIUS

1965	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	5.70	3.83	3.10	3.60	7.30	10.80	14.10	16.90	17.60	17.10	14.00	10.10
2	5.70	3.70	3.00	3.75	7.20	11.15	14.20	17.40	17.60	17.15	13.95	9.90
3	5.75	3.30	3.10	4.00	7.30	11.40	14.20	17.60	17.60	17.90	13.65	9.95
4	5.75	3.15	3.20	4.20	7.50	11.50	14.40	17.70	17.70	16.80	13.50	10.00
5	5.55	3.40	3.10	4.40	8.00	11.50	14.70	17.40	17.80	16.70	13.50	10.10
6	5.50	4.05	3.30	4.60	7.70	11.70	14.90	17.65	17.90	16.70	13.30	10.00
7	5.50	4.70	3.20	4.80	8.25	11.90	15.10	17.70	17.80	16.50	13.30	10.10
8	5.40	5.80	3.10	4.80	8.50	12.00	15.20	17.60	17.70	16.20	13.30	9.90
9	5.35	5.40	3.40	4.80	8.80	12.40	14.90	17.80	18.00	16.20	13.30	9.90
10	5.30	5.30	3.75	4.80	9.10	12.80	14.50	17.80	18.10	16.15	13.30	10.00
11	5.30	3.30	3.60	4.90	9.35	12.80	14.80	18.10	18.00	15.80	13.10	9.90
12	5.40	3.60	4.00	5.00	9.50	12.60	14.80	18.00	18.10	15.75	12.90	9.80
13	5.40	3.90	3.70	5.30	9.60	12.60	14.80	17.30	18.00	15.60	12.60	9.50
14	5.40	3.10	3.65	5.50	9.70	12.50	14.90	16.70	17.90	15.40	12.40	9.20
15	5.30	3.30	3.75	5.60	9.65	12.55	15.30	17.20	17.70	15.30	12.30	8.90
16	5.35	2.60	3.70	5.80	9.41	12.80	15.60	17.30	17.30	15.15	12.10	8.65
17	5.30	2.55	3.55	6.00	9.60	13.30	15.40	17.30	17.20	14.75	12.00	8.30
18	5.10	2.60	3.30	5.70	9.80	13.10	15.30	17.50	16.90	14.50	11.90	8.20
19	5.20	2.80	3.30	5.70	9.80	13.30	15.50	17.70	16.90	14.40	11.80	8.10
20	4.90	3.10	3.30	5.70	9.70	13.50	15.25	17.60	17.20	14.45	11.60	8.00
21	4.70	3.10	3.25	6.00	9.70	13.50	14.90	17.50	17.10	14.50	11.80	8.00
22	4.60	2.90	3.40	6.40	9.85	13.70	15.10	17.50	17.20	14.50	11.70	7.90
23	4.40	2.90	3.40	6.50	9.95	13.70	15.50	17.50	17.40	14.40	11.30	7.70
24	4.25	2.80	3.40	6.60	10.00	13.90	15.90	17.40	17.60	14.60	11.10	7.50
25	4.10	3.10	3.40	6.60	10.10	14.00	16.20	17.50	17.50	14.70	11.00	7.40
26	3.80	3.00	3.40	6.80	10.50	13.80	16.35	17.45	17.40	14.60	10.80	7.30
27	3.90	2.90	3.30	6.90	10.60	13.70	16.50	17.40	17.40	14.50	10.55	7.10
28	3.65	2.90	3.30	7.05	10.95	13.60	16.80	17.40	17.15	14.50	10.30	6.90
29	4.00		3.35	7.25	11.05	13.70	16.35	17.40	17.00	14.40	10.20	6.70
30	3.75		3.30	7.35	11.00	13.70	16.50	17.30	16.90	14.30	10.10	6.80
31	3.80		3.50		10.90		16.55	17.40		14.10		6.90

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
ROCKY REACH, DEGREES CENTIGRADE

1962	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	6.74	4.69	3.10	5.20	9.10	10.80	12.60	16.40	16.20	16.70	14.50	10.70
2	6.54	4.72	3.20	5.50	9.20	10.90	12.50	16.40	16.40	16.60	14.30	10.50
3	6.35	4.61	3.20	6.00	9.50	10.60	12.60	16.30	16.60	16.30	14.10	10.30
4	6.24	4.55	3.20	5.70	9.00	10.50	13.00	16.10	16.70	16.10	14.10	10.40
5	6.27	4.53	3.20	5.70	9.20	10.80	13.40	16.10	16.90	16.10	13.90	10.50
6	6.16	4.63	3.20	5.00	9.10	11.10	13.50	16.10	16.90	16.10	13.80	10.10
7	6.04	4.47	3.40	5.00	9.10	11.10	13.80	16.40	16.90	16.10	13.60	9.70
8	6.05	4.36	3.50	6.10	9.10	11.30	13.80	16.40	17.00	16.10	13.40	9.60
9	6.13	4.28	3.50	6.30	9.20	11.40	13.90	16.70	17.00	16.00	13.20	9.40
10	6.10	4.06	3.50	6.40	9.20	11.50	14.00	16.80	17.00	15.90	12.90	9.30
11	6.06	4.93	3.80	6.40	9.20	11.60	14.10	17.00	17.00	15.70	12.60	9.10
12	6.95	3.80	3.70	6.50	9.30	11.60	14.00	17.10	17.00	15.50	12.60	9.10
13	6.07	3.64	4.00	6.50	9.40	11.70	14.10	16.90	17.10	15.40	12.40	9.00
14	6.17	3.33	3.70	6.60	9.40	11.80	14.30	16.90	16.80	15.30	12.20	8.90
15	6.08	3.03	3.60	6.70	9.10	11.90	14.60	16.60	16.80	15.20	12.00	9.00
16	5.86	3.06	3.50	7.00	9.30	12.00	14.80	17.20	16.80	15.10	12.10	9.00
17	5.70	2.85	3.50	7.10	9.50	12.00	15.00	17.50	16.80	15.30	12.20	9.00
18	5.56	2.97	3.30	7.00	10.00	11.90	14.90	17.40	16.80	15.20	12.20	9.00
19	5.37	3.00	3.30	6.90	10.20	11.90	15.20	17.50	16.80	14.90	12.10	9.00
20	5.63	3.00	3.40	6.70	10.30	11.80	15.20	17.30	16.80	15.00	12.10	9.10
21	5.10	3.00	3.40	6.80	10.60	11.70	15.30	17.00	16.90	14.90	12.10	9.00
22	4.88	3.07	3.50	7.10	10.60	11.70	15.20	16.80	17.00	14.90	12.10	8.70
23	4.75	3.12	3.60	7.00	10.60	11.90	15.30	16.50	17.00	14.60	11.90	8.50
24	4.76	3.14	3.80	7.20	10.70	12.00	15.60	16.40	17.00	14.50	11.70	8.30
25	4.58	3.10	3.90	7.40	11.10	12.20	15.60	16.60	17.00	14.60	11.60	8.10
26	4.32	3.15	4.10	7.80	11.50	12.30	15.70	16.60	17.00	14.80	11.40	8.00
27	4.38	3.48	4.30	7.90	11.50	12.40	15.60	16.50	16.90	14.80	11.20	7.60
28	4.50	3.15	4.50	7.70	11.50	12.70	15.70	16.50	17.00	14.90	11.10	7.40
29	4.58		4.70	7.90	11.50	12.60	16.00	16.30	17.10	14.80	10.90	7.20
30	4.60		4.90	8.20	11.10	12.70	16.20	16.20	16.90	14.70	10.80	7.20
31	4.65		5.00		10.80		16.30	16.20		14.60		7.20

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
LOCKY REACH, DEGREES CELSIUS

1967	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	7.00	5.60	4.10	4.80	7.40	11.70	14.50	17.10	17.70	17.60	14.40	9.90
2	7.00	5.50	4.10	5.00	7.50	11.90	14.50	16.80	17.80	17.30	14.10	9.70
3	7.20	5.40	4.00	5.20	7.70	11.70	14.70	16.70	17.90	17.10	14.00	9.70
4	7.20	5.50	3.90	5.20	7.90	11.80	15.00	16.60	18.30	16.90	13.80	9.60
5	7.10	5.30	3.80	5.50	8.10	12.20	14.60	16.80	18.30	16.70	13.50	9.40
6	6.90	5.50	4.00	5.60	8.10	12.30	14.30	17.10	18.30	16.60	13.20	9.40
7	6.60	5.40	4.00	5.70	8.50	12.40	14.30	17.30	18.00	16.70	13.20	9.30
8	6.50	5.20	4.10	5.80	8.80	12.50	14.30	17.50	17.70	16.80	13.10	9.30
9	6.60	5.20	4.00	5.90	9.10	12.30	14.30	17.60	17.60	16.90	13.00	9.30
10	6.70	5.20	4.10	5.80	9.00	12.20	14.40	17.90	17.60	16.90	12.90	9.20
11	6.80	5.10	4.00	5.80	8.90	11.90	14.60	18.10	17.40	16.90	12.90	9.20
12	6.60	5.00	3.90	5.90	8.90	11.80	14.90	17.80	17.20	17.00	12.60	8.90
13	6.60	4.90	3.90	6.00	8.80	11.90	15.10	17.60	17.10	16.90	12.80	8.60
14	6.70	4.80	3.80	5.90	8.90	12.20	15.20	17.60	17.20	16.70	12.90	8.40
15	6.70	4.90	3.80	5.90	8.90	12.30	15.20	17.70	17.40	16.60	12.80	8.20
16	6.60	4.80	3.90	5.80	9.30	12.40	15.20	18.40	17.60	16.50	12.80	8.00
17	6.50	4.60	3.90	5.90	9.50	12.60	15.40	18.40	17.90	16.40	12.80	7.70
18	6.50	4.50	4.00	5.80	9.60	12.70	15.50	18.50	17.80	16.30	12.60	7.40
19	6.20	4.40	4.10	5.90	9.70	12.80	15.50	18.50	17.90	16.20	12.70	7.30
20	6.10	4.30	4.20	5.90	9.90	13.10	15.40	18.60	18.10	16.00	12.40	7.40
21	6.00	4.20	4.30	6.10	10.20	13.10	15.40	18.70	18.20	15.90	12.20	7.20
22	6.00	4.10	4.40	6.20	10.10	12.80	15.70	18.60	18.30	15.80	12.00	6.90
23	5.80	4.10	4.40	6.40	10.10	13.00	15.90	18.40	18.30	15.60	11.80	6.70
24	5.60	4.10	4.50	6.70	10.00	13.20	15.90	17.70	18.20	15.50	11.60	6.60
25	5.60	4.20	4.50	6.80	10.00	13.50	16.10	17.60	18.10	15.30	11.20	6.70
26	5.70	4.20	4.50	6.90	10.10	13.70	16.40	17.60	18.10	15.10	10.90	6.80
27	5.70	4.20	4.60	6.90	10.20	14.00	16.60	17.50	18.00	14.90	10.60	7.00
28	5.90	4.10	4.60	7.00	10.50	14.00	16.60	17.50	18.10	14.90	10.50	7.10
29	5.80		4.70	7.10	11.00	14.10	16.70	17.60	18.00	14.70	10.30	7.00
30	5.80		4.60	7.20	11.20	14.30	16.90	17.50	17.80	14.40	10.10	6.90
31	5.70		4.70		11.40		17.00	17.60		14.50		6.80

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
ROCKY REACH, DEGREES CENTIGRADE

1968	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	6.60	2.80	3.40	4.00	9.00	12.10	13.50	17.10	17.60	16.60	13.40	9.60
2	6.10	3.30	3.60	5.00	9.80	12.30	13.80	17.20	17.70	16.60	13.10	9.50
3	5.80	3.00	3.60	5.10	9.00	12.50	14.20	16.90	17.70	16.50	13.10	9.50
4	5.60	2.90	3.60	5.20	8.10	12.80	14.50	17.10	17.90	16.20	13.10	9.30
5	5.40	2.90	3.50	5.40	9.30	12.90	14.80	17.30	17.90	16.10	13.00	9.10
6	5.10	2.90	3.50	5.60	9.40	12.80	15.00	17.30	18.00	15.90	12.80	8.90
7	4.90	2.70	3.30	5.80	9.50	12.50	15.20	17.30	18.00	15.80	12.70	8.70
8	4.80	2.60	3.20	5.80	9.40	12.20	15.20	17.30	17.90	15.50	12.60	8.70
9	4.60	2.50	3.10	6.00	9.50	12.60	15.30	17.30	17.80	15.30	12.50	8.40
10	4.50	2.40	3.10	6.20	9.70	12.80	15.10	17.20	17.40	15.20	12.30	8.40
11	4.50	2.40	3.10	6.40	9.90	12.50	15.30	17.00	17.50	15.10	12.10	8.40
12	4.30	2.40	3.10	6.60	9.90	12.30	15.00	17.20	17.40	15.00	12.00	8.40
13	4.20	2.40	3.10	6.40	9.70	12.30	15.10	17.20	17.20	14.90	11.80	8.10
14	4.30	2.40	3.10	6.30	9.80	12.30	15.00	17.00	17.10	14.80	11.50	8.10
15	4.50	2.40	3.20	6.40	10.00	12.30	15.10	16.90	17.00	14.80	11.30	8.00
16	4.80	2.30	3.30	6.30	10.10	12.20	15.10	17.00	17.80	14.90	11.20	8.00
17	4.90	2.20	3.50	6.30	10.50	12.30	15.10	16.80	16.70	14.70	11.10	8.00
18	4.90	2.10	3.60	6.50	10.80	12.30	15.30	16.50	16.50	14.60	11.00	7.90
19	4.90	2.20	3.60	6.70	10.80	12.50	15.40	16.20	16.30	14.60	11.00	7.60
20	4.90	2.30	3.70	6.90	10.70	12.70	15.60	16.10	16.30	14.50	11.00	7.50
21	4.90	2.40	3.80	7.10	10.70	12.80	15.70	16.40	16.20	14.40	10.80	7.40
22	4.90	2.40	4.20	7.30	10.50	12.90	15.80	16.60	16.20	14.30	10.70	7.10
23	5.00	2.50	4.20	7.60	10.40	13.10	15.90	16.60	16.30	14.20	10.80	6.80
24	4.90	2.60	4.40	7.70	10.60	13.30	16.00	16.70	16.30	14.20	10.70	6.80
25	4.80	2.70	4.50	7.70	10.70	13.40	16.10	16.50	16.40	14.30	10.70	6.80
26	4.60	2.80	4.50	7.90	11.00	13.50	16.20	16.30	16.50	14.30	10.50	6.60
27	4.30	3.00	4.50	8.10	11.20	13.70	16.50	16.30	16.70	14.10	10.50	6.30
28	3.90	3.20	4.60	8.30	11.40	13.40	16.80	16.80	16.80	14.00	10.40	5.80
29	3.40	3.20	4.70	8.70	11.70	13.00	16.80	16.90	16.70	13.80	10.20	5.20
30	3.00		4.70	8.70	11.90	13.20	17.00	17.20	16.70	13.70	10.00	4.20
31	2.90		4.80		12.00		16.80	17.40		13.70		3.40

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
ROCKY BEACH, DEGREES CENTIGRADE

1969	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	3.10	.30	1.20	5.00	7.90	12.20	15.40	17.50	18.00	17.30	14.40	9.50
2	3.30	.50	1.40	5.10	8.10	12.40	15.60	17.80	18.20	17.00	14.20	9.40
3	3.80	.60	1.40	5.10	8.10	12.70	15.60	17.40	18.00	16.80	14.10	9.30
4	4.20	.80	1.50	5.30	8.10	12.80	15.60	17.30	18.00	16.80	14.10	9.10
5	4.30	1.10	1.50	5.40	8.20	13.00	15.70	17.30	17.80	16.70	14.00	9.00
6	4.50	1.10	1.50	5.60	8.30	13.10	15.70	17.30	17.80	16.80	13.70	8.90
7	4.60	1.00	1.50	5.80	8.50	13.00	15.90	17.30	17.70	16.70	13.60	8.90
8	4.50	1.10	1.50	5.90	8.80	12.90	16.10	17.60	17.80	16.60	13.30	8.90
9	4.30	1.00	1.60	6.20	9.00	13.10	16.30	17.90	17.70	16.50	13.20	8.90
10	4.20	1.00	1.50	6.40	9.20	13.70	16.30	17.80	17.90	16.50	13.00	8.90
11	4.00	1.10	1.50	6.60	9.30	13.70	16.30	17.30	18.10	16.40	12.80	8.60
12	3.70	1.20	1.50	6.80	9.50	13.90	16.30	17.40	18.10	16.30	12.80	8.30
13	3.60	1.30	1.60	6.90	9.80	14.10	16.20	17.70	18.10	16.10	12.50	8.30
14	3.40	1.30	1.60	7.00	10.00	13.90	15.90	17.90	17.90	15.90	12.30	8.30
15	3.30	1.30	1.80	7.00	10.20	14.20	15.80	18.10	17.80	15.60	12.10	8.20
16	3.30	1.30	1.90	7.00	10.50	14.20	16.00	17.90	17.70	15.30	11.90	8.10
17	3.30	1.30	2.20	7.00	10.80	14.20	16.10	17.70	17.70	15.40	11.50	8.20
18	3.30	1.30	2.50	7.00	11.00	14.40	16.30	17.60	17.70	15.30	11.30	8.30
19	3.20	1.30	2.70	7.20	11.40	14.60	16.50	17.50	17.60	15.30	11.20	8.10
20	2.90	1.20	2.90	7.10	11.60	15.00	16.80	17.10	17.60	15.30	11.00	8.10
21	2.60	1.10	2.90	7.30	11.80	15.10	17.00	17.20	17.60	15.30	10.90	7.90
22	2.30	1.00	3.10	7.30	12.00	15.20	17.10	17.50	17.50	15.30	10.80	7.80
23	1.70	.80	3.20	7.40	12.00	15.10	17.30	17.80	17.60	15.30	10.60	7.70
24	1.30	.80	3.40	7.40	12.00	14.80	17.50	17.80	17.60	15.20	10.40	7.40
25	1.00	.90	3.90	7.40	11.80	14.80	17.40	17.70	17.50	15.00	10.40	7.20
26	1.10	1.00	3.80	7.50	11.60	14.90	17.20	17.70	17.40	14.80	10.30	7.10
27	.90	1.10	3.90	7.60	11.50	14.80	17.10	17.50	17.20	14.80	10.20	7.00
28	.60	1.10	4.20	7.60	11.30	14.80	17.00	17.40	17.30	14.70	10.00	6.80
29	.30		4.50	7.70	11.30	15.00	16.90	17.30	17.30	14.60	9.80	6.50
30	.20		4.80	7.70	11.70	15.30	16.70	17.30	17.40	14.60	9.70	6.30
31	.20		4.90	11.90			16.80	17.70		14.50		6.10

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
PRIEST RAPIDS, DEGREES CENTIGRADE

1964	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	7.20	4.60	4.70	6.00	8.20	12.40	13.70	16.70	16.40	15.60	13.20	9.10
2	6.70	4.60	4.70	6.00	8.00	12.40	13.70	16.70	16.20	15.60	12.90	9.20
3	6.70	4.60	4.80	6.00	8.00	12.20	13.80	16.60	16.30	15.30	12.70	9.10
4	6.60	4.60	4.70	6.40	9.40	12.10	13.90	16.40	16.30	15.20	12.50	8.90
5	6.60	4.40	4.60	6.30	8.60	12.20	13.90	16.20	16.50	15.30	12.40	8.80
6	6.40	4.50	4.40	6.10	8.60	12.10	14.10	16.50	16.70	15.30	12.40	8.70
7	6.30	4.40	4.50	6.20	8.70	12.30	14.40	16.90	16.70	15.20	12.10	8.50
8	6.20	4.50	4.40	6.60	9.10	12.10	14.70	17.00	16.50	15.20	11.90	8.50
9	6.10	4.60	4.20	6.60	9.30	12.10	14.70	17.20	16.40	15.20	11.60	8.40
10	6.20	4.60	4.10	7.00	9.30	12.10	14.90	17.10	16.30	15.10	11.50	8.30
11	6.20	4.70	4.50	7.20	9.10	12.20	15.10	17.30	16.40	15.20	11.40	7.90
12	6.00	4.70	4.50	7.50	9.30	12.40	15.10	17.40	16.60	15.20	11.30	7.80
13	5.90	4.50	4.50	7.20	9.30	12.60	15.50	17.10	16.80	15.30	11.10	7.90
14	5.80	4.50	4.60	7.30	9.10	12.90	15.60	17.00	16.60	15.20	10.90	7.50
15	5.60	4.60	4.70	7.40	8.95	13.10	15.60	17.30	16.50	15.10	10.80	7.10
16	5.40	4.50	4.70	7.40	9.10	13.20	15.40	17.20	16.50	14.90	10.40	6.20
17	5.20	4.40	4.70	7.30	9.35	13.10	15.40	17.30	16.60	14.70	10.20	5.40
18	4.80	4.70	4.80	7.40	9.55	12.90	15.50	17.40	16.30	14.60	10.20	5.30
19	4.70	4.80	4.70	7.80	9.80	12.90	15.30	16.90	16.30	14.40	10.10	5.00
20	4.80	4.80	4.80	7.65	10.30	12.90	15.45	17.00	15.90	14.30	10.10	4.70
21	4.90	4.70	5.00	7.60	10.60	12.90	15.80	17.40	15.80	14.10	10.00	4.10
22	4.80	4.80	5.00	7.60	10.50	13.10	15.70	17.70	15.90	14.00	9.90	4.20
23	4.80	4.90	4.50	7.40	10.30	13.50	15.50	17.90	16.10	13.90	9.70	4.50
24	4.50	4.80	4.60	7.75	10.50	13.70	15.80	18.10	16.30	13.80	9.80	4.40
25	4.50	4.80	4.70	7.50	10.40	13.75	15.90	18.00	16.40	13.60	9.60	3.60
26	4.40	4.90	4.90	8.40	10.60	13.80	16.10	17.60	16.20	13.40	9.20	3.40
27	4.40	4.90	4.90	7.60	11.00	13.60	16.30	17.30	16.30	13.20	8.90	3.30
28	4.70	4.80	5.10	8.00	11.45	13.50	16.60	16.80	16.10	13.30	9.20	3.30
29	4.70	4.60	5.60	8.20	11.50	13.55	16.80	16.40	16.00	13.30	9.00	3.60
30	4.70		5.20	8.20	11.90	13.60	17.00	16.30	15.70	13.30	9.00	3.60
31	4.60		5.50		12.25		17.00	16.30		13.30		3.60

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
PRIEST RAPIDS, DEGREES CENTIGRADE

1965	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	3.60	4.20	3.20	4.90	8.30	11.80	14.80	18.20	17.70	16.80	13.70	9.30
2	3.80	3.80	3.30	4.90	8.10	12.00	14.90	18.30	17.50	16.90	13.80	9.20
3	4.10	3.70	3.50	5.10	8.10	12.10	15.00	17.80	17.20	17.10	13.70	9.10
4	3.90	3.60	3.60	5.20	8.10	12.20	15.00	17.70	17.20	16.90	13.60	9.20
5	4.00	3.40	3.60	5.30	7.90	12.40	15.30	17.90	17.30	16.70	13.50	9.00
6	4.20	3.50	3.80	5.30	8.10	12.50	15.40	18.20	17.40	16.50	13.20	8.80
7	4.30	3.40	3.80	5.30	8.40	12.50	15.90	18.70	17.60	16.50	13.10	8.90
8	4.40	3.30	3.80	5.60	8.80	12.70	15.70	19.00	17.70	16.70	12.90	9.00
9	4.50	3.20	4.10	5.70	9.20	12.80	15.80	18.90	17.60	16.70	12.90	9.10
10	4.40	3.00	4.30	5.80	9.60	13.00	15.70	19.00	17.80	16.40	12.60	8.80
11	4.40	3.10	4.30	6.20	9.90	13.10	15.50	19.00	18.00	16.20	12.40	8.80
12	4.50	3.10	4.30	6.40	10.20	13.10	15.30	19.00	18.10	16.00	12.20	8.80
13	4.50	3.20	4.40	6.70	10.40	13.00	15.50	18.80	18.20	16.00	12.00	8.60
14	4.60	3.30	4.50	6.80	10.40	13.00	15.70	18.80	17.90	15.90	12.10	8.50
15	4.60	3.00	4.60	6.90	10.40	12.90	15.90	19.10	17.50	15.30	11.90	8.30
16	4.70	2.90	4.60	7.00	10.40	13.00	16.00	19.50	17.10	14.90	11.90	8.10
17	4.70	3.00	4.40	6.80	10.40	13.10	16.20	18.70	16.90	14.80	11.90	8.00
18	4.80	3.20	4.20	7.00	10.40	13.40	16.40	18.40	16.90	14.50	11.90	7.80
19	4.90	3.50	4.10	7.00	10.30	13.70	16.50	18.40	17.00	14.50	11.80	7.50
20	4.90	3.60	4.30	7.30	10.30	14.00	16.20	18.20	17.00	14.50	11.60	7.40
21	5.00	3.50	4.50	7.30	10.40	14.20	15.90	18.30	17.10	14.40	11.30	7.40
22	4.80	3.20	4.50	7.20	10.60	14.20	15.90	18.30	17.20	14.30	11.00	7.20
23	4.50	3.10	4.30	7.20	10.60	14.40	15.90	18.30	17.10	14.40	10.90	6.80
24	4.40	3.10	4.00	7.50	10.70	14.50	16.00	18.30	17.20	14.30	10.70	6.50
25	4.20	3.10	4.00	7.90	11.00	14.60	16.30	18.20	17.20	14.00	10.60	6.30
26	4.30	3.30	4.00	8.00	11.20	14.30	16.70	18.10	17.10	13.90	10.20	6.40
27	4.40	3.50	3.90	8.10	11.30	14.30	17.10	18.10	16.80	13.80	10.00	5.70
28	4.40	3.40	4.20	8.30	11.60	14.40	17.40	17.60	16.70	13.90	9.70	5.90
29	4.80		4.20	8.30	11.80	14.60	17.60	17.30	16.60	13.80	9.60	5.70
30	4.80		4.50	8.40	11.70	14.60	17.80	17.40	16.60	13.90	9.40	5.80
31	4.50		4.70		11.70		18.00	17.60		13.80		5.60

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
PRIEST RAPIDS, DEGREES CENTIGRADE

1966	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	5.50	4.10	3.60	6.10	9.30	11.90	13.40	17.10	17.10	17.10	13.20	10.30
2	5.50	4.10	3.50	6.50	9.40	11.70	13.20	17.30	17.10	16.80	13.20	10.20
3	5.30	4.00	3.70	6.80	9.60	11.30	13.30	17.60	17.20	16.80	13.30	10.10
4	5.30	4.30	3.40	6.40	9.70	11.40	13.30	17.70	17.50	16.70	13.20	10.00
5	5.00	4.50	3.60	6.70	10.00	11.50	13.60	17.50	17.80	16.70	13.10	9.70
6	5.30	4.50	3.80	6.90	10.30	11.60	13.90	17.60	17.60	16.60	12.90	9.60
7	5.40	4.40	3.60	7.20	10.20	11.90	14.30	17.70	17.50	16.50	12.70	9.10
8	5.50	4.50	3.70	7.50	10.50	12.10	14.70	17.60	17.40	16.00	12.40	8.90
9	5.60	4.50	4.10	7.70	10.40	12.10	14.90	17.40	17.60	15.80	12.30	8.60
10	5.20	4.40	4.20	8.00	10.20	12.20	15.00	17.40	17.70	15.50	11.90	8.40
11	5.20	4.60	4.10	7.70	10.10	12.20	15.00	17.20	17.60	15.30	11.50	8.50
12	5.20	4.50	4.40	7.70	10.10	12.20	15.00	17.30	17.40	14.90	11.90	8.60
13	5.40	4.30	5.20	7.40	9.80	12.30	15.00	17.50	17.30	14.20	11.90	8.60
14	5.30	4.20	4.70	7.80	9.70	12.50	15.20	17.70	17.80	14.30	11.90	8.40
15	5.30	4.00	4.60	8.10	9.60	12.60	15.10	17.80	17.70	14.40	11.60	8.30
16	5.10	4.10	4.70	8.40	9.60	12.80	15.30	18.00	17.90	14.40	11.50	8.20
17	4.90	4.20	4.50	8.60	9.90	13.10	15.50	17.80	17.50	14.00	11.40	8.10
18	4.90	4.00	4.50	8.10	10.10	13.10	15.90	17.90	17.70	13.80	11.20	8.20
19	4.80	4.20	4.50	8.00	10.40	13.00	16.00	17.70	17.50	13.60	11.10	8.10
20	4.70	4.60	4.40	8.00	10.80	12.90	15.80	17.60	17.50	13.20	11.20	8.10
21	4.50	3.90	4.30	8.10	11.20	12.80	15.90	17.80	17.40	12.80	11.00	7.90
22	4.50	3.70	4.30	8.40	11.10	12.50	16.00	18.00	17.70	13.10	10.70	7.80
23	4.60	3.70	4.60	8.60	11.20	12.40	16.30	18.00	17.70	13.30	10.60	7.70
24	4.20	3.60	4.70	8.80	11.40	12.10	16.40	18.10	17.40	13.40	10.70	7.80
25	4.00	3.70	4.90	8.70	11.60	12.30	16.10	18.20	17.30	13.60	10.50	7.80
26	3.90	3.80	5.00	8.40	11.90	12.80	16.20	17.60	17.30	13.60	10.30	7.30
27	4.00	3.80	5.20	8.20	12.00	13.20	16.50	17.40	17.20	13.50	10.40	7.20
28	3.90	3.80	5.30	8.40	12.00	13.40	16.70	17.10	17.30	13.50	10.30	7.20
29	4.00		5.50	8.60	12.20	13.40	16.90	16.80	17.30	13.40	10.50	7.10
30	4.10		5.60	9.00	12.20	13.60	16.90	16.70	17.40	13.40	10.40	6.90
31	4.00		5.80		11.90		16.90	16.80		13.20		6.70

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
PRIEST RAPIDS, DEGREES CENTIGRADE

1967	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	5.70	5.40	4.90	5.80	7.80	11.50	14.90	17.70	18.80	17.10	13.50	9.30
2	6.60	5.40	4.80	5.90	8.20	12.10	15.10	17.60	18.90	16.80	13.00	9.00
3	6.40	5.60	4.80	5.80	8.40	12.10	15.40	18.00	18.90	16.40	12.80	9.20
4	6.50	5.80	4.90	6.00	8.40	12.20	15.50	18.00	18.60	16.40	12.40	8.80
5	6.20	5.70	4.80	6.10	8.70	12.70	15.60	17.90	18.60	16.60	12.10	8.60
6	6.00	5.50	4.90	6.20	9.40	12.80	15.40	17.80	18.50	16.40	12.00	8.50
7	6.00	5.60	4.80	6.40	9.50	13.30	15.20	17.50	18.40	16.60	11.90	8.50
8	6.20	5.50	4.80	6.80	9.60	13.60	15.00	17.60	18.50	16.70	11.90	8.30
9	6.00	5.50	4.80	7.00	9.50	13.20	14.90	18.00	18.60	16.60	11.80	8.10
10	6.20	5.50	4.70	6.90	9.30	12.80	15.00	18.00	18.30	16.50	11.80	8.30
11	6.20	5.50	4.90	6.80	9.20	12.60	15.20	18.10	18.10	16.50	11.70	8.00
12	6.10	5.60	5.00	7.00	9.40	12.50	15.40	18.60	17.80	16.10	11.70	7.50
13	6.00	5.40	4.70	6.80	9.70	12.60	15.70	18.90	17.70	16.00	11.70	7.40
14	6.00	5.30	4.60	7.00	10.20	12.80	15.80	18.90	17.80	15.80	11.80	7.20
15	6.20	5.20	4.70	7.20	10.20	12.90	16.10	19.10	17.70	15.60	11.90	7.10
16	6.00	5.20	4.80	7.00	10.40	13.10	16.10	19.30	17.80	15.60	11.70	6.90
17	5.90	5.20	4.80	6.90	10.60	13.30	16.20	19.10	18.20	15.80	11.50	6.70
18	5.80	5.00	5.00	6.80	10.60	13.50	16.20	18.90	17.80	15.50	11.40	6.30
19	5.90	5.00	5.00	6.60	10.50	13.70	16.20	18.90	17.70	15.10	11.00	6.30
20	5.90	4.80	5.00	6.70	10.70	13.80	16.30	19.00	17.70	15.00	10.90	6.10
21	5.80	4.80	5.10	6.60	10.90	13.80	16.40	19.10	18.20	15.00	11.00	5.60
22	5.80	4.80	5.20	6.50	11.00	13.70	16.40	19.10	18.10	14.70	10.90	5.80
23	5.70	4.80	5.20	7.00	11.20	13.70	16.20	19.20	18.10	14.40	10.80	5.90
24	5.50	4.80	5.20	7.10	11.20	13.60	16.70	18.80	18.10	14.30	10.60	6.40
25	5.40	5.10	5.30	7.20	10.90	13.90	16.90	18.90	18.10	14.00	10.10	5.90
26	5.30	5.10	5.60	7.40	10.90	14.10	17.30	19.00	18.10	14.00	9.90	5.90
27	5.30	4.90	5.40	7.50	10.80	14.30	17.10	19.00	18.30	13.90	9.60	6.20
28	5.40	4.90	5.30	7.50	10.90	14.50	17.30	19.00	18.40	13.60	9.60	6.30
29	5.60	5.30	5.30	7.60	11.10	14.60	17.40	18.70	18.30	13.60	9.70	6.10
30	5.40	5.20	5.20	7.90	11.10	14.70	17.70	18.50	17.90	13.70	9.40	6.00
31	5.50	5.20	5.20	11.30	11.30	14.70	17.70	18.60	17.70	13.70	9.40	6.00

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
PRIEST RAPIDS, DEGREES CENTIGRADE

1966	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	6.00	3.30	4.20	5.60	9.50	12.60	14.00	18.00	17.50	16.20	12.50	9.20
2	5.70	3.60	4.40	5.70	9.50	13.00	14.10	18.10	17.60	15.90	12.30	9.10
3	5.60	3.80	4.60	5.70	9.90	13.00	14.40	18.20	17.50	16.10	12.30	9.20
4	5.60	3.90	4.60	5.60	10.30	13.10	14.90	18.40	17.70	16.00	12.30	9.00
5	5.60	3.70	4.70	5.80	10.20	13.40	15.30	18.10	18.20	15.80	12.20	8.70
6	5.40	3.50	4.70	6.10	10.10	13.30	15.60	17.90	18.30	15.40	12.10	8.50
7	5.10	3.40	4.60	6.50	10.00	13.40	16.00	17.80	18.30	15.10	12.10	8.30
8	4.80	3.20	4.60	6.20	10.20	13.40	16.20	17.90	18.50	14.90	11.90	8.10
9	4.80	2.90	4.60	6.60	10.30	13.20	16.30	18.00	18.50	15.00	11.70	7.90
10	4.70	2.90	4.40	7.10	10.60	13.20	16.30	18.20	18.50	14.80	11.50	8.00
11	4.30	3.10	4.20	7.40	11.20	13.30	16.20	18.20	18.60	14.70	11.40	7.80
12	3.90	2.90	3.90	6.80	11.30	13.30	16.00	18.10	18.40	14.50	11.30	7.60
13	4.10	2.90	4.00	6.50	11.10	13.20	15.80	17.90	18.00	14.40	11.30	7.30
14	4.50	2.70	4.00	6.80	10.90	13.00	15.80	17.80	18.00	14.20	11.10	7.20
15	4.20	2.70	4.00	7.00	10.80	13.10	15.70	17.50	17.60	14.00	10.70	7.20
16	4.10	2.60	4.20	6.90	11.10	13.30	15.60	17.40	17.20	13.80	10.50	7.00
17	3.90	2.80	4.10	6.90	11.10	13.30	15.50	17.30	17.00	13.60	10.30	6.80
18	4.10	3.10	4.10	6.90	11.60	13.30	15.70	17.30	16.60	13.60	10.20	6.60
19	4.60	2.80	4.20	6.90	11.80	13.40	15.90	17.20	16.30	13.50	10.30	6.50
20	5.00	2.90	4.40	7.00	11.70	13.10	15.80	17.20	16.10	13.60	10.20	6.50
21	5.40	3.10	4.60	7.30	11.80	13.20	16.00	17.20	16.00	13.40	10.10	6.40
22	5.10	3.30	4.80	7.40	11.80	13.40	16.20	17.40	15.60	13.50	10.10	6.00
23	5.10	3.70	4.90	7.70	11.60	13.70	16.40	16.90	15.60	13.60	10.00	5.90
24	5.20	3.90	4.90	7.80	11.50	13.80	16.60	16.80	15.80	13.70	9.80	5.90
25	4.90	3.90	5.00	7.90	11.70	14.20	16.80	16.60	16.10	13.60	9.50	5.70
26	4.60	3.80	5.10	8.00	11.50	14.40	16.90	16.80	16.20	13.50	9.70	5.40
27	4.10	4.00	5.20	8.60	11.70	14.50	17.20	16.70	16.20	13.30	9.80	5.20
28	3.50	4.10	5.60	9.00	11.70	14.20	17.60	16.80	16.20	13.10	9.70	4.40
29	3.30	4.20	5.80	9.30	11.90	14.00	17.70	16.90	16.40	13.00	9.50	4.20
30	3.40		5.60	9.60	12.10	13.90	17.70	16.90	16.40	12.90	9.20	2.50
31	3.40		5.60	12.10	12.10	17.90	17.10	17.10	16.40	12.70		2.70

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
PRIEST RAPIDS, DEGREES CENTIGRADE

1965	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	2.90	.30	2.20	5.50	8.20	12.40	15.60	18.10	18.30	16.90	14.00	8.70
2	3.00	.50	2.30	5.50	8.30	12.80	16.00	17.90	18.10	16.30	13.90	8.60
3	3.30	.60	2.20	5.60	8.30	13.20	16.10	17.90	17.40	15.80	13.70	8.40
4	3.10	.80	2.40	5.60	8.60	13.50	16.10	17.90	17.00	15.80	13.60	8.40
5	2.90	1.10	2.60	5.90	8.90	13.80	16.30	17.70	16.90	15.70	13.50	8.30
6	2.80	1.20	2.60	6.00	9.20	13.80	16.30	17.90	17.20	16.00	13.20	8.10
7	2.80	1.10	2.60	6.00	9.40	14.10	16.30	18.20	17.90	15.90	13.00	8.10
8	3.10	1.20	2.70	6.30	9.70	14.20	16.50	17.90	18.10	15.60	12.90	8.00
9	3.50	1.20	2.80	6.60	9.80	14.00	16.70	18.30	18.40	15.50	12.90	7.90
10	3.90	1.20	2.70	6.70	10.00	14.00	17.00	18.20	18.60	15.20	12.90	7.90
11	3.90	1.40	2.80	6.90	10.10	14.00	17.20	18.10	18.70	15.20	12.80	7.70
12	3.60	1.70	2.80	7.10	10.20	14.50	17.10	17.80	18.70	14.90	12.70	8.00
13	3.50	1.70	2.70	7.20	10.30	14.70	16.80	18.00	18.20	14.80	12.40	7.90
14	3.50	1.60	2.60	7.40	10.50	14.80	16.80	18.60	17.90	14.70	12.10	8.00
15	3.40	1.70	2.90	7.60	10.50	15.00	16.80	18.60	17.50	14.50	11.80	7.90
16	3.20	2.00	2.90	7.80	10.70	15.00	16.80	18.30	17.60	14.30	11.40	7.70
17	3.00	1.90	3.10	7.80	10.90	15.00	16.60	18.20	17.70	14.30	11.10	7.60
18	2.80	1.90	3.20	7.80	11.20	15.20	16.70	18.40	17.80	14.30	11.00	7.60
19	2.80	2.10	3.20	7.80	11.50	15.30	17.00	18.50	17.60	14.30	10.80	7.50
20	2.70	1.90	3.40	7.80	11.60	15.50	17.30	18.70	17.60	14.20	10.70	7.60
21	2.50	1.70	3.50	7.90	12.20	15.50	17.30	18.70	17.60	14.30	10.60	7.60
22	2.10	1.70	3.80	8.10	12.50	15.60	17.50	18.60	17.60	14.40	10.40	7.50
23	1.80	1.70	4.50	8.20	12.70	15.60	17.80	18.70	17.40	14.30	10.10	7.40
24	1.60	1.70	4.30	8.20	12.90	15.50	18.10	18.70	17.40	14.10	9.80	7.40
25	1.20	1.60	4.50	8.10	12.80	15.30	18.10	18.40	17.30	14.00	9.60	7.30
26	1.10	1.70	4.60	8.10	12.60	15.20	18.10	18.20	17.20	13.90	9.40	7.30
27	.70	1.70	4.70	8.20	12.50	15.10	18.40	18.00	17.20	13.90	9.30	7.00
28	.40	2.00	4.90	8.30	12.20	15.10	18.40	17.90	17.40	14.00	9.10	6.60
29	.30		5.10	8.60	12.20	15.30	18.20	17.70	17.40	14.00	8.90	6.30
30	.40		5.20	8.10	12.20	15.30	18.20	17.90	17.20	14.00	8.80	6.40
31	.30		5.40		12.20		18.30	18.30		14.00		6.20

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
RICHLAND, DEGREES CENTIGRADE

