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A MATHEMATICAL MODEL FOR PREDICTING TEMPERATURES IN RIVERS AND RIVER-RUN RESERVOIRS

CLEAN WATER

FEDERAL WATER POLLUTION CONTROL ADMINISTRATION
NORTHWEST REGION
PORTLAND, OREGON

A MATHEMATICAL MODEL FOR PREDICTING TEMPERATURE IN RIVERS AND RIVER-RUN RESERVOIRS

Prepared by
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United States Department of the Interior
Federal Water Pollution Control Administration
Northwest Region, Portland, Oregon

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The development and testing of the temperature prediction model described in this paper has benefitted from the cooperation and contributions of several individuals, as well as various public and private agencies.

Initial development and programming of the model was done by Mr. William Morse * of the FWPCA, Pacific Northwest Water Laboratory, Corvallis, Oregon.

The hydraulic calculations are adapted from techniques developed by Dr. Bruce Tichenor and Mr. Alden Christianson of the FWPCA, Pacific Northwest Water Laboratory, Corvallis, Oregon.

Mr. Robert Cleary, a graduate student in chemical engineering at the University of Massachusetts, Amherst, Massachusetts, provided technical support while working for the FWPCA, Northwest Regional Office, Portland, Oregon, as a temporary employee during the summer of 1968.

A major part of developing and testing the model has been the compilation and organization of necessary data. The author wishes to thank the US Army Corps of Engineers; Weather Bureau; Bureau of Commercial Fisheries; US Geological Survey; Federal Aviation Agency; Atomic Energy Commission; Chelan, Grant and Douglas County PUD's and Battelle Northwest, for providing hydraulic, meteorologic and water temperature data.

* Mr. Morse is presently a mathematician with the Bonneville Power Administration, Portland, Oregon.

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SUMMARY

A one-dimensional temperature prediction model has been developed and tested on the Columbia River. The model in its present form is operational for use on rivers for which:

(1) Cross-sectional characteristics, including water surface width and cross-sectional area are available.

(2) Adequate meteorologic data is available.

(3) Water surface elevation data is available.

(4) Evaporation and sensible heat flux can be evaluated in terms of regional weather data and the results of representative field studies.

(5) Lateral and vertical variations in temperature are negligible.

(6) The flow can be considered quasi-steady.

Punched cards containing the FORTRAN statements shown in Appendix C can be obtained from the FWPCA, Northwest Regional Office, Portland, Oregon. The program can also be executed directly from the FWPCA data cell at the Department of the Interior Computer Center in Washington, D. C.

INTRODUCTION

Thermal loads imposed upon rivers as a result of heat rejection from manufacturing and power generating industries, impoundment by dams, and irrigation diversion have made temperature an important water quality parameter. Effective water resource planning must, therefore, include adequate methods for predicting and evaluating temperature changes. To fulfill this need the Federal Water Pollution Control Administration, Northwest Regional Office, is developing a computerized system of mathematical models which can be used to predict temperature in rivers and reservoirs.

The model described in this document has been developed primarily for predicting temperatures in rivers which are regulated by dams with run-of-the-river, or small usable storage capacity reservoirs; and which may also have reaches which are free-flowing.

In the river-run model, finite volumes of water, or water parcels, are released from an upstream starting point at specified intervals of time. Individual parcels are followed downstream through reservoirs and open river reaches, and changes in the parcel temperature due to weather, flow regulation, and advected sources are predicted.

The model development program was initiated at the beginning of FY 1968, and was conducted as the Columbia River Temperature Study, a Technical Project of FWPCA, Northwest Regional Office, until February 1968. Since that time the temperature prediction efforts have been incorporated, with the biological effects studies, into the Columbia River Thermal Effects Study. The purpose of the Study, a two-year program, is to provide a scientific basis for the evaluation of the temperature regime of the main stem Columbia River and its effects on the river's ecology, particularly upon the economically important anadromous fishery.

During FY 1968 a mathematical model of river-run reservoir water temperatures was developed and programmed. The model was tested on the portion of the Columbia River between Grand Coulee and Priest Rapids Dams. (See Figure 2.1) This model was limited to river systems which had no advected sources and provided reliable temperature predictions over periods of 10-14 days only. These restrictions have been eliminated in the present model, and portions of the net heat flux calculations have been updated, as well. In addition, test runs have been made on the Columbia River between Priest Rapids and Bonneville Dams, excluding the Hanford Operations area.

This model has been developed for the purpose of predicting temperatures in rivers which are regulated by dams with small storage capacity. It is essential for application of the model that the cross-sectional characteristics of the river be given. Furthermore, it has been assumed that:

(1) The prototype is thermally well-mixed vertically and laterally.

(2) Longitudinal diffusion and dispersion can be neglected

(3) The water surface profile between dams is a function of longitudinal distance only. (Water surface profile refers to the shape of the water surface as seen in a longitudinal section and does not imply an absolute surface elevation.)

(4) Weather data from a representative station is adequate for describing conditions along a specified portion of the river.

(5) Empirically derived coefficients can be used to evaluate heat and mass transfer at the air-water interface.

Given the above assumptions, temperature changes can be predicted from the one-dimensional energy equation:

$$\frac{dT}{dt} = \frac{\partial T}{\partial t} + U\frac{\partial T}{\partial x} = \frac{Q}{\rho c_p D} \qquad (3.1)$$

where

T = water temperature

U = longitudinal water velocity

Q = net heat flux at the water surface

t = time

D = depth of water

c_p = specific heat of water

ρ = density of water

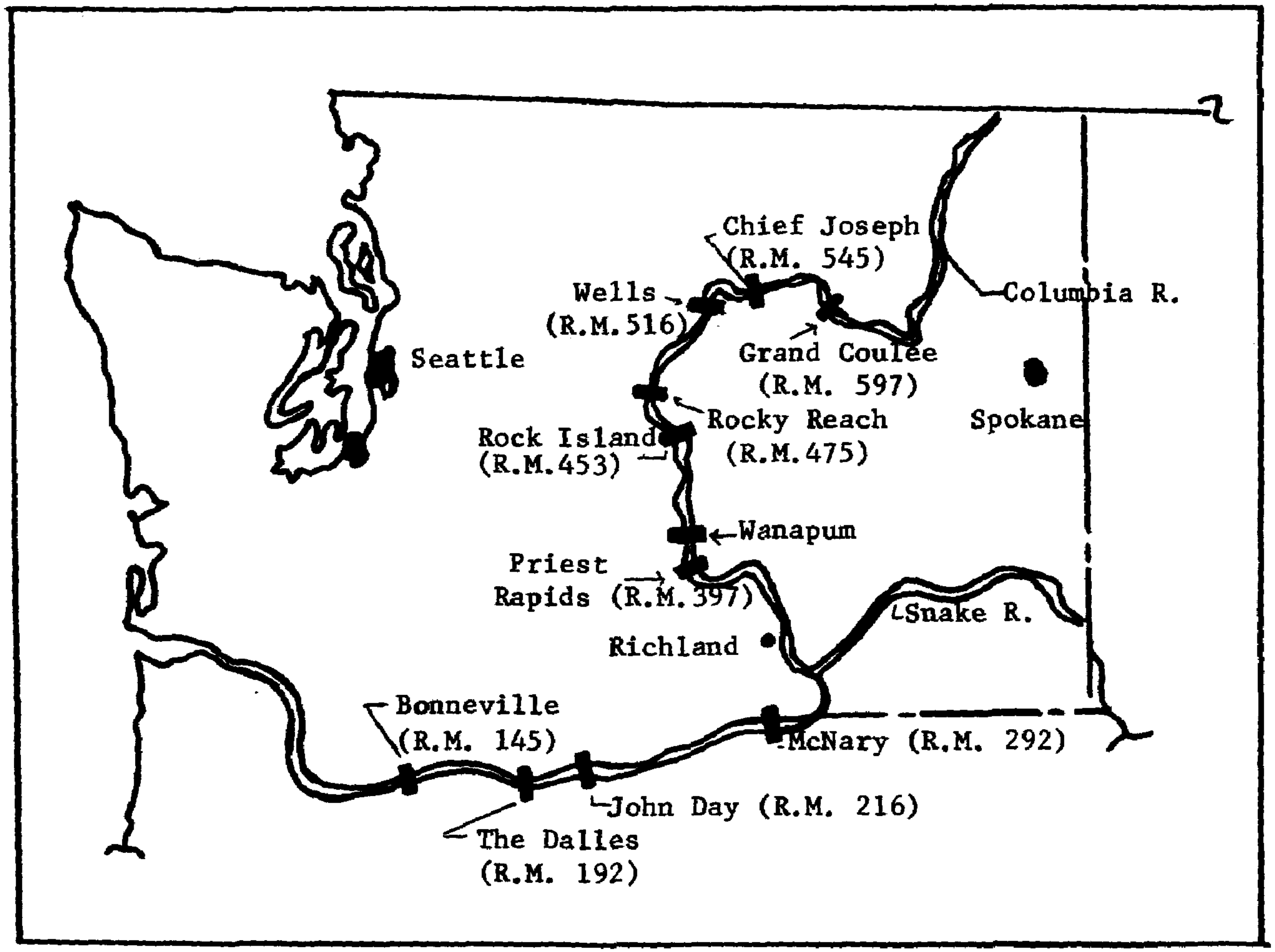

FIGURE 2.1 Map Showing Projects
On the Columbia River

The heat flux, Q, is composed of the following terms:

(1) Q_s - short wave incident solar radiation

(2) Q_r - short wave reflected solar radiation

(3) Q_a - net atmospheric radiation

(4) Q_b - back, or emitted radiation from the water surface

(5) Q_e - evaporative heat flux

(6) Q_h - sensible heat conduction

$$Q = Q_s - Q_r + Q_a - Q_b - Q_e + Q_h \quad (3.2)$$

In the model, the net heat flux, Q, can be expressed as either a linear or parabolic function of the water temperature, T. The model has been programmed so that either function can be chosen, however, comparison of the two indicates that the linear function is adequate for normal conditions.