1964	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	8.50	6.10	6.50	8.30	10.50	13.80	14.70	18.40	17.90	16.60	15.00	10.70
2	9.30	6.40	7.20	7.70	10.50	13.70	14.70	17.90	17.50	16.50	14.70	10.70
3	9.30	6.30	6.70	8.70	10.40	13.40	14.80	18.00	17.90	16.40	14.00	10.70
4	8.80	6.20	6.70	8.50	10.90	13.30	14.90	18.00	18.20	16.20	13.90	10.50
5	8.70	6.10	6.50	8.60	10.50	13.20	15.00	18.00	18.70	16.50	13.90	9.70
6	8.00	6.00	6.50	9.40	10.90	13.20	15.20	18.10	19.20	16.70	13.40	9.50
7	7.60	6.00	6.20	9.20	11.40	13.30	15.60	18.90	19.40	17.10	13.10	9.90
8	7.00	5.90	6.20	8.90	11.90	13.10	15.90	19.30	19.10	16.90	13.30	9.80
9	7.00	6.30	6.20	9.00	12.30	13.10	15.80	19.40	18.40	16.50	14.20	10.10
10	7.20	6.80	5.90	9.40	11.60	13.30	15.90	19.00	18.40	16.40	13.50	10.00
11	6.40	6.40	6.20	9.70	11.40	13.20	16.30	19.30	18.30	16.40	12.90	9.40
12	6.20	6.10	6.60	9.70	11.10	13.40	16.50	19.40	18.30	16.50	12.80	8.90
13	6.40	6.20	6.80	10.20	10.90	13.60	16.50	19.20	18.90	16.40	12.60	8.60
14	6.20	5.90	6.70	9.50	10.80	13.80	16.50	19.10	19.80	16.10	12.40	9.60
15	6.50	5.90	6.90	9.50	10.70	13.90	16.50	18.90	19.00	15.70	12.00	8.60
16	6.20	5.80	7.50	8.70	10.70	13.90	16.50	19.20	19.30	15.50	11.70	5.70
17	6.40	6.00	7.60	9.10	11.10	13.80	16.70	19.40	18.70	15.30	11.30	5.30
18	6.20	6.40	7.30	9.60	11.20	13.40	16.80	19.10	18.30	15.10	11.50	5.40
19	6.00	6.50	7.40	10.40	11.40	13.60	16.50	18.70	18.40	15.10	11.10	5.70
20	6.50	6.30	7.40	11.10	11.50	13.80	16.60	18.90	18.40	15.20	10.70	6.20
21	6.40	6.50	7.40	10.30	11.60	13.90	16.80	19.30	18.20	15.40	10.80	6.40
22	6.40	6.40	7.90	9.80	11.50	14.10	16.90	19.70	18.10	15.40	11.20	5.80
23	6.60	6.50	6.80	9.40	11.50	14.50	16.70	20.10	18.50	15.40	12.20	6.40
24	7.10	6.30	6.10	9.70	11.50	14.70	17.00	19.90	18.80	15.30	12.10	6.40
25	6.90	5.40	6.60	10.50	11.50	14.80	17.30	19.40	18.80	15.10	11.10	6.00
26	7.10	5.80	6.70	11.30	12.00	14.90	17.60	19.20	17.70	14.70	10.20	6.60
27	7.20	6.30	7.60	11.80	12.30	14.50	17.80	18.50	17.90	14.20	9.60	6.70
28	7.00	6.50	8.00	10.90	12.60	14.50	18.00	18.50	18.50	14.40	10.00	6.30
29	6.80	6.30	8.70	11.10	12.90	14.50	18.50	18.00	18.20	14.70	10.70	6.00
30	6.50	9.50	9.50	10.50	13.20	14.70	18.60	18.40	17.10	15.20	11.20	5.60
31	6.30	8.50	8.50		13.60	18.60	18.60	18.30		15.30		5.30

DAILY AVERAGE TEMPERATURE CO. UMBIA RIVER
RICHLAND, DEGREES CENTIGRADE

1965	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	5.40	8.10	5.50	7.60	9.70	12.90	15.70	19.90	19.20	17.30	15.90	9.80
2	5.30	6.90	4.90	7.20	9.60	13.20	15.90	20.20	19.20	17.90	14.90	9.70
3	5.30	5.60	4.90	7.10	9.20	13.10	15.80	20.00	18.70	18.40	14.50	9.70
4	5.80	5.40	4.90	7.80	9.10	13.10	16.20	19.70	18.80	18.50	14.20	9.40
5	5.70	5.80	4.90	8.40	8.60	13.30	16.50	19.70	18.60	17.70	13.80	9.50
6	6.00	5.10	5.60	7.60	8.90	13.60	16.70	19.90	18.80	17.70	13.80	9.50
7	5.70	5.30	6.00	7.90	9.30	13.60	16.90	19.30	19.40	18.10	13.90	9.10
8	5.50	5.30	5.90	8.30	9.90	13.80	16.90	20.70	19.10	18.00	14.10	9.60
9	5.50	4.90	5.90	8.30	10.30	14.00	16.50	20.60	19.20	18.20	13.80	9.90
10	5.70	4.90	6.50	7.80	10.50	14.20	16.50	20.20	19.20	17.70	13.30	10.00
11	6.60	4.80	6.40	8.30	10.90	14.10	15.40	20.00	19.60	17.40	13.00	9.90
12	6.00	4.90	6.00	9.40	11.40	14.10	16.40	19.80	19.80	16.90	12.70	10.30
13	5.90	5.10	6.50	9.60	11.60	14.00	16.40	19.50	20.00	17.00	12.60	9.70
14	5.80	5.40	7.10	9.70	11.50	13.90	16.70	19.80	19.10	16.70	13.20	8.70
15	6.00	5.10	7.40	9.90	11.40	13.90	17.10	20.40	18.30	15.90	13.10	8.40
16	6.30	4.70	6.60	9.50	11.40	14.00	17.50	20.70	16.90	15.40	12.70	8.20
17	6.60	4.90	6.10	9.10	11.20	13.90	17.60	20.50	17.30	15.40	12.30	8.10
18	6.80	5.20	6.20	9.40	11.50	14.10	17.60	20.40	17.30	15.70	12.50	7.90
19	6.50	5.40	6.20	9.60	11.20	14.40	17.70	19.50	17.70	15.60	12.40	7.70
20	6.20	5.40	6.70	9.60	11.20	14.60	17.50	19.70	18.40	15.40	12.00	7.80
21	6.10	5.60	7.20	10.10	11.40	14.90	16.90	20.10	18.80	15.40	11.60	8.00
22	6.20	5.40	7.60	9.50	11.40	15.10	17.00	20.10	18.90	15.40	11.50	7.80
23	5.80	5.00	6.60	9.40	11.40	15.10	17.40	19.90	18.30	15.30	11.10	7.20
24	6.30	4.60	6.10	9.70	11.50	15.30	17.50	19.90	18.20	15.40	10.60	7.20
25	6.40	4.90	6.30	9.70	11.90	15.30	17.70	19.90	18.20	15.40	10.60	6.90
26	5.90	5.30	5.90	10.20	12.30	14.90	18.00	19.80	18.50	14.50	10.70	7.40
27	6.10	5.50	5.90	10.30	12.60	14.70	18.60	19.60	17.70	14.60	10.70	7.40
28	6.50	5.60	6.80	10.60	12.60	14.80	19.10	18.80	17.30	15.00	10.40	7.10
29	6.50			10.60	12.90	15.20	19.60	18.60	17.60	15.40	10.70	7.00
30	7.10		6.90	10.40	12.80	15.50	19.80	18.80	17.90	15.40	9.90	6.70
31	7.70		7.30		12.80		19.70	18.80		15.60		6.00

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
PICHLAND, DEGREES CENTIGRADE

1966	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	5.70	6.20	5.20	8.80	11.90	12.90	14.40	17.90	19.20	18.10	14.10	11.30
2	6.00	6.20	5.70	9.10	12.30	12.90	14.20	18.40	19.70	18.10	14.20	11.00
3	6.60	6.20	6.10	10.00	12.00	12.30	14.30	18.60	19.70	18.20	14.00	10.90
4	6.50	6.70	6.00	10.90	12.30	12.30	14.70	18.70	20.00	17.70	14.00	10.30
5	6.00	6.70	6.60	10.30	12.20	12.60	14.90	18.70	20.70	18.10	14.10	10.40
6	5.90	7.20	6.90	10.10	12.10	12.70	14.80	18.80	21.10	18.00	14.40	10.20
7	6.70	7.70	7.00	10.20	12.70	12.70	15.30	19.00	19.60	17.90	14.40	9.70
8	6.40	6.70	5.80	10.90	12.20	13.00	15.80	19.00	19.60	17.30	13.40	9.80
9	6.40	6.60	6.20	10.70	12.20	13.10	15.80	18.70	19.70	16.50	12.30	9.80
10	7.20	6.40	6.40	10.60	11.40	13.10	15.80	18.60	19.50	16.40	12.50	9.70
11	6.60	6.40	6.20	10.60	11.50	12.80	15.80	18.30	18.80	16.10	12.10	9.90
12	6.10	6.30	6.50	9.80	11.50	13.10	15.70	18.20	18.50	15.60	12.50	10.30
13	6.30	6.30	6.80	9.80	10.90	13.30	15.80	18.30	18.60	15.50	12.70	10.30
14	6.40	6.50	7.50	9.80	10.60	13.40	16.00	18.50	18.70	15.10	13.00	9.30
15	6.00	5.70	7.10	10.50	10.30	13.60	16.00	18.90	19.00	15.00	13.00	9.70
16	5.80	5.40	6.90	10.60	10.40	14.10	16.00	19.00	19.50	15.10	12.80	9.90
17	5.80	5.40	6.50	10.50	11.00	14.20	16.20	19.10	19.70	15.20	12.70	9.50
18	5.80	5.80	6.50	10.10	11.50	14.30	16.60	19.10	19.30	14.50	12.50	9.60
19	5.70	5.80	6.30	9.90	11.80	14.40	16.70	19.10	19.00	14.10	12.00	10.10
20	5.30	6.60	6.40	9.80	12.20	14.10	16.60	18.60	19.00	13.60	12.60	9.90
21	5.55	7.30	6.50	9.90	12.10	13.70	16.60	18.80	19.40	13.00	12.70	9.20
22	5.70	6.20	6.00	10.30	12.00	13.60	16.90	18.80	19.90	13.30	11.80	8.40
23	5.50	5.70	6.40	10.60	12.30	13.60	17.10	18.80	19.80	14.20	11.40	8.30
24	5.60	5.60	6.90	11.20	12.60	13.30	17.10	19.20	19.20	15.30	11.40	8.40
25	5.20	5.70	7.40	11.30	13.00	13.40	17.00	19.30	18.90	15.20	11.20	8.90
26	5.10	5.90	7.40	10.30	13.30	13.80	17.10	19.30	19.30	15.10	11.10	9.00
27	5.10	5.90	7.90	10.10	13.10	14.50	17.20	19.00	18.90	14.60	10.00	9.00
28	5.30	5.90	8.40	10.50	13.30	14.50	17.60	19.10	18.90	14.50	11.30	7.80
29	5.30		8.30	10.90	13.40	14.40	17.80	19.30	19.20	14.30	11.50	7.80
30	6.00		8.30	11.20	13.30	14.50	17.90	18.20	18.40	14.40	11.30	7.90
31	5.90		8.60		12.80		17.80	18.50		14.40		7.80

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
RICHLAND, DEGREES CENTIGRADE

1967	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	7.80	7.10	7.00	7.00	10.70	12.70	15.50	18.90	20.20	18.00	14.50	9.60
2	7.90	7.40	6.70	8.40	10.40	13.00	15.70	19.10	19.90	16.90	13.60	9.40
3	8.10	7.30	6.50	9.80	10.90	12.90	16.10	19.20	20.10	16.30	13.40	9.50
4	7.40	7.90	6.50	8.60	11.20	13.00	16.20	19.40	20.80	16.70	12.90	9.90
5	6.90	8.30	7.30	8.40	11.50	13.00	16.40	19.20	20.80	17.30	12.70	9.20
6	6.80	7.80	7.30	8.30	11.20	13.10	16.50	19.20	20.20	17.30	12.40	8.70
7	6.80	7.00	5.90	8.40	11.90	13.30	16.10	19.10	20.10	17.40	12.20	9.00
8	7.30	6.60	6.20	9.10	12.30	13.60	15.80	19.10	20.10	17.40	12.30	9.00
9	7.70	6.90	6.30	9.40	11.80	13.80	15.50	19.20	19.90	17.80	12.30	9.00
10	7.00	7.20	5.80	9.50	11.00	13.70	15.70	19.80	19.40	17.60	12.50	9.30
11	7.40	7.00	6.30	9.20	10.60	13.50	15.90	20.20	18.80	17.70	12.40	9.10
12	7.40	7.20	6.90	8.90	11.00	13.30	16.20	20.40	18.80	17.20	12.70	8.20
13	7.10	7.30	7.20	8.90	11.80	13.30	16.60	20.60	18.80	16.90	13.20	7.60
14	7.10	6.50	6.10	9.00	12.70	13.50	16.70	21.10	18.80	16.30	12.80	7.10
15	7.80	6.10	6.10	9.30	13.80	13.70	16.90	21.10	18.90	16.40	12.70	6.90
16	8.00	6.40	6.50	9.50	13.30	13.90	17.00	21.20	18.90	16.40	12.60	6.50
17	7.40	6.90	5.90	9.80	13.10	14.00	17.10	21.40	19.20	16.20	12.70	6.50
18	7.20	6.40	6.00	9.40	13.00	14.30	17.20	21.50	19.40	16.10	12.30	6.50
19	7.40	6.50	6.50	8.00	13.50	14.50	17.10	21.00	18.90	15.80	12.00	6.40
20	7.30	6.40	6.90	7.80	13.10	14.50	17.30	20.80	18.90	15.40	11.60	6.50
21	7.40	6.60	6.60	8.10	13.00	14.30	17.50	20.80	19.10	15.60	11.20	6.50
22	6.90	6.50	6.40	8.50	12.90	14.20	17.70	20.60	19.20	15.40	11.30	6.50
23	7.00	6.40	6.40	9.00	12.60	14.30	17.80	20.70	19.00	14.90	11.30	6.80
24	6.70	6.30	6.66	8.70	12.10	14.20	18.00	20.50	19.00	14.60	11.00	7.80
25	7.10	6.60	6.50	8.30	11.90	14.20	17.90	20.30	19.20	14.30	10.40	8.20
26	6.90	7.60	7.50	8.70	11.80	14.40	17.90	20.30	18.90	14.20	9.90	8.20
27	7.10	6.10	8.00	8.50	11.90	14.70	18.20	20.60	19.20	14.20	9.90	7.40
28	8.00	7.30	7.30	9.00	11.80	14.90	18.30	20.60	19.50	14.10	9.90	7.10
29	8.30	7.10	7.10	9.00	12.00	15.20	18.50	20.50	19.30	13.90	10.20	6.90
30	7.90	6.90	6.90	9.30	11.80	15.30	18.90	20.20	18.40	14.40	9.90	6.80
31	7.10	7.10	6.70		12.30	19.00	19.00	20.10		14.90		6.60

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
RICHLAND, DEGREES CENTIGRADE

1968	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	6.60	4.50	6.00	6.90	11.30	13.50	14.90	19.30	18.50	17.70	12.90	9.30
2	6.50	5.00	6.10	7.00	11.70	13.80	15.00	19.40	18.60	16.80	13.00	9.40
3	5.90	5.40	6.60	6.70	12.10	14.00	15.20	19.40	19.10	16.50	13.30	9.40
4	6.20	5.70	7.00	6.90	12.30	14.40	15.70	19.70	19.20	16.70	13.30	9.60
5	6.50	5.60	6.40	6.80	12.00	14.90	16.20	19.50	19.10	16.60	12.30	9.40
6	6.00	4.60	6.20	6.60	12.20	14.80	16.50	18.90	19.50	16.20	12.20	9.30
7	5.80	4.50	5.90	7.20	12.20	14.20	16.90	18.80	19.90	15.80	12.10	9.20
8	6.00	4.20	5.70	8.70	12.40	14.10	17.10	19.20	19.90	15.70	12.20	9.20
9	6.30	4.10	5.80	8.60	12.90	14.00	17.30	19.20	19.90	15.20	12.20	9.50
10	5.60	3.80	5.70	9.10	13.20	14.00	17.20	19.40	19.60	15.30	12.20	8.90
11	5.00	3.80	5.50	9.20	13.30	13.70	17.10	19.70	19.70	15.30	12.50	8.60
12	4.70	4.50	5.20	8.70	14.20	13.70	16.80	19.70	19.70	15.10	12.00	8.20
13	4.70	3.90	5.20	8.30	14.10	13.90	16.60	18.90	19.10	14.40	11.70	7.80
14	4.90	3.80	5.30	8.20	12.50	13.80	16.50	18.40	18.60	14.20	11.70	7.80
15	5.50	3.60	5.10	8.60	12.60	13.90	16.40	19.00	18.20	14.00	11.60	7.90
16	5.70	3.60	5.20	8.30	13.10	14.10	16.40	18.70	18.50	14.40	10.80	8.10
17	5.20	3.50	5.30	8.20	13.30	14.20	16.40	18.50	18.20	14.70	10.80	7.40
18	5.50	4.00	5.30	8.20	13.50	14.20	16.30	18.20	17.90	14.70	11.10	7.20
19	6.00	5.10	5.20	8.00	13.80	14.10	16.60	18.20	17.20	14.20	11.10	6.90
20	6.80	5.20	5.70	8.20	13.70	14.00	16.50	18.30	16.60	14.60	11.30	6.40
21	7.40	5.70	5.90	9.10	12.80	14.00	16.90	18.40	16.40	14.70	10.90	6.40
22	7.30	5.40	6.10	10.40	12.80	14.00	16.80	18.50	16.10	14.60	10.70	6.50
23	6.40	6.10	6.30	9.60	12.90	14.30	16.90	18.30	16.80	14.80	10.60	7.00
24	6.50	6.70	6.40	9.70	12.80	14.70	17.40	18.00	17.00	15.10	10.20	6.90
25	6.00	7.00	6.50	9.50	12.60	15.00	17.70	17.70	17.50	14.60	10.30	6.50
26	5.40	7.00	6.60	10.20	12.60	15.30	18.00	18.10	17.60	13.80	10.00	6.30
27	3.80	6.00	6.70	11.00	12.80	15.30	18.30	18.30	17.50	13.70	10.00	6.10
28	4.20	5.90	7.10	12.10	12.80	14.60	19.00	18.00	17.30	14.00	9.80	5.10
29	4.40	5.90	7.50	12.80	13.10	14.50	19.70	18.30	17.70	13.60	9.80	3.10
30	4.30		7.00	12.00	13.00	14.70	19.30	18.60	18.10	13.40	9.50	2.40
31	4.40		7.00	13.30			19.20	18.60		13.20		2.40

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
EICHLEMAN, DEGREES CELSIUS

1964	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	2.70	7.1	2.40	6.60	9.90	13.40	16.00	19.50	19.50	17.30	14.30	6.70
2	2.90	1.00	3.10	6.60	9.90	13.70	16.40	19.30	19.70	17.10	14.30	5.50
3	3.00	1.20	4.30	6.60	9.10	14.20	16.90	19.40	18.50	17.10	14.20	5.60
4	3.20	1.90	3.00	6.60	9.20	14.90	16.90	19.10	17.60	16.70	13.90	6.50
5	3.20	1.10	3.10	6.90	9.40	14.50	16.70	18.30	17.40	16.70	13.70	6.50
6	3.60	1.80	3.30	6.70	10.00	14.50	16.90	18.50	17.60	16.30	13.60	6.60
7	3.40	1.60	3.60	6.90	10.00	14.80	16.90	18.60	18.20	16.40	13.30	6.70
8	3.10	1.20	3.50	7.00	10.60	15.20	16.90	18.80	19.00	16.00	12.90	6.60
9	3.70	1.70	3.70	7.40	10.70	15.20	17.30	18.60	19.40	15.60	13.20	6.20
10	3.80	1.10	3.70	7.60	10.80	14.70	17.50	19.20	19.60	15.70	13.60	6.30
11	4.10	2.10	3.50	7.50	10.90	14.80	17.60	19.50	20.10	15.50	13.10	6.30
12	4.20	1.40	3.50	7.70	11.20	15.00	17.60	19.60	19.50	16.20	13.00	6.30
13	4.10	1.40	3.80	7.40	11.10	15.20	17.70	19.80	19.50	13.80	12.80	6.30
14	4.60	2.40	3.80	7.60	11.10	15.20	17.50	19.20	18.60	14.50	12.40	6.50
15	3.80	1.40	4.30	8.20	11.20	15.40	17.40	19.80	18.50	14.50	12.10	6.30
16	3.70	1.80	4.80	8.60	11.30	15.50	17.50	19.40	18.30	14.30	11.50	6.00
17	3.50	1.90	4.90	8.50	11.40	15.70	17.40	19.50	18.50	14.70	11.40	6.90
18	3.50	1.50	4.40	8.60	11.60	16.90	17.40	19.30	18.70	14.60	11.00	6.20
19	3.60	1.30	4.30	8.60	11.80	16.10	17.70	19.60	18.30	14.80	11.10	6.10
20	3.60	1.30	4.40	8.50	12.10	16.30	17.60	19.60	18.20	14.30	10.80	7.60
21	2.40	1.10	4.20	8.60	12.50	16.10	16.40	19.90	18.40	14.70	10.80	6.00
22	2.40	1.00	4.20	9.00	12.90	16.10	16.50	20.00	18.70	15.00	10.70	7.90
23	1.70	2.00	4.80	9.10	13.30	16.10	13.90	20.00	18.40	15.80	10.00	7.80
24	1.60	1.40	5.40	9.00	13.40	16.10	19.20	20.00	18.10	14.40	9.60	7.80
25	1.40	1.10	5.30	8.60	13.30	16.00	19.10	19.70	18.30	14.10	9.30	7.30
26	1.20	1.90	5.70	8.60	13.20	15.90	19.00	19.30	18.20	13.90	9.20	7.50
27	1.10	2.20	5.40	8.60	12.80	15.80	19.40	19.90	18.10	13.90	9.10	7.40
28	1.70	2.40	5.40	9.00	12.70	15.70	19.70	19.90	18.40	14.20	8.90	7.20
29	1.20	2.00	5.80	8.90	12.60	15.90	19.80	19.60	18.30	14.40	8.80	7.30
30	1.20	2.00	6.30	8.80	12.90	16.00	19.70	18.80	17.90	14.30	8.90	7.00
31	1.60	2.60	6.70	8.80	13.00	16.00	19.70	19.10	17.90	14.20	8.90	6.90

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
PASCO, DEGREES CENTIGRADE

1964	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	7.90	6.40	6.10	8.10	10.10	13.50	14.30	18.00	17.40	16.00	14.50	10.30
2	8.00	5.90	6.20	7.80	10.10	13.40	14.30	17.40	17.00	16.00	13.90	10.20
3	8.60	6.60	6.30	7.90	10.10	13.20	14.30	17.50	17.10	16.00	13.70	10.10
4	8.40	6.60	6.60	8.30	10.50	13.00	14.50	17.50	17.40	15.80	13.30	9.90
5	8.10	5.90	6.10	8.20	10.60	13.00	14.60	17.40	17.80	15.80	13.30	9.50
6	7.00	5.90	6.10	8.30	10.40	12.90	14.80	17.60	18.30	15.90	13.00	9.10
7	7.50	5.90	6.40	9.20	11.00	13.00	15.10	18.20	18.60	16.40	12.70	9.10
8	6.70	6.30	6.20	9.10	11.50	12.80	15.50	18.60	18.80	16.40	12.70	9.50
9	7.00	6.00	6.10	8.80	11.80	12.80	15.40	18.70	18.00	16.00	13.00	9.70
10	7.00	6.50	5.90	8.90	11.60	13.10	15.50	18.40	17.60	15.80	13.40	9.70
11	6.80	6.00	5.70	9.00	11.30	13.00	15.80	18.50	17.70	15.80	12.70	9.10
12	6.00	5.80	6.10	9.10	11.20	13.00	16.10	18.80	17.70	15.80	12.40	8.70
13	6.20	5.80	6.30	9.50	10.80	13.30	16.10	18.50	18.00	15.70	12.10	8.10
14	6.50	6.00	6.50	9.80	10.70	13.50	16.20	18.50	18.70	15.70	11.80	8.20
15	6.20	5.60	7.00	9.30	10.60	13.60	16.10	18.30	18.60	15.20	11.50	8.90
16	6.00	5.50	7.20	8.60	10.60	13.60	16.10	18.40	18.30	15.00	11.20	6.60
17	6.10	5.70	7.20	8.50	11.00	13.50	16.30	18.70	18.10	14.90	11.00	5.00
18	6.50	6.00	7.10	9.10	11.20	13.40	16.30	18.50	17.70	14.90	10.90	4.20
19	6.20	6.30	7.10	9.70	11.30	13.40	16.30	18.00	17.90	14.60	10.80	4.30
20	5.80	6.20	7.20	10.40	11.60	13.50	16.30	18.20	17.70	14.50	10.40	5.10
21	6.40	6.20	6.90	10.50	11.50	13.60	16.40	18.40	17.80	14.60	10.60	5.70
22	6.20	6.40	7.10	9.40	11.30	13.70	16.50	18.80	17.50	14.70	10.30	6.10
23	6.50	6.30	7.10	9.20	11.40	14.10	16.50	19.20	17.60	14.60	10.90	6.10
24	6.70	6.20	6.20	9.30	11.60	14.30	16.50	19.20	17.90	14.60	11.90	5.30
25	6.60	6.00	6.10	9.90	11.60	14.40	16.90	18.80	18.10	14.60	11.00	4.70
26	6.80	5.70	6.20	10.50	11.80	14.40	17.20	18.30	17.50	14.10	9.90	5.00
27	6.60	5.90	6.70	11.30	12.00	14.10	17.30	18.00	17.20	13.70	9.20	5.20
28	6.60	6.30	7.50	11.20	12.20	14.10	17.50	17.90	17.50	13.50	9.50	5.30
29	6.60	5.90	7.80	10.80	12.60	14.10	17.90	17.50	17.70	13.70	9.90	5.50
30	6.60		8.60	10.60	12.90	14.30	18.10	17.60	16.80	14.30	10.40	5.40
31	6.60		8.70		13.40		17.90	17.70		14.60		5.00

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
PASCO, DEGREES CENTIGRADE

1965	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	5.00	5.70	6.50	7.00	9.70	12.90	15.90	19.50	18.90	17.80	15.70	10.00
2	5.00	5.80	6.80	6.60	9.60	13.10	16.10	20.10	19.10	17.80	15.30	9.90
3	5.00	5.60	6.00	6.50	9.20	13.30	16.00	19.90	18.70	18.00	14.70	9.80
4	5.10	5.10	5.50	7.20	9.10	13.10	16.30	19.50	18.60	18.30	14.50	9.70
5	5.20	5.20	5.60	7.80	8.60	13.30	16.70	19.60	18.40	18.20	14.10	9.40
6	5.30	5.00	5.60	7.00	8.90	13.70	16.90	19.80	18.70	17.70	13.90	9.40
7	5.30	4.80	6.10	7.30	9.30	13.70	17.00	20.10	19.20	17.90	13.90	9.50
8	4.90	4.90	6.60	7.70	9.80	13.80	17.10	20.50	19.90	18.00	13.80	9.60
9	4.90	4.70	7.00	7.70	10.30	14.00	16.70	20.60	19.00	18.10	14.20	10.00
10	4.90	4.50	6.00	7.20	10.50	14.20	16.70	20.30	18.90	17.90	13.50	10.00
11	5.40	4.40	5.50	7.70	10.80	14.10	16.70	20.10	19.30	17.50	13.10	10.10
12	5.70	4.40	5.70	8.80	11.40	14.00	16.60	19.80	19.60	17.10	13.00	9.90
13	5.50	4.40	5.30	9.00	11.60	14.00	16.60	19.40	19.80	16.80	12.70	10.00
14	5.40	4.80	4.90	9.10	11.50	13.80	16.80	19.70	19.40	16.90	12.70	9.20
15	5.30	4.50	4.30	9.30	11.30	13.80	17.20	20.10	18.40	16.00	12.60	8.60
16	5.70	4.10	4.30	8.90	11.20	13.90	17.50	20.60	17.40	15.60	12.50	8.20
17	6.10	4.30	4.30	8.50	11.20	13.80	17.70	20.40	17.20	15.10	12.40	8.20
18	6.10	4.60	4.30	8.80	11.40	13.90	17.70	20.40	17.50	15.30	12.30	8.20
19	6.10	4.80	5.00	9.00	11.20	14.40	17.90	19.50	17.50	15.70	12.20	7.90
20	6.00	4.80	5.40	9.00	11.20	14.70	17.60	19.30	17.90	15.30	12.20	7.80
21	5.90	5.00	5.30	9.50	11.40	15.00	16.90	19.90	18.60	15.30	11.60	8.20
22	5.90	4.80	5.30	9.20	11.40	15.20	17.00	20.00	18.70	15.30	11.50	7.90
23	5.60	4.90	5.90	9.00	11.40	15.20	17.40	19.70	18.40	15.30	11.30	7.50
24	5.80	4.00	5.30	9.10	11.50	15.30	17.50	19.60	18.10	15.00	10.90	7.30
25	5.60	4.30	5.40	9.10	11.90	15.30	17.70	19.70	18.30	15.40	10.60	7.30
26	5.60	4.70	5.90	9.40	12.30	15.10	18.00	19.70	18.40	15.10	10.30	7.00
27	5.60	4.90	5.30	9.70	12.70	14.80	18.50	19.60	18.30	14.40	10.90	7.30
28	6.00	5.00	6.20	9.60	12.80	15.00	19.10	18.80	17.40	14.90	10.40	7.60
29	6.10		6.90	9.90	12.90	15.30	19.30	18.50	17.40	15.20	10.30	7.30
30	5.90		6.30	9.80	12.70	15.70	19.50	18.60	17.70	15.40	10.40	7.00
31	5.40		6.70		12.80		19.60	18.60		15.10		6.40

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
PASCO, DEGREES CENTIGRADE

1966	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	6.00	5.90	5.30	8.60	11.30	12.80	14.50	18.00	18.70	18.20	14.20	11.30
2	5.90	5.50	5.20	8.80	11.30	12.90	14.20	18.30	19.20	17.80	13.90	11.10
3	6.50	5.30	4.90	9.10	11.80	12.50	14.10	18.60	19.50	18.00	14.10	10.90
4	7.00	5.60	4.90	10.10	11.70	12.30	14.60	18.70	19.70	17.90	13.90	10.50
5	6.40	6.00	5.20	10.20	11.80	12.70	15.00	18.70	19.80	17.90	13.90	10.40
6	6.00	6.00	5.50	9.60	12.00	12.70	14.80	18.60	21.00	18.00	13.80	10.50
7	6.50	6.50	6.50	9.50	12.00	12.70	15.20	18.80	20.30	17.70	14.10	9.70
8	6.70	6.50	6.30	10.30	12.20	13.00	15.80	19.10	19.20	17.30	14.10	9.60
9	6.10	5.80	6.10	10.70	12.30	13.10	16.00	18.70	19.30	16.70	12.50	9.60
10	6.50	5.70	6.20	10.60	11.80	13.20	15.90	18.50	19.20	16.40	12.50	9.60
11	7.30	5.50	6.20	10.50	11.60	12.80	16.00	18.30	18.90	16.30	12.10	9.60
12	6.30	5.70	6.30	9.80	11.50	13.10	15.80	18.20	18.40	15.60	12.20	9.40
13	6.40	5.50	6.60	9.40	10.90	13.30	15.80	18.20	18.70	15.30	12.30	10.70
14	6.60	5.50	6.90	9.50	10.60	13.40	16.10	18.30	18.60	15.20	12.60	9.40
15	6.40	5.30	7.50	9.70	10.30	13.60	16.10	18.60	18.80	14.80	13.00	9.50
16	6.10	5.00	6.90	10.10	10.30	14.10	16.20	18.90	19.20	14.70	12.80	9.80
17	6.00	4.90	6.60	10.00	10.90	14.20	16.40	19.00	19.50	14.80	12.60	9.50
18	6.20	5.00	6.50	10.10	11.60	14.40	16.70	19.00	19.40	14.90	12.60	9.30
19	5.90	5.50	6.40	9.90	11.90	14.40	16.80	18.80	18.90	14.20	12.10	9.30
20	5.70	5.90	6.30	9.70	12.20	14.20	16.70	18.60	18.80	13.50	12.00	10.20
21	5.40	6.30	6.30	9.60	12.20	13.80	16.70	18.40	19.10	13.20	12.40	9.40
22	5.90	6.60	6.20	9.80	11.80	13.60	16.90	18.60	19.70	13.00	12.30	8.70
23	5.70	5.60	6.20	10.20	12.30	13.70	17.20	18.50	19.60	13.50	11.40	8.30
24	5.60	5.40	6.50	10.60	12.70	13.30	17.30	18.80	19.40	14.40	11.20	8.40
25	5.90	5.30	6.90	11.00	13.10	13.40	17.10	19.10	19.00	15.30	10.90	8.30
26	5.30	5.60	7.10	10.30	13.40	13.70	17.20	19.00	18.90	15.10	10.90	8.20
27	5.30	5.60	7.30	9.90	13.30	14.40	17.30	19.00	19.00	14.70	11.10	8.70
28	5.40	5.40	7.90	10.20	13.30	14.60	17.70	18.90	18.70	14.50	11.00	8.20
29	5.60		8.20	10.60	13.40	14.50	17.90	19.00	19.00	14.40	11.50	7.90
30	5.70		8.20	10.80	13.20	14.50	18.00	18.30	18.50	14.30	11.30	7.90
31	6.10		8.20		12.90		18.00	18.00		14.20		7.80

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
PASCO, DEGREES CENTIGRADE

1967	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	7.70	7.10	7.10	6.80	9.70	12.70	15.50	18.90	20.10	18.10	14.40	9.50
2	7.60	7.20	6.70	7.10	10.60	13.00	15.70	19.10	19.80	17.20	13.60	9.20
3	7.20	7.50	6.50	6.10	10.30	12.80	16.00	19.10	20.00	16.60	13.20	9.10
4	7.70	7.40	6.30	6.80	10.70	13.00	15.10	19.30	20.70	16.40	12.90	9.10
5	6.90	7.90	6.60	8.30	11.00	13.10	16.20	19.20	20.70	16.90	12.30	8.20
6	6.80	6.10	7.30	8.20	11.10	13.20	16.20	19.20	20.40	17.20	12.10	8.40
7	6.80	7.60	6.40	8.40	11.50	13.40	16.00	18.80	20.20	17.20	11.90	8.40
8	6.90	6.80	6.10	8.60	12.00	13.60	15.80	18.90	19.90	17.20	11.90	8.60
9	7.40	6.80	6.30	9.00	12.20	13.80	15.50	18.90	19.70	17.40	12.00	8.70
10	7.50	7.20	5.80	9.20	11.00	13.70	15.60	19.10	19.40	17.50	12.20	8.80
11	7.20	7.10	6.10	9.10	10.70	13.60	15.80	19.60	18.90	17.40	12.10	8.70
12	7.30	7.20	6.50	9.00	10.60	13.30	16.00	19.90	18.70	17.00	11.80	8.10
13	7.40	7.30	7.00	9.00	11.20	13.30	16.40	20.10	18.60	16.90	12.40	7.60
14	7.40	6.90	6.50	8.70	11.90	13.50	16.50	20.50	18.60	16.60	12.80	7.00
15	7.60	6.20	6.00	8.90	12.90	13.70	16.80	20.80	18.60	16.20	12.40	6.70
16	7.80	6.30	6.50	9.20	13.10	13.90	16.80	20.90	18.60	16.10	12.40	6.30
17	7.90	6.70	6.20	9.40	12.90	14.00	17.00	21.00	18.90	16.20	12.20	6.30
18	7.40	6.60	6.00	9.50	12.80	14.20	17.20	21.10	19.20	15.90	12.10	6.00
19	7.30	6.40	6.20	8.30	13.10	14.50	17.00	20.80	19.00	15.70	11.60	6.00
20	7.30	6.40	6.80	7.90	13.20	14.50	17.20	20.60	18.60	15.40	11.30	6.00
21	7.30	6.60	6.70	8.00	13.00	14.30	17.40	20.70	18.80	15.30	11.20	6.00
22	7.10	6.60	6.50	8.30	12.90	14.30	17.50	20.50	19.10	15.00	11.00	6.00
23	7.00	6.50	6.50	8.50	12.70	14.30	17.70	20.60	18.90	14.80	11.20	6.40
24	7.20	6.40	6.50	9.20	12.30	14.50	17.90	20.40	19.00	14.50	10.50	6.90
25	6.90	6.50	6.50	8.90	12.00	14.20	17.90	20.20	18.90	14.20	10.20	7.40
26	7.10	6.70	7.00	8.50	11.90	14.40	17.90	20.20	18.80	14.00	9.60	7.50
27	7.00	7.70	7.80	8.90	12.00	14.70	18.10	20.50	18.90	14.00	9.50	7.40
28	7.40	7.80	7.60	8.70	11.80	15.00	18.10	20.50	19.30	13.80	9.60	7.00
29	8.10		7.10	9.10	11.90	15.20	18.30	20.40	19.20	13.40	9.70	6.80
30	7.80		6.90	9.20	11.70	15.30	18.50	20.10	18.50	13.40	9.80	6.70
31	7.70		6.90		12.20		18.90	20.00		14.40		6.30

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
PASCO, DEGREES CENTIGRADE

1966	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	6.10	4.50	6.10	7.00	11.00	13.40	15.00	18.90	18.40	17.90	13.00	9.60
2	6.20	4.90	6.20	6.90	11.40	13.70	15.00	19.10	18.40	17.00	13.00	9.50
3	6.00	5.30	6.20	6.80	11.80	13.90	15.20	19.00	18.80	16.60	13.30	9.70
4	5.80	5.60	6.80	6.90	12.00	14.20	15.70	19.40	18.90	16.60	13.10	10.00
5	5.70	5.60	6.60	6.80	11.70	14.60	16.20	19.50	18.80	16.60	13.00	9.70
6	5.60	5.10	6.10	6.50	11.90	14.90	16.50	18.90	19.10	16.20	12.30	9.40
7	5.50	4.70	6.10	6.90	11.70	14.20	16.90	18.90	19.60	16.10	12.30	9.50
8	5.50	4.50	5.80	8.00	11.80	14.10	17.00	19.00	19.80	15.70	12.30	9.20
9	6.30	4.20	5.80	8.60	12.10	14.00	17.20	18.90	19.70	15.20	12.40	9.10
10	5.90	4.00	5.70	8.80	12.70	14.00	17.10	18.90	19.40	15.30	12.10	9.50
11	5.00	3.90	5.60	9.00	12.70	13.60	17.10	19.30	19.30	15.30	12.30	8.90
12	4.80	4.00	5.30	8.60	13.50	13.60	16.80	19.50	19.60	15.00	12.20	8.50
13	4.90	4.20	5.30	8.30	13.80	13.80	16.60	19.00	19.10	14.40	11.80	8.30
14	4.90	3.90	5.40	8.10	12.70	13.80	16.50	18.40	18.60	14.30	11.70	8.10
15	5.00	3.70	5.40	8.30	12.10	13.90	16.40	18.70	18.20	14.00	11.60	8.00
16	5.60	3.70	5.40	8.30	12.70	14.00	16.40	18.70	18.10	14.20	11.20	8.10
17	5.30	3.80	5.60	8.10	12.70	14.20	16.40	18.50	18.30	14.70	11.20	8.00
18	5.30	3.60	5.50	8.10	12.90	14.10	16.30	18.30	18.00	14.70	11.40	7.50
19	5.60	4.50	5.30	7.80	13.30	14.10	16.60	18.10	17.40	14.40	11.50	7.40
20	6.20	5.70	5.60	8.10	13.40	14.00	16.50	18.10	16.80	14.10	11.50	6.90
21	6.90	5.60	5.90	8.60	12.80	13.90	16.70	18.20	16.40	14.30	11.50	6.70
22	7.10	5.50	5.90	10.10	12.80	14.00	16.80	18.30	16.20	14.70	11.00	6.80
23	7.00	5.60	6.10	9.30	12.90	14.30	16.90	18.30	16.40	14.70	10.80	6.80
24	6.50	6.10	6.40	9.40	12.80	14.60	17.20	18.00	16.80	15.00	10.50	7.20
25	6.20	6.60	6.60	9.20	12.70	14.90	17.60	17.80	17.20	14.90	10.50	7.00
26	5.80	6.90	6.40	9.90	12.60	15.20	17.80	17.90	17.40	14.20	10.40	6.60
27	4.60	6.50	6.70	10.70	12.70	15.30	18.00	18.30	17.50	13.70	10.20	6.40
28	4.00	5.90	7.10	11.80	12.80	14.90	18.60	17.90	17.30	13.90	10.10	5.30
29	4.30	6.00	7.30	12.50	12.90	14.50	19.20	18.20	17.50	13.80	9.80	3.30
30	4.30		7.10	11.70	13.10	14.60	19.10	18.40	17.90	13.50	9.90	2.60
31	4.40		7.00		13.20		18.90	18.40		13.40		2.60

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
PASCO, DEGREES CENTIGRADE

1969	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	3.00	.50	2.80	6.00	9.20	13.70	16.60	19.60	19.40	17.10	14.00	8.70
2	3.10	.90	3.00	6.80	9.20	14.10	16.60	19.40	20.00	16.70	13.80	8.50
3	3.20	1.50	4.00	6.00	9.40	14.60	17.00	19.40	19.00	16.70	13.70	8.60
4	3.40	1.30	3.60	7.00	9.60	15.00	17.10	19.10	18.20	16.60	14.10	8.50
5	3.40	1.40	3.50	7.10	9.90	15.10	17.10	18.60	17.70	16.20	13.70	8.50
6	3.80	1.10	3.70	7.10	10.40	15.20	17.20	18.60	17.60	16.30	13.40	8.60
7	3.80	1.20	4.00	7.20	10.90	15.20	17.40	19.10	17.90	16.40	13.20	8.70
8	3.40	1.40	3.90	7.50	11.20	15.60	17.60	19.10	18.80	15.80	12.90	8.60
9	3.80	1.70	4.00	7.80	11.20	15.50	17.80	19.10	19.40	15.10	12.80	8.20
10	4.10	2.20	3.90	8.10	11.30	15.30	18.00	19.40	19.40	15.20	13.00	8.30
11	3.00	2.40	4.00	8.00	11.30	15.20	18.00	19.80	19.90	15.30	13.30	8.30
12	4.10	2.60	4.00	8.10	11.50	15.40	18.00	19.10	19.90	14.90	12.90	8.30
13	4.20	2.70	4.20	8.10	11.60	15.70	17.90	19.00	19.70	13.70	12.70	8.30
14	4.40	2.60	4.30	8.20	11.40	15.70	17.90	19.30	19.00	14.00	12.40	8.50
15	4.10	2.70	4.50	8.60	11.60	15.80	17.90	19.80	18.70	14.20	12.00	8.30
16	4.10	3.00	5.00	9.00	11.70	16.00	18.00	19.70	18.40	14.50	11.40	8.00
17	3.90	3.20	5.20	8.90	11.80	16.20	18.00	19.50	18.40	14.40	11.20	7.90
18	3.90	2.90	4.80	8.90	11.90	16.40	18.00	19.90	18.70	14.50	11.10	8.20
19	3.80	2.70	4.70	8.80	12.10	16.70	18.10	19.80	18.30	14.10	11.00	8.10
20	3.70	2.60	4.90	8.70	12.40	16.70	18.40	19.80	18.20	14.20	10.60	7.60
21	3.00	2.40	4.90	9.20	12.90	16.60	18.50	19.90	18.20	14.40	10.60	8.00
22	2.50	2.20	4.70	9.40	13.40	16.30	18.60	20.10	18.50	14.50	10.70	7.90
23	1.80	2.10	5.00	9.50	13.80	16.30	19.10	20.10	18.70	14.50	10.20	7.80
24	1.50	2.50	5.50	9.30	13.90	16.40	19.50	20.40	17.90	14.20	9.60	7.80
25	1.40	2.70	5.70	9.30	13.60	16.30	19.50	20.00	17.80	14.00	9.30	7.30
26	1.10	2.60	6.10	9.30	13.60	16.20	19.10	19.70	18.00	13.60	9.20	7.50
27	1.30	2.60	6.10	9.30	13.30	16.00	19.50	19.20	17.80	13.60	9.10	7.40
28	.90	2.80	5.90	9.20	13.10	16.00	19.90	19.10	17.90	13.90	8.80	7.20
29	.30		6.30	8.80	13.00	16.10	19.70	18.90	17.90	14.10	8.70	8.70
30	.30		6.70	9.10	13.30	16.50	19.80	18.80	17.70	14.00	8.70	7.00
31	.50		7.20		13.40		19.90	19.10		13.90		6.90