For the linear function:

$$Q = A_1 + B_1 T \quad (3.3)$$

and equation (3.1) becomes

$$\frac{dT}{dt} = \frac{A_1 + B_1 T}{\rho c_p D} \quad (3.4)$$

Integrating equation (3.4):

$$\frac{T - \alpha_1}{T_0 - \alpha_1} = e^{-\gamma_1 \frac{(t - t_0)}{\rho c_p D}} \quad (3.5)$$

where:

T_0 = the initial temperature

$\alpha_1 = - A_1 / B_1$

$\gamma_1 = - B_1$

$t - t_0$ = exposure time

When the net heat flux, Q, is expressed as a parabolic function of the water temperature, T:

$$Q = A_2 + B_2 T + C_2 T^2 \tag{3.6}$$

the integration yields:

$$\frac{T-\alpha_2}{T-\beta_2} = \left(\frac{T_0-\alpha_2}{T_0-\beta_2}\right) e^{\frac{-\gamma_2(t-t_0)}{\rho C_p D}} \tag{3.7}$$

where

T_0 = the initial temperature

$\alpha_2 = \dfrac{-B_2 - \sqrt{B_2^2 - 4C_2A_2}}{2C_2}$

$\beta_2 = \dfrac{-B_2 + \sqrt{B_2^2 - 4C_2A_2}}{2C_2}$

$\gamma_2 = \sqrt{B_2^2 - 4C_2A_2}$

$t - t_0$ = the exposure time

It should be pointed out that the sum of the heat fluxes in equation 3.2 is zero, when $T = \alpha_1 = T_e$, or, $T = \alpha_2 = T_e$.

The temperature, T_e, is referred to as the equilibrium water temperature.

Finally, if the velocity of the particle, U(x,t), is known, the exposure time, $(t-t_0)$, can be determined from the equation:

$$t - t_0 = \int_{t_0}^{t} dt = \int_{x_0}^{x} \frac{dx}{U(x,t)} \tag{3.8}$$

and the predicted temperature, T, can be determined from either equation 3.5 or 3.7.

To accommodate advected sources, such as tributary streams, the temperature of the advected source is mixed completely with the temperature calculated in equations 3.5 or 3.7, according to the ratios of their respective discharges.

Net Heat Flux- The functional relationship between the net heat flux, Q, and the water temperature, T, is determined by calculating the heat flux over a selected range of water temperature, say 50^{o}F. to 80^{o}F, and fitting the resulting points to either a first- or second-order polynomial by the Method of Least Squares.

The following weather data is needed for these calculations:

(1) incident solar radiation

(2) wind speed

(3) cloud cover

(4) air temperature

(5) wet-bult temperature or dew-point

(6) barometric pressure

This data should be obtained from a station with weather typical of the region in which the river system is located.

Before the net heat flux is calculated the meteorological data are averaged over a specified number of days. The individual fluxes are then determined in the following manner:

(a) Q_s - obtained by measurement in an area with radiation characteristics similar to those of the river system

(b) $$Q_r = A\,\Theta^{B} \qquad (4.1)$$

where Θ = sun's altitude
and A and B are functions of cloud cover as given in reference (2).

(c) $$Q_a = 0.97\,\sigma\, T_a^{4}\, \beta' \qquad (4.2)$$

where σ = Boltzmann's constant

T_a = air temperature, ^{o}Rankine

β' = function of vapor pressure and cloud cover as given in reference (2).

(d) $$Q_b = 0.97\sigma T^4 \beta' \qquad (4.3)$$

where σ and β' are as previously defined, and

T = water temperature

(e) $$Q_e = \lambda k_1 w (e_w - e_a) \qquad (4.4)$$

where

λ = latent heat of vaporization

k_1 = an empirical constant

e_w = vapor pressure of water in saturated air at the temperature of the water

e_a = vapor pressure of water in the ambient air

w = wind speed

(f) $$Q_h = \lambda k_2 w \rho_a (T_a - T) \qquad (4.5)$$

where λ and w are as defined previously and

k_2 = and empirical constant

ρ_a = atmospheric pressure

T_a = air temperature

T = water temperature

Recapitulating:

$$Q = Q_s(1 - A\Theta^B) + 0.97(T_a^4 - T^4)\beta' - \lambda k_1 w (e_w - e_a) + \lambda k_2 w \rho_a (T_a - T) \qquad (4.6)$$

The values of Q_s, A, B, ew, ea, T_a, w, and p_a are obtained either directly or indirectly from the meteorologic data and are fixed for each averaging period. The net heat flux, Q, is determined by specifying the water temperature, T. A first- or second-order polynomial can be generated for each averaging period by calculating the heat flux, Q, for a range of water temperatures, T, and fitting the appropriate curve to the resulting points. As an example, weather data from Richland for the period August 20-29, 1967, collected by Battelle Northwest and made available by the U.S. Atomic Energy Commission, has been used to determine heat flux-water temperature relationships for the Columbia River below Priest Rapids Dam (see Figure 2.1). The meteorologic data for the four six-hour daily periods, averaged over ten days is given in Table 4.1. For water temperatures between heat flux and water temperature for each of the four periods are shown in Table 4.2.

Exposure Time - The period of time during which each water particle is exposed to heating and cooling is determined from equation 3.8. This requires calculating the longitudinal velocity, U(x,t), for the particle.

In order to make the calculations compatible with numerical analysis, the water particle has been replaced by a finite volume of water, or water parcel. Associated with each parcel as it leaves a particular dam is the dam discharge, QD, and the tailwater elevation, TL, for that time period when it is discharged. The parcel retains these values until it reaches an advected source, or the next dam.

Assuming that the water surface profile is a known function of the longitudinal distance from the dam, and is independent of pool elevations and discharge; and given the geometric characteristics of cross-sectional

TIME PERIOD	INCIDENT SOLAR RADIATION, BTU/ft.^{2}/hr	WIND SPEED, M.P.H.	CLOUD COVER, TENTHS	AIR TEMP., °F	WET BULB, TEMP, °F	AIR PRESSURE in. Hg.
0000-0600	1.9	14.2	2	69.5	54.6	29.20
0600-1200	159.0	8.0	4	81.3	59.2	29.20
1200-1800	145.7	9.5	5	91.5	61.8	29.20
1800-2400	1.0	16.0	3	76.3	56.1	29.20

TABLE 4.1 Weather Data From Richland for Four (4) daily Periods Averaged Over Ten Days (August 20-29 1967)

TIME PERIOD	LINEAR RELATIONSHIP Q-BTU/ft.^{2}/hr, T-$^{\circ}$F	PARABOLIC RELATIONSHIP Q-BTU/ft.^{2}/hr, T-$^{\circ}$F
0000-0600	$Q=332.-6.31T$	$Q=228.-2.96T-0.0268T^2$
0600-1200	$Q=377.-3.95T$	$Q=315.-1.94T-0.0161T^2$
1200-1800	$Q=417.-4.54T$	$Q=345.-2.20T-0.0187T^2$
1800-2400	$Q=380.-6.96T$	$Q=266.-3.25T-0.0297T^2$

TABLE 4.2 Linear and Parabolic equations relating heat flux and water temperature for the meteorology given in Table 4.1.

area and water surface width, as a function of longitudinal distance and water surface level, the parcel velocity can be determined.

The water surface profile, determined from the difference between the tailwater elevation of the upstream dam and the water surface elevations at selected stations can be obtained from backwater calculations or available stage records. Profiles obtained from backwater calculations or stage records are generally a function of dam discharge and pool elevation, and it is necessary to define a "representative" profile which will be independent of these effects.

Location of the profile is determined by the tailwater elevation of the upstream dam. This will give a satisfactory water surface level providing dam discharges and pool elevations are varied gradually, and that stretches of the river which are free-flowing are either very small or very large compared to that part which is impounded.

The geometric characteristics of cross-sectional area and water surface width are determined from available data such as sounding charts. River reaches between dams are divided into sub-reaches and representative cross-sectional data are assigned to each sub-reach.

Figure 4.1 is a schematic diagram of the idealized river as used in the model. The river reach between dam 1 and dam 2 is divided into sub-reaches. The longitudinal distance of each section, N, from the origin is X(N). The water surface profile is determined by the values, CTE(N), which are functions of longitudinal distance only. The absolute surface elevation at each section, N, is:

$$Z(N) = TL - CTE(N) \qquad (4.7)$$

where TL is the tailwater elevation of the upstream dam referenced to some DATUM.