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
UMATILLA, DEGREES CENTIGRADE

1969	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	2.40	.40	2.40	7.60	9.20	13.80	16.90	20.50	19.70	18.10	13.30	8.10
2	2.30	.40	2.50	7.80	9.40	13.80	17.10	20.60	19.80	17.80	13.30	7.90
3	2.10	.20	2.90	7.80	9.40	14.20	17.00	20.50	19.60	17.40	13.40	7.80
4	2.00	.40	3.00	7.80	9.60	14.50	17.10	20.30	19.30	17.20	13.40	7.80
5	1.90	.60	3.40	7.90	9.80	15.00	17.30	20.00	19.50	16.80	13.20	7.70
6	2.10	.70	3.70	8.00	9.90	15.30	17.30	19.90	19.50	16.50	12.90	7.50
7	2.40	.60	3.60	8.00	10.30	15.60	17.50	19.70	19.10	16.50	12.90	7.50
8	2.20	.50	3.80	8.10	10.80	15.90	17.60	19.40	19.10	16.40	13.00	7.40
9	2.10	.40	4.00	8.20	11.20	16.30	17.70	19.30	19.30	16.20	12.90	7.30
10	2.30	.80	4.50	8.40	11.70	16.40	18.00	19.50	19.40	16.10	12.80	7.30
11	2.40	1.20	4.40	8.60	12.30	16.40	18.40	19.70	19.60	15.80	12.80	7.20
12	2.40	1.50	4.40	8.80	12.80	16.30	18.40	19.80	19.80	15.30	12.60	7.30
13	2.70	1.80	4.40	8.90	13.00	16.40	18.30	19.90	19.80	14.60	12.50	7.40
14	2.70	2.00	4.50	9.00	12.70	16.70	18.50	20.00	20.00	14.50	12.50	7.20
15	2.70	2.20	4.50	9.10	12.30	16.60	18.50	20.10	19.50	14.30	12.40	7.30
16	3.10	2.30	4.60	9.20	12.30	16.60	18.50	20.20	19.60	13.70	12.00	7.20
17	3.20	2.50	4.80	9.50	12.30	16.70	18.50	20.30	19.40	13.40	11.60	7.10
18	3.20	2.60	5.10	9.60	12.20	16.70	18.60	20.40	19.10	13.60	11.30	7.10
19	3.10	2.90	5.50	9.40	12.20	16.90	18.70	20.50	18.90	13.70	10.80	7.10
20	3.00	2.70	5.50	9.40	12.40	17.20	18.80	20.60	18.80	13.80	10.50	7.00
21	3.00	2.50	5.50	9.40	12.80	17.30	19.00	20.90	18.50	14.00	10.50	7.00
22	2.70	2.50	5.60	9.50	13.20	17.30	19.20	21.00	18.60	13.90	10.50	7.00
23	2.50	2.40	5.60	9.80	13.30	17.00	19.40	21.10	18.50	14.00	10.30	7.10
24	2.30	2.20	5.80	9.80	13.70	16.90	19.60	21.10	18.40	14.20	10.20	7.00
25	2.00	2.20	6.10	9.60	13.70	16.80	19.90	20.90	18.30	14.10	10.00	7.00
26	1.80	2.20	6.50	9.80	13.80	16.70	20.00	20.80	18.40	13.90	9.70	7.00
27	1.50	2.40	6.60	9.90	13.80	16.80	20.10	20.90	18.40	13.80	9.30	6.90
28	1.30	2.40	6.80	10.10	13.70	16.80	20.10	20.50	18.20	13.50	9.00	6.80
29	1.10		6.90	9.70	13.70	16.70	20.10	20.50	18.20	13.30	8.60	6.00
30	.80		6.90	9.20	13.60	16.60	20.50	20.10	18.10	13.20	8.40	6.10
31	.60		7.20		13.70		20.40	19.80		13.20		6.30

DAILY AVERAGE TEMPERATURE COLUMBIA RIVER
JOINT DAY-BITES, DEGREES CENTIGRADE

1964	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	2.20	1.00	3.50	7.60	10.40	14.00	17.00	20.20	20.60	18.40	13.00	8.60
2	1.90	1.00	3.40	7.60	10.20	14.10	17.30	20.30	20.50	16.00	12.90	8.40
3	1.60	1.00	3.40	7.60	10.00	14.60	17.30	20.30	20.30	17.80	12.90	8.20
4	1.60	1.00	3.50	8.10	9.70	14.80	17.30	20.40	20.10	17.50	12.90	8.00
5	1.70	1.00	3.60	8.20	9.60	15.00	17.40	20.40	19.80	17.40	12.80	7.70
6	1.90	1.00	3.80	8.30	9.70	15.30	17.40	20.50	19.70	17.30	12.80	7.40
7	1.90	1.00	3.90	8.30	10.40	15.70	17.50	20.50	19.70	17.10	12.80	7.10
8	1.90	1.00	3.90	8.40	10.70	15.90	17.70	20.40	19.70	16.90	12.60	6.90
9	2.10	1.10	4.00	8.60	11.00	16.20	18.00	20.40	19.70	16.70	12.50	6.70
10	2.30	1.20	4.10	8.70	11.50	16.50	18.10	20.30	19.60	16.30	12.30	6.50
11	2.40	1.30	4.30	8.90	11.90	16.80	18.30	20.20	19.50	15.90	12.20	6.40
12	2.40	1.60	4.60	9.00	12.30	17.20	18.30	19.90	19.30	15.70	12.30	6.40
13	2.30	1.80	4.70	9.20	12.70	17.30	18.40	19.80	19.10	15.40	12.40	6.30
14	2.00	1.90	4.80	9.20	13.10	17.30	18.30	19.90	19.10	15.30	12.40	6.40
15	2.00	1.90	4.90	9.30	13.10	17.00	18.40	20.00	19.00	15.10	12.20	6.50
16	2.00	2.00	5.10	9.40	13.00	17.10	13.60	20.00	19.10	14.90	11.90	6.60
17	2.00	2.20	5.20	9.50	12.60	17.30	13.70	19.90	19.20	14.60	11.70	6.60
18	2.00	2.40	5.30	9.70	12.70	17.40	18.60	20.00	19.20	14.20	11.60	6.60
19	2.00	2.60	5.40	9.80	12.60	17.40	19.00	19.90	19.30	13.80	11.50	6.70
20	2.00	2.90	5.60	9.90	12.40	17.50	19.10	20.10	19.10	13.60	11.40	6.70
21	2.00	3.10	5.70	10.00	12.40	17.40	19.20	20.20	18.90	13.40	11.10	6.60
22	2.00	3.40	6.00	10.10	12.70	17.40	19.40	20.40	18.80	13.50	10.90	6.50
23	2.10	3.40	6.00	10.20	13.10	17.30	19.70	20.60	18.80	13.60	10.60	6.40
24	1.90	3.40	6.30	10.30	13.50	17.30	19.70	20.40	18.60	13.60	10.40	6.30
25	1.40	3.50	6.60	10.40	13.90	17.30	19.80	20.30	18.60	13.40	10.10	6.20
26	1.00	3.60	6.80	10.30	13.90	17.00	19.80	20.40	18.50	12.90	10.00	6.10
27	1.00	3.60	6.90	10.30	13.90	16.90	20.10	20.40	18.60	12.50	9.80	6.00
28	1.00	3.60	6.90	10.30	13.90	16.70	20.00	20.40	18.60	12.30	9.60	5.90
29	1.00		6.90	10.40	14.10	16.50	20.10	20.40	18.50	12.60	9.30	5.90
30	1.00		7.10	10.50	14.20	16.60	20.20	20.40	18.40	12.90	8.90	5.90
31	1.00		7.20		14.10		20.30	20.50		13.00		5.90

DAILY AVERAGE TEMPERATURE GRAND COULEE, DEGREES CENTIGRADE

1964 - 1969

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	7.4	4.2	2.9	4.4	7.1	11.2	13.2	15.8	16.7	17.1	14.8	11.0
2	7.2	4.1	2.9	4.5	7.2	11.3	13.3	15.9	16.6	17.0	14.6	11.0
3	7.1	4.2	2.9	4.7	7.3	11.3	13.4	16.0	16.7	17.0	14.6	10.8
4	7.0	4.1	2.9	4.6	7.4	11.3	13.4	15.9	16.7	17.0	14.5	10.8
5	6.9	3.9	2.9	4.7	7.5	11.4	13.5	16.0	16.8	16.9	14.4	10.5
6	6.9	3.8	2.9	4.8	7.5	11.5	13.6	15.9	16.7	16.9	14.1	10.4
7	6.8	3.8	2.9	4.9	7.5	11.6	13.6	16.0	16.8	16.9	14.0	10.4
8	6.8	3.9	2.9	5.0	7.7	11.6	13.8	16.0	16.9	16.8	13.9	10.2
9	6.7	3.8	2.9	5.1	7.9	11.6	13.8	15.9	17.0	16.8	13.8	10.1
10	6.4	3.6	2.9	5.2	8.0	11.7	14.0	16.0	17.0	16.7	13.7	10.0
11	6.4	3.5	2.9	5.2	8.2	11.7	13.9	16.0	16.9	16.7	13.6	9.8
12	6.3	3.4	3.0	5.3	8.5	11.8	14.0	16.0	17.0	16.6	13.4	9.7
13	6.3	3.2	3.1	5.3	8.6	11.9	14.2	16.1	17.0	16.6	13.3	9.6
14	6.2	3.1	3.2	5.4	8.9	11.9	14.3	16.1	17.0	16.5	13.2	9.5
15	6.1	3.2	3.2	5.5	9.0	11.9	14.3	16.3	17.0	16.5	13.0	9.5
16	5.9	3.1	3.3	5.6	9.2	12.0	14.4	16.3	17.1	16.4	12.9	9.2
17	5.9	3.1	3.4	5.7	9.3	12.2	14.7	16.3	17.1	16.3	12.8	9.1
18	5.7	3.0	3.4	5.9	9.5	12.2	14.7	16.2	17.1	16.3	12.7	8.9
19	5.6	2.9	3.4	6.0	9.6	12.2	14.7	16.0	17.1	16.2	12.7	8.9
20	5.5	3.0	3.5	6.1	9.8	12.4	14.8	16.2	17.1	16.1	12.5	8.8
21	5.5	2.9	3.6	6.1	9.7	12.4	14.9	16.1	17.1	16.0	12.4	8.6
22	5.4	2.8	3.7	6.1	9.8	12.5	14.9	16.3	17.1	16.0	12.2	8.5
23	5.3	2.9	3.7	6.2	9.9	12.6	15.0	16.2	17.1	15.7	12.1	8.4
24	5.3	2.9	3.7	6.3	10.1	12.7	15.0	16.3	17.1	15.7	12.0	8.3
25	5.0	2.9	3.7	6.5	10.3	12.8	15.0	16.4	17.2	15.6	11.9	8.2
26	4.8	2.9	3.8	6.5	10.6	12.8	15.0	16.5	17.2	15.5	11.7	8.0
27	4.8	2.9	3.9	6.6	10.7	12.8	15.3	16.6	17.1	15.4	11.5	7.8
28	4.6	2.8	4.1	6.9	10.8	12.9	15.5	16.6	17.2	15.3	11.5	7.8
29	4.4	3.4	4.2	7.1	11.0	13.0	15.4	16.7	17.2	15.1	11.4	7.7
30	4.4		4.3	7.1	11.0	13.1	15.5	16.6	17.2	15.0	11.2	7.5
31	4.3		4.4		11.1		15.6	16.6		14.9		7.4

DAILY AVERAGE TEMPERATURE ICE HARBOR, DEGREES CENTIGRADE

1963 - 1969

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	4.1	3.2	4.0	6.1	10.8	13.1	17.0	22.5	21.3	17.9	12.2	7.4
2	3.8	3.1	5.0	3.3	10.8	13.2	17.0	22.7	20.9	18.0	12.0	7.2
3	3.7	3.2	5.2	8.6	11.0	13.2	17.2	22.8	20.9	18.0	11.9	7.0
4	3.6	3.1	5.4	8.8	11.1	13.3	17.5	22.8	20.8	17.9	11.5	6.8
5	3.8	2.9	5.4	8.8	11.0	13.4	17.8	22.8	20.8	17.7	11.4	6.7
6	3.6	3.0	5.6	8.9	11.1	13.4	18.0	22.9	20.8	17.4	11.3	6.5
7	3.5	3.4	5.6	6.9	11.3	13.3	18.3	23.0	20.7	17.3	11.2	6.4
8	3.7	3.4	5.5	9.0	11.6	13.4	19.0	23.0	20.7	16.8	11.0	6.3
9	3.8	3.8	5.5	9.1	11.7	13.5	19.3	23.0	20.6	16.6	10.9	6.3
10	3.7	3.8	5.5	9.3	11.8	13.3	19.5	23.0	20.5	16.5	10.7	6.2
11	3.7	3.8	5.7	9.6	12.2	13.8	19.8	23.2	20.4	16.4	10.7	6.1
12	3.7	3.6	5.8	9.8	11.9	13.8	20.0	23.1	20.3	16.2	10.4	6.0
13	3.5	3.6	6.0	9.7	12.6	14.1	20.2	23.1	20.3	16.1	10.3	5.9
14	3.5	3.6	6.1	9.8	12.1	14.2	20.5	23.1	20.1	15.7	9.9	5.8
15	3.4	3.8	6.1	9.9	12.0	14.6	20.8	23.1	19.9	15.5	9.7	5.7
16	3.3	3.8	6.1	9.9	11.9	14.9	21.0	23.0	19.8	15.3	9.7	5.4
17	3.4	3.8	6.2	9.8	12.0	14.7	21.0	23.1	19.8	15.3	9.6	5.1
18	3.3	3.8	6.3	9.9	12.2	15.0	21.2	23.3	19.6	14.9	9.2	4.9
19	3.2	3.8	6.3	9.9	12.0	15.1	21.2	23.1	19.5	14.7	9.0	4.9
20	3.2	3.9	6.5	9.8	12.5	15.5	21.3	22.6	19.2	14.2	8.9	4.7
21	3.4	4.1	6.7	9.8	12.6	15.6	21.3	22.5	19.1	14.1	8.8	4.4
22	3.3	4.2	6.8	9.8	12.4	15.7	21.4	22.5	18.8	13.8	8.6	4.1
23	3.3	4.3	6.8	9.8	12.4	16.0	21.5	22.5	18.6	13.5	8.6	4.0
24	3.2	4.5	6.8	9.8	12.5	16.2	21.6	22.3	18.6	13.5	8.6	4.4
25	3.1	4.5	6.9	9.9	12.3	16.4	21.8	22.2	18.4	13.3	8.4	4.1
26	2.9	4.7	7.1	10.1	12.2	16.4	21.8	22.0	18.2	13.1	8.1	4.2
27	2.8	4.9	7.2	10.0	12.5	16.4	21.9	22.0	18.0	12.9	7.9	4.3
28	2.7	4.9	7.3	10.1	12.6	16.7	22.0	21.8	18.1	12.3	7.8	4.5
29	2.7		7.5	10.3	12.8	16.8	22.2	21.8	18.0	12.6	7.7	4.4
30	3.0		7.7	10.6	13.0	16.8	22.3	21.6	18.0	12.4	7.7	4.5
31	3.0		8.0		13.0		22.3	21.4		12.2		4.5

DAILY AVERAGE TEMPERATURE PRIEST RAPIDS, DEGREES CENTIGRADE
1961 - 1969

DAY	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	5.5	3.8	3.7	5.6	8.6	12.0	14.6	17.7	17.8	16.7	13.4	9.3
2	5.5	3.8	3.7	5.7	8.7	12.3	14.7	17.8	17.7	16.6	13.2	9.2
3	5.5	3.9	3.7	5.8	8.8	12.2	14.9	17.8	17.6	16.5	13.1	9.2
4	5.4	4.0	3.8	5.8	8.9	12.3	15.1	17.8	17.6	16.4	13.0	9.0
5	5.3	4.0	3.7	6.0	8.9	12.5	15.2	17.7	17.8	16.3	12.8	8.9
6	5.3	4.0	3.8	6.1	9.1	12.6	15.3	17.8	17.8	16.2	12.7	8.7
7	5.3	3.9	3.8	6.2	9.2	12.8	15.5	17.9	17.8	16.0	12.5	8.6
8	5.4	3.9	3.8	6.4	9.5	13.0	15.6	17.9	17.9	15.9	12.3	8.5
9	5.4	3.8	4.0	6.6	9.5	12.9	15.7	18.1	17.9	15.8	12.3	8.4
10	5.4	3.8	4.0	6.7	9.7	12.9	15.8	18.1	18.0	15.6	12.1	8.3
11	5.2	3.9	4.0	6.8	9.8	13.0	15.8	18.1	18.0	15.5	11.9	8.1
12	5.0	3.9	4.1	6.8	9.9	13.1	15.9	18.2	17.9	15.3	11.9	7.9
13	4.9	3.9	4.1	6.8	10.0	13.2	16.0	18.2	17.7	15.2	11.8	7.9
14	5.0	3.8	4.1	6.9	10.1	13.4	16.1	18.3	17.7	15.1	11.7	7.8
15	4.9	3.8	4.2	7.0	10.2	13.5	16.1	18.4	17.5	15.0	11.5	7.7
16	4.8	3.7	4.3	7.1	10.3	13.7	16.1	18.4	17.4	14.8	11.3	7.4
17	4.7	3.7	4.4	7.2	10.5	13.7	16.2	18.2	17.4	14.8	11.1	7.2
18	4.6	3.8	4.4	7.2	10.7	13.8	16.3	18.1	17.3	14.6	11.0	7.1
19	4.6	3.8	4.5	7.2	10.8	13.9	16.4	18.1	17.3	14.5	10.9	7.0
20	4.5	3.8	4.5	7.3	11.0	13.9	16.4	18.1	17.2	14.4	10.8	7.0
21	4.5	3.7	4.6	7.3	11.2	13.9	16.5	18.2	17.2	14.3	10.7	6.8
22	4.4	3.7	4.7	7.4	11.3	13.9	16.6	18.2	17.2	14.3	10.5	6.7
23	4.3	3.7	4.7	7.6	11.3	14.0	16.7	18.2	17.2	14.2	10.3	6.6
24	4.2	3.7	4.7	7.8	11.3	14.1	16.9	18.2	17.2	14.2	10.2	6.6
25	4.0	3.7	4.8	7.9	11.3	14.2	17.0	18.1	17.2	14.1	10.0	6.4
26	4.0	3.7	4.9	8.0	11.4	14.3	17.1	17.9	17.2	13.9	9.8	6.2
27	3.9	3.7	4.9	8.1	11.5	14.3	17.3	17.7	17.2	13.8	9.7	6.0
28	3.8	3.7	5.1	8.3	11.6	14.3	17.5	17.6	17.1	13.7	9.6	5.9
29	3.9		5.3	8.4	11.7	14.4	17.6	17.4	17.0	13.7	9.5	5.7
30	3.9		5.3	8.5	11.8	14.4	17.7	17.5	16.9	13.7	9.4	5.6
31	3.8		5.4		11.9		17.8	17.7		13.5		5.6

TABLE 4. Priest Rapids 20-Year Average of Daily Maximum Temperature in Degrees Centigrade for the Years 1947 Through 1967

47/67	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	7.30	6.70	5.60	6.70	9.60	13.10	15.60	19.40	19.40	18.30	14.70	10.60
2	7.20	6.10	5.30	6.70	9.60	13.10	16.10	19.20	19.20	18.30	14.40	10.60
3	7.30	6.10	5.00	7.00	10.00	13.30	16.10	19.40	18.90	18.30	14.40	10.60
4	7.30	6.10	5.00	6.60	9.70	13.60	16.10	18.40	18.90	18.30	14.40	10.60
5	7.20	6.70	5.00	6.70	10.00	13.90	16.30	18.60	18.90	18.30	13.90	11.10
6	7.20	6.70	5.00	6.90	10.30	14.20	16.70	18.90	18.90	18.30	14.40	10.60
7	7.20	6.10	5.60	7.20	10.20	14.40	16.70	18.90	18.90	18.10	14.70	10.60
8	7.20	6.10	5.60	7.50	10.50	14.40	16.90	19.00	19.40	17.80	14.40	10.60
9	7.20	6.10	5.60	7.70	10.40	14.40	17.20	18.90	19.40	17.30	13.90	10.00
10	7.20	5.80	5.60	8.00	10.20	15.00	17.20	19.40	19.40	17.30	13.60	10.00
11	6.70	5.60	5.60	7.70	10.30	14.70	17.80	19.40	19.40	17.20	13.30	10.00
12	6.70	5.60	5.60	7.70	10.20	14.70	17.80	19.30	19.40	17.20	13.30	10.30
13	6.70	5.60	5.60	7.40	10.40	15.00	17.80	19.50	19.20	17.20	13.60	10.00
14	6.70	5.60	5.60	7.80	10.40	15.00	18.10	19.40	18.90	16.90	13.30	10.00
15	6.70	5.60	5.00	8.10	10.40	15.00	17.30	19.50	18.90	17.20	13.60	10.00
16	6.50	5.60	4.80	8.40	10.60	15.00	17.60	19.40	18.90	16.90	13.30	10.00
17	6.70	5.60	5.00	8.60	10.80	15.00	17.90	19.20	18.90	16.70	13.30	9.70
18	6.70	5.60	5.20	8.10	11.00	15.60	18.30	19.40	18.60	16.70	13.30	9.70
19	6.70	5.60	5.30	8.00	11.20	15.60	18.30	19.70	18.60	16.70	12.80	9.70
20	6.10	5.60	5.10	8.00	11.50	15.60	18.90	20.00	18.60	16.10	12.80	9.40
21	6.70	5.60	5.20	8.10	11.70	15.60	18.90	20.00	18.30	15.80	12.80	9.40
22	6.70	5.60	5.20	8.40	12.20	16.10	18.90	20.00	18.30	15.80	12.80	9.20
23	6.70	6.10	5.30	8.60	12.30	16.10	18.90	20.00	18.30	15.80	12.20	8.90
24	6.40	6.10	5.30	8.80	12.50	15.90	18.90	20.00	18.10	16.10	11.70	8.60
25	6.70	6.10	5.60	8.70	12.80	15.30	18.90	20.00	18.10	16.70	11.10	8.60
26	6.70	5.80	5.60	8.50	12.80	15.60	18.60	19.40	18.10	16.10	11.10	8.30
27	6.40	5.60	5.60	8.70	12.80	15.60	18.70	19.40	18.30	16.10	11.10	8.30
28	6.10	5.60	5.60	9.00	13.30	15.60	18.90	19.40	18.40	15.00	10.60	7.80
29	6.10		6.00	9.40	13.30	15.60	19.20	19.40	18.30	15.00	10.60	7.20
30	6.10		6.10	9.60	13.30	15.60	18.90	19.40	18.30	15.00	10.60	7.20
31	6.10		6.60		13.30		18.90	19.40		15.00		7.30

TABLE 5. Priest Rapids 20-Year Average of Daily Minimum Temperature
in Degrees Centigrade for the Years 1947 Through 1967

47/67	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER
1	3.60	1.10	1.90	3.30	5.60	10.00	11.70	15.60	16.40	15.00	12.80	8.60
2	3.80	1.10	1.70	3.60	5.60	10.00	11.70	15.60	16.20	14.70	12.50	8.60
3	4.10	1.10	1.90	3.60	6.10	10.00	12.20	15.80	16.30	14.70	12.20	8.30
4	3.90	1.10	1.40	3.60	6.10	10.30	12.80	15.80	16.30	14.40	12.20	8.30
5	3.90	1.70	1.40	3.60	6.10	10.60	12.80	15.60	16.50	14.20	11.70	8.10
6	3.90	1.70	1.70	3.90	6.10	10.60	12.80	15.60	16.70	14.20	11.70	7.80
7	3.90	1.70	1.70	3.90	6.60	10.80	13.30	15.60	16.70	14.20	11.60	7.20
8	3.90	1.70	1.90	4.00	6.60	10.80	13.30	15.80	16.50	15.00	11.50	7.20
9	3.90	1.70	1.70	4.10	6.90	10.60	13.30	16.10	16.40	14.60	11.40	7.20
10	3.90	1.90	1.90	4.10	6.90	10.60	13.30	16.10	16.30	14.40	11.30	7.20
11	3.90	1.90	2.20	4.20	7.20	11.10	13.30	16.10	16.40	14.10	10.90	6.80
12	3.90	2.20	1.70	4.20	7.80	11.10	13.30	16.10	16.50	13.90	10.90	6.40
13	3.60	1.90	1.90	4.20	7.80	11.10	13.30	16.70	16.40	13.90	8.90	6.20
14	3.30	1.10	1.90	4.40	7.90	11.10	13.30	16.40	16.40	13.90	8.60	6.20
15	2.80	1.10	2.50	4.40	8.30	11.10	13.30	16.40	15.80	13.90	8.90	6.10
16	2.80	1.10	2.80	4.40	8.30	11.10	13.60	15.60	15.60	13.90	8.30	6.10
17	3.10	.80	2.80	4.40	8.10	11.10	13.90	15.60	16.10	14.00	8.10	5.40
18	3.10	1.10	2.80	4.40	8.10	11.10	13.90	15.80	16.10	13.80	8.90	5.30
19	3.10	1.10	2.80	4.70	7.80	11.10	13.60	15.80	16.10	13.60	8.90	5.00
20	2.40	1.10	2.80	4.70	8.10	11.10	13.90	16.10	15.90	13.20	8.90	4.70
21	2.20	1.40	2.80	5.00	8.60	11.10	13.90	15.80	15.80	12.80	8.90	4.10
22	2.40	1.70	2.80	5.00	8.60	11.10	13.90	16.10	15.90	12.80	9.20	4.20
23	2.50	1.90	3.10	5.30	8.90	11.40	13.90	16.10	15.80	12.80	9.10	4.50
24	2.60	1.90	2.80	5.00	8.90	11.70	14.40	15.60	16.10	12.80	8.90	4.40
25	2.70	1.70	2.80	5.00	9.40	11.70	14.40	15.60	16.00	12.80	8.70	3.60
26	1.70	1.70	2.80	5.00	8.90	11.70	14.40	15.60	16.10	12.20	8.40	3.40
27	1.70	1.70	2.80	5.00	9.40	11.40	14.70	15.80	16.10	12.80	8.30	3.30
28	2.20	1.90	3.30	5.00	9.40	11.40	14.40	15.80	15.60	12.80	8.30	3.30
29	2.20		3.30	5.60	9.40	11.70	14.40	16.10	15.00	12.20	8.30	3.60
30	1.70		3.30	5.60	9.70	11.70	15.00	16.10	14.70	12.80	8.30	3.60
31	1.10		3.30		9.70		15.60	16.30		12.80		3.60

3.43

BNWL-1345

LEAST-SQUARES FITTED CURVES

The following least-squares fitted curves, Figures 6 through 31, were made using the observed temperatures, at Ice Harbor on the Snake River and various sites on the Columbia. Using the available analytical techniques of the Pacific Northwest Laboratory (Battelle-Northwest), it was possible to utilize this data in a least-squares curve fitting routine.

The general success of this method of least squares analyses has permitted the generation of a series of least-squares-fitted functional models to be used with daily flows, dew points, Langleys, air temperature, water temperature or other water quality data.

For temperature correlations, the function $T = A + B \sin(Cd + D)$ originally used in oceanography and described by Ward⁽²⁾ was adopted because of the excellence of representation of annual temperature data afforded by its use. In the operations research supporting this study, the data points were grouped by year from January 1 through December 31 using 365 or 366 days/year as appropriate. The data were then analyzed by means of a nonlinear, maximum-likelihood, least-squares-fit routine capable of handling nonlinearities and saddle points reliably. This program makes use of numeric rounding for accuracy, ill-conditioned matrix inversion logic, and statistical determination of saddle points on the parametric surface. In addition, it contains a two-stage recovery logic. If the usual first order approximation fails, the routine tries the second order terms of the multivariate Taylor expansion. Failing this, the routine branches into a series of approximations best described as "reverse-and halve the last change" logic. The analysis of the data yields the best-fit parameters and, in addition, produces the root-mean-square error associated with that parameter estimate.

Also included as output are a series of graphs drawn by the CALCOMP plotter from magnetic tapes generated by the computer. These plots include the observed data, the calculated curve, and another pair of curves of plus or minus one standard deviation on each side of the calculated curve.

If a function of the form $T = A + B \sin (Cd + D)$ is fitted to annual temperature data, then $C \approx 2\pi/365.25 \approx 0.017$. As an added check on the goodness of fit, this parameter was allowed to vary in each case to see what value the computer would calculate.

Table 6 shows a series of values of four parameters for a series of data points from International Border, Northport site, to Beaver Terminal for calendar years 1964 through 1969. Included are calculations from data supplied by other agencies for Chief Joseph, Ice Harbor, McNary, and The Dalles.

TABLE 6. Least-Squares Fit Expressions Using the Single Function $T = \bar{T} + B \sin(Cd + D)$

January - December						
		Temp, °C	Model Mean A, °C	Comp. Extreme B, °C	Daily Shift-C Radians	Peak Shift-D Radians
International Border (Northport)	1966	T =	9.29	6.66	0.0178	3.70
	1967		9.64	6.64	0.0181	3.81
	1968		8.83	6.56	0.0193	4.01
	1969		9.36	8.14	0.0172	3.97
Grand Coulee	1964	T =	10.6	5.7	0.0180	3.47
	1965		10.4	7.2	0.0164	3.75
	1966		10.40	6.48	0.0165	3.67
	1967		10.98	6.95	0.0173	3.51
	1968		10.39	6.88	0.0166	3.78
	1969		10.09	7.84	0.0172	3.92
Chief Joseph	1964	T =	10.50	6.52	0.0176d	3.46
	1965		10.62	7.40	0.0165d	3.77
	1966		10.71	6.51	0.0166d	3.69
	1967		11.33	6.74	0.0175	3.48
	1968		10.46	6.49	0.0165d	3.82
	1969		10.76	7.99	0.0172	3.73
Rocky Reach	1964	T =	10.47	6.32	0.0180	3.55
	1965		10.46	7.29	0.0169	3.77
	1966		10.43	6.53	0.0166	3.80
	1967		11.05	6.98	0.0177	3.58
	1968		10.24	7.06	0.0167	3.90
	1969		10.45	8.26	0.0172	3.83
Priest Rapids	1964	T =	10.57	6.48	0.0178	3.72
	1965		10.64	7.40	0.0169	3.87
	1966		10.65	6.63	0.0166	3.95
	1967		11.31	7.00	0.0180	3.63
	1968		10.56	7.04	0.0170	3.94
	1969		10.63	8.24	0.0172	3.91
Richland	1964	T =	12.20	6.25	0.0176	3.78
	1965		12.12	6.99	0.0172	3.86
	1966		12.04	6.24	0.0163	4.04
	1967		12.63	6.69	0.0183	3.63
	1968		11.70	6.87	0.0171	3.99
	1969		11.24	8.39	0.0172	3.94
Pasco	1964	T =	11.80	6.09	0.0177	3.78
	1965		11.88	7.27	0.0170	3.90
	1966		11.94	6.34	0.0164	4.02
	1967		12.53	6.67	0.0185	3.60
	1968		11.61	6.82	0.0169	4.00
	1969		11.42	8.34	0.0172	3.97
Ice Harbor	1964	T =	11.31	8.53	0.0181	3.83
	1965		11.78	8.39	0.0173	4.01
	1966		12.41	9.08	0.0175	4.00
	1967		12.87	9.13	0.0186	3.72
	1968		12.09	8.59	0.0180	4.00
	1969		11.83	9.65	0.0172	3.56

TABLE 6. (contd)

January - December						
		Temp, °C	Model Mean A, °C	Comp. Extreme B, °C	Daily Shift-C Radians	Peak Shift-D Radians
McNary	1964	T =	11.92	6.88	0.0178	3.79
	1965	T =	11.97	7.64	0.0165	4.09
	1966	T =	12.21	7.16	0.0165	4.09
	1967	T =	12.90	7.33	0.0182	3.67
	1968	T =	11.89	7.21	0.0168	4.06
	1969	T =	11.75	8.69	0.0172	3.97
Umatilla	1969	T =	11.52	8.86	0.0172	4.02
John Day - Biggs	1969	T =	11.60	8.91	0.0172	4.04
The Dalles	1964	T =	11.70	7.03	0.0178	3.90
	1965	T =	11.87	7.74	0.0166	4.11
	1966		12.12	7.16	0.0166	4.14
	1967	T =	12.91	7.56	0.0182	3.75
	1968	T =	12.01	7.61	0.0172	4.05
	1969	T =	11.76	9.12	0.0172	4.03
Bonneville Dam	1964	T =	11.62	6.97	0.0180	3.89
	1965	T =	11.75	7.70	0.0165	4.15
	1966	T =	11.93	7.20	0.0165	4.17
	1967	T =	12.99	7.46	0.0183	3.74
	1968	T =	12.14	7.63	0.0171	4.08
	1969	T =	11.84	9.11	0.0172	4.04
Warrendale	1968	T =	11.81	7.8	0.0170	4.12
	1969		11.51	9.14	0.0172	4.06
Longview	1969	T =	11.51	8.23	0.0172	4.11
Beaver Terminal	1969	T =	11.82	8.64	0.0172	4.14

ACKNOWLEDGEMENT

An attempt to summarize the salient features of a program as long as the Division of Production supported study 02 50 10 10, "Effects of Reactor Effluent on the Quality of Columbia River Water," would require a great deal of painstaking search to discover all of the research effort which should be individually acknowledged. In the present instance, which is limited to a summary of the temperature data alone, a great number of persons made contributions. The collection of meaningful data on a major river in all sorts of weather, good and bad, and in many seasons of the year entails sacrifices often overlooked in the eagerness to derive meaningful conclusions of significance to an immediate problem. It is hoped that the information about the Columbia River which has been derived from this program is useful to the scientific community and of lasting value to persons seeking to optimize the value of the Columbia for the good of society.

The following persons because of unique circumstances made significant contributions in leadership and personal participation to this program.

R. F. Foster, who, recognizing the future necessity to create a meaningful relation of plant activities to the water quality of the Columbia River, initiated the program and was the person in charge until recent years.

J. P. Corley, in various capacities as research supervisor, principal investigator and consultant, collected the majority of data in the Hanford reach of the plant. This work involved great sacrifices of a personal nature in terms of time, discomfort and potential hazard to ensure consistency and confidence in the numerical information achieved.

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To all persons, mentioned or not, who in the course of the past eight year gave willing assistance in order that this body of information be the state-of-the-art in the development of a factual data base.

REFERENCES AND BIBLIOGRAPHYCITED REFERENCES

1. R. T. Jaske and J. L. Spurgeon. "A Special Case, Thermal Digital Simulation of Waste Heat Discharges," Water Research, vol. 2, pp. 777-802. 1968.
2. J. C. Ward. "Annual Variation of Stream Water Temperature," J. Sanit, Div., Am. Soc. Civil Engrs. December 1963.
3. R. T. Jaske and J. B. Geobel. "Effects of Dam Construction on Temperatures of Columbia River," J. Am. Water Works Assoc., vol. 59, no. 8, pp. 935-942. August 1967.
4. R. T. Jaske. "Thermal Modification of River Water Quality," Proceedings of the Sixth Biennial WSU Hydraulics Conference, Moscow, Idaho, November 30, 1967.
5. R. T. Jaske and D. G. Daniels. A Simulation of the Effects of the Hanford Plant at the Washington-Oregon Border, BNWL-1344. Battelle-Northwest, Richland, Washington, August 1970.
6. R. T. Jaske. An Evaluation of the Use of Selective Discharges to Cool the Columbia River, BNWL-208. Battelle-Northwest, Richland, Washington, March 15, 1966.

BIBLIOGRAPHY

- BNWC-82 J. P. Corley. Future River Temperatures at 181-N.
May 11, 1965. (SECRET)
- BNWL-20 R. T. Jaske. The Density Current Regime of Franklin D. Roosevelt Lake. March 16, 1965.
- BNWL-390 B. Duane. Maximum Likelihood Nonlinear Correlated Fields, (Program Likely). September 1967.
- BNWL-628 R. T. Jaske. A Test Simulation of the Temperatures of the Deerfield River. December 1967.
- BNWL-733 R. T. Jaske. A Preliminary Evaluation of the Thermal Effects of the Ben Franklin Dam Project on Columbia River Temperatures Below the Hanford Plant. April 1968.
- BNWL-728 R. T. Jaske. A Test Simulation of the Temperature of the Illinois River and a Prediction of the Effects of Dresden II and Dresden III Reactors. April 1968.
- BNWL-999 D. E. Peterson and R. T. Jaske. A Test Simulation of Potential Effects of Thermal Power Plants on Streams in the Upper Mississippi River Basin. December 1968.
- BNWL-1228 R. A. Burnett and D. G. Daniels. Evaluation of the Simpl-1 Hybrid Computer Concept on a Water Quality Benchmark Problem. November 1969.
- BNWL-1277 D. E. Peterson and R. T. Jaske. Simulation Modeling of Thermal Effluent in an Irrigation System. January 1970.
- BNWL-1299 D. E. Peterson and R. T. Jaske. Potential Thermal Effects of an Expanding Power Industry: Ohio River Basin 1. February 1970.
- BNWL-1342 D. G. Daniels, J. C. Sonnichsen and R. T. Jaske. Simulation of Thermal Effluent Discharges in Estuaries. June 1970.
- BNWL-1343 R. W. Legan and R. T. Jaske. A Cost Analysis of Improved Regulation of Columbia River to Increase Minimum Flow in the Hanford Plant Vicinity. August 1970.

- BNWL-1405 D. E. Peterson and R. T. Jaske. Potential Thermal Effects of an Expanding Power Industry: Upper Mississippi Basin. June 1970.
- BNWL-CC-492 J. P. Corley. Comparison of Upstream and Downstream River Temperatures 1964-1965. April 8, 1966. (SECRET)
- BNWL-CC-656 J. P. Corley. River Temperature Cycling at 181-D. May 13, 1966. (SECRET)
- BNWL-CC-807 J. P. Corley. Inter-Reactor River Temperature Data. September 9, 1966. (SECRET)
- BNWL-CC-979 R. F. Foster and R. T. Jaske. Progress Report on Research and Development Mission 14-Columbia River Studies. December 30, 1966. (Unpublished Data)
- BNWL-CC-1056 R. F. Foster and J. P. Corley. Environmental Effects of an Extended Hanford Plant Shutdown. February 28, 1967. (SECRET)
- BNWL-CC-1236 R. T. Jaske. Columbia River Hydrograph. June 15, 1967. (Unpublished Data)
- BNWL-CC-1261 R. T. Jaske. An Analysis of the Physical Factors Governing the Size and Gradients of the Hanford Effluent Plumes. July 1966.
- BNWL-CC-1355 R. T. Jaske. A Preliminary Appraisal of a Canal Lake Cooling System. September 1967. (SECRET)
- BNWL-CC-1628 J. P. Corley. Effluent Plume Temperature Data. June 3, 1968. (SECRET)
- BNWL-CC-1931 J. F. Honstead and R. T. Jaske. 1967 Columbia River Temperature Analysis. November 1968. (SECRET)
- BNWL-SA-1483 R. T. Jaske. Digital Simulation System for Prediction of Water Quality. November 1, 1967. See also Proceedings of the Fourth International Conference on Water Pollution Research, Prague, Czechoslovakia, April 1969.
- BNWL-SA-2376 R. T. Jaske. Columbia River Trends - Fact and Fallacy. May 8, 1969.

- BNWL-SA-2536 R. T. Jaske. "Columbia River Temperature Trends - Fact and Fallacy," Presented at the Fourth Annual Snake River Editors Conference, Walla Walla, Washington, May 8, 1969.
- BNWL-SA-3193 "Improved Methods for Planning of Thermal Discharges Before Site Acquisition with a Specific Case Example on the Columbia River," IAE Symposium on Environmental Aspects of Nuclear Power Stations, New York City, August 10-14, 1970.
- DUN-959 W. N. Adachi and J. W. Ballowe. Columbia River Cooling Program CY 1965. April 15, 1966. (SECRET)
- HW-69368 J. P. Corley, H. A. Kramer and J. K. Soldat. A Compilation of Basic Data Relating to the Columbia River, Sections I-VI. December 1961. (Unpub. Data)
- HW-80888 J. P. Corley. Effects of Hanford Operations on Columbia River Temperature. December 3, 1965. (SECRET)
- J. R. Adams. "Thermal Power, Aquatic Life, and Kilowatts on the Pacific Coast," Presented at the American Power Conference, Chicago, Illinois, April 1969.
- F. A. Davidson. The Temperature Regime of the Columbia River from Priest Rapids, Washington to the Arrow Lakes in British Columbia. Public Utility District No. 2 of Grant County, Washington, January 1964.
- R. E. Glover. Dispersion of Dissolved or Suspended Materials in Flowing Streams. U.S.G.S. Professional Paper 433-B, Washington D.C., 1962.
- J. P. Heaney. Mathematical Programming Model for Long-Range River Basin Planning with Emphasis on the Colorado River Basin. Northwestern University, Evanston, Illinois, 1968. (Ph.D. Dissertaion)
- R. T. Jaske. "Heat as a Pollutant," Seminar WR 002.64, Oregon State University, Fall 1964.
- R. T. Jaske. "Thermal Modification of River Water Quality," Proceedings of the 6th Biennial Washington State University Hydraulics Conference, October 1967.
- R. T. Jaske for The Bureau of Commercial Fisheries. Final Report on Study Program to Determine the Potential Impact of Thermal Power Plants on Pacific Northwest Streams. October 1966.