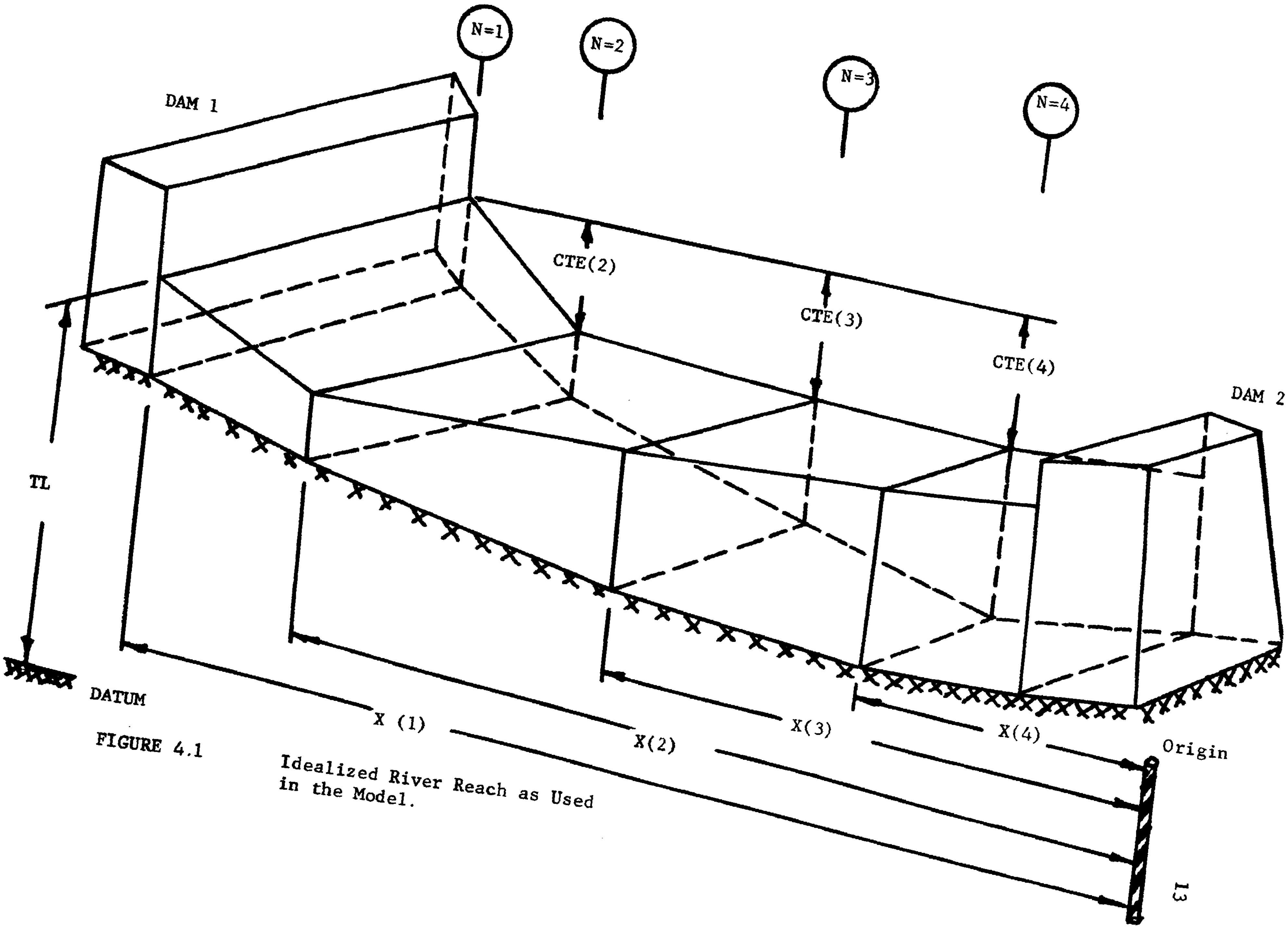

FIGURE 4.1 Idealized River Reach as Used in the Model.

Representative cross-sectional characteristics are given at each of the sections, N. The cross-sectional characteristics at each station must be specified for various surface elevations, covering the entire range of elevations which can occur during the modelling period.

If the maximum tailwater elevation at the upstream dam is TL_{max} and the minimum is TL_{min} and the distance below the tailwater in CTE(N) at station N, then the table containing cross-sectional characteristics must cover the range of heights.

$$TL_{min} - CTE(N) \leqslant Z(N) \leqslant TL_{max} - CTE(N)$$

Z(N) is the water surface height at which the cross-sectional area and water surface width are specified. The manner in which this data must be prepared is described in more detail in Appendix B.

Parcel velocities are calculated as follows:

(1) The leading edge of the parcel, P, is flagged as it leaves the dam (Figure 4.2a). Associated with the parcel is the dam tailwater elevation and discharge for the time period during which the parcel is released.

(2) The geometrical characteristics of the sub-reach in which the parcel is located is taken as the average of these values at section N and N+1, which constitute the upstream and downstream boundary of the sub-reach respectively.

The surface elevation at section N is

$$Zp\,(N) = TLp - CTE(N)$$

and at N + 1

$$Zp\,(N+1) = TLp - CTE(N+1)$$

The values of Zp(N) and Zp(N+1) are used to enter the tables containing cross-sectional area, AX(Zp(N),N) and AX(Zp(N+1), N+1) and water surface width WX(Zp(N),N) and WX(Zp(N+1),N+1).

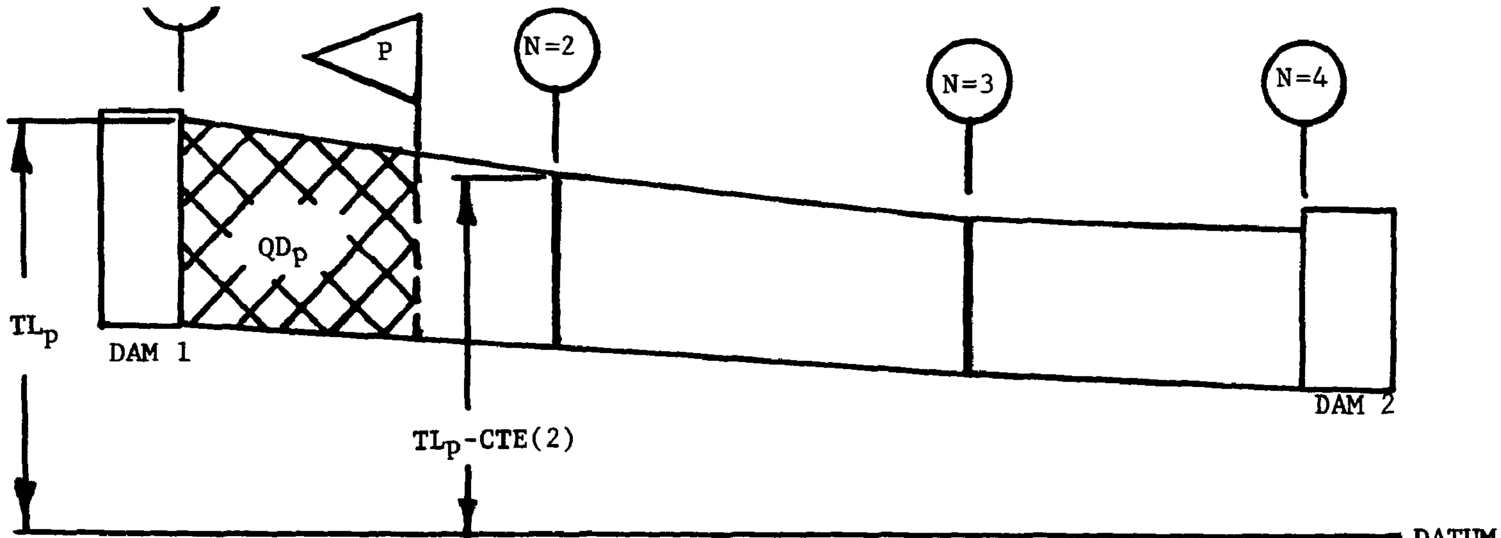

FIGURE 4.2(a) - Schematic diagram showing parcel, P, as it is released from Dam 1.

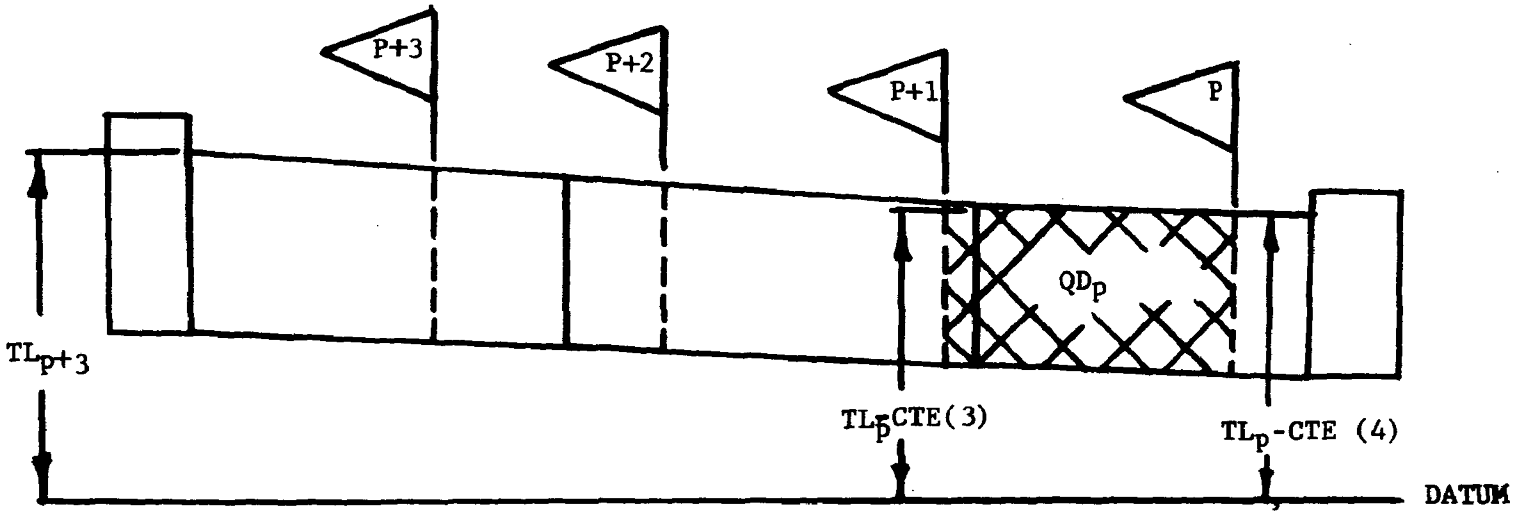

FIGURE 4.2(b) - Schematic diagram showing parcel, P, after progressing through two river sections.