R. T. Jaske. "The Use of Digital Systems Modeling in the Evaluation of Regional Water Quality Involving Single or Multiple Releases," Am. Inst. Chem. Engrs., Water 1968. vol. 4, no. 90, pp. 1-9.

R. T. Jaske. "An Independent View of the Thermal Effects and Radioactive Releases from Nuclear Power Plant," Presented at the University of Montana Seminar on Hydrologic Problems, January 15, 1969.

R. T. Jaske. "Improved Methods for Evaluation of Thermal Discharge Practices and Alternative Actions," Presented at the 16th Annual Technical Meeting of the Institute of Environmental Sciences, Boston, Massachusetts, April 12-16, 1970.

R. T. Jaske. "The Need for Advance Planning of Thermal Discharges Before Site Acquisition," Presented at the American Power Conference, Illinois Institute of Technology, Chicago, Illinois, April 22-24, 1969.

R. T. Jaske. "Methods for Evaluating Effects of Transient Conditions in Heavily Loaded and Extensively Regulated Streams," Presented at the 1969 ASME/AICHE Stream Pollution Abatement Conference at Rutgers University, June 10-12, 1969. (in press)

R. T. Jaske. "The Need for Advance Planning of Thermal Discharges Before Site Acquisition," Proceedings of American Power Conference, Nuclear News, September 1969. Also Selected Materials on Environmental Effects of Producing Electric Power, Joint Committee on Atomic Energy, Congress of the United States, August 1969.

R. T. Jaske. "The Use of Advanced Methods for Studies of Environmental Impact of Industrial Operations," Presented at the International Water Conference of the Engineers' Society of Western Pennsylvania, Pittsburgh, Pennsylvania, November 1969.

R. T. Jaske. "Improved Methods for Planning of Thermal Discharges Before Site Acquisition," Presented at the Winter Meeting of the American Nuclear Society, San Francisco, California, November 30-December 4, 1969.

R. T. Jaske. "Comments Pertinent to the Use and Abuse of Energy in the American Economy," Presented at the Annual Meeting of the American Association for the Advancement of Science, Boston, Massachusetts, December 26-31, 1969.

R. T. Jaske, M. H. Karr and C. J. Touhill. "Multiple Purpose Use of Thermal Condenser Discharges from Large Nuclear Systems to Supplement Inter-Regional Water Supply," Presented at the 67th National Meeting of the AIChE, Atlanta, Georgia, February 17, 1970.

R. T. Jaske, J. F. Fletcher and K. R. Wise. "A National Estimate of Public and Industrial Heat Rejection Requirements by Decades Through the Year 2000," Presented at the 67th National Meeting of the AIChE, Atlanta, Georgia, February 17, 1970. Chemical Engineering Progress, March, 1970.

N. C. Matalas and W. J. Conover. Deviation of the Velocity Profile from a Statistical Model of Turbulence, Water Resources Research, Washington D.C., Second Quarter 1965.

C. A. Oster, J. C. Sonnichsen and R. T. Jaske. "Numerical Solution to the Convective-Diffusion Equation," ASCE J. Sanitary Engineering Division, (in press).

G. E. Raines and R. T. Jaske. "The Hierarchical Systems Approach as Related to Simulation in the Water Resources Area, Presented at the Great Lakes Environmental Conference, Buffalo, New York, March 30-April 2, 1970.

J. M. Raphael. The Effect of Wanapum and Priest Rapids Dams on the Temperature of the Columbia River. Public Utility District No. 2 of Grant County, Washington, September, 1961.

J. C. Sonnichsen and C. A. Oster. "Examination of the Thermocline," Journal of the Sanitary Engineering Division, Proceedings of the American Society of Civil Engineers, April 1970.

Compilation of Records of Surface Waters of the United States Through September 1950, Part 12, Pacific Slope Basins. Paper No. 1316, USGS Water Supply, Washington, D.C.

US Geological Survey Professional Paper. "Water Loss Investigations: Lake Hefner Report," Proceedings of the Symposium on Stream Flow Regulation for Quality Control Department of Health, Education and Welfare, Washington, D.C., June 1965.

Study Program to Determine the Potential Impact of Thermal Power Plants on Pacific Northwest Streams, Research Report to Bureau of Commercial Fisheries, Seattle, Washington. Battelle-Northwest, Richland, Washington, October, 1966.

Final Report on Nuclear Power Plant Siting in the Pacific Northwest, Battelle-Northwest for the Bonneville Power Administration, July 1, 1967.

New Washington State Water Quality Standards. Water Pollution Control Commission, Olympia, Washington, December 18, 1967.

Research Related to the Development of a Power Reactor Site on the Lower Columbia River, Research Report to Portland General Electric Company. Battelle-Northwest, Richland, Washington, June 15, 1968.

"Research Needs in the Civil Engineering Aspects of Power," Proceedings ASCE Specialty Conference, Washington State University, Pullman, Washington, September 11-13, 1968.

Research Related to the Prediction of Temperature at a Power Reactor Site on the Lower Columbia River, Research Report to Portland General Electric Company. Battelle-Northwest, Richland, Washington, March 1, 1969.

A Three Dimensional Study of Parameters Related to the Current Distribution in Lake Roosevelt, Research Report to Office of Water Resources Research United States Department of the Interior, Washington, D.C. Battelle-Northwest, Richland, Washington, April 23, 1969.

Temperature Prediction and Current Measurements Related to the Development of a Power Reactor Site on the Lower Columbia River in the Vicinity of Kalama, Washington, Research Report to Clark and Cowlitz County Public Utility Districts. Battelle-Northwest, Richland, Washington, June 3, 1969.

Prediction of Columbia River Temperatures Downstream from Grand Coulee for Wide Extremes of Flow and Weather Conditions, Contract report to Fish Passage Research, Bureau of Commercial Fisheries, U.S. Fish and Wildlife Service, U.S. Department of Interior, Washington, D.C.*

*Copy may be made available by G. B. Collins, Program Director.

APPENDIX A
RELATED STUDIES

APPENDIX A

RELATED STUDIES

Tables A-1 and A-2 show weather factors and dewpoint at Hanford. Flow of the Columbia River from Trinidad, just below Rock Island Dam, to Priest Rapids for 1954 through 1969 is shown in Table A-3.

Figures A-1 through A-8 depict the least-squares-fit curves of the Columbia River flow and the Hanford solar radiation, dewpoint and air temperature for 1964 and 1965.

TABLE A-1. Weather Factors at Hanford

Year	Temperature			Solar Radiation						
	Function, °F	Rank r			Function (Langley)	Rank r				r ₁ + r ₂
		T _{max}	Day T _{max}	Low High		S.R. _{max}	S.R. _{max}	Day S.R. _{max}	Low High	
1955	51.68 + 23.07 sin(0.0172d + 4.39)	74.75	201	3	360.5 + 275.9 sin(0.0172d + 4.79)	636.4	178	3	6	
1956	53.74 + 24.06 sin(0.0172d + 4.43)	77.80	199	10	354.7 + 290.4 sin(0.0168d + 4.90)	645.1	176	4	14	
1957	53.23 + 23.80 sin(0.0172d + 4.43)	77.03	199	7	388.5 + 288.3 sin(0.0177d + 4.71)	676.8	177	13	20	
1958	57.29 + 23.03 sin(0.0172d + 4.45)	80.32	197	13	370.7 + 299.3 sin(0.0168d + 4.86)	670.0	178	10	23	
1959	53.46 + 21.32 sin(0.0172d + 4.48)	74.78	196	4	376.7 + 281.6 sin(0.0172d + 4.89)	658.3	173	9	13	
1960	53.77 + 23.89 sin(0.0172d + 4.40)	77.66	201	9	381.7 + 292.8 sin(0.0171d + 4.85)	674.5	175	12	21	
1961	55.98 + 22.52 sin(0.0172d + 4.51)	78.50	194	12	381.1 + 293.4 sin(0.0174d + 4.71)	674.0	180	11	23	
1962	54.43 + 20.26 sin(0.0172d + 4.35)	74.69	203	2	361.9 + 293.3 sin(0.0168d + 4.92)	655.2	169	8	10	
1963	54.60 + 22.60 sin(0.0172d + 4.36)	77.21	203	8	370.6 + 278.8 sin(0.0179d + 4.63)	649.4	180	6	14	
1964	52.87 + 20.63 sin(0.0172d + 4.40)	73.50	200	1	365.1 + 283.8 sin(0.0168d + 4.91)	648.9	175	5	6	
1965	54.68 + 21.12 sin(0.0172d + 4.40)	75.81	200	6	367.1 + 284.2 sin(0.0167d + 5.01)	651.3	170	7	13	
1966	55.83 + 18.92 sin(0.0172d + 4.38)	74.86	199	5	341.7 + 288.0 sin(0.0161d + 5.09)	629.7	171	2	7	
1967	57.21 + 20.79 sin(0.0172d + 4.29)	78.00	206	11	366.6 + 259.8 sin(0.0178d + 4.66)	626.4	179	1	12	
Mean		76.53				Mean	654.0			
σ		1.80				σ	12.4			

$$\text{Correlation Coefficient} = \frac{\sum xy}{[(\sum x^2)(\sum y^2)]^{1/2}} = \underline{\underline{0.410}}$$

TABLE A-2. Dewpoint at Hanford Modeled to General Function:
 $T = \bar{T} + B \sin (Cd + D)$

Calendar Year	Function Model	Computed Value, °F	
		T Max	T Min
1955	$T = 36.6 + 10.7 \sin (0.0199d+3.56)$	43.3	21.9
1956	$T = 33.3 + 11.0 \sin (0.0169d+4.36)$	44.3	22.3
1957	Not Available		
1958	$T = 38.9 + 8.5 \sin (0.0205d+3.88)$	47.4	30.4
1959	$T = 32.2 + 8.0 \sin (0.0170d+4.1)$	40.2	24.2
1960	$T = 29.4 + 12.5 \sin (0.0126d+5.2)$	41.9	16.9
1961	$T = 37.4 + 9.1 \sin (0.0206d+4.0)$	46.5	28.3
1962	$T = 32.4 + 11.1 \sin (0.0126d+4.94)$	43.5	21.3
1963	$T = 23.5 + 21.3 \sin (0.0096d+5.89)$	44.8	2.2
1964	$T = 32.9 + 10.3 \sin (0.0198d+3.49)$	43.2	22.6
1965	$T = 33.8 + 9.1 \sin (0.0181d+3.7)$	42.9	24.7
1966	$T = 33.9 + 7.9 \sin (0.0178d+3.7)$	41.8	26.0
1967	$T = 34.8 + 9.0 \sin (0.0189d+3.9)$	43.8	25.8

TABLE A-3. Columbia River Flow: Trinidad-Priest Rapids
 $\text{Flow} = A + B_e^{-[(d-C)/E]^2}$

Year	Function, kcfs	Volume in Thousands Acre-Feet
1954	$69.2 + 351.8_e^{-[(d-177.1)/46.8]^2}$	107,900
1955	$75.5 + 341.0_e^{-[(d-185.3)/31.1]^2}$	92,000
1956	$71.2 + 373.8_e^{-[(d-159.7)/45.2]^2}$	11,070
1957	$69.3 + 331.0_e^{-[(d-154.2)/30.0]^2}$	85,140
1958	$72.9 + 288.2_e^{-[(d-159.6)/29.9]^2}$	82,670
1959	$98.5 + 295.4_e^{-[(d-172.3)/40.4]^2}$	113,200
1960	$68.9 + 220.9_e^{-[(d-170.7)/52.0]^2}$	90,970
1961	$76.5 + 407.1_e^{-[(d-163.8)/27.4]^2}$	94,870
1962	$69.5 + 199.8_e^{-[(d-167.3)/46.2]^2}$	81,890
1963	$73.3 + 207.8_e^{-[(d-173.1)/35.3]^2}$	78,782
1964	$69.5 + 349.2_e^{-[(d-176.7)/35.1]^2}$	92,990
1965	$76.7 + 236.4_e^{-[(d-165.5)/46.1]^2}$	95,130
1966	$69.3 + 217.3_e^{-[(d-172.0)/43.2]^2}$	83,310
1967	$81.5 + 389.9_e^{-[(d-173.9)/28.7]^2}$	97,950
1968	$87.0 + 218.6_e^{-[(d-177.8)/30.8]^2}$	86,530
1969	$90.8 + 169.0_e^{-[(d-151.9)/54.1]^2}$	97,520

APPENDIX B

LEAST-SQUARES FITTING PROGRAM LEARN

D. A. Kottwitz

APPENDIX B

LEAST-SQUARES FITTING PROGRAM LEARN

D. A. Kottwitz

The nonlinear least-squares fitting program LEARN is a direct descendant of the computer program MISFIT, which was used in previously reported river studies.^(B1) The principles on which LEARN is based are given in Reference B2, and instructions for practical use are given in Reference B3. In this appendix we shall concentrate on those features of particular interest in the present work.

The calculations reported here were performed over a period of several months by means of three closely related FORTRAN V (UNIVAC 1108) versions, designated LEARN-I-A,^(B2) LEARN-I-B, and LEARN-I-C. These evolving versions differ from the original in two major respects. First, the iterative portion of the program, in which the least-squares minimum is sought, has been extensively modified to increase the reliability and speed of convergence. This improvement in performance is due to the use of improved saddle-detection, step-reversal, step-reduction, and gradient techniques. The second major difference is an increase in the flexibility of control of the CALCOMP plotter output. The other important features of the program, including the basic structure and the statistical analyses, are unchanged.

Two variants of the temperature-fitting program are in use. In the first variant, all four parameters in the fitting function are adjustable; in the second, the frequency parameter is held fixed at a value specified by the user (normally about $2\pi/365.25 = 0.0172$ radian/day). Of course the four-parameter fit is better, but the frequency so obtained may not be "reasonable."

In both variants of the temperature fitting program, the average temperature is explicitly calculated. For cross-checking this is done in three ways: (1) analytically from the fitted parameters, (2) approximately by summing the input data values, and (3) approximately by summing the corresponding discrete fitted values. The values obtained in this way usually agree to four or five significant figures.

REFERENCES

- B1. R. T. Jaske and J. B. Goebel. "Effects of Dam Construction on Temperatures of Columbia River," J. Am. Water Works Assoc., vol. 59, pp. 935-942. 1967.
- B2. B. H. Duane. Maximum Likelihood Nonlinear Correlated Fields (BNW Program LIKELY), BNWL-390. Battelle-Northwest, Richland, Washington, September 1967.
- B3. G. D. Seybold. User's Aid: Programs LEARN and LIKELY, BNWL-1057. Battelle-Northwest, Richland, Washington, May 1969.

APPENDIX C

SUMMARY OF EFFLUENT MIXING STUDIES

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SUMMARY OF EFFLUENT MIXING STUDIES

Commencing with the initiation of operations at Hanford, the dispersion of plant effluents into the Columbia River in relation to public safety has been the subject of intensive study. In the early days, the use of boat traverses or floats constituted the state-of-the-art in the development of early models which described effluent mixing. Early investigators such as Glover^(C1) and HONSTEAD (unpublished) produced satisfactory expressions for the one-dimensional description of radionuclide dispersion. This was relatively easy because the fine structure of mixing was unaffected by the effluent temperature and the means for measurement of radiation gave many orders of magnitude of concentration as compared with a relatively narrow span for thermal modifications.

In 1964 Corley initiated an intensive program to describe the thermal regimen of the river close-in to the reactor discharges. The results of this work are summarized in Figures C-1 and C-2. Hundreds of hours of boat time and a great deal of planning were required to coordinate the research operations with the plant operations and the regulated flow changes of the Columbia River. The results had to remain classified until the spring of 1969 when the Office of Classification began a series of administrative actions which have permitted the disclosure of much previously classified documentation.

Beginning in 1966 and continuing to the present, Battelle-Northwest has developed remote imagery technology which has obsoleted the old methods of boat surveys except for the essential purposes of calibration and vertical concentration sounding. The mixing action at the point of discharge to a

FIGURE C-1. Incremental Temperature Above Base River Temperature (Summary of Cross-Section Traverses, River Mile 378-384, All Reactors Operating, 41,000 cfs)

distance of 300 yards downstream has always been too difficult to measure because of the combination of river and effluent turbulence and the size of the system under investigation. The use of remote imagery now permits real time analysis of thermal releases and the compression of data collection costs and time by orders of magnitude. Figures C-3, C-4 and C-5 illustrate the type of real-time data which can be generated by a single time frame of imagery using advanced computer analysis techniques under development at Pacific Northwest Laboratory. These data also permitted advances in the development of mathematical models of dispersion in two dimensions and the first realistic attempts to model the mixing zone immediately at the point of discharge. The findings that cold effluent releases always disperse less rapidly than warmed releases remains to be corroborated by additional investigators, but this finding and that of the estimate of lateral dispersion discussed below would not have been possible without the use of advanced computer systems for the visual representation of remote imagery.

These determinations of temperature gradients are limited to two dimensions using present state-of-the-art technology and must still be supplemented by boat or buoy surveys to determine vertical current and concentration gradient profiles. However, using these two-dimensional methods and supplementing them with surface probing, information of the type shown in Figures C-3, C-4 and C-5 can be developed. These figures are engineering drawings of the concentration isopleths in the mixing area below the discharge of the 100-K production area at Hanford. The mathematical treatment of a series of data plots of this type on a real-time basis permits vastly improved insight into the physical mechanics of the mixing process. The significance of improved understanding of the physical mixing regimen cannot be overstated in the light of new standards limiting temperature differentials of mixing zones.

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FIGURE C-3. Columbia River Surface Temperature Patterns by Imagery
(41,000 cfs Flow)

*Detection Limit of Aerial Infrared Imaging System $\sim 0.5^\circ C$

Neg PNL-703538-15

FIGURE C-4. Columbia River Surface Temperature Patterns by Imagery (80,000 cfs Flow)

*Detection Limit of Aerial Infrared Imaging System $\sim 0.5^\circ C$

Neg PNL-703538-16

FIGURE C-5. Columbia River Surface Temperature Patterns by Imagery
(110,000 cfs Flow)

STUDY OF THE MIXING ZONE

Below a few hundred meters from the point of release, the discharges in a relatively turbulent stream have been shown to follow the classical work of Taylor; however, the use of a single value of the dispersion coefficient for entire reaches of the sample stream can produce erroneous results. A solution of the Taylor expression:

$$\frac{\partial \bar{c}}{\partial t} = - \bar{u} \frac{\partial \bar{c}}{\partial x} + D_x \frac{\partial^2 \bar{c}}{\partial x^2}$$

where $\bar{c}$ = the cross-sectional mean concentration

$\bar{u}$ = the mean flow velocity

t = time

x = distance in the direction of mean flow

D_x = longitudinal dispersion coefficient

K_x = a scaling factor proportional to C_0 , the original concentration can be written:

$$\bar{c}(x,t) = \frac{K_x}{t^{1/2}} \exp - \frac{(x - \bar{u}t)^2}{4D_x t}$$

Then, estimates of the variables K_x , D_x , and $\bar{u}$ were obtained from a series of reaches for which real-time concentration data have been accumulated using a nonlinear least-squares fitting method developed at Pacific Northwest Laboratory^(C2) and modified by Kottwitz (unpublished). The special program called LEARN/DISPERS employs the general relationship:

$$c = \frac{A_1}{(t^d)^{1/2}} \exp - \left[\frac{1}{4t} \left(\frac{(x - A_1 t)^2}{|A_2|} + \frac{(y - A_3 t)^2}{|A_4|} + \frac{(z - A_5 t)^2}{|A_6|} \right) \right]$$

where x, y, z = space coordinates

A_1, A_3, A_5 = convective speed parameters

A_2, A_4, A_6 = dispersion coefficients
 A_7 = amplitude (concentration) parameter
 d = number of space dimensions, e.g.,
 if $d = 1$, y and z terms are omitted
 if $d = 2$, z term is omitted
 if $d = 3$, all terms are included.

The resulting program is capable of fitting separately a set of data for any number of discrete locations or fitting sequentially several sets of consecutive data sets. In addition to the numerical determination of the parameters, the program plots the results or graphical interpretation. An example of the output of such an analysis is shown in Figure C-6. The numerical values obtained indicated that the combination of remote sensing for concentration input and the use of improved evaluation of D_x with relation to stream reach gives improved insight into predictive computations.

At present no well developed theory exists for predicting mixing in the lateral direction. Data summaries have been generally in the form which estimates the value of D_y as follows:

$$D_y = 0.23 U_x h$$

where h = the depth of flow

U_x = mean velocity of a vertical transect.

In 1967, using boat data measured in the Hanford effluent plumes, Jaske^(C3) developed an expression which correlated the spreading velocity as a function of downstream travel time t

$$\frac{dy}{dt} = a \exp - (b x)$$

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FIGURE C-6. Computer Generated Output of Best Fit to One-Dimensional Dispersion Using LEARN/DISPERS

where y, x = spacial parameters in consistent time frame

t = time

a, b = experimental constants.

Using this expression, the external edge of the spreading mixing zone could be accurately predicted to the point where only one-dimensional effects became paramount.

Currently, using the dye imagery discussed above, a new approach has yielded additional insight into numerical values of the lateral dispersion coefficient D_y . If the assumption that the lateral distribution is Gaussian can be made, (generally true for reaches where momentum effects from the discharge jet or initial density differences are zero), the width of the plume at any distance (x) from the point of release can be described as:

$$\sigma_{(x)} = \sigma_D + \sigma_M$$

where $\sigma_{(x)}$ = space variance at some distance from the release point

σ_D = space variance due to the initial convective mixing

σ_M = dispersion represented by the diffusion process

then

$$\sigma_M = (2D_y t)^{1/2}$$

where D_y = lateral diffusion coefficient (ft^2/sec).

Using the theory of convolution and making the further assumption that 95% or 4σ of the tracer is the extent of the conservation of tracer to be included, it is possible to state:

$$D_y = \frac{W_2^2 - W_1^2}{32\Delta t}$$

where $W_{(x)}$ = plume width at a distance x from x_o
 W_o = initial width at tracer release point
 x_o = origin of the diffusion process

then

$$D_y = \frac{W_2^2 - W_1^2}{32 \left(\frac{\Delta x}{\bar{u}} \right)} \text{ or } \frac{W_{(x)}^2 - W_o^2}{32 \left(\frac{x - x_o}{\bar{u}} \right)}$$

under the assumption that the conveyance velocity is uniform. Evaluations of the size of the spreading plume were made for both hot and cold conditions, all other effluent flow conditions being constant. The results are summarized in Table C-1.

TABLE C-1. Summary of Lateral Diffusion Coefficients

<u>River Flow</u>		<u>Effluent Condition</u>	<u>D_y m²/sec</u>	<u>ft²/sec</u>
<u>(cumecl)</u>	<u>ft³/sec</u>			
1,420	50,108	Cold	0.177	1.9042
2,850	100,560	Cold	0.184	1.9799
2,270	80,100	Hot	0.492	5.2931
3,130	110,450	Hot	0.680	7.3157
4,120	145,380	Hot	0.271	2.9155

The cases involving cold effluent or essentially neutral bouyant conditions reveal a lateral diffusion coefficient approximately equal to 0.18 m²/sec. These results agree well with the work performed independently by Glover.^(C1) Under heated conditions, the lateral diffusion coefficient was generally higher. The assumption that dye particles are of zero size can be made, and for very low dye concentrations, (less than 10 ppb) the mixture of fluid and dye should have essentially the same density and kinematic viscosity as the normal, heated effluent. Therefore, the use of dye does not change the hydrodynamic character of the heated or cold plume

to any measurable extent. This being the case, the results suggest that the thermal eddy diffusivity of the heated plume is greater than the natural eddy diffusivity of the river for the current ranges examined. This observation also suggests that as the momentum of the receiving water increases, the difference between the two coefficients will decrease asymptotically to a value identical with the eddy diffusivity of the river itself. These tentative conclusions appear to indicate that mixing from heated plums is greater in the cases where initial momentum differences between the receiving stream and the point of discharge are the greatest. This relationship has been qualitatively suggested in a number of publications and reports at Pacific Northwest Laboratory and is the basis for the recommendation that high velocity single point discharges are superior to canal discharges as a means of minimizing the temperatures of the mixing zone. This recommendation runs counter to standard design practice in many countries including the United States.

For a full treatment of this concept, please refer to "Dye Studies Through Use of Advancements in an Aerial Optical Mechanical Imaging System," by J. R. Eliason and H. P. Foote, BNWL-SA-3204, April 1970, and "Dispersion Characteristics: Columbia River Between River Mile 383 and River Mile 355," by J. C. Sonnichsen, R. T. Jaske and D. A. Kottwitz, BNWL-1477 (in publication).

REFERENCES

- C1. R. E. Glover. Dispersion of Dissolved or Suspended Materials in Flowing Streams. U.S.G.S. Professional Paper 433-B, Washington D.C., 1962.
- C2. B. Duane. Maximum Likelihood Nonlinear Correlated Fields, PROGRAM LIKELY, BNWL-390. Battelle-Northwest, Richland, Washington, September 1967.
- C3. R. T. Jaske. Unpublished Data. Battelle-Northwest, Richland, Washington, June 1967. (Preliminary Report: "An Analysis of the Physical Factors Governing the Size and Temperature Gradients of the Hanford Effluent Plumes.")

APPENDIX D
SECTION I

EFFECTS OF HANFORD OPERATIONS
ON COLUMBIA RIVER TEMPERATURES*

J. P. Corley

*Declassified Exerpts from HW-80888,
dated December 3, 1964

Neg 26119-1

Traverse Locations - Temperature Studies

APPENDIX D

SECTION I

EFFECTS OF HANFORD OPERATIONS
ON COLUMBIA RIVER TEMPERATURES

J. P. Corley

INTRODUCTION

The effluent cooling water from the Hanford reactors differs markedly from its Columbia River source in its high temperature and chemical characteristics, as well as its radioactivity content. The effluents disperse slowly after discharge to the river; lateral variations being still measurable at Richland, some 30 miles downstream from the last reactor at 100-F Area. Direct measurement of these changes is difficult because of the uneven lateral distribution of the effluents, the variations with time due to rapidly varying water releases from Priest Rapids Dam, and external influences of weather and tributary and ground water inflows.

Columbia River temperatures are receiving increased attention by regulatory agencies (as well as potentially affected industries) because of the potential losses from increased temperatures of aquatic life, especially salmon. Increasing recognition of the thermal effects of dams in the rivers of the Pacific Northwest does not change the position of Hanford as the largest single man-made source of heat on the main stem of the Columbia. Accurate assessment of the actual impact of Hanford on river temperatures is, therefore, highly desirable. Related areas of local interest include local effluent distributions (for assessment of maximum concentration effects) and the accuracy with which Hanford production rates can be estimated from river temperatures (a plant security problem). In

addition, detailed knowledge of changes in river chemical characteristics caused by reactor effluents is desired to evaluate the status of the river with respect to quality criteria for human consumption and for aquatic life.

A research and development project for study of the effects of reactor effluent on Columbia River water quality is being sponsored by the AEC Division of Production. Work was started in October 1962. The first effort was aimed at furnishing an immediate answer to a security question: how closely can Hanford production be estimated by measurement of river temperatures? An interim progress report^(D1) gave the results of the preliminary investigation. During the calendar year 1963, the study was expanded to meet broader program objectives. This document is a progress report for the year, covering the temperature and effluent distribution phases of the program. Progress on the chemical characteristics phase of the program is documented separately.^(D2) The frontispiece shows the section of the river under study.

SUMMARY

The first and major objective of the study program is determination of the net reactor heat effect on overall river temperatures. Progress during the year consisted primarily of instrument procurement and data collection. Investigation was started to determine the accuracy of existing upstream and downstream temperatures at the same locations, the heat losses from the effluent between the reactors and the river, the effluent travel times, and the adequacy of meteorological data from the Meteorology Tower for use along the river. Specific items of interest found during the study included the probable inadequacy of any shoreline location as a direct

monitoring point for river temperatures, and the probable existence of one or two points in every river cross section which would consistently give the mean cross-section temperature with adequate accuracy (± 0.2 °C).

Figures D.I 1 to D.I 3 show the envelopes of cross-section temperatures measured during 1963 at three locations. Note that the temperatures across each section were plotted in all cases as departures from the mean for a particular traverse. The mean temperatures varied from 5 to 20 °C.

The F Area sewer temperature was recorded continuously during September and October, 1963. This temperature cycled between 2 and 10 °C higher than the raw water temperature, and represents a total heat input to the river of less than 0.01 °C at all times. The data is summarized in Table D.I-11.

Downstream River Flow Rate Estimation

No progress was made on this part of the study for lack of a satisfactory base. Recorded gage elevations when translated to river flow rates showed consistent errors when compared with water release rates from Priest Rapids Dam as reported by Grant County P.U.D. The source of this error had not yet been found by the end of the calendar year. (Prior to issuing this report, the major source of error was found in a piece of mismatched equipment at the gage station. Corrections have been made and satisfactory base flow data established for proceeding with this part of the study.)

Flow Time Measurement

A total of five instantaneous dye releases were made from various reactors from which time of travel measurements could be taken. The travel time data is summarized in Table D.I-1. The times of dye arrival were fairly close to those estimated from Reference D3.

FIGURE D.I-1. Temperature Cross Sections at Hanford

FIGURE D.I-2. Temperature Cross Sections Above 300 Area

FIGURE D.I-3. Temperature Cross Sections at Pasco

TABLE D.I-1. Flow Time Tests with Dye Releases

Date	Q, cfs	Location	Time	Downstream Location	Estimated* Time of Arrival	Observed		Time of Max. Conc.		Time of Last Dye	
						Channel	Shore	Channel	Shore	Channel	Shore
8-22-63	80,000- 115,000	Vernita Ferry	0600	100-K	0800	--	--	0815	0845	0915	>0945
				100-D	0900	--	1000	0945	1015	--	>1045
				100-H	1000	--	1115	1030	1200	--	>1300
				100-F	1100	1115	1130	1145	1215	--	1400
8-30-63	55,000- 80,000	Hanford	0740	Hanford	1400	1315	1430	1330	1515	1530	>1600
				Ringold	0900	1030	>1100	1045	--	--	--
				Above 300 Area	1300	1400	>1600	1445	--	--	--
				Richland Ferry	1500	1600	>1800	1630	--	--	--
10-22-63	45,000- 55,000	100-H	00810	100-F	0900	0930	1000	0945	1015	>1015	>1130
				Hanford	1230	1215	>1230	--	--	--	--
				Above 300 Area	1800	>1830	--	--	--	--	--
				100-H	1000	1000	1015	--	--	--	--
11-5-63	50,000- 70,000	100-D	00820	100-F	1130	1115	1130	1145	>1200	>1200	--
				Hanford	1430	1400	>1445	1415	--	>1445	--
				ACRMS-300 Area	2100	--	0030	--	0200	--	0330
							(11/6)		(11/6)		(11/6)
11-19-63	40,000- 60,000	100-K	0745	100-N	0830	0830	0900	0345	--	--	--
				100-D	0915	0915	>1100	0930	--	--	--
				100-H	1045	1130	1200	1145	--	--	--
				100-F	1215	1300	1315	1330	--	>1445	--
				Hanford	1515	1545	>1645	1600	--	>1645	--
				ACRMS-300 Area	2100	--	2330	--	0030	--	--
									(11/20)		

* HW-58312 REV

TABLE D.I-2. Cross-Section Mean Versus Recorded Temperatures

<u>Location</u>	<u>Date</u>	<u>Time</u>	<u>Approximate River Flow, cfs</u>	<u>Recorder Temp, °C</u>	<u>Mean River Temp, °C</u>	<u>ΔT (Recorder - mean)</u>
300 Area	11-29-62	1330	80,000	10.2	10.2	0
	2-12-63	0800		5.4	4.8	+0.6
	4-2-63	1400	75,000	7.3	6.5	+0.8
	4-18-63	1200	95,000	8.0	7.7	+0.3
	5-23-63	1130	80,000	14.5	13.9	+0.6
	6-24-63	1100	285,000	16.2	15.2	+1.0
	6-27-63	1100	280,000	16.8	15.8	+1.0
	7-18-63	1330	230,000	18.0	17.3	+0.7
	8-7-63	1300	105,000	20.0	19.6	+0.4
	8-30-63	1800	70,000	20.9	20.9	0
	10-10-63	1100	70,000	18.1	17.7	+0.4
	10-16-63	1630	60,000	18.8	18.8	0
	10-29-63	1330	75,000	15.0	14.9	+0.1
	10-31-63	1330	65,000	14.5	14.4	+0.1
	12-11-63	1400	75,000	8.3	8.2	+0.1
	12-16-63	0930	50,000	9.5	9.5	0
Pasco	2-20-63	1630	85,000	5.6	5.3	+0.3
	4-3-63	1400	85,000	6.6	6.7	-0.1
	5-8-63	1400	125,000	10.0	9.7	+0.3
	5-16-63	1330	102,000	12.2	12.3	-0.1
	6-13-63	1000	280,000	14.7	15.0	-0.3
	6-18-63	1200	305,000	15.6	15.9	-0.3
	7-11-63	1100	225,000	16.4	16.1	+0.3
	10-10-63	1400	70,000	18.0	18.4	-0.4
	12-9-63	1400	80,000	8.6	8.9	-0.3
	12-13-63	1330	65,000	8.0	8.4	-0.4

TABLE D.I-3. River Temperature Traverses - Priest Rapids Gage
(River Mile: 395.4)

Date: 1-3-63 Time: 1120			Date: 4-3-63 Time: 1000			Date: 5-21-63 Time: 1200			Date: 7-26-63 Time: 1040		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
2	4	7.4	2	3	5.0	5	1	12.4	3	4	17.0
50	28	7.5	40	27	5.0	40	27	11.8	45	30	17.1
100	31	7.5	90	32	4.9	90	30	11.7	95	38	17.0
150	35	7.5	140	32	5.0	140	30	11.7	145	38	16.9
200	32	7.5	190	29	4.9	190	28	11.6	195	34	17.0
250	29	7.4	240	27	5.0	240	25	11.6	245	33	17.0
300	27	7.4	290	24	5.1	290	25	11.5	295	32	16.9
350	20	7.4	340	21	5.1	340	22	11.5	345	27	17.0
380	3	7.5	390	3	5.0	390	13	11.7	395	17	17.0
						405	1	13.7	435	5	17.2
$A_t = 30,100 \text{ ft}^2$			$A_t = 28,700 \text{ ft}^2$			$A_t = 28,900 \text{ ft}^2$			$A_t = 37,400 \text{ ft}^2$		
$T_m = 7.46 \text{ } ^\circ\text{C}$			$T_m = 4.99 \text{ } ^\circ\text{C}$			$T_m = 11.65 \text{ } ^\circ\text{C}$			$T_m = 16.98 \text{ } ^\circ\text{C}$		
Gage = 7.3 °C			Gage = 5.0 °C			Gage = 11.65 °C			Gage = 17.0 °C		

NOTE: On Tables D.I-3 through D.I-10 the following nomenclature is used:

A_t = cross section area, ft^2

T_m = mean stream temperature, °C

T_{PR} = river temperature at Priest Rapids, °C

TABLE D.I-4. River Temperature Traverses - Reactor Areas

Location: Below 1904-K			Location: Below 181-D			Location: Below 181-D		
River Mile: 381.5			River Mile: 376.3			River Mile: 376.3		
Date: 8-22-63			Date: 8-22-63			Date: 8-22-63		
Time 0830			Time: 0940			Time: 1000		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	3	18.8	5	3	19.3	20	5	19.4
100	8	19.0	15	4	19.3	70	8	19.4
130	11	19.2	25	6	19.3	100	9	19.35
175	19	18.9	55	8	19.3	115	10	19.4
230	31	18.9	95	9	19.3	135	10	19.4
270	25	19.5	115	10	19.35	155	10	19.4
300	17	20.1	140	10	19.4	185	11	19.45
355	12	18.8	185	11	19.4	200	11	19.5
375	8	18.5	200	11	19.5	225	12	19.5
430	6	18.4	220	12	19.5	245	12	19.5
450	4	18.4	290	11	19.5	275	12	19.5
			310	11	19.5	295	11	19.5
			335	10	19.5	320	10	19.45
			365	11	19.45	345	11	19.4
			395	12	19.4	365	11	19.3
			415	13	19.3	390	12	19.25
			445	13	19.2	415	13	19.15
			470	12	19.1	440	13	19.0
			495	11	19.0	475	12	18.9
			525	8	18.9	495	11	18.8
			550	6	18.9	525	8	18.7
			570	4	18.8	570	4	18.7
$A_t = 23,800 \text{ ft}^2$			$A_t = 17,500 \text{ ft}^2$			$A_t = 17,300 \text{ ft}^2$		
$T_m = 19.04 \text{ }^\circ\text{C}$			$T_m = 19.32 \text{ }^\circ\text{C}$			$T_m = 19.25 \text{ }^\circ\text{C}$		
$DA/avg/T_{PR} = 18.2 \text{ }^\circ\text{C}$			$T_{PR} = 18.2 \text{ }^\circ\text{C}$			$T_{PR} = 18.2 \text{ }^\circ\text{C}$		

TABLE D.I-4. (contd) River Temperature Traverses -
Reactor Areas

Location:	Above 181-F		Location:	Above 181-F		Location:	Above 181-F	
River Mile:	369.3		River Mile:	369.3		River Mile:	369.3	
Date:	8-22-63		Date:	8-22-63		Date:	10-22-63	
Time:	1120		Time:	1130		Time:	0915	
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
25	13	20.25	45	23	20.2	5	5	17.3
55	28	20.2	80	41	20.15	25	11	17.45
70	36	20.2	100	40	20.15	50	26	17.5
90	41	20.15	120	40	20.1	85	35	17.5
110	40	20.1	150	37	20.0	135	33	17.5
135	39	20.1	165	33	19.95	185	23	17.25
175	31	20.0	200	28	19.95	210	19	17.2
190	29	19.95	225	25	19.9	235	17	17.05
215	26	19.9	250	22	19.9	285	12	16.95
235	24	19.85	275	19	19.9	310	9	16.85
270	20	19.8	295	18	19.85	335	8	16.9
295	18	19.8	320	16	19.8	360	7	17.0
320	16	19.8	350	15	19.7	385	6	17.0
350	15	19.8	370	13	19.7	410	4	16.9
375	13	19.8	400	12	19.8	435	3	16.85
400	12	19.75	440	11	19.8			
425	11	19.75	500	6	19.85			
455	11	19.8						
480	10	19.8						
$A_t = 32,400 \text{ ft}^2$			$A_t = 32,200 \text{ ft}^2$			$A_t = 22,900 \text{ ft}^2$		
$T_m = 19.98 \text{ }^\circ\text{C}$			$T_m = 19.98 \text{ }^\circ\text{C}$			$T_m = 17.30 \text{ }^\circ\text{C}$		
$DA/avg/T_{PR} = 18.2 \text{ }^\circ\text{C}$			$DA/avg/T_{PR} = 18.2 \text{ }^\circ\text{C}$			$DA/avg/T_{PR} = 15.6 \text{ }^\circ\text{C}$		

TABLE D.I-4. (contd) River Temperature Traverses -
Reactor Areas

Location:	Above 181-F		Location:	Above 181-F		Location:	Above 181-F	
River Mile:	369.3		River Mile:	369.3		River Mile:	369.3	
Date:	10-22-63		Date:	10-22-63		Date:	10-29-63	
Time:	0950		Time:	1005		Time:	1045	
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	5	17.5	5	5	17.55	5	5	15.5
25	18	17.5	25	18	17.5	25	20	15.6
50	24	17.5	50	18	17.5	50	29	15.6
85	34	17.45	85	32	17.45	75	39	15.6
135	36	17.35	135	40	17.4	125	36	15.5
185	28	17.3	185	29	17.15	175	27	15.4
210	23	17.2	210	24	17.0	200	22	15.3
235	18	17.15	235	19	16.85	225	18	15.25
285	14	17.05	260	15	16.85	250	16	15.2
310	11	16.95	285	13	16.9	275	14	15.2
335	9	16.9	310	10	16.95	300	11	15.15
360	7	16.9	335	9	16.95	325	10	15.1
385	6	16.85	360	8	16.95	350	9	15.05
410	5	16.85	385	7	16.9	375	8	14.95
435	3	16.9	410	5	16.85	400	6	14.9
			435	4	16.8	425	5	14.85
			460	3	16.8	450	4	14.8
						475	4	14.8
$A_t = 24,900 \text{ ft}^2$			$A_t = 25,000 \text{ ft}^2$			$A_t = 26,000 \text{ ft}^2$		
$T_m = 17.31 \text{ } ^\circ\text{C}$			$T_m = 17.21 \text{ } ^\circ\text{C}$			$T_m = 15.38 \text{ } ^\circ\text{C}$		
$DA/avg/T_{PR} = 15.6 \text{ } ^\circ\text{C}$			$T_{PR} = 15.6 \text{ } ^\circ\text{C}$			$DA/avg/T_{PR} = 14.1 \text{ } ^\circ\text{C}$		

TABLE D.I-4. (contd) River Temperature Traverses -
Reactor Areas

Location:	Above 181-F		Location:	Above 181-F		Location:	Above 181-F	
River Mile:	369.3		River Mile:	369.3		River Mile:	369.3	
Date:	10-29-63		Date:	11-5-63		Date:	11-5-63	
Time:	1100		Time:	1045		Time:	1150	
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	4	15.7	5	5	14.4	10	11	14.65
25	20	15.65	25	19	14.3	25	21	14.65
50	26	15.65	50	27	14.25	50	34	14.65
75	36	15.55	75	28	14.2	75	37	14.65
125	37	15.45	100	38	14.15	100	38	14.65
175	28	15.35	125	36	14.1	125	36	14.6
200	23	15.3	150	32	13.95	150	31	14.55
225	18	15.25	175	27	13.9	175	27	14.45
250	16	15.2	200	21	13.75	200	21	14.35
275	14	15.05	225	18	13.7	225	17	14.2
300	11	15.0	250	15	13.65	250	15	14.25
325	10	15.0	275	12	13.65	275	12	14.25
350	9	14.95	300	10	13.6	300	10	14.2
375	6	14.85	325	17	13.55	325	8	14.15
400	6	14.85	350	14	13.45	350	7	14.15
425	6	14.85	375	10	13.45	375	5	14.1
450	4	14.8	400	7	13.45	400	4	14.05
475	3	14.8	425	5	13.5	425	4	14.05
			450	5	13.5			

$$A_t = 26,100 \text{ ft}^2$$

$$T_m = 15.35 \text{ } ^\circ\text{C}$$

$$DA/avg/T_{PR} = 14.1 \text{ } ^\circ\text{C}$$

$$A_t = 25,200 \text{ ft}^2$$

$$T_m = 13.91 \text{ } ^\circ\text{C}$$

$$DA/avg/T_{PR} = 13.0 \text{ } ^\circ\text{C}$$

$$A_t = 24,300 \text{ ft}^2$$

$$T_m = 14.49 \text{ } ^\circ\text{C}$$

$$DA/avg/T_{PR} = 13.0 \text{ } ^\circ\text{C}$$

TABLE D.I-4. (contd) River Temperature Traverses - Reactor Areas

Location:	Below 181-N		Location:	Above 181-D		Location:	Above 181-F	
River Mile:	379.6		River Mile:	378.0		River Mile:	369.3	
Date:	11-19-63		Date:	11-19-63		Date:	11-19-63	
Time:	0820		Time:	0935		Time:	1350	
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	4	12.5	20	4	12.85	10	6	13.8
50	23	12.7	40	6	13.05	50	30	13.75
85	22	13.15	65	7	13.15	75	39	13.7
110	20	13.25	115	9	13.3	100	38	13.65
135	17	13.3	140	12	13.35	125	35	13.55
160	15	13.35	165	13	13.3	150	31	13.5
185	15	13.35	190	12	13.3	175	25	13.4
210	14	13.3	215	13	13.25	200	19	13.35
235	15	13.25	240	9	13.15	225	17	13.25
260	25	13.15	265	8	13.05	250	14	13.25
285	30	12.95	290	9	12.95	275	12	13.25
310	29	12.8	315	11	12.8	300	8	13.3
335	30	12.45	340	11	12.7	325	8	13.25
360	29	12.2	365	11	12.6	350	6	13.25
385	22	11.95	390	9	12.45	375	5	13.2
410	18	11.85	415	9	12.35	400	4	13.2
435	13	11.6	440	10	12.25	425	3	13.15
495	3	11.1	465	14	12.2	450	3	13.15
			490	15	12.05			
			515	9	11.7			
			540	4	11.45			
$A_t = 28,300 \text{ ft}^2$			$A_t = 15,600 \text{ ft}^2$			$A_t = 23,600 \text{ ft}^2$		
$T_m = 12.70 \text{ }^\circ\text{C}$			$T_m = 12.76 \text{ }^\circ\text{C}$			$T_m = 13.50 \text{ }^\circ\text{C}$		
$T_{PR} = 11.8 \text{ }^\circ\text{C}$			$T_{PR} = 11.8 \text{ }^\circ\text{C}$			$T_{PR} = 11.8 \text{ }^\circ\text{C}$		

TABLE D.I-5. River Temperature Traverses - Hanford Ferry
(River Mile: 361.6)

Date: 1-3-63 Time: 1325			Date: 2-26-63 Time: 0900			Date: 4-17-63 Time: 1400		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
2	3	9.5	45	9	6.3	3	2	8.2
50	10	9.5	95	11	6.4	35	9	8.2
100	13	9.5	145	16	6.0	85	15	8.0
150	14	9.4	195	17	6.0	135	16	7.9
200	14	9.3	245	17	5.8	185	20	7.6
250	15	9.3	295	18	5.1	235	19	7.5
300	18	9.2	345	17	5.1	285	20	7.6
350	23	9.1	395	14	4.8	335	19	7.5
400	23	9.0	445	11	4.5	385	21	7.5
450	20	8.9	495	2	4.5	435	17	7.4
500	15	8.8				485	7	7.4
550	2	8.6				505	1	7.5
$A_t = 25,100 \text{ ft}^2$			$A_t = 19,600 \text{ ft}^2$			$A_t = 24,300 \text{ ft}^2$		
$T_m = 9.17 \text{ }^\circ\text{C}$			$T_m = 5.53 \text{ }^\circ\text{C}$			$T_m = 7.64 \text{ }^\circ\text{C}$		
$T_{PR} = 7.3 \text{ }^\circ\text{C}$			$T_{PR} = 3.8 \text{ }^\circ\text{C}$			$T_{PR} = 6.6 \text{ }^\circ\text{C}$		

TABLE D.I-5. (contd) River Temperature Traverses -
Hanford Ferry (River Mile: 361.6)

Date: 6-20-63 Time: 1130			Date: 8-7-63 Time: 1200			Date: 8-22-63 Time: 1235		
<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>	<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>	<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>
2	2	16.0	10	5	20.6	30	11	21.25
50	20	16.1	40	12	20.5	65	16	21.15
100	26	16.3	120	14	20.3	85	18	21.0
150	31	16.1	175	19	20.0	115	20	20.95
200	35	16.2	200	17	19.9	130	22	20.85
250	32	16.1	225	21	19.8	150	22	20.75
300	34	16.0	250	22	19.7	190	24	20.65
350	33	16.0	275	21	19.65	200	24	20.6
400	32	16.0	300	21	19.55	215	25	20.5
450	32	16.0	325	20	19.5	250	25	20.45
500	30	16.0	350	20	19.45	280	24	20.4
550	18	16.1	375	19	19.4	315	24	20.35
600	16	16.1	400	20	19.35	335	23	20.25
670	1	16.0	425	17	19.25	365	23	20.2
			450	10	19.1	400	21	20.15
			475	9	19.1	425	20	20.0
			500	4	19.1	445	19	19.95
			545	2	19.1	475	12	19.9
						490	9	19.85
$A_t = 53,100 \text{ ft}^2$			$A_t = 24,150 \text{ ft}^2$			$A_t = 29,700 \text{ ft}^2$		
$T_m = 16.07 \text{ }^\circ\text{C}$			$T_m = 19.74 \text{ }^\circ\text{C}$			$T_m = 20.48 \text{ }^\circ\text{C}$		
$T_{PR} = 6.8 \text{ }^\circ\text{C}$			$T_{PR} = 18.6 \text{ }^\circ\text{C}$			$T_{PR} = 18.2 \text{ }^\circ\text{C}$		

TABLE D.I-5. (contd) River Temperature Traverses -
Hanford Ferry (River Mile:
361.6)

Date: 8-22-63 Time: 1410			Date: 8-22-63 Time: 1445			Date: 8-22-63 Time: 1555		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
10	6	21.7	5	3	21.85	5	3	21.75
25	10	21.7	35	12	21.85	85	18	21.45
40	12	21.7	70	17	21.75	110	20	21.1
80	17	21.7	85	18	21.65	135	23	20.85
105	20	21.6	110	20	21.4	160	22	20.7
135	23	21.25	140	23	21.1	185	23	20.6
155	22	21.05	170	22	20.75	200	24	20.5
190	24	20.85	215	25	20.35	215	25	20.45
205	24	20.7	250	25	20.25	240	26	20.4
230	26	20.6	280	24	20.2	265	25	20.35
260	25	20.5	295	24	20.15	285	24	20.3
285	24	20.4	345	23	20.15	315	24	20.3
310	24	20.3	370	23	20.15	355	23	20.25
335	23	20.3	390	22	20.15	395	22	20.2
360	23	20.25	420	20	20.2	420	20	20.2
380	23	20.25	440	19	20.25	455	17	20.2
400	21	20.25	470	13	20.35	475	12	20.35
430	20	20.3				510	3	20.9
460	15	20.3						
$A_t = 29,800 \text{ ft}^2$			$A_t = 29,700 \text{ ft}^2$			$A_t = 29,300 \text{ ft}^2$		
$T_m = 20.72 \text{ } ^\circ\text{C}$			$T_m = 20.59 \text{ } ^\circ\text{C}$			$T_m = 20.56 \text{ } ^\circ\text{C}$		
$T_{PR} = 18.2 \text{ } ^\circ\text{C}$			$T_{PR} = 18.2 \text{ } ^\circ\text{C}$			$T_{PR} = 18.2 \text{ } ^\circ\text{C}$		

TABLE D.I-5. (contd) River Temperature Traverses -
Hanford (River Mile: 361.0)

Date: 9-25-63 Time: 0930			Date: 10-16-63 Time: 0920			Date: 10-16-63 Time: 1000		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	3	19.85	5	3	18.75	5	3	19.0
25	7	19.75	50	13	18.65	25	7	18.85
50	10	19.7	75	16	18.4	75	17	18.65
75	13	19.6	95	18	18.35	125	23	18.6
100	15	19.5	125	23	18.3	165	21	18.3
125	17	19.4	175	18	18.0	200	15	18.1
150	18	19.25	205	14	17.75	225	12	18.05
175	20.5	18.95	230	11	17.7	250	9	17.9
200	19.5	18.75	255	9	17.65	275	8	17.8
225	15	18.7	285	7	17.6	300	8	17.9
250	11	18.65	305	7	17.55	325	8	17.75
275	8.5	18.6	350	7	17.5	350	8	17.6
300	7	18.6	385	7	17.45	375	8	17.55
325	6.5	18.55	400	7	17.4	405	8	17.5
350	7	18.45	425	7	17.3	425	7	17.5
375	7	18.4	450	6	17.2	445	7	17.45
400	7	18.35	505	2	16.85	475	7	17.5
425	7	18.35				500	3	17.35
465	7	18.35						
515	6	18.4						
540	3	18.9						
$A_t = 17,000 \text{ ft}^2$			$A_t = 15,700 \text{ ft}^2$			$A_t = 17,100 \text{ ft}^2$		
$T_m = 18.92 \text{ }^\circ\text{C}$			$T_m = 17.94 \text{ }^\circ\text{C}$			$T_m = 18.22 \text{ }^\circ\text{C}$		
$DA/avg/T_{PR} = 17.9 \text{ }^\circ\text{C}$			$T_{PR} = 16.6 \text{ }^\circ\text{C}$			$T_{PR} = 16.6 \text{ }^\circ\text{C}$		

TABLE D.I-5. (contd) River Temperature Traverses -
Hanford (River Mile: 361.0)

Date: 10-16-63 Time: 1030			Date: 10-16-63 Time: 1120			Date: 10-16-63 Time: 1200		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	3	19.1	10	6	19.2	10	6	19.4
25	7	19.05	25	13	19.1	25	6	19.4
70	14	18.95	75	16	19.0	50	9	19.5
125	23	18.6	125	22	18.75	75	14	19.5
175	18	18.35	150	20	18.6	100	18	19.35
200	15	18.3	175	17	18.5	125	19	19.2
225	11	18.2	200	15	18.35	150	19	18.95
250	10	18.15	225	9	18.2	175	19	18.8
275	8	18.05	250	8	18.15	200	14	18.65
300	7	18.05	275	6	18.1	225	9	18.5
325	7	18.0	300	6	18.05	250	7	18.5
350	7	17.95	325	6	18.0	275	6	18.45
375	7	17.9	350	6	18.0	300	6	18.4
400	7	17.75	375	6	17.95	325	6	18.4
425	7	17.75	400	8	17.9	350	6	18.3
455	6	17.7	425	6	17.85	375	6	18.3
475	7	17.5	450	5	17.65	400	6	18.25
495	4	17.6	470	3	17.5	425	6	18.15
						450	5	18.1
						475	3	18.0

$$A_t = 16,300 \text{ ft}^2$$

$$T_m = 18.33 \text{ } ^\circ\text{C}$$

$$T_{PR} = 16.6 \text{ } ^\circ\text{C}$$

$$A_t = 15,300 \text{ ft}^2$$

$$T_m = 18.51 \text{ } ^\circ\text{C}$$

$$T_{PR} = 16.6 \text{ } ^\circ\text{C}$$

$$A_t = 13,700 \text{ ft}^2$$

$$T_m = 18.85 \text{ } ^\circ\text{C}$$

$$T_{PR} = 16.6 \text{ } ^\circ\text{C}$$

TABLE D.I-5. (contd) River Temperature Traverses -
Hanford (River Mile: 361.0)

Date: 10-16-63 Time: 1245			Date: 10-22-63 Time: 1110			Date: 10-22-63 Time: 1230		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	3	19.6	10	4	17.6	10	4	17.65
15	6	19.65	25	5	17.8	25	5	17.7
50	10	19.7	50	7	17.85	80	17	17.85
75	11	19.6	95	14	17.7	120	21	17.55
125	20	19.3	120	16	17.55	170	17	17.3
175	20	19.1	170	18	17.4	195	13	17.15
200	18	18.9	195	14	16.85	220	10	16.95
225	13	18.8	220	9	16.95	245	8	16.95
250	9	18.7	245	7	16.9	270	5	16.9
385	7	18.45	270	5	16.85	295	5	16.9
415	7	18.4	295	5	16.85	320	5	16.85
435	7	18.35	320	5	16.7	345	5	16.85
465	6	18.3	345	6	16.65	370	5	16.8
475	5	18.3	370	6	16.8	395	6	16.75
			395	6	16.55	420	6	16.65
			420	5	16.5	445	4	16.55
			450	4	16.5	470	3	
$A_t = 15,500 \text{ ft}^2$			$A_t = 12,000 \text{ ft}^2$			$A_t = 12,800 \text{ ft}^2$		
$T_m = 19.00 \text{ }^\circ\text{C}$			$T_m = 17.27 \text{ }^\circ\text{C}$			$T_m = 17.30 \text{ }^\circ\text{C}$		
$T_{PR} = 16.6 \text{ }^\circ\text{C}$			$T_{PR} = 15.6 \text{ }^\circ\text{C}$			$T_{PR} = 15.6 \text{ }^\circ\text{C}$		

TABLE D.I-5. (contd) River Temperature Traverses -
Hanford (River Mile: 361.0)

Date: 10-29-63 Time: 1130			Date: 10-31-63 Time: 1115			Date: 11-5-63 Time: 1300		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	3	15.75	5	3	15.1	5	2	14.2
20	6	15.8	30	6	15.3	50	10	14.3
40	12	16.0	50	11	15.4	70	13	14.35
65	15	16.1	70	15	15.35	95	10	14.35
85	17	15.9	95	21	15.05	120	20	14.35
115	19	15.7	120	21	14.85	145	20	14.3
140	19	15.55	145	19	14.55	170	18	14.25
175	20	15.4	170	17	14.6	195	12	14.05
195	14	15.2	195	13	14.5	220	8	14.05
215	11	15.1	220	9	14.55	245	6	14.0
245	9	15.05	245	7	14.45	270	5	14.0
270	8	15.0	270	6	14.45	295	5	13.9
295	7	15.0	295	6	14.4	320	5	13.9
320	7	14.95	320	6	14.4	345	6	13.85
340	7	14.9	345	6	14.4	370	6	13.8
365	7	14.85	370	6	14.2	395	6	13.75
395	7	14.7	395	6	14.2	420	5	13.6
425	6	14.7	420	5	14.2	445	5	13.55
465	3	14.7	445	4	14.2	450	3	13.55
$A_t = 14,700 \text{ ft}^2$			$A_t = 13,600 \text{ ft}^2$			$A_t = 11,300 \text{ ft}^2$		
$T_m = 15.35 \text{ } ^\circ\text{C}$			$T_m = 14.70 \text{ } ^\circ\text{C}$			$T_m = 14.12 \text{ } ^\circ\text{C}$		
$T_{PR} = 14.1 \text{ } ^\circ\text{C}$			$T_{PR} = 13.7 \text{ } ^\circ\text{C}$			$T_{PR} = 13.0 \text{ } ^\circ\text{C}$		

TABLE D.I-5. (contd) River Temperature Traverses -
Hanford (River Mile: 361.0)

Date: 11-19-63 Time: 1550			Date: 11-19-63 Time: 1630			Date: 12-17-63 Time: 1230		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
25	5	14.4	5	3	14.3	5	4	9.55
50	6	14.4	20	4.5	14.3	25	10	10.15
75	15	14.45	25	5	14.35	50	13	10.2
110	17	14.35	35	7	14.45	75	14	10.1
125	21	14.0	80	15	14.3	100	17	10.0
150	15	13.45	110	17	14.15	125	18	10.0
175	11	13.3	140	19	13.75	150	19	9.35
200	8	13.2	165	17	13.5	175	19	9.2
225	6	13.2	185	13.5	13.45	200	14	8.95
255	7	13.2	210	10.5	13.35	225	10	8.8
275	6	13.2	230	7.5	13.35	250	6	8.7
300	6	13.15	260	7	13.3	275	4	8.65
325	6	13.1	280	6	13.3	300	4	8.6
350	7	13.05	310	6	13.25	325	5	8.5
375	6	13.05	335	6.5	13.25	350	5	8.45
400	6	13.0	355	6.5	13.2	375	5	8.35
425	5	12.85	380	6	13.15	400	5	8.3
450	4	12.45	405	6	13.05	425	4	8.15
475	1	12.15	440	4.5	13.0	450	3	7.95

$$A_t = 12,800 \text{ ft}^2$$

$$T_m = 13.60 \text{ }^{\circ}\text{C}$$

$$T_{PR} = 11.8 \text{ }^{\circ}\text{C}$$

$$A_t = 12,600 \text{ ft}^2$$

$$T_m = 13.68 \text{ }^{\circ}\text{C}$$

$$T_{PR} = 11.8 \text{ }^{\circ}\text{C}$$

$$A_t = 12,600 \text{ ft}^2$$

$$T_m = 9.31 \text{ }^{\circ}\text{C}$$

$$T_{PR} = 7.1 \text{ }^{\circ}\text{C}$$

TABLE D.I-6. River Temperature Traverses - Ringold
(River Mile: 354.4)

Date: 2-26-63 Time: 1110			Date: 6-24-63 Time: 1320			Date: 8-30-63 Time: 1030		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
30	7	5.7	2	3	16.2	25	4	20.8
80	12	5.6	50	14	15.6	80	14	20.6
130	10	6.0	100	15	15.4	130	12	20.5
180	7	5.7	150	19	15.5	180	9	20.45
230	7	5.6	200	24	15.4	230	9	20.4
280	7	5.5	250	26	15.4	280	9	20.3
330	4	5.6	300	22	15.3	330	6	20.3
380	6	5.4	350	20	15.2	380	8	20.25
430	6	5.5	400	19	15.1	405	8	20.2
480	10	5.2	450	18	15.1	430	8	20.2
530	20	5.0	500	18	15.1	455	10	20.2
580	7	4.8	550	20	15.1	480	12	20.1
630	3	6.2	600	24	15.1	505	17	20.1
			650	30	15.1	530	22	20.1
			700	34	15.1	555	16	20.1
			750	21	15.2	580	9	20.1
			800	18	15.3	605	7	20.0
			850	10	15.4	630	5	20.0
			900	8	15.5	675	4	20.0
$A_t = 15,400 \text{ ft}^2$			$A_t = 54,300 \text{ ft}^2$			$A_t = 20,600 \text{ ft}^2$		
$T_m = 5.44 \text{ }^\circ\text{C}$			$T_m = 15.26 \text{ }^\circ\text{C}$			$T_m = 20.30 \text{ }^\circ\text{C}$		
$T_{PR} = 3.80 \text{ }^\circ\text{C}$			$T_{PR} = 14.6 \text{ }^\circ\text{C}$			$T_{PR} = 18.0 \text{ }^\circ\text{C}$		

TABLE D.I-6. (contd) River Temperature Traverses -
Ringold (River Mile: 354.4)

Date: 8-30-63 Time: 1035			Date: 10-22-63 Time: 1350			Date: 10-29-63 Time: 1225		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
25	4	20.8	25	3	17.05	10	2	15.5
50	9	20.8	75	10	17.35	25	3	15.5
80	14	20.7	125	12	17.3	50	6	15.45
105	13	20.7	175	7	17.3	75	9	15.45
130	12	20.6	225	6	17.3	125	15	15.4
155	11	20.6	275	5	17.25	175	9	15.35
180	9	20.5	325	4	17.2	225	8	15.3
205	9	20.5	375	5	17.15	275	7	15.3
230	9	20.4	425	6	17.05	325	6	15.25
255	9	20.4	475	10	16.95	375	6	15.2
280	9	20.4	525	16	16.85	425	7	15.15
305	8	20.3	575	18	16.7	475	11	15.1
330	6	20.3	625	20	16.6	525	17	15.0
355	7	20.3	650	3	16.5	575	20	15.0
380	8	20.3				625	9	14.95
405	8	20.2				675	3	14.95
430	8	20.2						
455	10	20.2						
480	12	20.2						
505	17	20.1						
530	22	20.1						
555	16	20.1						
580	9	20.1						
605	7	20.1						
630	5	20.0						
655	4	20.0						

$$A_t = 19,300 \text{ ft}^2$$

$$T_m = 20.34 \text{ } ^\circ\text{C}$$

$$T_{PR} = 18.0 \text{ } ^\circ\text{C}$$

$$A_t = 17,400 \text{ ft}^2$$

$$T_m = 16.99 \text{ } ^\circ\text{C}$$

$$T_{PR} = 15.6 \text{ } ^\circ\text{C}$$

$$A_t = 16,300 \text{ ft}^2$$

$$T_m = 15.15 \text{ } ^\circ\text{C}$$

$$T_{PR} = 14.10 \text{ } ^\circ\text{C}$$

TABLE D.I-6. (contd) River Temperature Traverses -
Ringold (River Mile: 354.4)

Date: 10-31-63

Time: 1200

<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>
10	2	15.0
25	5	14.85
50	5	14.85
85	9	14.8
110	13	14.8
135	10	14.8
160	9	14.75
185	7	14.7
210	7	14.75
225	7	14.75
260	7	14.7
285	6	14.7
310	5	14.7
335	5	14.65
360	6	14.65
385	6	14.6
410	6	14.6
435	8	14.6
460	5	14.5
485	13	14.45
510	16	14.4
535	15	14.35
560	19	14.3
585	11	14.25
635	3	14.4

$$A_t = 15,800 \text{ ft}^2$$

$$T_m = 14.62 \text{ } ^\circ\text{C}$$

$$T_{PR} = 13.9 \text{ } ^\circ\text{C}$$

TABLE D.I-7. River Temperature Traverses -
Power Line Crossing
(River Mile: 350.5)

Date: 2-26-63 Time: 1215			Date: 8-30-63 Time: 1200			Date: 8-30-63 Time: 1245		
<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>	<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>	<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>
55	8	6.0	5	3	21.5	5	3	21.9
105	14	5.8	80	16	21.2	80	16	21.4
155	18	5.6	130	21	21.0	130	21	21.05
205	16	5.5	180	24	20.85	180	24	21.0
255	15	5.4	230	25	20.7	230	25	20.7
305	17	5.2	280	26	20.5	280	26	20.6
355	18	5.2	330	26	20.4	330	26	20.55
405	5	5.5	380	19	20.35	380	19	20.6
455	3	6.1	430	11	20.45	430	11	20.7
			480	5	20.45	480	5	20.65
			500	3	20.5	500	3	20.7
$A_t = 16,900 \text{ ft}^2$			$A_t = 26,400 \text{ ft}^2$			$A_t = 26,300 \text{ ft}^2$		
$T_m = 5.47 \text{ } ^\circ\text{C}$			$T_m = 20.65 \text{ } ^\circ\text{C}$			$T_m = 20.82 \text{ } ^\circ\text{C}$		
$T_{PR} = 3.8 \text{ } ^\circ\text{C}$			$T_{PR} = 18.3 \text{ } ^\circ\text{C}$			$T_{PR} = 18.3 \text{ } ^\circ\text{C}$		

TABLE D.I-7. (contd) River Temperature Traverses -
Power Line Crossing
(River Mile: 350.5)

Date: 8-30-63 Time: 1355			Date: 8-30-63 Time: 1230			Date: 8-30-63 Time: 1400		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	3	21.9	5	3	21.9	5	3	21.9
130	21	20.9	30	9	21.5	30	9	21.6
180	24	20.8	55	13	21.4	55	13	21.6
230	25	20.7	80	16	21.2	80	16	21.4
280	26	20.6	105	19	21.0	105	19	21.1
330	26	20.4	130	21	21.0	130	21	21.0
380	19	20.5	155	23	20.9	155	23	20.9
430	11	20.55	180	24	20.8	180	24	20.8
480	5	20.6	205	25	20.7	205	25	20.7
500	3	20.6	230	25	20.6	230	25	20.7
			255	26	20.5	255	26	20.6
			280	26	20.5	280	26	20.5
			305	26	20.5	305	26	20.5
			330	26	20.5	330	26	20.4
			355	23	20.5	355	23	20.4
			380	19	20.5	380	19	20.5
			405	15	20.6	405	15	20.5
			430	11	20.6	430	11	20.6
			455	8	20.6	455	8	20.6
			480	5	20.6	480	5	20.6
			500	3	20.7	500	3	20.7
$A_t = 26,700 \text{ ft}^2$			$A_t = 27,300 \text{ ft}^2$			$A_t = 27,300 \text{ ft}^2$		
$T_m = 20.75 \text{ } ^\circ\text{C}$			$T_m = 20.73 \text{ } ^\circ\text{C}$			$T_m = 20.75 \text{ } ^\circ\text{C}$		
$T_{PR} = 18.3 \text{ } ^\circ\text{C}$			$T_{PR} = 18.3 \text{ } ^\circ\text{C}$			$T_{PR} = 18.3 \text{ } ^\circ\text{C}$		

TABLE D.I-7. (contd) River Temperature Traverses -
Power Line Crossing
(River Mile: 350.5)

Date: 10-16-63 Time: 1340			Date: 10-16-63 Time: 1410			Date: 10-16-63 Time: 1415		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
10	6	19.4	10	6	19.4	5	3	19.7
25	8	19.25	25	8	19.25	25	12	19.3
50	11	19.2	50	15	19.1	75	18	19.05
75	18	19.1	75	18	19.0	100	20	19.0
100	22	18.95	100	24	18.95	125	24	18.95
125	23	18.85	125	23	18.9	150	24	18.85
150	23	18.8	150	23	18.85	175	25	18.8
175	24	18.75	175	24	18.75	200	25	18.75
200	24	18.7	200	26	18.7	225	26	18.6
225	25	18.65	225	26	18.6	250	27	18.5
250	26	18.6	250	27	18.55	275	27	18.45
275	26	18.5	275	28	18.5	300	27	18.45
300	26	18.4	300	26	18.45	325	27	18.45
325	26	18.4	325	27	18.45	350	26	18.45
350	26	18.4	350	26	18.4	375	19	18.5
375	26	18.4	375	23	18.4	400	11	18.55
400	12	18.4	400	14	18.4	425	10	18.7
425	8	18.3	425	6	18.3	450	6	18.75
						475	5	18.85
$A_t = 27,200 \text{ ft}^2$			$A_t = 27,200 \text{ ft}^2$			$A_t = 27,700 \text{ ft}^2$		
$T_m = 18.66 \text{ }^\circ\text{C}$			$T_m = 18.66 \text{ }^\circ\text{C}$			$T_m = 18.71 \text{ }^\circ\text{C}$		
$T_{PR} = 16.6 \text{ }^\circ\text{C}$			$T_{PR} = 16.6 \text{ }^\circ\text{C}$			$T_{PR} = 16.6 \text{ }^\circ\text{C}$		

TABLE D.I-7. (contd) River Temperature Traverses -
Power Line Crossing
(River Mile: 350.5)

Date: 10-16-63 Time: 1445			Date: 10-16-63 Time: 1510			Date: 10-16-63 Time: 1530		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	3	19.7	5	3	19.75	5	3	19.6
25	12	19.5	25	11	19.3	25	10	19.3
75	18	19.2	50	12	19.2	50	12	19.25
100	20	19.1	75	17	19.1	75	18	19.2
125	24	19.05	100	20	19.05	100	22	19.1
150	24	18.95	125	24	18.95	125	23	19.0
175	25	18.9	150	24	18.9	150	24	19.0
200	26	18.85	175	25	18.85	175	25	18.95
225	26	18.8	200	26	18.75	200	25	18.9
250	27	18.7	225	26	18.65	225	26	18.8
275	27	18.6	250	27	18.6	250	26	18.7
300	28	18.55	275	28	18.55	275	27	18.7
325	27	18.5	300	27	18.55	300	26	18.6
350	25	18.55	325	28	18.5	325	26	18.6
375	19	18.55	350	27	18.5	350	25	18.6
400	11	18.55	375	22	18.5	375	22	18.6
425	6	18.55	400	21	18.55	400	16	18.6
450	4	18.55	425	11	18.55	425	16	18.6
475	4	18.55	450	6	18.55	450	6	18.6
			475	5	18.55	475	5	18.6
$A_t = 27,700 \text{ ft}^2$			$A_t = 28,600 \text{ ft}^2$			$A_t = 28,600 \text{ ft}^2$		
$T_m = 18.80 \text{ } ^\circ\text{C}$			$T_m = 18.70 \text{ } ^\circ\text{C}$			$T_m = 18.82 \text{ } ^\circ\text{C}$		
$T_{PR} = 16.6 \text{ } ^\circ\text{C}$			$T_{PR} = 16.6 \text{ } ^\circ\text{C}$			$T_{PR} = 16.6 \text{ } ^\circ\text{C}$		

TABLE D.I-7. (contd) River Temperature Traverses -
Power Line Crossing
(River Mile: 350.5)

Date: 10-29-63 Time: 1250			Date: 10-29-63 Time: 1255			Date: 10-31-63 Time: 1235		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	3	15.35	5	2	15.4	5	3	14.7
25	12	15.35	25	8	15.45	30	8	14.75
50	11	15.4	50	10	15.45	55	12	14.8
75	19	15.35	75	17	15.45	80	13	14.8
100	22	15.35	100	21	15.4	105	23	14.75
125	24	15.3	125	23	15.35	130	23	14.7
150	24	15.25	150	25	15.3	155	23	14.65
175	25	15.2	175	25	15.25	180	24	14.6
200	26	15.2	200	25	15.15	205	25	14.55
225	26	15.15	225	26	15.15	230	24	14.5
250	27	15.1	250	27	15.1	255	27	14.4
275	28	15.05	275	28	15.05	280	26	14.35
300	27	15.0	300	28	15.0	305	26	14.3
325	27	14.95	325	27	14.95	330	26	14.3
350	27	14.9	350	27	14.9	355	23	14.3
375	20	14.85	375	24	14.8	380	22	14.25
400	15	14.8	400	15	14.75	405	6	14.2
425	9	14.8	425	9	14.8	430	4	14.15
450	5	14.75	450	5	14.8	455	4	14.15
475	3	14.75	475	4	14.85	480	4	14.15
500	3	15.1	500	3	14.85			
$A_t = 28,400 \text{ ft}^2$			$A_t = 27,900 \text{ ft}^2$			$A_t = 25,800 \text{ ft}^2$		
$T_m = 15.12 \text{ } ^\circ\text{C}$			$T_m = 15.08 \text{ } ^\circ\text{C}$			$T_m = 14.48 \text{ } ^\circ\text{C}$		
$T_{PR} = 14.1 \text{ } ^\circ\text{C}$			$T_{PR} = 14.1 \text{ } ^\circ\text{C}$			$T_{PR} = 13.7 \text{ } ^\circ\text{C}$		

TABLE D.I-8. River Temperature Traverses - Above 300 Area
(River Mile: 344.9)

Date: 2-12-63 Time: 0730			Date: 4-2-63 Time: 1300			Date: 4-18-63 Time: 1110		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	3	5.2	3	5	7.9	2	1	8.2
30	14	5.1	50	12	7.2	50	15	7.8
80	21	5.1	85	13	7.0	85	21	7.9
125	32	5.0	135	30	6.6	125	31	7.8
180	30	5.0	185	25	6.5	175	32	7.7
230	18	4.8	235	20	6.4	225	18	7.7
275	15	4.9	285	10	6.4	275	18	7.7
325	13	4.7	335	12	6.4	325	13	7.7
375	10	4.7	385	8	6.4	375	9	7.7
425	10	4.8	435	7	6.3	425	9	7.7
465	11	4.8	485	6	6.3	475	8	7.7
520	11	4.6	535	4	6.3	525	9	7.7
575	12	4.6	585	8	6.3	575	10	7.7
630	14	4.6	635	10	6.3	625	12	7.7
680	16	4.6	684	11	6.3	675	12	7.6
740	15	4.7	735	11	6.3	725	13	7.6
785	10	4.5	785	13	6.5	775	10	7.6
830	3	4.6	835	8	6.5	875	3	8.3
			865	3	8.0			
$A_t = 38,000 \text{ ft}^2$			$A_t = 31,100 \text{ ft}^2$			$A_t = 36,700 \text{ ft}^2$		
$T_m = 4.84 \text{ } ^\circ\text{C}$			$T_m = 6.52 \text{ } ^\circ\text{C}$			$A_m = 7.72 \text{ } ^\circ\text{C}$		
PRTR Recorder = 5.4 °C			PRTR Recorder = 7.2 °C			PRTR Recorder = 8.0 °C		
$T_{PR} = 4.15 \text{ } ^\circ\text{C}$			$T_{PR} = 5.0 \text{ } ^\circ\text{C}$			$T_{PR} = 6.7 \text{ } ^\circ\text{C}$		

TABLE D.I-8. (contd) River Temperature Traverses -
Above 300 Area
(River Mile: 344.9)

Date: 5-23-63 Time: 1100			Date: 6-24-63 Time: 1040			Date: 6-27-63 Time: 1100		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
2	2	15.3	2	3	15.7	5	5	16.3
50	13	14.6	37	20	15.5	85	27	16.1
100	21	14.2	87	27	15.3	185	38	15.75
150	32	13.9	137	40	15.3	285	24	15.7
200	32	13.8	187	38	15.1	385	20	15.65
250	18	13.8	237	27	15.1	485	16	15.65
300	14	13.7	287	24	15.1	585	19	15.65
350	13	13.7	337	23	15.1	685	21	15.65
400	9	13.7	387	20	15.1	785	23	15.65
450	8	13.7	437	18	15.1	885	21	15.85
500	8	13.7	487	16	15.1	935	13	15.85
550	8	13.6	537	18	15.1	955	3	15.9
600	9	13.6	587	19	15.1			
650	13	13.7	637	19	15.1			
700	9	13.8	687	21	15.1			
750	11	13.8	737	21	15.0			
800	11	14.0	787	23	15.1			
840	3	15.3	837	22	15.1			
			887	21	15.1			
			937	19	15.2			
			987	13	15.2			
			1027	2	16.4			
$A_t = 33,900 \text{ ft}^2$			$A_t = 66,900 \text{ ft}^2$			$A_t = 64,900 \text{ ft}^2$		
$T_m = 13.91 \text{ }^\circ\text{C}$			$T_m = 15.16 \text{ }^\circ\text{C}$			$T_m = 15.77 \text{ }^\circ\text{C}$		
PRTR Recorder = 14.5 °C			PRTR Recorder = 16.2 °C			PRTR Recorder = 16.8 °C		
$T_{PR} = 12.3 \text{ }^\circ\text{C}$			$T_{PR} = 14.6 \text{ }^\circ\text{C}$			$T_{PR} = 14.9 \text{ }^\circ\text{C}$		

TABLE D.I-8. (contd) River Temperature Traverses -
Above 300 Area
(River Mile: 344.9)

Date: 7-18-63 Time: 1330			Date: 8-30-63 Time: 1500			Date: 10-10-63 Time: 1100		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	5	17.9	25	9	21.5	5	3	17.6
75	23	17.6	50	16	21.4	50	16	17.7
175	38	17.3	75	19	21.3	80	19	17.8
275	20	17.3	100	22	21.2	130	28	17.8
375	15	17.25	125	27	21.2	180	33	17.7
475	14	17.25	150	32	21.0	230	25	17.7
575	15	17.2	175	33	21.0	280	19	17.7
675	17	17.2	200	33	21.0	330	17	17.6
775	20	17.2	225	26	20.9	380	12	17.6
875	17	17.25	250	19	20.9	430	10	17.6
975	10	17.5	275	19	20.9	480	9	17.6
1005	5	17.7	300	19	20.8	630	12	17.6
			325	17	20.8	880	5	17.5
			350	14	20.8	920	3	17.4
			375	12	20.8			
			400	10	20.8			
			425	10	20.8			
			450	10	20.8			
			475	9	20.7			
			500	9	20.7			
			525	10	20.7			
			550	10	20.7			
			575	11	20.7			
			600	11	20.7			
			625	12	20.8			
			650	13	20.8			
			675	13	20.8			
			700	13	20.8			
			725	14	20.8			
			750	14	20.9			
			775	13	20.9			
			800	11	20.9			
			825	9	20.9			
			850	7	21.0			
			875	5	21.2			
			900	4	21.5			
$A_t = 55,400 \text{ ft}^2$			$A_t = 40,000 \text{ ft}^2$			$A_t = 37,900 \text{ ft}^2$		
$T_m = 17.32 \text{ } ^\circ\text{C}$			$T_m = 20.94 \text{ } ^\circ\text{C}$			$T_m = 17.66 \text{ } ^\circ\text{C}$		
PRTR Recorder = 18.0 °C			PRTR Recorder = 20.9 °C			PRTR Recorder = 18.1 °C		
$T_{PR} = 16.8 \text{ } ^\circ\text{C}$			$T_{PR} = 18.00 \text{ } ^\circ\text{C}$			$T_{PR} = 17.3 \text{ } ^\circ\text{C}$		

**TABLE D.I-8. (contd) River Temperature Traverses -
Above 300 Area
(River Mile: 344.9)**

Date: 10-16-63 Time: 1615			Date: 10-29-63 Time: 1330			Date: 10-31-63 Time: 1540		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
10	8	19.3	20	5	15.15	5	3	14.6
25	8	19.3	50	7	15.15	25	9	14.65
50	13	19.25	100	12	15.2	70	18	14.65
70	16	19.2	150	33	15.05	120	29	14.65
95	30	19.05	200	27	15.0	170	31	14.5
170	31	18.75	250	18	15.0	220	17	14.45
195	19	18.7	300	14	14.95	270	14	14.4
220	15	18.7	350	12	14.9	320	11	14.45
245	14	18.7	400	10	14.9	370	8	14.35
270	14	18.7	450	10	14.85	420	7	14.3
295	12	18.65	500	10	14.85	470	7	14.35
320	12	18.65	550	9	14.85	520	8	14.3
355	9	18.6	600	12	14.8	570	8	14.25
370	8	18.65	650	13	14.8	620	12	14.3
395	7	18.65	700	14	14.75	670	12	14.2
420	7	18.7	750	15	14.75	720	14	14.2
445	6	18.7	800	14	14.75	770	12	14.1
470	6	18.7	850	4	14.8	820	12	14.2
495	6	18.7				870	3	14.3
520	6	18.7						
545	7	18.7						
570	7	18.7						
595	8	18.7						
620	9	18.5						
670	11	18.65						
720	12	18.65						
770	14	18.6						
820	11	18.6						
870	10	18.7						
900	6	18.7						
$A_t = 33,600 \text{ ft}^2$			$A_t = 34,800 \text{ ft}^2$			$A_t = 33,400 \text{ ft}^2$		
$T_m = 18.77 \text{ }^\circ\text{C}$			$T_m = 14.92 \text{ }^\circ\text{C}$			$T_m = 14.4 \text{ }^\circ\text{C}$		
PRTR Recorder = 18.8 °C			PRTR Recorder = 15.0 °C			PRTR Recorder = 14.5 °C		
$T_{PR} = 16.6 \text{ }^\circ\text{C}$			$T_{PR} = 14.1 \text{ }^\circ\text{C}$			$T_{PR} = 13.7 \text{ }^\circ\text{C}$		

TABLE D.I-8. (contd) River Temperature Traverses -
Above 300 Area
(River Mile: 344.9)

Date: 12-11-63			Date: 12-16-63		
Time: 1400			Time: 0930		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	3	7.75	5	4	9.15
50	11	7.85	25	8	8.95
75	18	8.15	50	18	9.5
125	35	8.25	75	17	9.75
175	31	8.3	125	33	9.8
225	18	8.25	175	30	9.65
275	15	8.3	225	17	9.55
325	13	8.3	275	14	9.5
375	10	8.25	325	12	9.45
425	10	8.2	375	9	9.45
475	10	8.2	425	10	9.45
525	9	8.15	475	10	9.4
575	10	8.15	525	9	9.4
625	12	8.1	575	10	9.35
675	12	8.1	625	12	9.35
725	15	8.05	675	13	9.3
775	11	8.0	725	13	9.25
805	12	8.0	775	12	9.15
825	9	7.9	825	7	9.05
$A_t = 36,500 \text{ ft}^2$			$A_t = 35,000 \text{ ft}^2$		
$T_m = 8.18 \text{ }^\circ\text{C}$			$T_m = 9.49 \text{ }^\circ\text{C}$		
PRTR Recorder = 8.2 °C			PRTR Recorder = 9.5 °C		
$T_{PR} = 7.6 \text{ }^\circ\text{C}$			$T_{PR} = 7.1 \text{ }^\circ\text{C}$		

TABLE D.I-9. River Temperature Traverses - Richland Ferry
(River Mile: 340.9)

Date: 2-12-63 Time: 0935			Date: 4-18-63 Time: 0915			Date: 5-9-63 Time: 1345		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	4	5.2	2	1	7.7	2	3	10.4
50	14	5.0	50	11	7.6	50	17	10.0
100	15	5.0	100	15	7.5	100	17	10.0
140	13	5.0	150	12	7.5	150	15	9.9
185	11	4.9	200	8	7.5	200	11	9.9
235	8	4.6	250	7	7.5	250	9	9.9
295	23	5.0	300	16	7.6	300	17	10.0
340	25	4.9	350	24	7.5	350	21	9.9
390	23	4.9	400	26	7.5	400	28	9.9
455	12	4.9	450	20	7.5	450	26	9.8
505	10	4.7	500	11	7.5	500	17	9.8
540	10	4.7	550	10	7.5	550	14	9.8
595	10	4.7	600	7	7.5	600	15	9.8
640	10	4.9	650	10	7.5	650	15	9.7
695	11	4.9	700	13	7.5	700	16	9.8
750	17	4.2	750	16	7.5	750	19	9.8
805	25	5.0	800	22	7.5	800	25	9.8
840	26	4.8	850	23	7.5	850	26	9.8
850	25	4.7	900	13	7.5	900	23	10.0
885	16	4.9	955	2	8.5	1000	3	10.5
915	6	4.4						
$A_t = 41,400 \text{ ft}^2$			$A_t = 35,300 \text{ ft}^2$			$A_t = 52,000 \text{ ft}^2$		
$T_m = 4.87 \text{ } ^\circ\text{C}$			$T_m = 7.53 \text{ } ^\circ\text{C}$			$T_m = 9.90 \text{ } ^\circ\text{C}$		
$T_{PR} = 4.15 \text{ } ^\circ\text{C}$			$T_{PR} = 6.7 \text{ } ^\circ\text{C}$			$T_{PR} = 8.8 \text{ } ^\circ\text{C}$		