(3) The average cross-sectional area and width are calculated:

$$\langle AX \rangle = \frac{AX(Zp(N),N) + AX(Zp(+1),N+1)}{2}$$

$$\langle WX \rangle = \frac{WX(Zp(N),N) + WX(Zp(N+1),N+1)}{2}$$

(4) The discharge used to determine the velocity of parcel, P, is a function of all the parcels in the reach behind P. This is so because the hydraulic model is a kinematic model and involves only a solution of the continuity equation. To account for the effect of parcels behind parcel, P, the velocity Up is :

$$Up = \frac{QD_p'}{\langle AX \rangle}$$

where in the example of Figure 4.2b

$$QD_p' = \frac{\left(QD_p + \dfrac{(QD_{p+1}^2 + QD_{p+2}^2 + QD_{p+3}^2)}{QD_p}\right)}{1 + \dfrac{(QD_{p+1} + QD_{p+2} + QD_{p+3})}{QD_p}}$$

For constant cross-sectional area it can be shown that QD_p' is a length average of QD_p, QD_{p+1}, QD_{p+2}, and QD_{p+3}.

The nominal depth is

$$D_p = \frac{\langle AX \rangle}{\langle WX \rangle}$$

The value of the longitudinal velocity, U_p, is used in equation 3.8, to determine the exposure time, $(t-t_o)$, which, in turn, is used with D_p, and the α, β, and γ values appropriate to that time period, for predicting the water temperature. The value of U_p is also used to determine how far the front of the parcel has traveled.

When a new reach is enountered the longitudinal velocity, U_p, and nominal depth, p, are recalculated. The same discharge, QD_p, is used, but new geometric characteristics will be necessary.

If a new time period begins the values of α, β, and γ are updated.

(5) Parcel temperature, T_p, is recorded or reinitialized as the flagged portion reaches those stations at which these operations have been specified.

(6) When the parcel, P, reaches stations with an advected source, the temperature, T_{ADV}, of the source is mixed into the main stream according to equation (3.9)

(7) Upon leaving the advected source, the parcel will have a new discharge:

$$QD_p = QD_p + QD_{ADV}$$

but the same tailwater, TL_p.

(8) When the parcel, P, for the 1st time period, reaches a new dam the parcel assumes a discharge and tailwater elevation equal to that of the new dam for the time period during which the parcel arrived at the new dam. If the new dam is the last dam, calculations begin for the second time period as parcel, P+1, from the first dam.

MODEL TESTING

The model has been tested using Columbia River main-stem reservoirs as prototypes. Description of the various tests is given in Table 5.1, and Figure 2.1 shows the location of the projects. Temperatures of parcels at selected points for each test are shown in Figure 5.1 - 5.5. Where sufficient data were available, predicted temperatures were compared with observed.

Suitable data for comparison of predicted and observed travel times were not available.

In all the test cases, heat flux associated with evaporation and sensible heat conduction have been calculated from equation 4.4 and 4.5, using the empirical constants obtained from the Lake Hefner study (1). It would be possible to find the best fit between observed and predicted data by varying these empirical constants. This would not be meaningful unless errors in other heat flux calculations, hydraulic calculations, observed temperature data and meteorologic data could be controlled more precisely.

CONDITION	PERIOD	FIRST DAM	LAST DAM	STATION PROVIDING METEOROLOGY DATA
1	July 22-31 1966	Grand Coulee (R.M. 597)	Priest Rapids (R.M. 397)	Wenatchee FAA
2	August 20- Sept. 12,1967	Priest Rapids (R.M. 397)	Bonneville (R.M. 145)	Hanford Area
3	Sept. 14-19 1967	Wells (R.M. 516)	Rock Island (R.M. 453)	Wenatchee FAA

TABLE 5.1 Description of conditions used for testing the one-dimensional temperature model.