TABLE D.I-9. (contd) River Temperature Traverses -
Richland Ferry
(River Mile: 340.9)

Date: 5-16-63 Time: 1045			Date: 6-18-63 Time: 1340			Date: 6-26-63 Time: 1340		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
3	1	12.4	2	5	16.5	2	3	16.2
43	13	12.0	50	21	16.2	50	18	16.0
93	15	11.9	100	22	16.1	100	20	15.9
143	13	11.8	150	20	16.1	150	19	15.9
193	10	11.8	210	17	16.0	200	17	15.9
243	7	11.9	245	15	16.0	250	13	15.8
293	13	11.8	305	32	16.0	300	28	15.9
343	24	11.7	350	33	16.1	350	31	15.8
393	25	11.5	400	27	15.9	400	29	15.8
443	18	11.6	450	19	15.9	450	21	15.7
493	13	11.6	500	16	15.9	500	16	15.7
543	10	11.6	550	14	15.9	550	14	15.7
593	8	11.6	610	15	15.9	600	14	15.7
643	10	11.6	650	16	16.0	650	15	15.7
693	12	11.6	700	17	15.9	700	17	15.8
743	18	11.6	750	19	15.9	750	17	15.7
793	24	11.6	800	25	15.9	800	21	15.7
843	23	11.7	850	29	15.9	850	27	15.6
893	24	11.6	900	32	15.9	900	30	15.7
943	15	11.9	950	33	16.0	950	30	15.7
993	3	12.3	1000	31	16.0	1000	27	15.8
			1050	15	16.1	1050	10	15.9
			1100	1.5	16.8	1100	2	16.2
$A_t = 44,100 \text{ ft}^2$			$A_t = 70,300 \text{ ft}^2$			$A_t = 66,400 \text{ ft}^2$		
$T_m = 11.71 \text{ } ^\circ\text{C}$			$T_m = 15.99 \text{ } ^\circ\text{C}$			$T_m = 15.77 \text{ } ^\circ\text{C}$		
$T_{PR} = 10.6 \text{ } ^\circ\text{C}$			$T_{PR} = 14.8 \text{ } ^\circ\text{C}$			$T_{PR} = 14.9 \text{ } ^\circ\text{C}$		

TABLE D.I-9. (contd) River Temperature Traverses -
Richland Ferry
(River Mile: 340.9)

Date: 8-30-63 Time: 1700			Date: 8-30-63 Time: 1800			Date: 10-10-63 Time:		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	3	21.3	5	3	21.5	5	3	17.95
50	17	21.2	50	17	21.2	45	13	17.95
90	17	21.1	90	17	21.2	95	15	18.0
140	15	21.1	140	15	21.1	145	13	18.0
190	11	21.1	190	11	21.0	195	10	17.95
240	9	21.1	240	9	21.0	245	11	17.95
290	17	21.0	290	17	20.9	295	23	17.9
340	21	20.9	340	21	20.8	345	25	17.85
390	28	20.8	390	28	20.8	395	23	17.85
440	26	20.8	440	26	20.8	445	15	17.85
490	17	20.8	490	17	20.8	495	11	17.85
540	14	20.8	540	14	20.8	545	10	17.85
590	15	20.9	590	15	20.8	595	10	17.85
640	15	20.9	640	15	20.8	645	11	17.85
690	16	20.9	690	16	20.8	695	12	17.85
740	19	20.9	740	19	20.8	745	16	17.8
790	25	20.9	790	25	20.8	795	23	17.8
840	26	20.9	840	26	20.7	845	26	17.8
890	23	20.9	890	23	20.8	895	16	17.7
940	15	21.0	940	15	21.0	945	5	17.6
990	4	21.0	990	4	21.1			
$A_t = 52,500 \text{ ft}^2$			$A_t = 52,500 \text{ ft}^2$			$A_t = 42,800 \text{ ft}^2$		
$T_m = 20.93 \text{ } ^\circ\text{C}$			$T_m = 20.91 \text{ } ^\circ\text{C}$			$T_m = 17.86 \text{ } ^\circ\text{C}$		
$T_{PR} = 18.0 \text{ } ^\circ\text{C}$			$T_{PR} = 18.0 \text{ } ^\circ\text{C}$			$T_{PR} = 17.3 \text{ } ^\circ\text{C}$		

TABLE D.I-9. (contd) River Temperature Traverses -
Richland Ferry
(River Mile 340.9)

Date: 10-16-63 Time: 1715			Date: 10-16-63 Time: 1830			Date: 10-29-63 Time: 1445		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
25	10	18.85	25	11	18.7	5	3	15.1
75	13	18.85	75	12	18.6	50	12	15.1
125	12	18.8	125	14	18.6	100	14	15.1
175	11	18.8	175	11	18.6	150	14	15.1
200	8	18.7	200	8	18.55	200	13	15.05
275	5	18.75	275	9	18.5	250	11	15.05
325	23	18.8	325	24	18.5	300	8	15.05
375	24	18.65	375	24	18.5	350	4	15.05
425	25	18.6	425	22	18.5	400	21	15.05
475	17	18.6	475	15	18.5	450	27	14.95
525	11	18.6	525	9	18.5	500	26	14.95
575	8	18.6	575	9	18.5	550	16	14.95
625	6	18.6	625	7	18.5	600	7	14.95
675	7	18.6	675	6	18.5	650	9	14.9
725	9	18.6	725	8	18.5	700	10	14.9
775	10	18.6	775	11	18.5	750	11	14.9
825	15	18.6	825	17	18.5	800	12	14.95
850	17	18.6	875	22	18.5	850	22	14.9
875	19	18.6	925	25	18.5	900	26	14.9
900	21	18.55	975	25	18.5	950	23	14.8
925	23	18.55	1025	22	18.4	1000	10	14.7
950	25	18.5				1020	3	14.8
975	25	18.5						
1025	24	18.6						
$A_t = 43,300 \text{ ft}^2$			$A_t = 43,700 \text{ ft}^2$			$A_t = 44,300 \text{ ft}^2$		
$T_m = 18.64 \text{ }^\circ\text{C}$			$T_m = 18.51 \text{ }^\circ\text{C}$			$T_m = 14.96 \text{ }^\circ\text{C}$		
$T_{PR} = 16.6 \text{ }^\circ\text{C}$			$T_{PR} = 16.6 \text{ }^\circ\text{C}$			$T_{PR} = 14.1 \text{ }^\circ\text{C}$		

TABLE D.I-9. (contd)
River Temperature Traverses -
Richland Ferry
(River Mile: 340.9)

Date: 10-29-63			Date: 12-16-63		
Time: 1500			Time: 1020		
Distance from Plant			Distance from Plant		
Shore, yd			Shore, yd		
Depth, ft			Depth, ft		
Temp, °C			Temp, °C		
15	7	15.3	10	9	8.95
50	12	15.25	60	12	9.4
100	14	15.2	110	14	9.45
150	14	15.2	160	11	9.5
200	13	15.15	210	8	9.5
250	11	15.15	260	5	9.45
300	8	15.15	310	26	9.5
350	5	15.2	360	23	9.5
400	24	15.2	410	22	9.5
450	26	15.15	460	12	9.5
500	27	15.1	510	9	9.45
550	21	15.05	560	7.5	9.45
600	12	15.05	610	8	9.45
650	10	15.05	660	11	9.45
700	8	15.05	710	14	9.45
750	9	15.05	760	20	9.4
800	11	15.05	810	24	9.4
850	19	15.05	860	20	9.2
900	26	14.95	885	21	8.85
950	24	14.85	935	14	8.75
1020	3	14.85	955	5	8.5
$A_t = 44,300 \text{ ft}^2$			$A_t = 41,000 \text{ ft}^2$		
$T_m = 15.08 \text{ }^\circ\text{C}$			$T_m = 9.37 \text{ }^\circ\text{C}$		
$T_{PR} = 14.1 \text{ }^\circ\text{C}$			$T_{PR} = 7.1 \text{ }^\circ\text{C}$		

TABLE D.I-10. River Temperature Traverses -
Pasco Water Plant
(River Mile: 328.7)

Date: 2-20-63 Time: 1620			Date: 4-3-63 Time: 1350			Date: 5-8-63 Time: 1350		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	7	5.8	3	2	7.4	3	3	10.6
50	30	5.5	50	22	7.4	50	23	10.5
95	39	5.4	95	38	7.0	95	38	9.9
145	46	5.4	145	40	6.6	145	43	10.0
190	48	5.2	195	48	6.5	195	48	9.6
235	60	5.4	245	56	6.4	245	53	9.4
290	53	5.1	295	55	6.4	300	54	9.6
350	38	5.1	345	55	6.4	350	44	9.6
390	31	5.2	395	41	6.7	395	38	9.6
415	5	5.8	445	32	6.5	445	35	9.6
			485	8	7.0	465	8	10.5
$A_t = 50,800 \text{ ft}^2$			$A_t = 57,500 \text{ ft}^2$			$A_t = 61,800 \text{ ft}^2$		
$T_m = 5.30 \text{ }^\circ\text{C}$			$T_m = 6.71 \text{ }^\circ\text{C}$			$T_m = 9.74 \text{ }^\circ\text{C}$		
Recorder			Recorder			Recorder		
Temperature = 5.6 °C			Temperature = 6.6 °C			Temperature = 10.0 °C		
$T_{PR} = 4.1 \text{ }^\circ\text{C}$			$T_{PR} = 5.0 \text{ }^\circ\text{C}$			$T_{PR} = 8.5 \text{ }^\circ\text{C}$		
Date: 5-16-63 Time: 1320			Date: 6-13-63 Time: 0950			Date: 6-18-63 Time: 1150		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	4	13.0	5	3	15.3	2	2	16.2
50	23	13.0	50	25	15.5	50	28	16.2
95	40	12.5	100	37	15.3	100	45	16.1
145	42	12.2	150	45	15.0	150	50	16.0
195	47	12.3	200	49	14.9	200	50	16.0
245	50	12.1	250	55	14.9	250	56	15.9
295	52	12.1	300	55	14.8	300	56	15.9
345	42	12.1	350	48	14.7	350	52	15.9
395	38	12.1	400	38	14.9	408	42	15.7
445	33	12.3	450	38	15.1	450	38	15.8
495	26	12.5	500	10	15.4	500	20	16.2
515	20	12.5						
$A_t = 58,300 \text{ ft}^2$			$A_t = 58,500 \text{ ft}^2$			$A_t = 64,300 \text{ ft}^2$		
$T_m = 12.28 \text{ }^\circ\text{C}$			$T_m = 14.97 \text{ }^\circ\text{C}$			$T_m = 15.90 \text{ }^\circ\text{C}$		
Recorder			Recorder			Recorder		
Temperature = 12.3 °C			Temperature = 14.7 °C			Temperature = 15.6 °C		
$T_{PR} = 10.6 \text{ }^\circ\text{C}$			$T_{PR} = 14.2 \text{ }^\circ\text{C}$			$T_{PR} = 14.8 \text{ }^\circ\text{C}$		

TABLE D.I-10. (contd) River Temperature Traverses -
Pasco Water Plant
(River Mile: 328.7)

Date: 7-11-63 Time: 1100			Date: 10-10-63 Time: 1400			Date: 12-9-63 Time: 1400		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	8	16.6	5	5	18.4	10	10	8.35
100	37	16.3	50	25	18.4	25	23	8.45
200	49	16.05	105	38	18.45	50	24	8.4
300	55	15.95	155	42	18.45	75	25	8.4
400	38	15.9	205	50	18.5	95	38	8.9
500	38	16.0	265	56	18.45	120	48	8.9
535	10	16.25	305	55	18.45	145	52	8.9
			355	52	18.4	170	54	8.95
			405	38	18.35	195	52	9.0
			455	27	18.35	220	62	9.0
			505	7	18.35	245	66	9.0
						270	68	9.0
						295	58	9.0
						320	54	8.9
						345	47	8.9
						370	43	8.85
						395	40	8.8
						420	30	8.7
						445	22	8.5
$A_t = 62,800 \text{ ft}^2$			$A_t = 57,400 \text{ ft}^2$			$A_t = 59,700 \text{ ft}^2$		
$T_m = 16.08 \text{ }^\circ\text{C}$			$T_m = 18.43 \text{ }^\circ\text{C}$			$T_m = 8.88 \text{ }^\circ\text{C}$		
Recorder			Recorder			Recorder		
Temperature = 16.4 °C			Temperature = 18.0 °C			Temperature = 8.6 °C		
$T_{PR} = 15.8 \text{ }^\circ\text{C}$			$T_{PR} = 17.3 \text{ }^\circ\text{C}$			$T_{PR} = 8.4 \text{ }^\circ\text{C}$		

TABLE D.I-10. (contd) River Temperature Traverses -
Pasco Water Plant
(River Mile: 328.7)

Date: 12-13-63

Time: 1330

<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>
5	6	7.75
25	13	7.8
50	24	7.85
75	33	8.05
95	40	8.25
120	46	8.45
145	50	8.45
170	53	8.45
195	52	8.55
220	55	8.55
245	60	8.55
270	60	8.5
295	61	8.5
320	60	8.5
345	55	8.5
370	47	8.45
395	39	8.4
420	27	8.15
445	18	8.15
470	20	8.1

$$A_t = 59,800 \text{ ft}^2$$

$$T_m = 8.41 \text{ } ^\circ\text{C}$$

Recorder

$$\text{Temperature} = 8.0 \text{ } ^\circ\text{C}$$

$$T_{PR} = 7.3 \text{ } ^\circ\text{C}$$

TABLE D.I-11. F-Area Fewer Temperatures

<u>Date</u>	<u>Average Raw Water Temp, °C</u>	<u>Weighted Average Sewer Temp, °C</u>
8-29-63	20.0	24
8-30	20.3	24.5
8-31	20.7	25
9-1	20.6	24.5
9-2	20.1	24.5
9-3	20.3	25.5
9-4	20.0	25
9-5	20.7	26
9-6	20.7	25
9-7	21.0	25
9-8	21.2	25.5
9-13	20.9	26
9-14	20.7	25
9-15	20.5	24
9-16	20.0	24
9-17	20.2	24
9-18	20.3	24
9-19	19.7	23
9-20	19.9	25.5
9-21	20.3	23.5
9-25	20.4	24
9-26	20.6	24
9-27	20.8	24
9-30	21.0	24
10-1	20.6	24
10-2	20.0	24.5
10-3	20.0	25
10-4	19.9	22.5
10-5	19.8	22.5
10-6	20.4	22.5
10-7	20.3	23
10-11	19.2	24
10-12	19.1	21.5
10-15	18.9	21.5
10-16	18.8	22
10-17	18.5	22
10-18	18.3	22
10-19	18.8	22
10-20	18.8	22.5
10-21-63	18.5	22
10-22	17.8	21
10-23	17.5	20.5
10-24	17.3	20.5
10-25	17.0	19.5
10-26	16.5	19.5
10-27	17.0	19.5
10-28	16.5	19.5
10-29	15.8	19
10-30	15.5	19
10-31	15.1	18.5
11-1	15.1	18
11-2	15.0	17.5
11-3	15.3	17.5

TABLE D.I-12. Temperatures in Effluent
Bubbles and Plumes

<u>Outfall Location</u>	<u>Depth, ft</u>	<u>Date</u>	<u>Time</u>	<u>Maximum Temp, °C</u>	<u>Upstream Temp, °C</u>	<u>Maximum Temp at 100 yd Downstream</u>
B	1	11-26-63	1230-	17.2	10.6	--
	4		1330	17.7	10.6	14.1
	8			16.3	10.6	--
	15			19.5	10.6	--
C	3	11-26-63	1330	19.5	--	14.4
	10			17.6	--	--
D	1	11-26	1430	28.1		
	10			22.3	13.8	16.9
F	1	10-16-63	0800	26.1	18.0	--
	1	12-3-63	1330	23.8	10.8	--
	5			20.3	--	
H	1	12-3-63	1130	16.7	11.0	--
K (shore)	3	11-26-63	1400	17.9	11.3	12.9
(main	3			21.7		12.8
bubble)	15			23.7		

TABLE D.I-13. Equilibrium Dye Concentrations

Location	River Mile	L, mi.	$R_{\max}$, units	$C_{\max}$, ppb	$\frac{C_{\max}}{C_m}$	$\frac{C_{\max}}{C_o}$
<u>10-29-63 1904-H River Mile 372.6</u>						
Reactor Flow Rate - 84,700 gpm			Average River Flow Rate - 75,000 cfs			
$C_o = 29$ ppb			$C_m = 0.081$ ppb			
Above 181-F	369.3	3.3	3	0.048	0.56	0.0017
Hanford	361.0	11.6	2-1/2	0.040	0.49	0.0014
Ringold	354.4	18.2	1-1/2	0.024	0.30	0.0008
Power Line Crossing	350.5	22.1	1	0.016	0.20	0.0006
Above 300 Area	345.0	27.6	1-1/2	0.024	0.30	0.0008
Richland Ferry	340.9	31.7	1	0.016	0.20	0.0006
<u>10-31-63 1904-F River Mile 369.0</u>						
Reactor Flow Rate - 89,700 gpm			Average River Flow Rate - 65,000 cfs			
$C_o = 21$ ppb			$C_m = 0.065$ ppb			
50 yd below	369.0	<0.1	25-1/2	0.41	6.3	0.020
Hanford	361.0	8.0	6-1/2	0.105	1.6	0.0050
Ringold	354.4	14.6	3	0.048	0.75	0.0023
Power Line Crossing	350.5	18.5	2-1/2	0.040	0.6	0.0019
Above 300 Area	345.0	24.0	1-1/2	0.024	0.4	0.0012
Richland Ferry	340.9	28.1	1	0.016	0.25	0.0008

REFERENCES

- D1. J. P. Corley. Effects of Hanford Operations on Columbia River Temperatures - Interim Report, HW-76210. February 13, 1963. (SECRET)
- D2. J. P. Corley. Effects of Hanford Operations on Columbia River Chemical Characteristics, HW-84537. December 10, 1964. (Unpublished Data)
- D3. J. K. Soldat. Columbia River Flow-Time Calculations, HW-58312. July 1, 1963.

APPENDIX D

SECTION II

INTER-REACTOR RIVER TEMPERATURE DATA*

J. P. Corley

* Declassified excerpts from Battelle-Northwest internal report BNWL-CC-807, dated September 9, 1966.

INTER-REACTOR RIVER TEMPERATURE DATA

J. P. Corley

Table D.II-1

This table shows direct temperature measurements made just downstream from the ends of the reactor outfall lines. The procedure generally was to probe the river at the selected distance to find the maximum temperature in the cross section. Temperatures were measured with a resistance thermometer.

In most cases, readings were taken at several depths at the indicated point to determine the degree of mixing, and the depth of the maximum reading. Although not shown, the depth readings show little difference vertically at 400-yard distances, even at the lower river flow rates. At 100-yard distances and low river flow rates, vertical mixing is not complete and the maximum reading frequently occurs at some depth beneath the water surface.

In the table, Q_R is river flow rate as measured at the Priest Rapids gage station, adjusted for time of wave travel to the outfall whenever the flow rate was changing rapidly. T_R is the river temperature measured just upstream from the end of the outfall line. ΔT equals $T_{\max}$ minus T_R .

B and C outfall lines, like the D and DR lines, are less than 400 yards apart. The 400-yard distances, therefore, were measured from the downstream line, C and DR respectively.

Except where noted by an approximation symbol, the accuracy of the data is believed to be:

$$T_R \text{ and } T_{\max} \text{ at 400 yards} = \pm 0.2 \text{ } ^\circ\text{C}$$

$$Q_R = \pm 5\%$$

Table D.II-2

Sets of traverse markers have been set up at 400 yards, 1/2 mile, and 1 mile below each of the reactor outfalls, and above N and D Area river pump intakes. Data for all these locations is given in the several sections of Table D.II-2. Time has not permitted measurements at all points on any one date.

River traverses for temperature measurements only were made with the resistance thermometer probe suspended from the boat at a water depth of about 2 feet. When temperature measurements were taken in conjunction with dye tests, a continuous sample line was used with the intake about 2 feet beneath the water and the resistance thermometer installed through a fitting into the sample line. A stadimeter was used for lateral distance measurement, and a fathometer for water depth. The instruments, procedure and some early data have been discussed in more detail in HW-80888.*

In the tables, those reactors operating upstream from the traverse location are indicated. Where an asterisk appears, the reactor was shut down and effluent flow rate had been reduced; but, the temperature of the effluent was still well above river temperature.

River flow rate was determined, as in Table D.II-1 from the Priest Rapids gage record, as was the base river temperature, T_{PR} . A_t , the cross-sectional area, was calculated from the tabulated distance and depth measurements, and the mean river temperature T_m for the cross section was calculated by the mean-section method as:

$$T_m = \frac{\sum (w \times d_{ave} \times T_{ave})}{\sum (w \times d_{ave})}$$

* J. P. Corley, *Effects of Hanford Operations on Columbia River Temperatures - Interim Report No. 2*, HW-80888. December 3, 1964. (original classified)

In some of the tables, a column is shown headed, for example, "B Effluent Units." This is the measured relative concentration of effluent from the named reactor at the cross section. In all such tables, Rhodamine B dye was being pumped continuously into the reactor outfall. The units shown are actually dial readings on the Turner Fluorometer used to measure dye concentrations in river water. Since the addition rate and apparent dye loss varied between tests, it is not possible to compare directly the indicated units values for different days. However, for the same date at different locations, the indicated units should be comparable.

Accuracy of the temperature data is the same as for Table D.II-1 data, except where the notation "est." appears. Depth accuracy is generally ± 2 feet, although frequent difficulties with fathometer equipment may be reflected in several traverses for which the depths and calculated areas do not reconcile with other data from the same location. The most frequent errors in the data occur in the lateral distance measurement. It is difficult to maintain a straight line with the boat at uniform traverse speed in the high and fluctuating water velocities usually found in this section of the river.

No attempt has been made here to reconcile all the traverses at a given location; the only changes in the raw data have been calibration corrections. It is believed that showing the actual run-to-run variations will permit the user of this data to do so more intelligently.

TABLE D.II-1. Effluent Plume TemperaturesTABLE D.II-1. Effluent Plume Temperatures

Outfall	Q _R , cfs	T _R , °C	100 yd		400 yd	
			T _{max} , °C	ΔT, °C	T _{max} , °C	ΔT, °C
1904-B-C	41,000	7.15	11.1	3.95	7.65	3.6
	54,000	6.45	10.6	4.15	9.45	3.0
	87,000	10.5	14.4	2.6	11.8	1.3
	115,000	4.6	8.3	3.7	6.4	1.8
	160,000	9.35	10.95	1.6	-	-
	189,000	16.7	17.85	1.15	17.95	1.25
	255,000	10.45	11.65	1.15	11.4	0.95
1904-K	~45,000	3.80	10.15	6.35	9.35	5.55
	71,000	7.45	10.15	2.7	9.5	2.05
	~80,000	5.45	9.45	4.0	7.85	2.40
	153,000	9.1	9.9	0.8	-	-
	241,000	10.95	12.95	2.0	12.3	1.35
	277,000	12.8	-	-	14.15	1.35
1904-D-DR	77,000	9.1	13.7	4.6	12.5	3.4
	108,000	6.15	8.3	2.15	7.25	1.1
	140,000	18.05	20.35	2.3	19.90	1.85
	237,000	11.3	12.6	1.3	12.2	0.9
	277,000	13.2	-	-	14.05	0.85
1908-N	140,000	3.55	6.8	3.25	6.05	2.5

TABLE D.II-2. River Temperature Traverses -
400 Yards Below C
(River Mile: 383.8)

Date: 3-18-65				Date: 3-18-65			
Time: 1025				Time: 1035			
River Flow Rate: 95,000 cfs				River Flow Rate: 95,000 cfs			
Distance from Plant Shore, yd	Depth, ft	Temp, °C	B Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	B Effluent Units
25	7.5	4.6	0	25	8.5	4.8	0
50	22	4.55	0	50	14	4.6	0
75	22.5	4.5	0	75	16	-	0
100	23.5	4.85	0	100	18	4.55	0
125	25.5	5.65	32	125	21	-	0
150	25.5	5.6	70	150	23.5	4.55	0
175	24	5.45	46	175	23.5	5.7	16
200	22.5	5.75	19	200	22.5	5.45	68
225	23.5	4.85	2	225	26.5	4.75	14
250	17	4.55	0	250	24.5	4.6	0
275	13	4.55	0	275	17	4.6	0
300	8.5	4.5	0	300	12	4.6	0
325	5.5	4.5	0	325	8.5	4.6	0
350	4.5	4.5	0	350	7.5	4.6	0
375	3.5	4.5	0	375	5.5	4.6	0
400	3.5	4.5	0	400	9.5	4.55	0
425	4.5	4.5	0	425	9.5	4.55	0
450	5.5	4.5	0	450	5.5	4.5	0
475	6.5	4.5	0	475	3	4.7	0
480	0	-		480	0	-	

$$A_t = 19,600 \text{ ft}^2$$

$$T_m = 4.95 \text{ }^{\circ}\text{C}$$

$$T_{PR} = 4.1 \text{ }^{\circ}\text{C}$$

$$A_t = 20,200 \text{ ft}^2$$

$$T_m = 4.8 \text{ }^{\circ}\text{C}$$

NOTE: On Tables D.II-2 through D.II-15 the following nomenclature is used:

A_t = cross section area, ft^2

T_m = mean stream temperature, $^{\circ}\text{C}$

T_{PR} = river temperature at Priest Rapids, $^{\circ}\text{C}$

TABLE D.II-2. (contd) River Temperature Traverses -
400 Yards Below C
(River Mile: 383.8)

Date: 5-26-66
Time: 1105
River Flow Rate: 175,000 cfs

Date: 11-8-64
Time: 0920
River Flow Rate: 40,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	C Effluent Units
0	2	12.5	30	9.5	11.6	0
25	7	12.2	50	10.5	15.0	25
45	20	11.85	75	13	15.0	52
70	27	12.8	100	13	18.6	71
95	30	13.0	125	11.5	17.1	29
120	30	11.85	150	8	15.6	5
145	28	11.75	175	7.5	13.9	0
170	28	11.75	200	13.5	12.0	0
195	24	11.75	225	13	11.6	0
220	19	11.75	250	11.5	11.6	0
245	15	11.75	275	8.5	11.5	0
270	14	11.75	290	5.5	11.3	0
295	10	11.75	330	0	-	0
320	10	11.75				
345	9	11.75				
370	9	11.8				
395	9	11.8				
420	12	11.85				
445	7	11.9				
470	7	12.1				
495	6	12.25				
520	4	12.6				
545	2	13.4				
570	2	13.45				
580	0	-				

$$A_t = 24,600 \text{ ft}^2$$

$$T_m = 12.05 \text{ } ^\circ\text{C}$$

$$T_{PR} = 11.8 \text{ } ^\circ\text{C}$$

$$A_t = 8,500 \text{ ft}^2$$

$$T_m = 14.0 \text{ } ^\circ\text{C}$$

$$T_{PR} = 12.0 \text{ } ^\circ\text{C}$$

TABLE D.II-3. River Temperature Traverses - 0.5 Mile Below C
[River Mile: 383.5 (Plant shore to island only)]

Date: 5-26-66
Time: 1250
River Flow Rate: 185,000 cfs

Date: 5-26-66
Time: 1300
River Flow Rate: 185,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	2	12.55
25	11	12.35
50	15	12.15
70	21	12.05
95	22	13.0
120	24	13.1
145	20	12.25
170	20	11.95
195	23	11.9
220	25	11.9
245	23	11.9
270	21	11.9
295	17	11.9
320	16	11.95
345	12	11.95
370	9	12.0
395	7	12.0
420	5	12.05
445	4	12.05
470	4	12.1
495	2	12.1
505	2	12.1

Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	2	12.5
25	-	12.45
50	-	-
70	18	12.4
95	21	12.2
120	25	12.9
145	22	12.9
170	24	12.3
195	25	11.95
220	25	11.75
245	25	11.75
270	22	11.75
295	20	11.75
320	18	11.75
345	16	11.8
370	15	11.8
395	13	11.8
420	12	11.8
445	9	11.85
470	5	11.95
495	4	11.9
505	2	12.0

$$A_t = 22,300 \text{ ft}^2$$

$$T_m = 12.15 \text{ } ^\circ\text{C}$$

$$T_{PR} = 11.8 \text{ } ^\circ\text{C}$$

$$A_t = 25,500 \text{ ft}^2$$

$$T_m = 12.1 \text{ } ^\circ\text{C}$$

TABLE D.II-4. River Temperature Traverses - 1 Mile Below C
(River Mile: 383.0)

Date: 8-4-64

Time: 1340

River Flow Rate: 185,000 cfs

Date: 8-6-64

Time: 0830

River Flow Rate: 160,000 cfs

Date: 8-6-64

Time: 0840

Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	3.5	17.35	25	11.5	16.85	25	-	16.5
25	7.5	17.25	50	12	-	50	14	16.8
50	14	17.35	75	13	16.95	75	15	16.85
65	17	17.0	100	14	-	100	16	17.0
90	18	16.95	125	15	17.05	125	18	17.25
115	19	17.1	150	15.5	-	150	-	-
140	20	17.15	175	16	17.45	175	-	17.5
165	18	17.15	200	17	17.55	200	19	17.45
190	-	17.05	225	17	17.5	225	19	17.3
215	20	16.95	250	18	17.3	250	17	17.15
240	20	16.9	275	17	17.05	275	16	17.0
265	20	16.9	300	15	16.95	300	17	16.95
290	19	16.9	325	15.5	-	325	17	16.95
315	19	16.9	350	16	16.9	350	15	16.9
365	17	16.9	375	15.5	-	375	14	16.9
415	15	16.9	400	15	16.9	400	12	16.9
465	9.5	16.9	425	11	-	425	9.5	16.9
510	0	-	450	6.5	16.95	450	7.5	16.9
			490	0	--	490	0	-

$$A_t = 23,900 \text{ ft}^2$$

$$T_m = 17.0 \text{ } ^\circ\text{C}$$

$$T_{PR} = 16.4 \text{ } ^\circ\text{C}$$

$$A_t = 18,900 \text{ ft}^2$$

$$T_m = 17.1 \text{ } ^\circ\text{C}$$

$$T_{PR} = 16.4 \text{ } ^\circ\text{C}$$

$$A_t = 18,900 \text{ ft}^2$$

$$T_m = 17.1 \text{ } ^\circ\text{C}$$

TABLE D.II-4. (contd) River Temperature Traverses -
1 Mile Below C
(River Mile: 383.0)

Date: 3-18-65 Time: 1050 River Flow Rate: 95,000 cfs				Date: 5-26-66 Time: 1142 River Flow Rate: 177,000 cfs		
Distance from Plant Shore, yd	Depth, ft	Temp, °C	B Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	3.5	4.8	0	5	2	12.2
25	6.5	4.75	0	25	10	12.0
50	12	4.75	0	60	15	11.95
65	16	4.75	0	85	17	12.1
90	17	4.9	0	110	18	12.6
115	18	5.0	0	135	16	12.25
140	20	5.3	4	160	19	11.95
165	15.5	5.6	25	185	18	11.75
190	13.5	5.45	48	210	18	11.7
215	22	4.85	23	235	18	11.7
240	21	4.7	2	260	17	11.7
265	15.5	4.6	0.5	285	16	11.7
290	15.5	4.65	0	310	15	11.75
315	13	4.65	0	335	13	11.75
340	9.5	4.65	0	360	10	11.85
365	6.5	4.65	0	385	9	12.05
390	5.5	4.65	0	410	10	12.1
415	3	4.65	0	495	10	12.0
440	0	-	0	510	10	12.1
				535	5	12.2
				560	2	12.3
				-	-	-

$$A_t = 16,700 \text{ ft}^2$$

$$T_m = 4.9 \text{ } ^\circ\text{C}$$

$$T_{PR} = 4.1 \text{ } ^\circ\text{C}$$

$$A_t = 21,600 \text{ ft}^2$$

$$T_m = 11.95 \text{ } ^\circ\text{C}$$

$$T_{PR} = 11.8 \text{ } ^\circ\text{C}$$

TABLE D.II-5. River Temperature Traverses -
400 Yards Below K
(River Mile: 381.5)

Date: 3-4-66

Time: 1315

River Flow Rate: 115,000 cfs

<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>
5	3.5	5.1
25	8.5	4.0
40	10.5	4.0
65	10.5	4.0
90	10.5	4.9
115	12	4.7
140	16	4.2
165	20	3.8
190	26.5	3.9
215	31.5	4.7
240	31.5	6.0
265	29	3.6
290	28	3.5
315	26.5	3.5
340	16	3.5
365	9.5	3.5
390	9.5	3.5
415	9.5	3.5
440	4.5	3.5
450	3.5	3.6
470	0	-

$$A_t = 22,900 \text{ ft}^2$$

$$T_m = 4.15 \text{ } ^\circ\text{C}$$

$$T_{PR} = 3.4 \text{ } ^\circ\text{C}$$

TABLE D.II-5. (contd) River Temperature Traverses -
400 Yards Below K
(River Mile: 381.5)

Date: 4-3-66
Time: 1015

Date: 4-3-66
Time: 1025
River Flow Rate: 39,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C	KE Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	KE Effluent Units
10	2	11.3	24	10	2	-	-
30	5	11.25	51	30	4	-	30
55	5	13.5	78	55	7	12.0	65
80	15	12.0	51	80	8	13.0	67
105	8	11.5	24	105	9	10.8	24
130	3	11.3	27	130	13	11.5	9
155	11	10.5	21	155	18	12.7	22
180	21	13.5	53	180	33.5	13.0	62
205	29	12.9	78	205	32	14.0	69
230	40	12.7	64	230	36.5	-	62
255	35.5	12.6	65	255	32	-	57
280	30	-	2	280	30	6.5	5
305	29	6.7	0	305	28	6.4	0
330	23	6.5	0	330	25	6.4	0
355	5	6.5	0	355	8	6.4	0
380	5	6.5	0	380	6	6.5	0
405	7	6.6	0	405	7	6.6	0
410	0	-	0	410	0	-	0

$A_t = 20,200 \text{ ft}^2$
 $T_m = 10.8 \text{ }^\circ\text{C}$
 $T_{PR} = 6.3 \text{ }^\circ\text{C}$

$A_t = 21,900 \text{ ft}^2$
 $T_m = 10.0 \text{ }^\circ\text{C (est.)}$

TABLE D.II-5. (contd) River Temperature Traverses -
400 Yards Below 1904-K
(River Mile: 381.5)

Date: 5-20-66

Time: 1105

River Flow Rate: 195,000 cfs

<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>
5	2	12.8
25	11	11.1
50	16	11.1
75	15	11.15
100	15	11.45
125	16	11.55
150	21	11.4
175	26	13.35
200	36.5	13.3
225	39	11.1
250	40	10.95
275	36.5	10.95
300	34.5	11.0
325	31	11.0
350	25	11.05
375	16	11.1
400	17	11.15
425	15	11.2
450	7	11.65
475	4	12.3
490	2	12.7
515	0	-

$$A_t = 31,600 \text{ ft}^2$$

$$T_m = 11.45 \text{ } ^\circ\text{C}$$

$$T_{PR} = 10.6 \text{ } ^\circ\text{C}$$

TABLE D.II-6. River Temperature Traverses -
0.5 Mile Below K
(River Mile: 381.3)

Date: 8-4-64

Time: 1405

River Flow Rate: 185,000 cfs

<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>
50	7.5	17.1
80	15	17.05
105	17	17.2
130	18	17.2
155	21	17.1
180	23.5	17.15
205	24.5	17.45
230	31.5	18.05
255	37.5	18.05
280	37.5	17.5
305	36.5	17.0
355	35.5	16.8
380	34.5	16.8
405	29	16.8
430	18	-
480	0	-

$$A_t = 30,900 \text{ ft}^2$$

$$T_m = 17.2 \text{ } ^\circ\text{C}$$

$$T_{PR} = 16.4 \text{ } ^\circ\text{C}$$

TABEL D.II-6. (contd) River Temperature Traverses -
0.5 Mile Below K
(River Mile: 381.3)

Date: 9-1-64

Time: 1020

River Flow Rate: 80,000 cfs (est.)

Distance from Plant Shore, yd	Depth, ft	Temp, °C	KW Effluent Units
25	5.5	16.8	1
50	5.5	16.8	2
75	7.5	17.2	8
100	8.5	17.4	11
125	12	17.35	10
150	14	17.0	4
175	17	17.15	4
200	25.5	17.4	6
225	28	17.9	15
250	29	17.8	16
275	28	17.2	10
300	28	17.0	1
325	28	16.8	1
350	-	16.6	1
375	20	16.6	1
400	12	16.6	0
425	19	16.55	0
450	18	-	0
500	5.5	16.5	0
525	0	-	0

$$A_t = 25,600 \text{ ft}^2$$

$$T_m = 17.05 \text{ }^{\circ}\text{C}$$

$$T_{PR} = 16.2 \text{ }^{\circ}\text{C}$$

Date: 9-1-64

Time: 0830

River Flow Rate: 80,000 cfs (est.)

Distance from Plant Shore, yd	Depth, ft	Temp, °C	KW Effluent Units
25	5.5	16.8	2
50	7.5	17.05	2
75	8.5	17.2	8
100	8.5	17.6	14
125	11.5	17.3	9
150	14	17.1	2
175	14	17.2	3
200	22.5	17.2	5
225	26.5	17.8	13
250	30.5	17.75	15
275	24.5	17.6	13
300	28	17.1	6
325	27	16.9	-
350	25.5	16.75	-
375	20	16.6	0
400	10.5	16.5	0
425	19	16.5	0
450	18	16.5	0
500	5.5	16.5	0
525	0	-	0

$$A_t = 25,000 \text{ ft}^2$$

$$T_m = 17.45 \text{ }^{\circ}\text{C}$$

$$T_{PR} = 16.1 \text{ }^{\circ}\text{C}$$

TABLE D.II-6. (contd) River Temperature Traverses -
0.5 Mile Below K
(River Mile: 381.3)

Date: 11-28-64

Time: 0830

River Flow Rate: 41,000 cfs

<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>	<u>KW Effluent Units</u>
55	3.5	13.2	20
70	5.5	13.2	30
95	9.5	12.6	34
120	7.5	12.75	36
145	10.5	12.6	35
170	17.5	13.0	35
195	24.5	13.0	36
220	25.0	12.55	31
245	25.5	12.4	34
270	25.5	12.7	37
295	25.5	11.9	31
320	20	-	16
345	10.5	-	7
370	-	8.95	0
395	7.0	8.9	0
420	-	8.9	0
445	-	8.9	0
470	3.5	8.95	0
480	0	-	0

$$A_t = 17,700 \text{ ft}^2$$

$$T_m = 11.75 \text{ } ^\circ\text{C}$$

$$T_{PR} = 9.4 \text{ } ^\circ\text{C}$$

TABLE D.II-6. (contd) River Temperature Traverses -
0.5 Mile Below K
(River Mile: 381.3)

Date: 3-18-65				Date: 3-18-65			
Time: 1130				Time: 1140			
River Flow Rate: 95,000 cfs				River Flow Rate: 95,000 cfs			
Distance from Plant Shore, yd	Depth, ft	Temp, °C	B Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	B Effluent Units
5	-	-	2	5	-	5.55	2
25	3.5	5.2	2	25	5.5	5.2	2
50	8.5	5.3	2	50	4.5	5.25	2
75	8.5	5.2	2	75	7.5	5.4	3
100	10.5	5.5	2	100	-	5.7	3
125	9.5	6.1	3	125	7.5	5.7	7
150	12	6.0	3	150	8.5	5.3	10
175	15	5.6	10	175	12	5.7	18
200	24.5	5.4	14	200	17	6.7	20
225	30.5	6.4	16	225	27	7.1	18
250	33.5	7.5	19	250	32.5	6.2	14
275	32.5	7.8	16	275	31.5	4.75	9
300	29	5.6	9	300	33.5	4.65	3
325	27	5.2	3	325	29	4.6	1
350	23.5	5.0	3	350	29	4.6	1
375	15	4.85	1	375	22	4.6	0
400	7.5	4.8	1	400	8.5	4.6	0
425	10.5	4.75	1	425	9.5	4.6	0
450	9.5	4.7	0	450	7.5	4.7	0
475	5.5	4.75	0	475	5.5	4.7	0
480	0	-	0	480	0	-	0

$$A_t = 23,400 \text{ ft}^2$$

$$T_m = 5.85 \text{ } ^\circ\text{C}$$

$$T_{PR} = 4.2 \text{ } ^\circ\text{C}$$

$$A_t = 22,500 \text{ ft}^2$$

$$T_m = 5.25 \text{ } ^\circ\text{C}$$

TABLE D.II-6. (contd) River Temperature Traverses -
0.5 Mile Below K
(River Mile: 381.3)

Date: 4-8-65
Time: 1043
River Flow Rate: 65,000 cfs
(est.)

Distance from Plant Shore, yd	Depth, ft	Temp, °C
20	4.8	7.95
40	7.2	7.5
90	10.2	7.55
140	15.3	7.05
190	23.3	7.75
240	29.5	7.55
290	28.8	6.0
340	22.3	6.0
390	10	6.0
440	7.5	6.0
455	5.5	6.4
470	0	-

$$A_t = 23,200 \text{ ft}^2$$

$$T_m = 6.8 \text{ } ^\circ\text{C}$$

$$T_{PR} = 5.4 \text{ } ^\circ\text{C}$$

Date: 3-4-66
Time: 1325
River Flow Rate: 115,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C
25	3.5	4.1
70	9.5	4.0
95	10.5	4.3
120	12	4.4
170	14	3.9
195	16	4.0
220	20	4.1
245	24.5	5.9
270	29	5.5
295	29	4.0
320	29	3.5
345	29	3.5
370	26.5	3.5
395	19	3.5
420	13	3.5
445	12	3.5
470	10.5	3.6
495	2	3.6
510	0	-

$$A_t = 24,300 \text{ ft}^2$$

$$T_m = 4.1 \text{ } ^\circ\text{C}$$

$$T_{PR} = 3.4 \text{ } ^\circ\text{C}$$

TABLE D.II-6. (contd) River Temperature Traverses.-
0.5 Mile Below K
(River Mile: 381.3)

Date: 4-3-66				Date: 4-3-66			
Time: 1055				Time: 1105			
River Flow Rate: 39,000 cfs				River Flow Rate: 39,000 cfs			
Distance from Plant Shore, yd	Depth, ft	Temp, °C	KE Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	KE Effluent Units
55	4	11.75	22	55	3	-	-
65	8	12.2	56	65	6	-	43
90	8	12.2	44	90	8	12.05	37
115	10	11.5	30	115	10	12.25	20
140	15	10.9	15	140	14	11.45	16
165	15	10.8	37	165	16	10.5	28
190	16	11.0	50	190	28	11.0	45
215	23	11.1	42	215	31	10.9	40
240	30	10.3	32	240	33.5	10.8	35
265	33.5	9.5	27	265	31	10.1	29
290	36.5	8.5	17	290	31	9.8	28
315	28	7.1	3	315	26	8.45	12
340	16	6.8	0	340	21	6.95	0
365	10	6.7	0	365	19	6.95	0
390	11	6.8	0	390	15	7.55	0
415	9	6.8	0	415	8	7.25	0
440	5	-	0	440	10	7.15	0
455	4	8.0	0	455	4	8.45	0
470	0	-	0	470	0	-	0

$$A_t = 20,400 \text{ ft}^2$$

$$T_m = 9.35 \text{ }^{\circ}\text{C}$$

$$T_{PR} = 6.3 \text{ }^{\circ}\text{C}$$

$$A_t = 20,500 \text{ ft}^2$$

$$T_m = 9.6 \text{ }^{\circ}\text{C}$$

$$T_{PR} = 6.2 \text{ }^{\circ}\text{C}$$

TABLE D.II-6. (contd) River Temperature Traverses -
0.5 Mile Below K
(River Mile: 381.3)

Date: 5-20-66
Time: 1120
River Flow Rate: 195,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	2	11.9
25	6	11.4
70	14	11.3
95	16	11.8
120	16	11.8
145	19	11.45
170	22	11.45
195	23	12.45
220	30	12.6
245	36.5	12.45
270	36.5	11.3
295	36.5	11.0
320	36.5	10.9
345	35.5	10.85
370	29	10.9
395	18	10.95
420	17	10.95
445	15	11.0
470	11	11.7
495	3	12.45
520	0	-

$$A_t = 32,000 \text{ ft}^2$$

$$T_m = 11.45 \text{ } ^\circ\text{C}$$

$$T_{PR} = 10.6 \text{ } ^\circ\text{C}$$

TABLE D.II-7. River Temperature Traverses - 1 Mile Below K
(River Mile: 380.8)

Date: 8-4-64
Time: 1415

River Flow Rate: 185,000 cfs

Date: 8-6-64
Time: 0855

River Flow Rate: 160,000 cfs

Date: 8-6-64
Time: 0905

River Flow Rate: 160,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
50	5.5	16.95	70	3.5	17.1	70	3.5	17.05
75	6.5	16.95	95	6.5	17.0	95	-	-
100	7.5	16.95	120	13	17.1	120	8.5	17.25
125	14	17.15	145	17	17.2	145	-	-
150	20	17.2	170	19	17.3	170	16	17.4
175	28	17.4	195	29	17.5	195	21	17.55
200	34.5	17.7	220	40	18.05	220	39	17.65
225	36.5	17.85	245	40	18.2	245	40	18.1
250	39	17.5	270	-	-	270	40	18.2
275	40	17.05	295	37.5	17.65	295	37.5	17.85
300	40	16.8	320	37.5	17.3	320	36.5	17.25
325	39	16.7	345	38.5	17.0	345	36.5	17.0
350	39	16.65	370	36.5	16.9	370	36.5	16.85
375	38.5	16.65	395	36.5	16.85	395	38.5	16.8
400	34.5	16.7	420	31.5	16.8	420	34.5	16.8
425	28	16.75	445	27	16.8	445	16	16.75
450	19	16.95	470	12	16.75	470	10.5	16.75
475	10.5	-	530	0	-	530	0	-
500	5.5	-						
540	0	-						

$$A_t = 34,300 \text{ ft}^2$$

$$T_m = 17.15 \text{ }^{\circ}\text{C}$$

$$T_{PR} = 16.4 \text{ }^{\circ}\text{C}$$

$$A_t = 34,200 \text{ ft}^2$$

$$T_m = 17.35 \text{ }^{\circ}\text{C}$$

$$T_{PR} = 16.4 \text{ }^{\circ}\text{C}$$

$$A_t = 31,900 \text{ ft}^2$$

$$T_m = 17.35 \text{ }^{\circ}\text{C}$$

TABLE D.II-7. (contd) River Temperature Traverses -
1 Mile Below K
(River Mile: 380.8)

Date: 9-1-64

Time: 1105

River Flow Rate: 100,000 cfs (est.)

Distance from Plant Shore, yd	Depth, ft	Temp, °C	KW Effluent Units
25	4.5	17.3	2
50	11	17.4	5
75	22.5	17.3	6
100	25.5	17.25	3
125	30.5	17.5	7
150	30.5	17.85	11
175	33.5	17.85	9
200	23.5	17.5	1
225	32.5	17.1	0
250	32.5	17.0	0
275	31.5	16.85	0
300	33	16.8	0
325	23.5	16.8	0
350	11	16.8	0
375	4	16.8	0
380	0	-	0

$$A_t = 26,200 \text{ ft}^2$$

$$T_m = 17.25 \text{ } ^\circ\text{C}$$

$$T_{PR} = 16.3 \text{ } ^\circ\text{C}$$

Date: 9-1-64

Time: 1115

River Flow Rate: 100,000 cfs (est.)

Distance from Plant Shore, yd	Depth, ft	Temp, °C
25	4.5	17.3
50	5.5	17.3
75	15	17.3
100	24.5	17.4
125	26.5	17.8
150	33.5	17.8
175	33.5	18.0
200	33.5	17.6
225	32.5	17.0
250	30.5	16.0
275	29	16.9
300	23.5	16.8
325	19	16.8
350	8.5	16.8
375	-	16.9
380	0	-

$$A_t = 23,800 \text{ ft}^2$$

$$T_m = 17.3 \text{ } ^\circ\text{C}$$

TABLE D.II-7. (contd) River Temperature Traverses -
1 Mile Below K
(River Mile: 380.8)

Date: 11-8-64
Time: 1015
River Flow Rate: 40,000 cfs

<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>	<u>C Effluent Units</u>
25	4.5	16.3	12
60	11	16.0	13
85	22	16.05	20
110	27	16.2	25
135	28	15.7	25
160	27	14.95	24
185	27	14.65	20
210	27.5	13.95	13
235	25	13.1	6
260	24	12.55	3
285	19.5	12.25	1
310	9	11.65	0
335	4.5	11.5	0
340	0	-	0

$$A_t = 19,000 \text{ ft}^2$$

$$T_m = 14.45 \text{ } ^\circ\text{C}$$

$$T_{PR} = 12.0 \text{ } ^\circ\text{C}$$

TABLE D.II-7. (contd) River Temperature Traverses -
1 Mile Below K
(River Mile: 380.8)

Date: 11-28-64 Time: 0910 River Flow Rate: 41,000 cfs				Date: 11-28-64 Time: 0925 River Flow Rate: 41,000 cfs			
Distance from Plant Shore, yd	Depth, ft	Temp, °C	KW Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	KW Effluent Units
5	3.5	13.0	10	5	3.5	-	11
20	-	-	11	20	12	-	29
45	22	12.95	32	45	24.5	12.9	38
70	26.5	13.15	37	70	27	13.2	37
95	29	13.35	37	95	29	12.8	33
120	26.5	13.0	37	120	29	12.2	28
145	27	12.0	30	145	26.5	11.2	19
170	29	11.0	23	170	27	10.7	13
195	27	10.4	15	195	29	10.2	1
220	24.5	10.1	12	220	22	9.3	0
245	17	9.5	8	245	-	-	0
270	14	9.1	5	270	8.5	8.8	0
295	5.5	8.9	3	295	-	-	0
315	3.5	8.6	0	315	3.5	8.7	0
320	0	-	0	320	0	-	0

$$A_t = 18,700 \text{ ft}^2$$

$$T_m = 11.55 \text{ } ^\circ\text{C}$$

$$T_{PR} = 9.4 \text{ } ^\circ\text{C}$$

$$A_t = 19,900 \text{ ft}^2$$

$$T_m = 11.35 \text{ } ^\circ\text{C}$$

TABLE D.II-7. (contd) River Temperature Traverses -
1 Mile Below K
(River Mile: 380.8)

Date: 4-4-65

Time: 1030

River Flow Rate: 42,000 cfs

Date: 3-4-66

Time: 1440

River Flow Rate: 115,000 cfs

<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>	<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>
25		9.3	65	3.5	4.4
35		9.1	90	6.5	4.2
60		8.1	115	14	4.3
85		7.2	140	15	4.4
110	No	7.2	165	29	4.1
135	valid	7.35	190	32.5	4.0
160	data	7.25	215	31.5	5.1
185		6.5	240	32.5	5.2
210		5.9	265	31.5	4.1
235		5.5	290	30.5	3.6
260		5.35	315	29	3.6
285		5.3	340	28	3.5
310		5.3	365	19	3.6
335		5.3	390	14	3.6
360		6.1	415	5.5	3.6
375		-	425	3.5	3.7
			455	0	-

 A_t = Unknown T_m = 6.4 °C (est.) T_{PR} = 5.2 °C A_t = 24,000 ft² T_m = 4.1 °C T_{PR} = 3.4 °C

TABLE D.II-7. (contd) River Temperature Traverses -
1 Mile Below K
(River Mile: 380.8)

Date: 5-20-66

Time: 1145

River Flow Rate: 195,000 cfs

<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>
5	2	11.6
25	5	11.7
50	6	11.45
75	6	11.45
100	8	11.7
125	16	11.5
150	25	11.45
175	35.5	11.8
200	39	12.3
225	40	12.3
250	40	11.5
275	39	11.0
300	38	10.95
325	31	11.0
350	29	11.1
375	24	11.2
400	17	11.35
425	9	11.9
450	3	13.5
475	0	-

$$A_t = 30,700 \text{ ft}^2$$

$$T_m = 11.5 \text{ } ^\circ\text{C}$$

$$T_{PR} = 10.6 \text{ } ^\circ\text{C}$$

TABLE D.II-8. River Temperature Traverses - Above N
(River Mile: 380.0)

Date: 2-1-65
Time: 1230

River Flow Rate: 65,000 cfs

Date: 2-10-65
Time: 1350

River Flow Rate: 135,000 cfs

Date: 3-5-65
Time: 0810

River Flow Rate: 90,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	3.5	8.7
25	8.5	8.1
50	12	7.65
95	15.5	6.45
145	14.5	6.2
195	11.5	6.45
245	14	6.8
295	19.5	6.9
345	32.5	5.75
395	33.5	4.8
445	18.5	4.4
495	8.5	4.35
545	5.5	4.35
565	0	-

Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	5.5	4.85
25	14.5	4.35
50	20	4.05
90	22.5	4.05
140	21	4.05
190	18	4.25
240	20.5	4.4
290	25.5	4.6
340	39	4.3
390	40	3.75
440	28	3.45
490	19	3.45
540	12.5	3.5
590	8.5	3.55
600	0	-

Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	4.5	4.0
25	16	4.1
50	15	4.1
75	16.5	4.2
90	17.5	4.2
115	18	4.2
140	18.5	4.2
165	16	4.2
190	16	4.2
215	14.5	4.25
240	15	4.3
265	18.5	4.35
290	21	4.35
315	23	4.4
340	27.5	4.35
365	30.5	4.2
390	35.5	4.0
415	35.0	3.9
440	30	3.65
465	23	3.65
490	15.5	3.6
515	12	3.6
540	10	3.6
565	7.5	3.55
590	3.5	3.55
595	0	-

$$A_t = 27,700 \text{ ft}^2$$

$$T_m = 5.85 \text{ } ^\circ\text{C}$$

$$T_{PR} = 4.2 \text{ } ^\circ\text{C}$$

$$A_t = 39,900 \text{ ft}^2$$

$$T_m = 4.0 \text{ } ^\circ\text{C}$$

$$T_{PR} = 3.0 \text{ } ^\circ\text{C}$$

$$A_t = 33,500 \text{ ft}^2$$

$$T_m = 4.05 \text{ } ^\circ\text{C}$$

$$T_{PR} = 3.6 \text{ } ^\circ\text{C}$$

ABLE D.II-9. River Temperature Traverses - 100 Yards Below N
(River Mile: 379.6)

Date: 6-5-64

Time: 0914

River Flow Rate: 325,000 cfs

<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>
5	5.5	15.3
100	41	12.6
125	39.5	12.65
150	35.5	12.75
175	33.5	12.9
200	-	12.95
225	32.5	13.0
250	37.5	12.95
275	41	12.9
300	45.5	12.75
325	46.5	12.65
350	47.5	12.6
375	46.5	12.5
400	41	12.5
425	35.5	12.5
450	26.5	12.5
475	24.5	12.5
500	22	12.55
525	19	12.55
550	17	12.6
575	12	-
600	7.5	12.7
620	0	-

$$A_t = 56,000 \text{ ft}^2$$

$$T_m = 12.85 \text{ } ^\circ\text{C}$$

$$T_{PR} = 12.0 \text{ } ^\circ\text{C}$$

TABLE D.II-10. River Temperature Traverses - 400 Yards Below N
(River Mile: 379.4)

Date: 8-27-64

Time: 1142

River Flow Rate: 110,000 cfs (est.)

Date: 8-27-64

Time: 1148

River Flow Rate: 110,000 cfs (est.)

Distance from Plant Shore, yd	Depth, ft	Temp, °C	N Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	N Effluent Units
5	5.5	19.3	3	5	3.5	18.9	2
25	12	19.0	3	25	8.5	18.7	2
50	18	18.9	3	50	17	18.5	1
85	25.5	18.45	0	85	26.5	18.35	1
110	28	18.4	0	110	28	18.5	2
135	25.5	18.4	2	135	26.5	18.6	4
160	24.5	19.1	49	160	25.5	19.0	29
185	22.5	19.1	60	185	23.5	19.35	65
210	21	18.8	22	210	22	19.3	73
235	23.5	18.4	3	235	21	18.9	50
260	-	18.25	1	260	22.5	18.4	1
285	30.5	18.15	1	285	30.0	18.1	0
310	31.5	18.0	1	310	31.5	18.1	0
335	31.5	18.0	0	335	30.5	18.05	0
360	27	18.0	0	360	30.5	18.0	0
385	17	17.95	0	385	29.0	17.9	0
410	13	17.9	0	410	21	17.9	0
435	10.5	17.9	0	435	14	17.9	0
460	18	17.9	0	460	9.5	17.9	0
485	7.5	17.9	0	485	7.5	17.95	0
505	7.5	18.0	0	505	7.5	18.0	0
520	0	-	0	520	0	-	0

$$A_t = 32,000 \text{ ft}^2$$

$$T_m = 18.35 \text{ }^{\circ}\text{C}$$

$$T_{PR} = 17.3 \text{ }^{\circ}\text{C}$$

$$T_N = 25 \text{ }^{\circ}\text{C}$$

$$A_t = 32,900 \text{ ft}^2$$

$$T_m = 18.4 \text{ }^{\circ}\text{C}$$

$$T_{PR} = 17.3 \text{ }^{\circ}\text{C}$$

TABLE D.II-10. (contd) River Temperature Traverses -
400 Yards Below N
(River Mile: 379.4)

Date: 9-1-64				Date: 9-1-64			
Time: 1150				Time: 1200			
River Flow Rate: 105,000 cfs (est.)				River Flow Rate: 105,000 cfs (est.)			
Distance from Plant Shore, yd	Depth, ft	Temp, °C	N Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	N Effluent Units
5	4.5	18.0	8	5	4.5	18.1	9
25	5.5	18.0	9	25	7.5	18.0	8
50	7.5	17.9	8	50	20	17.7	7
90	24.5	17.6	6	90	27	17.5	6
115	28	17.8	4	115	22.5	17.5	2
140	26.5	17.8	1	140	26	17.6	1
190	23.5	17.8	-	190	22.5	17.8	-
215	22	17.55	1	215	22	17.75	2
240	24.5	17.35	1	240	22.5	17.7	2
265	23.5	17.2	0	265	29	17.5	2
290	32.5	17.2	0	290	31.5	17.3	2
315	32.5	17.2	0	315	32.5	17.2	2
340	32.5	17.15	0	340	32.5	17.15	2
365	32.5	17.05	0	365	22.5	17.1	2
390	20	17.0	0	390	20	17.0	2
415	15	17.0	1	415	12	17.0	1
440	12	16.95	1	440	10.5	17.0	1
465	9.5	16.9	0	465	8.5	17.0	1
490	7.5	16.95	0	490	6.5	17.0	1
515	7.5	17.1	0	515	4.5	17.3	1
530	3.5	17.2	0	530	-	17.3	0
535	0	-	0	535	0	-	0

$$A_t = 32,300 \text{ ft}^2$$

$$T_m = 17.4 \text{ } ^\circ\text{C}$$

$$T_{PR} = 16.3 \text{ } ^\circ\text{C}$$

$$A_t = 31,200 \text{ ft}^2$$

$$T_m = 17.4 \text{ } ^\circ\text{C}$$

TABLE D.II-10. (contd) River Temperature Traverses -
400 Yards Below N
(River Mile: 379.4)

Date: 9-4-64

Time: 1038

River Flow Rate: 65,000 cfs
(est.)

Date: 9-4-64

Time: 1043

River Flow Rate: 65,000 cfs
(est.)

Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	2	17.85	5	2	18.65
25	7.5	18.35	25	4.5	18.4
50	14	18.2	50	13	18.2
75	22.5	17.9	75	22.5	17.85
100	24.5	17.75	100	24.5	17.9
125	22.5	18.15	125	23.5	18.4
150	20	18.75	150	21	18.85
175	17	19.05	175	19	19.0
200	17	18.5	200	18	18.6
225	22.5	17.95	225	21.5	17.9
250	29	17.55	250	28	17.3
275	28	17.25	275	28	16.9
300	28	17.05	300	28	16.75
325	26	16.8	325	29	16.65
350	17	16.7	350	21	16.6
375	10.5	16.65	375	13	16.55
400	7.5	16.6	400	9.5	16.55
425	4.5	16.6	425	6.5	16.55
450	3.5	16.65	450	4.5	16.6
465	3.5	16.7	465	3.5	16.75
490	0	-	490	0	-

$$A_t = 24,100 \text{ ft}^2$$

$$T_m = 17.65 \text{ } ^\circ\text{C}$$

$$T_{PR} = 16.0 \text{ } ^\circ\text{C}$$

$$T_N = 30 \text{ } ^\circ\text{C (est.)}$$

$$A_t = 25,200 \text{ ft}^2$$

$$T_m = 17.55 \text{ } ^\circ\text{C}$$

TABLE D.II-10. (contd) River Temperature Traverses -
400 Yards Below N
(River Mile: 379.4)

Date: 11-8-64 Time: 1040 River Flow Rate: 40,000 cfs				Date: 11-8-64 Time: 1050 River Flow Rate: 40,000 cfs			
Distance from Plant Shore, yd	Depth, ft	Temp, °C	C Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	C Effluent Units
25	-	-	-	25	4	-	11
50	7.5	16.7	11	50	13	16.6	11
75	16	16.5	10	75	19	16.6	11
100	20	16.3	10	100	20	16.3	11
125	19	15.7	10	125	19	15.9	11
150	18	15.6	11	150	18	15.5	10
175	17	15.6	11	175	18	15.3	9
200	16	15.5	11	200	16	15.35	8
225	15	15.1	11	225	16	15.4	8
250	22.5	15.4	11	250	20	15.3	7
275	24.5	15.0	11	275	23.5	14.8	7
300	24.5	14.6	11	300	24.5	14.2	6
325	24.5	14.0	11	325	24.5	13.9	5
350	23.5	13.3	11	350	22.5	13.5	3
375	20	12.9	9	375	22.5	13.1	1
400	14	12.5	7	400	18	12.7	0
425	6.5	-	3	425	9.5	12.2	0
450	3.5	12.0	0	450	-	12.0	0
460	0	-	0	460	0	-	0

$$\begin{aligned}
 A_t &= 20,600 \text{ ft}^2 \\
 T_m &= 14.85 \text{ }^\circ\text{C} \\
 T_{PR} &= 12.0 \text{ }^\circ\text{C} \\
 T_N &= 45 \text{ }^\circ\text{C (est.)}
 \end{aligned}$$

$$\begin{aligned}
 A_t &= 22,600 \text{ ft}^2 \\
 T_m &= 14.8 \text{ }^\circ\text{C}
 \end{aligned}$$

TABLE D.II-10 (contd) River Temperature Traverses -
400 Yards Below N
(River Mile: 379.4)

Date: 11-28-64				Date: 11-28-64			
Time: 0940				Time: 1000			
River Flow Rate: 41,000 cfs				River Flow Rate: 41,000 cfs			
Distance from Plant Shore, yd	Depth, ft	Temp, °C	KW Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	KW Effluent Units
5	3.5	12.1	30	5	3.5	12.5	30
25	5.5	12.55	30	25	5.5	-	30
50	10.5	12.6	30	50	10.5	-	30
80	20	12.55	31	80	18	12.7	30
105	-	-	-	105	20	12.7	27
130	18	12.2	31	130	18	12.55	24
155	18	-	30	155	18	12.2	21
180	16	11.85	28	180	17	11.9	18
205	16	11.65	27	205	15	-	17
230	15	11.45	26	230	15	11.5	15
255	20	11.3	25	255	20	11.4	15
280	24.5	11.05	23	280	26.5	11.2	12
305	24.5	10.7	20	305	24.5	10.9	9
330	24.5	10.5	17	330	24.5	10.6	6
355	24.5	10.1	14	355	24.5	10.2	2
380	22	9.75	12	380	20	9.85	0
405	12	9.35	8	405	12	9.5	0
430	9.5	9.1	6	430	5.5	9.3	0
455	3.5	-	4	455	4.5	9.1	0
480	3.5	8.8	1	480	3.5	8.8	0
500	0	-	0	500	0	-	0

$$\begin{aligned}
 A_t &= 23,100 \text{ ft}^2 \\
 T_m &= 11.15 \text{ }^\circ\text{C} \\
 T_{PR} &= 9.4 \text{ }^\circ\text{C} \\
 T_N &= 25 \text{ }^\circ\text{C (est.)} \\
 T \text{ (181-N)} &= 12.1 \text{ }^\circ\text{C}
 \end{aligned}$$

$$\begin{aligned}
 A_t &= 22,800 \text{ ft}^2 \\
 T_m &= 11.3 \text{ }^\circ\text{C}
 \end{aligned}$$

TABLE D.II-10. (contd) River Temperature Traverses -
400 Yards Below N
(River Mile: 379.4)

Date: 3-18-65 Time: 1200 River Flow Rate: 95,000 cfs				Date: 3-18-65 Time: 1210 River Flow Rate: 95,000 cfs			
Distance from Plant Shore, yd	Depth, ft	Temp, °C	KW Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	KW Effluent Units
5	2	6.4	10	5	3.5	6.3	10
25	12	6.2	9	25	10.5	6.0	10
50	12	6.2	9	50	18	5.9	10
75	25.5	6.3	14	75	22.5	6.0	11
100	25.5	6.25	14	100	25.5	6.15	14
125	25.5	6.3	14	125	26.5	6.15	14
150	24.5	6.25	14	150	24.5	6.1	14
175	24.5	6.2	14	175	23.5	6.1	14
200	20	6.15	14	200	22	5.95	14
225	26.5	6.1	14	225	20	5.85	13
250	31.5	6.05	14	250	34.5	5.7	13
275	23.5	6.1	13	275	33.5	5.2	11
300	32.5	5.8	10	300	31.5	5.1	8
325	31.5	5.4	6	325	31.5	5.0	5
350	29	5.1	5	350	29	4.9	3
375	23.5	5.05	5	375	20	4.9	2
400	15	4.9	3	400	24.5	4.9	1
425	10.5	4.8	1	425	15	4.8	1
450	7.5	4.8	1	450	13	4.8	1
475	6.5	4.8	1	475	14	4.9	1
500	5.5	4.8	0	500	5.5	4.8	1
515	3.5	5.1	0	515	3.5	5.15	0
520	0	-	0	520	0	-	0

$$A_t = 31,500 \text{ ft}^2$$

$$T_m = 5.8 \text{ } ^\circ\text{C}$$

$$T_{PR} = 4.2 \text{ } ^\circ\text{C}$$

$$A_t = 33,400 \text{ ft}^2$$

$$T_m = 5.55 \text{ } ^\circ\text{C}$$

TABLE D.II-10. (contd) River Temperature Traverses -
400 Yards Below N
(River Mile: 379.4)

Date: 3-31-66

Time: 1055

River Flow Rate: 85,000 cfs

<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>
5	3.5	10.7
25	8.5	9.5
50	24.5	8.3
85	30.5	7.4
110	33.5	7.5
135	29	8.0
160	26.5	11.3
185	24.5	11.1
210	23.5	9.5
235	30	10.1
260	37.5	7.0
285	35.5	6.6
310	35.5	6.1
333	37.5	5.9
360	24.5	5.9
385	15	5.9
410	12	5.9
435	7.5	6.0
460	8.5	6.2
485	6.5	7.3
490	3.5	7.7
495	0	-

$$A_t = 34,600 \text{ ft}^2$$

$$T_m = 7.76 \text{ }^{\circ}\text{C}$$

$$T_{PR} = 5.7 \text{ }^{\circ}\text{C}$$

$$T_N = 54 \text{ }^{\circ}\text{C}$$

$$T (181-N) = 8.0 \text{ }^{\circ}\text{C}$$

TABLE D.II-11. River Temperature Traverses - 0.5 Mile Below N
(River Mile: 379.2)

Date: 2-20-66 Time: 0800 River Flow Rate: 39,000 cfs				Date: 2-20-66 Time: 0810 River Flow Rate: 39,000 cfs			
Distance from Plant Shore, yd	Depth, ft	Temp, °C	N Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	N Effluent Units
5	2	7.95	2	5	2	7.95	4
25	8	7.65	20	25	5	7.85	20
50	14	8.2	53	50	10	8.15	33
80	19	8.35	49	80	19	8.45	51
130	19	8.65	54	130	19	8.45	53
180	16	8.85	57	180	17	8.85	61
230	14	8.05	51	230	15	8.25	53
280	24	6.8	17	280	23	7.05	27
330	23	5.15	0	330	23	5.25	0
380	18	4.45	0	380	18	4.45	0
430	5	4.2	0	430	6	4.2	0
465	2	4.15	0	465	2	4.15	0
485	0	-	0	485	0	-	0

$$\begin{aligned}
 A_t &= 21,900 \text{ ft}^2 \\
 T_m &= 7.0 \text{ }^\circ\text{C} \\
 T_{PR} &= 4.4 \text{ }^\circ\text{C} \\
 T_N &= 53 \text{ }^\circ\text{C} \\
 T(181-N) &= 5.4 \text{ }^\circ\text{C}
 \end{aligned}$$

$$\begin{aligned}
 A_t &= 21,700 \text{ ft}^2 \\
 T_m &= 7.0 \text{ }^\circ\text{C}
 \end{aligned}$$

TABLE D.II-11. (contd) River Temperature Traverses -
0.5 Mile Below N
(River Mile: 379.2)

Date: 3-31-66

Time: 1145

River Flow Rate: 90,000 cfs

<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>
5	3.5	9.8
25	12	8.6
70	26.5	7.3
90	30	7.4
115	30	7.8
140	28	8.4
165	27	10.0
190	26.5	10.1
215	24.5	9.8
240	23.5	7.6
265	30.5	7.1
290	35.5	6.9
315	36.5	6.4
340	36.5	6.1
365	32.5	6.0
390	23.5	6.0
415	12	6.0
440	5.5	6.5
505	3.5	7.5
515	0	-

$$A_t = 34,500 \text{ ft}^2$$

$$T_m = 7.55 \text{ } ^\circ\text{C}$$

$$T_{PR} = 5.7 \text{ } ^\circ\text{C}$$

$$T_N = 54 \text{ } ^\circ\text{C}$$

$$T (181-N) = 8.0 \text{ } ^\circ\text{C}$$

TABLE D.II-12. River Temperature Traverses - 1 Mile Below N
(River Mile: 378.7)

Date: 2-20-66

Time: 0825

River Flow Rate: 39,000 cfs

Date: 2-20-66

Time: 0837

River Flow Rate: 39,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C	N Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	N Effluent Units
5	2	6.95	6	5	2	6.95	14
25	5	7.6	19	25	4	7.65	22
50	8	7.85	37	50	6	7.95	30
70	11	8.0	33	70	11	8.15	35
120	13	8.0	37	120	15	8.15	42
170	17	8.05	34	170	16	8.05	37
220	15	8.45	48	220	16	8.35	51
270	16	7.35	21	270	15	7.05	29
320	19	6.8	4	320	19	5.9	10
370	20	5.4	0	370	20	4.95	0
420	8	4.85	0	420	8	4.5	0
470	6	4.45	0	470	7	4.35	0
500	2	4.25	0	500	-	4.25	0
515	0	-	0	515	0	-	0

$$A_t = 19,100 \text{ ft}^2$$

$$T_m = 7.0 \text{ } ^\circ\text{C}$$

$$T_{PR} = 4.4 \text{ } ^\circ\text{C}$$

$$T_N = 53 \text{ } ^\circ\text{C}$$

$$A_t = 19,200 \text{ ft}^2$$

$$T_m = 6.9 \text{ } ^\circ\text{C}$$

TABLE D.II-12. (contd) River Temperature Traverses -
1 Mile Below N
(River Mile: 378.7)

Date: 3-31-66

Time: 1205

River Flow Rate: 90,000 cfs

<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>
5	4.5	10.0
25	9.5	9.1
40	12	8.2
60	17	7.6
85	21	7.4
110	28	7.4
135	27	7.8
160	26.5	8.1
185	26.5	9.3
210	27	9.5
235	25.5	8.2
260	26.5	7.1
285	31.5	6.8
310	32.5	6.5
335	33.5	6.2
360	33.5	6.1
385	30	6.0
410	22.5	6.0
435	18	-
460	12	6.1
485	7.5	6.4
510	4.5	6.9
525	3.5	7.6
540	0	-

$$A_t = 35,100 \text{ ft}^2 \quad T_{PR} = 5.7 \text{ } ^\circ\text{C}$$

$$T_m = 7.24 \text{ } ^\circ\text{C} \quad T_N = 54 \text{ } ^\circ\text{C}$$

TABLE D.II-13. River Temperature Traverses -
Above 181-D
(River Mile: 378.0)

Date: 8-4-64
Time: 1440
River Flow Rate: 185,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	8.5	17.55
25	16	17.35
50	19	17.3
75	17	17.35
100	17	17.45
125	19	17.6
150	22	17.85
175	22.5	18.1
200	22	18.0
225	21	17.85
250	18	17.65
275	17	17.45
300	19	17.25
325	21	17.1
350	21	17.0
375	21	16.95
400	19	16.9
425	18	16.9
450	23.5	16.9
475	24.5	16.95
500	22.5	17.1
525	15	-
545	6.5	-
565	0	-

$A_t = 29,300 \text{ ft}^2$
 $T_m = 17.35^\circ \text{C}$
 $T_{PR} = 16.4^\circ \text{C}$
 $T_N = 25^\circ \text{C}$

Date: 6-5-64
Time: 0940
River Flow Rate: 320,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C
60	23.5	13.0
85	22.5	13.05
110	23.5	13.1
135	24.5	13.15
160	27	13.3
185	29	13.4
210	28	13.5
235	28	13.6
260	24.5	13.65
285	23.5	13.7
310	24.5	13.65
335	25.5	13.6
360	26.5	13.6
385	26.5	13.45
410	25.5	13.4
435	25.5	13.35
460	24.5	13.3
485	30	13.3
510	31.5	13.3
535	26.5	13.3
560	20	13.3
585	17	13.3
610	10.5	13.3
635	4.5	13.3
645	0	-

$A_t = 41,900 \text{ ft}^2$
 $T_m = 13.4^\circ \text{C}$
 $T_{PR} = 12.0^\circ \text{C}$

TABLE D.II-13. (contd) River Temperature Traverses -
Above 181-D
(River Mile: 378.0)

Date: 8-6-64

Time: 0940

River Flow Rate: 155,000 cfs

Date: 8-6-64

Time: 1050

River Flow Rate: 155,000 cfs

<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>	<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>
25	13.5	17.45	25	10.5	17.8
60	16.5	17.5	60	16	17.65
85	16	17.55	85	15	17.7
110	15.5	17.65	110	15	17.8
135	16.5	17.8	135	17	17.95
160	19	17.85	160	20	18.1
185	19.5	17.95	185	20	18.15
210	20.5	18.0	210	20	18.1
235	20.5	17.95	235	20	18.0
260	18.5	17.9	260	17	17.9
285	17.5	17.7	285	15	17.85
310	18	17.55	310	17	17.75
335	17	17.5	335	19	17.65
360	19	17.3	360	19	17.55
385	19	17.2	385	19	17.4
410	17	17.1	410	17	17.35
435	20.5	16.95	435	17	17.25
460	23.5	16.95	460	17	17.2
485	23.5	-	485	22	17.15
510	23	16.85	510	23.5	17.15
535	16	16.8	535	22.5	17.1
560	11	16.8	560	12	-
580	0	-	580	0	-

$$A_t = 29,000 \text{ ft}^2$$

$$T_m = 17.45 \text{ } ^\circ\text{C}$$

$$T_{PR} = 16.4 \text{ } ^\circ\text{C}$$

$$A_t = 28,000 \text{ ft}^2$$

$$T_m = 17.6 \text{ } ^\circ\text{C}$$

$$T_{PR} = 16.4 \text{ } ^\circ\text{C}$$

**TABLE D.II-13. (contd) River Temperature Traverses -
Above 181-D
(River Mile: 378.0)**

Date: 8-27-64

Time: 1200

River Flow Rate: 100,000 cfs (est.)

Date: 8-27-64

Time: 1215

River Flow Rate: 100,000 cfs (est.)

Distance from Plant Shore, yd	Depth, ft	Temp, °C	N Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	N Effluent Units
5	3.5	19.1	2	5	3.5	18.8	2
25	10.5	18.9	2	25	12	18.7	2
40	-	-	2	40	12	18.5	1
65	13	-	1	65	12	18.45	1
90	13	18.4	1	40	10.5	18.4	1
115	13	18.4	2	110	13	18.4	2
140	16	18.5	9	140	15	18.5	8
165	16	18.6	20	165	16	18.6	19
190	16	18.7	28	190	16	18.7	29
215	16	18.7	31	215	16	18.7	28
240	15	18.6	18	240	13	18.35	13
265	13	18.4	7	265	13	18.25	6
290	13	18.25	2	290	13	18.15	2
315	15	18.2	1	315	15	18.1	1
340	15	18.15	1	340	15	18.1	0
365	15	18.1	1	365	15	18.0	0
390	15	18.1	1	390	13	18.0	0
415	15	18.05	0	415	13	18.0	0
440	13	18.0	0	440	15	18.05	0
465	15	18.0	0	465	20	18.0	0
490	20	18.05	0	490	20	18.1	0
515	20	18.1	0	515	15	18.15	0
540	17	18.1	0	540	6.5	18.2	0
565	5.5	18.3	0	565	5.5	-	0
575	0	-	0	575	0	-	0

$$A_t = 24,400 \text{ ft}^2$$

$$T_m = 18.35 \text{ } ^\circ\text{C}$$

$$T_{PR} = 17.3 \text{ } ^\circ\text{C}$$

$$T_N = 25 \text{ } ^\circ\text{C (est.)}$$

$$A_t = 22,700 \text{ ft}^2$$

$$T_m = 18.25 \text{ } ^\circ\text{C}$$

$$T_{PR} = 17.3 \text{ } ^\circ\text{C}$$

$$T_N = 25 \text{ } ^\circ\text{C (est.)}$$

TABLE D.II-13. (contd) River Temperature Traverses -
Above 181-D
(River Mile: 378.0)

Date: 9-1-64

Time: 1245

River Flow Rate: 105,000 cfs
(est.)

Date: 11-8-64

Time: 1100

River Flow Rate: 40,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C	C Effluent Units
5	4.5	18.3	5	5.5	16.6	6
25	10.5	18.15	30	7.5	16.1	6
50	14	17.85	55	7.5	16.0	6
75	12.5	17.7	80	7.5	15.85	6
100	12.5	17.7	105	8.5	15.65	6
125	14	17.75	130	9.5	15.55	6
150	16	17.9	155	10.5	15.35	7
175	18	17.9	180	12	15.25	7
200	17.5	17.9	205	12	14.95	7
225	17	17.9	230	8.5	14.7	7
250	17	17.8	255	9.5	14.5	7
275	15	17.8	280	9.5	14.35	7
300	13.5	17.7	305	10.5	14.3	7
325	15	17.6	330	10.5	14.1	7
350	16	17.55	355	11.5	13.95	7
375	16	17.4	380	11.5	13.8	7
400	15.5	17.35	405	10.5	13.6	7
425	15	17.3	430	9.5	13.45	6
450	14.5	17.25	455	7.5	13.35	6
475	15	17.2	480	8.5	13.2	5
500	19	17.2	505	7.5	13.05	5
525	21.5	17.2	530	13	12.55	4
550	18	17.15	555	9.5	-	3
575	9	17.2	580	3.5	11.65	0
600	5	17.4	590	0	-	0
625	4	17.5	(Long)			
635	0	-				

(Long)

$$A_t = 26,700 \text{ ft}^2$$

$$T_m = 17.7 \text{ } ^\circ\text{C}$$

$$T_{PR} = 16.3 \text{ } ^\circ\text{C}$$

$$A_t = 16,200 \text{ ft}^2$$

$$T_m = 14.3 \text{ } ^\circ\text{C}$$

$$T_{PR} = 12.0 \text{ } ^\circ\text{C}$$

$$T_N = 45 \text{ } ^\circ\text{C (est.)}$$

TABLE D.II-13. (contd) River Temperature Traverses -
Above 181-D (River Mile: 378.0)

Date: 11-28-64
Time: 1020
River Flow Rate: 41,000 cfs

<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>	<u>KW Effluent Units</u>
5	3.5	12.5	24
30	8	12.6	29
55	6.5	12.7	29
80	6.5	12.7	29
105	7.5	12.65	29
130	9.5	12.5	28
155	11.5	12.3	26
180	12	12.0	25
205	11.5	11.75	23
230	10	11.6	21
255	8.0	11.4	20
280	8.5	11.3	19
305	10	11.25	18
330	10.5	11.05	17
355	10.5	10.85	15
380	8	10.7	14
405	8	10.55	13
430	8.5	10.45	12
455	14.5	10.35	10
480	14	10.0	8
505	12.5	9.5	5
530	2	8.9	0
535	0	-	0

$$A_t = 14,900 \text{ ft}^2$$

$$T_m = 11.3 \text{ } ^\circ\text{C}$$

$$T_{PR} = 9.4 \text{ } ^\circ\text{C}$$

$$T_N = 25 \text{ } ^\circ\text{C (est.)}$$

TABLE D.II-13. (contd) River Temperature Traverses -
Above 181-D
(River Mile: 378.0)

Date: 3-18-65
Time: 1230
River Flow Rate: 95,000 cfs

Date: 3-18-65
Time: 1240
River Flow Rate: 95,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C	B Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	B Effluent Units
5	3	6.5	13	5	3.5	6.5	13
25	8.5	6.45	13	25	6.5	6.45	13
50	10	6.3	12	50	8.5	6.25	13
75	12	6.2	12	75	10.5	6.0	13
100	10	6.15	13	100	10.5	6.0	13
125	12	6.15	13	125	15	6.0	13
150	15	6.05	13	150	16	5.95	13
175	16	6.0	12	175	16	5.95	13
200	16	5.95	12	200	17	5.95	13
225	14	5.95	12	225	13	5.9	13
250	12	5.95	12	250	12	5.8	13
275	12	5.95	12	275	14	5.6	11
300	14	5.85	11	300	14	5.45	9
325	15	5.8	11	325	15	5.3	8
350	15	5.7	10	350	15	5.2	7
375	14	5.55	9	375	14	5.1	6
400	12	5.35	7	400	14	5.05	6
425	13	5.25	6	425	19	4.95	5
450	17	5.15	5	450	18	4.9	3
475	18	5.1	5	475	16	4.9	1
500	17	5.0	4	500	22	5.0	1
525	8.5	5.0	2	525	12	5.2	0
550	3.5	5.2	0	550	3.5	-	0
555	0	-	0	555	0		

$$A_t = 21,200 \text{ ft}^2$$

$$T_m = 5.7 \text{ } ^\circ\text{C}$$

$$T_{PR} = 4.2 \text{ } ^\circ\text{C}$$

$$A_t = 22,600 \text{ ft}^2$$

$$T_m = 5.5 \text{ } ^\circ\text{C}$$

$$T_{PR} = 4.2 \text{ } ^\circ\text{C}$$

TABLE D.II-13. (contd) River Temperature Traverses -
Above 181-D
(River Mile: 378.0)

Date: 4-8-65
Time: 1120
River Flow Rate: 65,000 cfs
(est.)

Date: 2-13-66
Time: 0745
River Flow Rate: 42,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	2	9.75	5	3	6.8
40	14	8.55	40	9	7.15
90	12	8.05	65	8	7.1
140	17	7.85	90	9	7.1
190	17	7.6	115	13	7.0
240	14	7.5	140	-	6.9
290	14	7.25	190	-	6.9
340	15	6.95	215	8	6.85
390	14	6.65	240	9	6.6
440	18	6.4	265	8	6.3
490	19	6.4	290	10	6.0
540	2	7.05	315	10	5.7
545	0	-	340	11	5.25
			365	10.5	5.15
			390	10	5.1
			415	9	5.9
			440	10	4.8
			465	15	4.65
			490	14	4.45
			515	6	4.2
			525	3	4.2
			530	0	-

$$A_t = 22,800 \text{ ft}^2$$

$$T_m = 7.28 \text{ } ^\circ\text{C}$$

$$T_{PR} = 5.6 \text{ } ^\circ\text{C}$$

$$T_N = 20 \text{ } ^\circ\text{C}$$

$$A_t = 14,900 \text{ ft}^2$$

$$T_m = 5.95 \text{ } ^\circ\text{C}$$

$$T_{PR} = 4.6 \text{ } ^\circ\text{C}$$

$$T_N = 53 \text{ } ^\circ\text{C}$$

TABLE D.II-13. (contd) River Temperature Traverses -
Above 181-D
(River Mile: 378.0)

Date: 2-20-66

Time: 0905

River Flow Rate: 38,000 cfs

Date: 2-20-66

Time: 0915

River Flow Rate: 38,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C	N Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	N Effluent Units
5	2	7.45	19	5	2	7.65	23
25	7	7.8	29	25	8	7.85	25
50	8	8.05	38	50	8	-	-
60	8	8.05	39	60	8	8.15	36
90	6	8.05	40	90	7	8.15	41
140	10	8.15	39	140	9	8.15	39
190	10	8.4	50	190	11	8.3	46
215	-	-	-	215	11	7.95	49
240	8	7.55	26	240	9	7.55	39
290	8	6.95	15	290	9	6.55	20
340	10	6.2	6	340	10	5.9	11
390	10	5.65	2	390	9	5.2	2
440	7	5.15	0	440	9	4.95	1
490	13	4.85	0	490	12	4.85	0
540	6	4.5	0	540	5	4.45	0
550	2	4.45	0	550	-	4.45	0
555	0	-	0	555	0	-	0

$$A_t = 14,100 \text{ ft}^2$$

$$T_m = 6.7 \text{ } ^\circ\text{C}$$

$$T_{PR} = 4.5 \text{ } ^\circ\text{C}$$

$$T_N = 53 \text{ } ^\circ\text{C}$$

$$A_t = 14,600 \text{ ft}^2$$

$$T_m = 6.6 \text{ } ^\circ\text{C}$$

TABLE D.II-13. (contd) River Temperature Traverses -
Above 181-D
(River Mile: 378.0)

Date: 3-17-66
Time: 1040
River Flow Rate: 68,000 cfs

Date: 3-31-66
Time: 1300
River Flow Rate: 90,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	4	7.95
25	9	7.55
40	11	7.35
90	10	7.65
140	14	8.2
190	15	7.9
240	11	6.8
290	11	6.0
340	13	5.6
390	12	5.05
440	11	4.85
490	16	4.7
540	4	4.65
550	0	-

$$A_t = 18,900 \text{ ft}^2$$

$$T_m = 6.4 \text{ } ^\circ\text{C}$$

$$T_{PR} = 4.4 \text{ } ^\circ\text{C}$$

$$T_N = 55 \text{ } ^\circ\text{C}$$

Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	3.5	8.9
40	17	7.7
65	13	7.5
90	15	7.5
140	21	8.3
165	21	9.1
190	21	8.9
215	14	7.7
240	17	7.3
265	18	7.1
290	20	6.9
340	20	6.5
365	16	6.4
390	17	6.3
415	22	6.2
440	24.5	6.1
465	20	-
490	16	6.2
515	10.3	6.4
530	3.5	7.5
540	0	-

$$A_t = 27,100 \text{ ft}^2$$

$$T_m = 7.15 \text{ } ^\circ\text{C}$$

$$T_{PR} = 5.7 \text{ } ^\circ\text{C}$$

$$T_N = 54 \text{ } ^\circ\text{C}$$

**TABLE D.II-13. (contd) River Temperature Traverses -
Above 181-D
(River Mile: 378.0)**

Date: 4-3-66
Time: 1320
River Flow Rate: 38,000 cfs

Date: 4-3-66
Time: 1340
River Flow Rate: 38,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C	KE Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	KE Effluent Units
5	3	-	30	5	3	12.9	30
20	9	12.8	31	20	11	12.9	32
45	9	12.7	31	45	9	12.8	32
70	9	12.5	32	70	9	12.5	33
95	11	11.9	33	95	11	12.3	34
120	15	11.7	33	120	16	12.0	35
145	15	11.5	33	145	15	11.6	33
170	15	11.7	31	170	16	11.4	32
195	15	11.0	28	195	16	11.3	31
220	13	10.6	26	220	13	11.2	30
245	10	10.2	26	245	13	10.9	28
270	11	10.0	25	270	13	10.6	26
295	14	10.0	24	295	13	9.9	24
320	16	9.5	23	320	13	9.8	23
345	14	9.3	22	345	13	9.6	23
370	14	8.8	20	370	17	9.0	20
395	12	8.6	18	395	16	8.7	17
420	12	8.5	17	420	13	8.5	15
445	16	8.4	15	445	21	8.2	13
470	21	8.1	13	470	19	8.0	9
495	18	7.9	10	495	13	7.9	6
520	6	-	3	520	8	8.0	4
525	2	9.0	2	525	2	9.0	2
535	0	-	-	535	0	-	-

$A_t = 20,500 \text{ ft}^2$
 $T_m = 10.0 \text{ }^\circ\text{C}$
 $T_{PR} = 6.4 \text{ }^\circ\text{C}$
 $T_N = 54 \text{ }^\circ\text{C}$

$A_t = 21,000 \text{ ft}^2$
 $T_m = 2.65 \text{ }^\circ\text{C}$
 $T_{PR} = 6.4 \text{ }^\circ\text{C}$

TABLE D.II-14. River Temperature Traverses -
0.5 Mile Below 1904-DR
(River Mile: 376.8)

Date: 8-14-64
Time: 1020
River Flow Rate: 130,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C	DR Effluent Units
70	3.5	18.1	0
95	7.5	18.1	0
120	7.5	18.0	0
145	11.5	17.85	0
170	12	17.85	0
195	18	17.85	0
220	21	17.95	1
245	34.5	18.45	24
370	49.5	18.65	23
295	49.5	18.7	22
320	49.5	18.6	15
345	52.5	18.3	4
370	55	17.85	3
395	17	17.4	0
420	16	17.15	0
470	20	17.1	0
495	12	17.1	0
515	5.5	17.5	0
520	0	-	0

$$A_t = 33,700 \text{ ft}^2$$

$$T_m = 18.1 \text{ } ^\circ\text{C}$$

$$T_{PR} = 16.8 \text{ } ^\circ\text{C}$$

TABLE D.II-14. (contd) River Temperature Traverses -
0.5 Mile Below 1904-DR
(River Mile: 376.8)

Date: 4-11-65

Time: 1015

River Flow Rate: 53,000 cfs

Date: 4-11-65

Time: 1030

River Flow Rate: 53,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C	D Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	D Effluent Units
25	4.5	8.7	11	25	4.5	8.7	11
40	5.5	8.7	11	40	6.5	8.7	11
65	8.5	8.65	10	65	11	8.85	6
90	17	8.55	9	90	15	9.0	2
115	21	8.65	9	115	25.5	8.8	0
140	25.5	8.75	6	140	38.5	8.7	0
165	40	8.9	2	165	39	8.7	24
190	40	8.45	25	190	41	8.7	26
215	42	8.45	31	215	-	8.5	-
240	43	8.25	22	240	38.5	8.3	27
265	45.5	7.35	8	265	44.5	7.55	6
290	33.5	7.05	0	290	44	7.35	1
310	24.5	7.15	0	310	33.5	7.35	1
335	16	7.25	0	335	20	7.35	0
355	2	7.55	0	355	2	7.35	0
360	0	-	0	360	0	-	0

$$A_t = 26,600 \text{ ft}^2$$

$$T_m = 8.15 \text{ } ^\circ\text{C}$$

$$T_{PR} = 6.0 \text{ } ^\circ\text{C}$$

$$T_N = 35 \text{ } ^\circ\text{C}$$

$$A_t = 29,100 \text{ ft}^2$$

$$T_m = 8.2 \text{ } ^\circ\text{C}$$

TABLE D.II-14. (contd) River Temperature Traverses -
0.5 Mile Below 1904-DR
(River Mile: 376.8)

Date: 3-31-66
Time: 1420
River Flow Rate: 90,000 cfs

<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>
15		9.2
35		8.7
60		8.5
85		8.1
110		7.9
135		7.8
160	No	7.8
185	valid	8.9
210	data	9.1
235		9.1
260		9.0
285		8.0
310		6.6
335		6.3
360		6.3
390		6.3
415		6.4
435		6.4
440		-

A_t = Unknown
 T_m = 7.8 °C (est.)
 T_{PR} = 5.7 °C
 T_N = 54 °C

TABLE D.II-15. River Temperature Traverses -
1 Mile Below DR
(River Mile: 376.3)

Date: 8-14-64
Time: 1030
River Flow Rate: 130,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C	DR Effluent Units
15	5	18.1	0
65	32	18.3	10
90	36	18.4	12
115	32	18.5	13
140	32	18.6	14
165	26	18.6	14
190	24	18.5	13
215	22	18.5	11
240	21	18.4	11
265	22	18.35	8
290	21	18.25	7
315	20	18.15	5
340	21	17.95	5
365	22	17.9	5
390	22	17.9	6
415	23	17.95	1
440	24	17.8	0
465	22	17.6	0
515	26	17.3	0
540	13	17.3	0
560	4	17.3	0
565	0	-	0

$$A_t = 38,000 \text{ ft}^2$$

$$T_m = 18.1 \text{ } ^\circ\text{C}$$

$$T_{PR} = 16.8 \text{ } ^\circ\text{C}$$

TABLE D.II-15. (contd) River Temperature Traverses -
1 Mile Below DR
(River Mile: 376.3)

Date: 8-27-64

Time: 1245

River Flow Rate: 115,000 cfs

Date: 8-27-64

Time: 1255

River Flow Rate: 115,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C	N Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	N Effluent Units
5	3.5	19.8	5	5	4.5	19.0	2
30	8.5	19.3	2	30	15	19.0	7
55	22	19.2	5	55	26.5	19.0	14
80	25.5	19.1	12	80	29	18.9	14
105	25.5	19.0	12	105	25.5	18.9	14
130	25.5	19.1	15	130	24.5	18.9	12
155	22.5	19.1	15	155	22.5	18.85	9
180	27	19.1	16	180	22.5	18.8	9
205	20	19.1	17	205	22.5	18.8	11
230	20	19.1	17	230	22.5	18.8	13
255	18	18.95	14	255	22.5	18.8	12
280	18	18.8	9	280	24.5	18.7	11
305	18	18.7	8	305	24.5	18.6	10
330	19	18.65	8	330	25.5	18.35	6
355	19	18.55	7	355	26.5	18.3	5
380	19	18.6	8	380	26.5	18.2	3
405	18	18.5	8	405	26.5	18.1	2
430	26.5	18.45	5	430	29	18.1	2
470	20	18.2	1	470	15	18.0	1
495	10.5	18.2	1	495	7.5	18.1	0
515	4.5	18.1	0	515	-	-	0
520	0	-	0	520	0	-	0

$$\begin{aligned}
 A_t &= 29,900 \text{ ft}^2 \\
 T_m &= 18.85 \text{ } ^\circ\text{C} \\
 T_{PR} &= 17.3 \text{ } ^\circ\text{C} \\
 T_N &= 25 \text{ } ^\circ\text{C (est.)}
 \end{aligned}$$

$$\begin{aligned}
 A_t &= 33,800 \text{ ft}^2 \\
 T_m &= 18.55 \text{ } ^\circ\text{C} \\
 T_{PR} &= 17.3 \text{ } ^\circ\text{C}
 \end{aligned}$$

TABLE D.II-15. (contd) River Temperature Traverses -
1 Mile Below DR
(River Mile: 376.3)

Date: 9-1-64
Time: 1300
River Flow Rate: 110,000 cfs
(est.)

Date: 9-1-64
Time: 1310
River Flow Rate: 110,000 cfs
(est.)

Distance from Plant Shore, yd	Depth, ft	Temp, °C	KW Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	KW Effluent Units
5	4	17.3	10	5	4	-	10
25	7	17.1	10	25	20	17.1	10
50	14	17.2	9	50	27	17.15	9
100	25	17.4	8	100	26	17.2	8
125	23.5	17.5	7	125	24.5	17.3	6
150	22.5	17.5	6	150	24.5	17.45	5
175	22.5	17.55	6	175	24.5	17.55	4
200	21.5	17.75	6	200	24.5	17.7	3
225	21	17.8	5	225	23.5	17.8	3
250	20	17.9	4	250	24.5	17.8	3
275	21	17.95	3	275	22.5	17.8	3
300	21	18.0	3	300	22.5	17.9	3
325	21	18.05	2	325	23.5	17.9	3
350	21	18.1	2	350	24.5	17.9	2
375	22.5	18.1	2	375	24.5	17.9	2
400	24.5	18.1	2	400	24.5	17.9	2
425	31	18.0	2	425	26	17.9	2
450	-	18.0	2	450	29	17.95	2
475	31	18.25	2	475	28	18.0	1
500	32.5	18.3	-	500	7	18.15	1
525	20	18.4	-	525	5	18.8	1
540	3	18.8	1	540	3	18.8	1
545	0	-	-	545	0	-	-

$$A_t = 33,900 \text{ ft}^2$$

$$T_m = 17.9 \text{ }^{\circ}\text{C}$$

$$T_{PR} = 16.3 \text{ }^{\circ}\text{C}$$

$$A_t = 33,000 \text{ ft}^2$$

$$T_m = 17.75 \text{ }^{\circ}\text{C}$$

TABLE D.II-15. (contd) River Temperature Traverses -
1 Mile Below DR
(River Mile: 376.3)

Date: 9-4-64
Time: 1200
River Flow Rate: 85,000 cfs (est.)

<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>
10	5.5	18.95
15	12	18.9
40	36.5	18.85
65	42	18.8
90	29	18.75
115	22.5	18.65
140	20	18.55
165	18	18.45
190	19	18.35
215	20	18.2
240	19	18.05
265	19	17.9
290	20	17.75
315	20	17.55
340	21	17.45
365	21.5	17.35
390	22.5	17.25
425	27	17.25
450	21.5	17.2
470	4.5	17.25
475	0	-

$$A_t = 31,200 \text{ ft}^2$$

$$T_m = 17.7 \text{ } ^\circ\text{C}$$

$$T_{PR} = 16.1 \text{ } ^\circ\text{C}$$

$$T_N = 30 \text{ } ^\circ\text{C (est.)}$$

TABLE D.II-15. (contd) River Temperature Traverses -
1 Mile Below DR
(River Mile: 376.3)

Date: 9-9-64

Time: 1145

River Flow Rate: 100,000 cfs
(est.)

Date: 9-9-64

Time: 1155

River Flow Rate: 100,000 cfs
(est.)

Distance from Plant Shore, yd	Depth, ft	Temp, °C
10	3.5	19.75
35	28	19.5
60	21	19.35
85	22.5	19.25
110	27	19.2
135	24.5	19.2
160	22.5	19.15
185	-	-
210	22	18.95
235	22	18.8
260	20	18.7
285	20	18.6
310	21	18.55
335	22.5	18.4
360	22.5	18.1
385	22.5	17.7
410	24.5	17.2
440	28	17.0
465	21	16.9
485	2	17.0
490	0	-

$$A_t = 32,400 \text{ ft}^2$$

$$T_m = 18.55 \text{ }^{\circ}\text{C}$$

$$T_{PR} = 16.1 \text{ }^{\circ}\text{C}$$

$$T_N = 35 \text{ }^{\circ}\text{C (est.)}$$

Distance from Plant Shore, yd	Depth, ft	Temp, °C
10	-	19.75
35	15	19.7
60	15	19.55
85	24.5	19.45
110	25.5	19.25
135	24.5	19.15
160	22.5	19.0
185	22	18.8
210	22.5	18.55
235	22	18.2
260	21	18.15
285	22	18.45
310	22.5	18.6
335	22.5	18.35
360	22.5	17.95
385	23.5	17.75
410	24.5	17.35
440	29	17.1
465	25.5	16.9
485	3.5	15.85
490	0	-

$$A_t = 30,200 \text{ ft}^2$$

$$T_m = 18.35 \text{ }^{\circ}\text{C}$$

$$T_{PR} = 16.1 \text{ }^{\circ}\text{C}$$

TABLE D.II-15. (contd) River Temperature Traverses -
1 Mile Below DR
(River Mile: 376.3)

Date: 9-9-64

Time: 1200

River Flow Rate: 100,000 cfs
(est.)

Date: 9-9-64

Time: 1300

River Flow Rate: 110,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C
10	4.5	19.65
35	24.5	19.4
60	15	19.3
85	25.5	19.25
110	27	19.15
135	24.5	19.1
160	22.5	19.0
185	21	18.9
210	22	18.7
235	22.5	18.55
260	20	18.3
285	21	18.1
310	22	18.0
335	22	17.85
360	22.5	17.6
385	23.5	17.3
410	24.5	17.15
440	29	16.95
465	19	16.9
485	3.5	16.95
490	0	-

$$A_t = 31,100 \text{ ft}^2$$

$$T_m = 18.3 \text{ } ^\circ\text{C}$$

$$T_{PR} = 16.1 \text{ } ^\circ\text{C}$$

Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	2	19.05
10	4.5	18.95
35	15	18.9
60	26.5	18.7
85	24.5	18.5
110	28	18.3
135	23.5	18.3
160	22.5	18.25
185	20	18.15
210	20	18.05
235	21	17.95
260	20	17.8
285	20	17.8
310	21	17.8
335	21	17.65
360	22	17.55
385	22.5	17.5
410	24.5	17.1
440	29	17.0
465	18	16.95
485	3.5	17.0
490	0	-

$$A_t = 30,600 \text{ ft}^2$$

$$T_m = 17.9 \text{ } ^\circ\text{C}$$

$$T_{PR} = 16.2 \text{ } ^\circ\text{C}$$

TABLE D.II-15. (contd) River Temperature Traverses -
1 Mile Below DR
(River Mile: 376.3)

Date: 11-8-64

Time: 1140

River Flow Rate: 40,000 cfs

Date: 11-8-64

Time: 1150

River Flow Rate: 40,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C	C Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	C Effluent Units
5	3.5	-	5	5	-	15.4	6
30	13	-	5	30	27	15.1	6
55	18	15.6	5	55	22	15.1	6
80	22.5	15.55	5	80	18	15.1	6
105	22.5	15.3	5	105	19	15.3	6
130	21	15.2	5	130	20	15.2	6
155	19	15.2	5	155	24.5	15.1	6
180	18	15.2	5	180	22.5	15.1	6
205	18	15.3	5	205	23.5	15.05	6
230	18	15.3	5	230	24.5	15.0	6
255	17	15.3	5	255	24.5	15.0	6
280	18	15.35	5	280	24.5	15.0	6
305	18	15.35	5	305	24.5	15.0	6
330	19	15.3	5	330	24.5	15.25	6
355	19	15.3	5	355	20	15.25	6
380	19	15.3	5	380	21	15.0	6
405	20	15.2	5	405	21	15.0	6
430	21	15.2	5	430	22.5	14.95	6
455	23.5	15.25	5	455	24.5	14.9	6
480	17	15.25	4	480	-	-	6
500	6.5	15.0	0	500	4.5	-	6
505	0	-	0	505	0	-	-

$$A_t = 27,300 \text{ ft}^2$$

$$T_m = 15.3 \text{ } ^\circ\text{C}$$

$$T_{PR} = 12.0 \text{ } ^\circ\text{C}$$

$$T_N = 45 \text{ } ^\circ\text{C (est.)}$$

$$A_t = 30,400 \text{ ft}^2$$

$$T_m = 15.05 \text{ } ^\circ\text{C}$$

$$T_{PR} = 12.0 \text{ } ^\circ\text{C}$$

TABLE D.II-15. (contd) River Temperature Traverses -
1 Mile Below DR
(River Mile: 376.3)

Date: 11-28-64

Time: 1120

River Flow Rate: 41,000 cfs

Date: 2-28-65

Time: 1005

River Flow Rate: 100,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C	KW Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	3.5	12.2	25	5	4.5	5.0
30	10.5	-	25	30	7.5	5.65
55	14	12.4	25	55	14	5.6
80	22	12.4	25	80	23.5	5.55
105	22	12.45	25	105	26.5	5.55
130	21	12.5	25	130	25.5	5.5
155	19	12.6	25	155	23.5	5.45
180	18	12.65	25	180	21	5.25
205	19	12.5	24	205	22	5.15
230	19	12.4	24	230	22	5.15
255	18	12.3	23	255	22.5	5.15
280	20	12.2	23	280	20	5.15
305	20	12.15	23	305	21	5.05
330	21	11.85	22	330	22	4.95
355	22	11.7	22	355	22	4.85
380	22.5	11.6	22	380	22	4.85
405	22.5	11.5	22	405	22.5	4.85
430	23.5	11.45	22	430	25.5	4.8
450	24.5	11.2	22	465	29	4.75
475	20	11.3	22	490	19	4.7
495	3.5	11.2	22	510	4.5	4.6
500	0	-	-	515	0	-

$$A_t = 28,100 \text{ ft}^2$$

$$T_m = 12.05 \text{ } ^\circ\text{C}$$

$$T_{PR} = 9.4 \text{ } ^\circ\text{C}$$

$$T_N = 25 \text{ } ^\circ\text{C (est.)}$$

$$A_t = 31,800 \text{ ft}^2$$

$$T_m = 5.1 \text{ } ^\circ\text{C}$$

$$T_{PR} = 3.2 \text{ } ^\circ\text{C}$$

$$T_N = 50 \text{ } ^\circ\text{C}$$

TABLE D.II-15. (contd) River Temperature Traverses -
1 Mile Below DR
(River Mile: 376.3)

Date: 2-28-65

Time: 1040

River Flow Rate: 100,000 cfs

Date: 3-6-65

Time: 0920

River Flow Rate: 85,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	4.5	5.4
35	14	5.4
60	18	5.4
85	25.5	5.35
110	26.5	5.35
135	25.5	5.3
160	23.5	-
185	20	-
210	23.5	5.1
235	22.5	5.1
260	21	5.0
285	22	4.95
310	24.5	-
335	27	4.8
360	25.5	-
385	23.5	4.7
410	24.5	4.55
435	25.5	4.4
470	29	4.25
495	24.5	4.25
515	4.5	4.2
520	0	-

Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	3.5	5.8
20	7.5	5.8
45	14	5.9
70	22	5.85
95	24.5	5.7
120	27	5.6
145	23.5	5.55
170	22	5.55
195	21	5.5
220	22	5.5
245	21	5.5
270	21	5.45
295	20	5.4
320	21	5.35
345	22	5.25
370	-	5.2
395	22.5	5.15
420	22.5	5.1
445	23.5	-
480	25.5	-
505	16	-
525	4.5	-
530	0	-

$$A_t = 34,400 \text{ ft}^2$$

$$T_m = 4.95 \text{ }^{\circ}\text{C}$$

$$T_{PR} = 3.2 \text{ }^{\circ}\text{C}$$

$$A_t = 25,800 \text{ ft}^2$$

$$T_m = 5.5 \text{ }^{\circ}\text{C (est.)}$$

$$T_{PR} = 3.6 \text{ }^{\circ}\text{C}$$

TABLE D.II-15. (contd) River Temperature Traverses -
1 Mile Below DR
(River Mile: 376.3)

Date: 4-11-65
Time: 1040
River Flow Rate: 55,000 cfs

<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>	<u>D Effluent Units</u>
5	3.5	8.55	17
10	12	8.45	17
35	29	8.45	17
60	23.5	8.45	17
85	22.5	8.5	17
110	24.5	8.5	19
135	20	8.45	22
160	17	8.35	23
185	16	8.3	24
210	16	8.25	23
235	17	8.25	20
260	15	8.25	20
285	-	8.15	19
310	17	8.1	17
335	17	7.9	16
360	-	7.75	13
385	18	7.6	9
410	20	7.6	9
440	23.5	7.7	12
465	20	7.65	11
485	3.5	7.4	5
490	0	-	-

$$A_t = 27,100 \text{ ft}^2$$

$$T_m = 8.15 \text{ } ^\circ\text{C}$$

$$T_{PR} = 6.0 \text{ } ^\circ\text{C}$$

$$T_N = 35 \text{ } ^\circ\text{C}$$

TABLE D.II-15. (contd) River Temperature Traverses -
1 Mile Below DR
(River Mile: 376.3)

Date: 2-13-66

Time: 0915

River Flow Rate: 42,000 cfs

Date: 2-13-66

Time: 1140

River Flow Rate: 48,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C
15	2	7.05
25	16	7.05
50	35.5	7.05
75	33.5	7.05
100	34.5	7.1
125	21	7.15
150	18	7.15
175	16	7.1
200	15	7.05
225	15	6.85
250	-	6.85
275	-	6.8
300	15	6.75
325	16	6.7
350	17	6.6
375	18	6.3
400	19	6.0
425	19	5.7
455	21	-
480	23	5.6
500	3	6.1
505	0	-

$$A_t = 28,600 \text{ ft}^2$$

$$T_m = 6.7 \text{ } ^\circ\text{C}$$

$$T_{PR} = 4.6 \text{ } ^\circ\text{C}$$

$$T_N = 53 \text{ } ^\circ\text{C}$$

Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	2	7.3
15	21	7.25
40	31	7.2
65	34	7.2
90	29	7.2
115	20	7.15
140	17	6.95
165	16	6.9
190	14.5	6.9
215	13	6.9
240	14	6.95
265	15	6.95
290	15	6.4
315	15	6.7
340	15	6.55
365	17	6.3
390	17	6.0
415	19	5.7
445	24	5.65
470	21	5.55
490	3	5.55
495	0	-

$$A_t = 27,400 \text{ ft}^2$$

$$T_m = 6.7 \text{ } ^\circ\text{C}$$

$$T_{PR} = 4.4 \text{ } ^\circ\text{C}$$

TABLE D.II-15. (contd) River Temperature Traverses -
1 Mile Below DR
(River Mile: 376.3)

Date: 2-20-66

Time: 0950

River Flow Rate: 38,000 cfs

Date: 2-20-66

Time: 1000

River Flow Rate: 38,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C	N Effluent Units	Distance from Plant Shore, yd	Depth, ft	Temp, °C	N Effluent Units
5	3	7.45	25	5	3	7.55	28
15	13	7.4	25	15	16	7.6	28
65	29	7.55	27	65	29	7.65	28
115	19	7.7	29	115	23	7.6	30
165	15	7.55	27	165	16	7.55	28
215	16	7.55	26	215	15	7.65	30
265	15	7.55	28	265	16	7.55	29
315	17	7.45	26	315	16	7.45	29
365	16	7.15	24	365	18	6.85	26
415	18	6.95	17	415	18	6.4	17
445	22	6.3	14	445	16	6.0	13
470	18	6.15	12	470	9	5.9	12
490	3	6.0	12	490	3	6.0	12
495	0	-	-	495	0	-	-

$$A_t = 25,500 \text{ ft}^2$$

$$T_m = 7.3 \text{ } ^\circ\text{C}$$

$$T_{PR} = 4.6 \text{ } ^\circ\text{C}$$

$$T_N = 53 \text{ } ^\circ\text{C}$$

$$A_t = 25,600 \text{ ft}^2$$

$$T_m = 7.3 \text{ } ^\circ\text{C}$$

TABLE D.II-15. (contd) River Temperature Traverses -
1 Mile Below DR
(River Mile: 376.3)

Date: 3-17-66

Time: 1105

River Flow Rate: 70,000 cfs

Date: 3-17-66

Time: 1120

River Flow Rate: 70,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C
10	2	9.0
35	26	8.85
85	28	8.7
135	24	8.35
185	19	7.8
235	18	7.75
285	18	7.9
335	20	8.05
385	21	6.85
435	22	6.4
465	26	5.75
490	12	5.65
510	3	5.65
515	0	-

Distance from Plant Shore, yd	Depth, ft	Temp, °C
10	2	9.0
35	15	9.05
85	25	8.9
135	24	8.8
185	17	8.9
235	18	8.45
285	18	7.85
335	19	6.95
385	21	6.4
435	24	6.55
465	26	6.55
490	15	6.4
510	3	5.65
515	0	-

$$A_t = 30,900 \text{ ft}^2$$

$$T_m = 7.7 \text{ } ^\circ\text{C}$$

$$T_{PR} = 4.3 \text{ } ^\circ\text{C}$$

$$T_N = 55 \text{ } ^\circ\text{C}$$

$$A_t = 29,200 \text{ ft}^2$$

$$T_m = 7.8 \text{ } ^\circ\text{C}$$

$$T_{PR} = 4.3 \text{ } ^\circ\text{C}$$

TABLE D.II-15. (contd) River Temperature Traverses -
1 Mile Below DR
(River Mile: 376.3)

Date: 3-17-66

Time: 1235

River Flow Rate: 73,000 cfs

Date: 3-31-66

Time: 1445

River Flow Rate: 90,000 cfs

Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	2	8.95
35	21	8.85
85	27	8.65
135	25	8.35
185	20	8.15
235	19	7.5
285	18	7.35
335	20	7.15
385	21	6.95
435	22	6.3
465	25	5.9
490	13	5.65
510	3	5.6
515	0	-

Distance from Plant Shore, yd	Depth, ft	Temp, °C
5	2	8.7
10		8.8
35		8.9
60		8.1
85		8.2
110		8.4
135	No	8.3
160	valid	8.3
185	data	8.2
210		8.0
235		7.9
260		8.1
285		7.9
310		8.4
360		8.1
410		7.1
445		6.5
470		6.5
490	3	6.5
495	0	-

$$A_t = 31,500 \text{ ft}^2$$

$$T_m = 7.6 \text{ }^{\circ}\text{C}$$

$$T_{PR} = 4.3 \text{ }^{\circ}\text{C}$$

$$A_t = \text{Unknown}$$

$$T_m = 7.9 \text{ }^{\circ}\text{C (est.)}$$

$$T_{PR} = 5.7 \text{ }^{\circ}\text{C}$$

$$T_N = 54 \text{ }^{\circ}\text{C}$$

TABLE D.II-15. (contd) River Temperature Traverses -
1 Mile Below DR
(River Mile: 376.3)

Date: 4-3-66
Time: 1430
River Flow Rate: 39,000 cfs

<u>Distance from Plant Shore, yd</u>	<u>Depth, ft</u>	<u>Temp, °C</u>	<u>KE Effluent Units</u>
10		11.5	26
35		11.5	26
60		11.5	26
85		11.6	27
110		11.5	27
135		11.5	27
160		11.55	26
185	No valid data	11.5	26
210		11.35	26
235		11.25	26
260		11.25	26
285		11.2	26
310		11.3	25
335		11.45	26
360		10.95	26
385		10.65	24
410		10.25	23
420		10.1	21
445		9.8	20
465		9.8	20
470	0	-	-

A_t = Unknown

T_m = 11.1 °C (est.)

T_{PR} = 6.6 °C

T_N = 54 °C

APPENDIX E
ENVIRONMENTAL EFFECTS
OF AN EXTENDED HANFORD PLANT SHUTDOWN

Abstracted from unpublished notes by R. B. Hall,
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APPENDIX E

ENVIRONMENTAL EFFECTS
OF AN EXTENDED HANFORD PLANT SHUTDOWNINTRODUCTION

The work stoppage and consequent shutdown of the plutonium production facilities in the summer of 1966 resulted in a marked reduction in the discharge of radionuclides and heat to the Columbia River and, to a lesser extent, to the discharge of effluents from the Chemical Separations Plants to the atmosphere and to the ground. The extent to which this curtailment of effluent discharge resulted in reductions in the levels of radioactive materials in the environment and in the thermal and chemical impacts on the Columbia River is of substantial interest to the Division of Production and Operational Safety and to the Research Divisions sponsoring studies on the river. Because of this broad interest, the Pacific Northwest Laboratory was asked^(E1) to prepare a comprehensive report assessing the impact of the shutdown. This report is in response to that request.

On July 8, 1966, one reactor (KE) was already down. N Reactor was also shut down on July 8. The other reactors (B,C,D and KW) were shut down by early morning of July 9, because of the work stoppage. All reactors remained down until one reactor (D) resumed operation on August 23, one (KW) on August 24, and three (B,C, and KE) on August 25. Cooling water flow in the five production reactors was reduced to a fraction of normal during the outage.

The river flow rate, illustrated in Figure E-1, dropped from levels near the maximum for the year to levels near normal for the fall and winter months during the outage period.

FIGURE E-1. Columbia River Flow Rate at Richland

Under ordinary conditions, the concentration of reactor effluent in the Columbia River increases markedly during this time because of the reduced flow available for dilution.

A shortage of personnel also forced curtailment of chemical separations processing from July 8 to August 22. No fuel processing was done at the Purex Plant in 200 East Area, but the Redox Plant continued to process material already present in the system. The total radioiodine release did not reach a minimum until September. Water flow was maintained to open pond areas to prevent spread of contamination by the wind. Liquid discharges to the several waste cribs also continued, though of less than normal volume.

The environmental parameters and the operating history during the strike period were such that significant changes were expected only in those environmental measurements directly related to reactor effluents, i.e., river temperature, radioactivity, and chemical content.

The Pacific Northwest Laboratory has, for several years, carried on programs for the AEC that involve the presence and movement of radionuclides through various physical, chemical, and biological systems of the Columbia River and the impact of reactor heat. The simultaneous shutdown of all of the production reactors for an extended period of time caused a unique perturbation that afforded an opportunity to develop additional information on the dynamics of the flux of radionuclides through these systems and on natural heating of the river. Insofar as possible, both regular and special sampling and analysis were undertaken during the period of the shutdown to capitalize on this unusual opportunity.

A full treatment of this is carried in declassified report BNWL-CC-1056.

SUMMARY AND CONCLUSIONS

With the shutdown of the reactors during the work stoppage, formation of radionuclides in the coolant system ceased. Small releases of longer-lived nuclides such as ^{46}Sc , ^{54}Mn , ^{65}Zn , and ^{60}Co continued however, owing to erosion and desorption from films on reactor fuels and piping.

Within a few days after the shutdown, the concentrations of reactor-produced radionuclides in the Columbia River dropped to very low levels (in most cases, below the detection levels of analytical procedures used routinely for surveillance purposes). However, the quantities of ^{65}Zn , ^{54}Mn , ^{46}Sc , and ^{60}Co in river water did not drop as much as would be expected from the reactor effluent data. It was evident that significant amounts of these nuclides, retained in the bed of the river, were recycled to the water through continued scouring and leaching of the sediments. Samples of sediments from behind McNary Dam indicated that small amounts of radionuclides were leached from the top layers during the shutdown period. During the shutdown, more of the radioactive material transported by the river water was associated with particulates than was present in solution.

In the absence of "fresh" radioactive materials from the reactors, the dose rate from the shoreline within the reservation remained low (ordinarily it increases as river flow diminishes during the summer).

Concentrations of radionuclides in invertebrate organisms of the river decreased by one or two orders of magnitude during the shutdown. The change was greatest in the case of ^{32}P and ^{51}Cr . The levels of ^{65}Zn decreased less than those of other nuclides, suggesting recycling of zinc within the river ecosystem.

Because of the reactor shutdown, the concentration of ^{32}P in juvenile fish decreased by as much as two orders of magnitude. For the flesh of adult fish, the change was about one order of magnitude. The loss was greatest among herbivorous species. In the case of whitefish, the decrease amounted to about 75 percent. The levels of ^{65}Zn in the fish changed much less than those of ^{32}P .

Ordinarily, the concentration of ^{65}Zn in Willapa Bay oysters and in milk from local farms irrigated with Columbia River water increases slightly during the summer. In 1966, the concentration diminished slightly in both of these products.

The radiation dose to Tri-City residents from drinking water was nil during the shutdown period. In effect, this reduced the annual dose to the GI tract for 1966 by about 10 percent for both Richland and Pasco.

Following startup of the reactors late in August, the concentrations of most radionuclides in the effluent, the local river water, and the invertebrate organisms returned to "normal" within a few days time. However, recharging of the storage capacity of the river bed was indicated for ^{65}Zn and some other nuclides by a greater-than-normal time of recovery to preflood concentrations in river water. In the case of adult fish, nearly a month was required before the usual seasonal trends in the concentrations of radionuclides were re-established. The maximum levels obtained during the fall were undoubtedly lower than would have been reached in the absence of the shutdown.

To the casual observer, the effect of the shutdown on Columbia River temperatures was obscured by natural fluctuations of greater magnitude during this period. The real effects are about as predicted, however. Because of the relatively high velocity and turbulence of the river within the reservation, the natural temperature rise (without reactor

heat) between Priest Rapids and Richland is substantially higher than in impounded portions of the river during the summer months. This could easily lead the uninformed observer to an overestimation of the effects of the Hanford reactors.

The chemical separations plants do not ordinarily release enough ^{131}I or other nuclides to the environment to be quantitatively measurable with routine procedures in air, milk, and other samples taken offsite. For this reason, any effect of the shutdown on the levels of airborne contaminants beyond the project boundaries was not evident.

The relatively small and brief decrease in the discharge of liquid waste to ground at the 200 Areas had essentially no effect on the level of contamination in the ground water.

EFFECTS OF A COMPLETE REACTOR SHUTDOWN ON COLUMBIA RIVER TEMPERATURES

During the reactor shutdown, normal temperature monitoring activities were carried out to provide a comparative basis for reference purposes. In addition, several spot surveys were taken at established river mile locations to double check the routine records and examine the transverse temperature distribution of the river under natural conditions.

Several conclusions were developed as a result of these measurements. They are as follows:

1. The normal temperature rise (without reactor heat) between Priest Rapids and Richland is a good deal higher than would be expected from temperature prediction for impounded portions of the river. It is apparent that the increased velocity of the river in this reach increases the heat conduction to a point where the overall exchange coefficient reaches values on the order of 200 to 300 Btu/(day)(°F). Figure E-2 is illustrative of typical values for a lake.

FIGURE E-2. Equilibrium and Surface Temperatures, and Exchange Coefficients for Lake Colorado City, Texas

2. Studies of traverse measurements indicate a very low temperature differential across the river. Elevated temperatures were noted on both river banks. Other than bank heating effects, no individual run exceeded a temperature differential of 0.5 °C.
3. Inasmuch as the run of the river portions on the Columbia system frequently show temperature differentials higher than impounded reaches, it would easily be possible for the uninformed observer to over estimate the effects of the Hanford Plant.

Routine data taken during the shutdown period are illustrated in Figure E-3. Superimposed on the routine data are computed values of river temperature derived by subtracting known reactor input information from the measured values. During the high flow portion of the season, between June 1 and the commencement of the shutdown, reactor temperature inputs did not exceed 0.43 °C on any one day and averaged about 0.35 °C for the period. The measured rise in the plant reach, taking into account the travel time, averaged approximately 0.65 °C in June, 0.75 °C in July, and 0.85 °C through the 25th of August. As the reactors came back on stream the river flows had decreased substantially and temperature increases from plant contribution are noted in the figure. By comparison, essentially little temperature differential of any consequence was noted between Richland and Pasco, a distance of some nine miles, having a total river surface area approximately equal to that between 100 B Area and the city of Richland. It is apparent that the exchange coefficients for the different portions of the river are affected by the current velocity as would be expected by film coefficient correlations. Wind direction undoubtedly plays an important part in absolute computations of surface

FIGURE E-3. Daily Average Columbia River Temperature

coefficients since vector addition of air velocity would be required to compare rapidly moving stream coefficients with those measured on stagnant lakes. As indicated above, coefficients of 200 to 300 were routinely observed in the plant reaches of the Columbia as compared with the values of 150 for impounded reaches.

As an added item of interest, temperatures measured at Grand Coulee (discharge) and Rocky Reach are also illustrated in Figure E-3. During July when the average travel time from Grand Coulee to Richland was about 5 1/3 days, the temperature differential between these points never exceeded 2.6 °C, of which approximately 0.75 °C represents the plant reach increment. Subtraction leaves 1.85 °C as the rise between Grand Coulee and Priest Rapids during the example period illustrated (A on Figure E-3). Since the surface area of the impounded river between Grand Coulee and Priest Rapids exceeds the surface area of the local reach by a factor of 4, it is safe to conclude that exchange coefficients for the impounded river will probably be 50 to 60% of the values for the run-of-the-river reaches. Application of these values to the Richland-to-Pasco reach yields a small, appropriate temperature rise. Examples B and C on Figure E-3 provide a further justification for the conclusions drawn from the data. Most of the input information pertinent to the analysis is available in theoretical form; however, it is rare that an opportunity is given to evaluate theoretical computations with excellent instrumentation on a local basis.

Figure E-4 shows the plotted values for the individual traverse measurements. Thus unusual bank heating noticed in the Hanford-Ringold reach is evident in the data plots. It has been speculated that warm ground water may account for some of this temperature differential. If this were the case, it would be expected that the majority of the temperature rise in the

FIGURE E-4. River Traverse Data for July 13, 1966
(River Flow, 254,000 cfs)

plant reach would occur in this area. The evidence does not strongly support this condition. Ground water inputs can not be ruled out on the basis of present data, however.

EFFECTS OF AN EXTENDED REACTOR OUTAGE ON CHEMICAL CONCENTRATIONS IN THE COLUMBIA RIVER

The only chemicals used routinely by the Hanford plants in sufficient amounts to cause a measurable change in the chemical characteristics of the river are hexavalent chromium and nitrate ion. These chemical species are monitored routinely in the river water below the reactors at Richland. Several other normal chemical characteristics, such as pH, dissolved oxygen, sulfate ion, phosphate, etc., are also measured routinely in the vicinity of the reactors, but no effects of the plant effluents on them have been observed.^(E2)

Sodium dichromate is used as a corrosion inhibitor in the reactor cooling water. The resulting concentration in the Columbia River is ordinarily in the range of 2 to 7 ppb, depending on river flow. During the reactor shutdown, the reduced coolant flow contributed much lower quantities to the river and estimates place the concentration of hexavalent chromium at Richland in the range of 0.2 and 0.7 ppb on the basis of effluent and river flows. Inasmuch as the analytical method used by the laboratory is not sensitive to concentrations below about 1 ppb, positive values were not expected during the shutdown period. Figure E-5 shows the results of the hexavalent chromium measurements for 1966. The result of 4 ppb obtained from a water sample collected during the first week of August was confirmed by laboratory recheck, but remains an unexplained anomaly.

FIGURE E-5. Hexavalent Chromium Ion
in Columbia River Water

The largest potential source of nitrate ion to the Columbia River from Hanford is the chemical separations plants. However, the nitrate must travel with the ground water for many years before reaching the river and even under low river flow conditions, the increment is not obvious. Because of the relatively large amount of natural nitrate ion in the river, the large reservoir of nitrate ion in the ground water beneath the reservation, and the very long travel time between the separations plants and the river, no detectable effect of the work stoppage on the nitrate ion in the Columbia can be expected.

REFERENCES

- E1. P. G. Holsted. *Unpublished Data. AEC Richland Operations Operations Office, August 12, 1966. (Letter: to R. S. Paul).*
- E2. J. P. Corley, H. A. Kramer, and J. K. Soldat. "Section 4-Chemical Characteristics," A Compilation of Basic Data Relating to the Columbia River, HW-69368. December 1961.

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