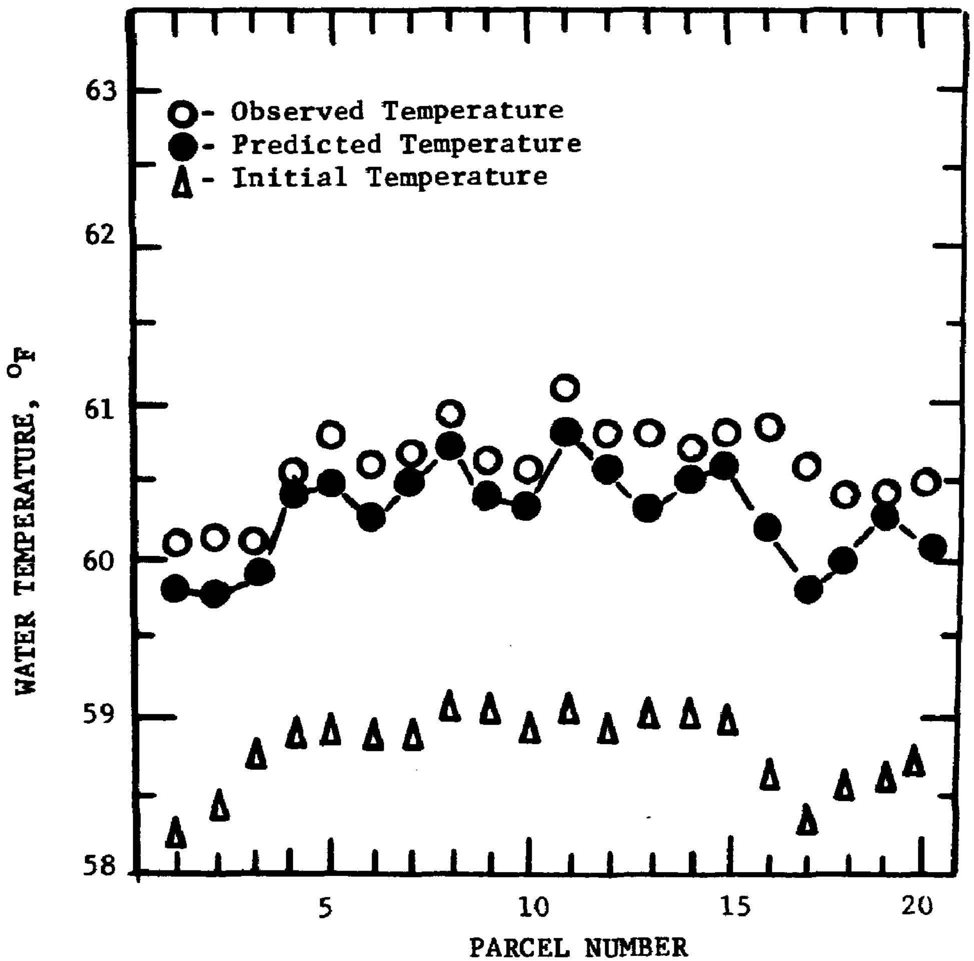

FIGURE 5.1 Analysis of Water Temperatures at Rocky Reach Dam For Condition 1 In Table 5. 1

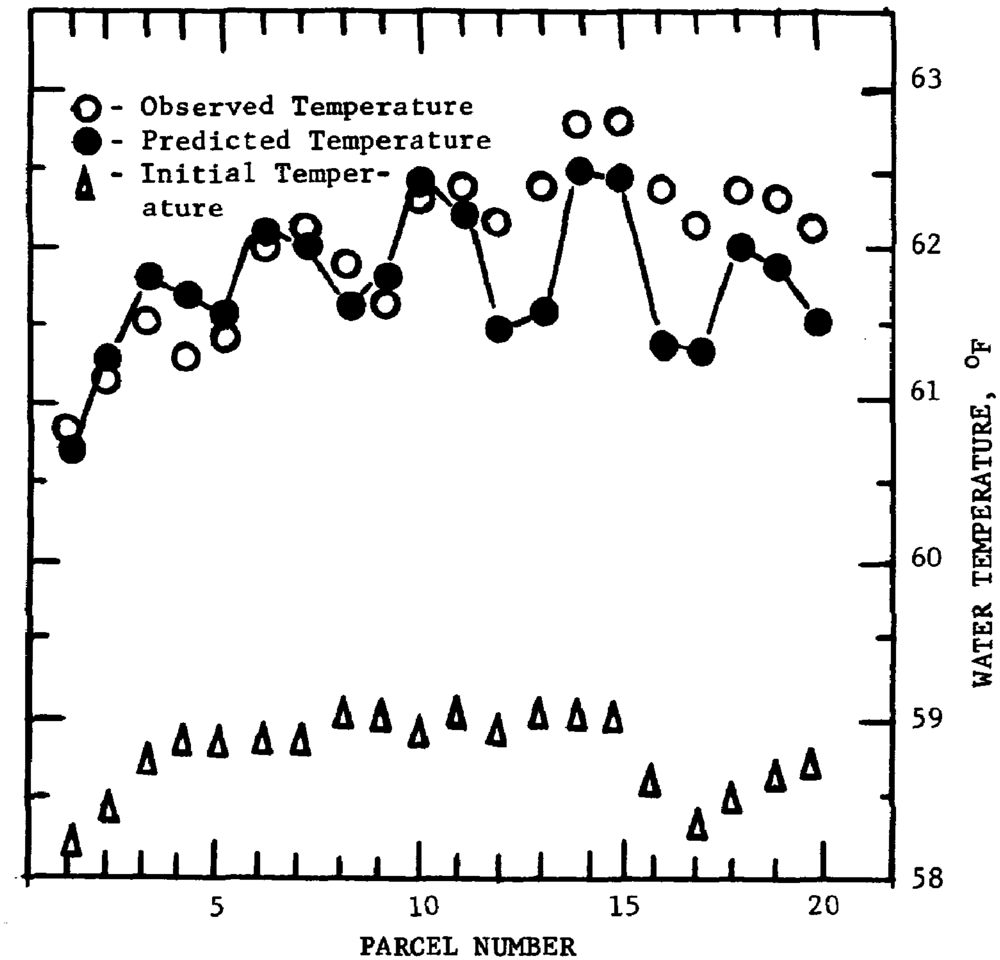

FIGURE 5.2 Analysis of Water Temperatures at Priest Rapids Dam For Condition 1 In Table 5. 1

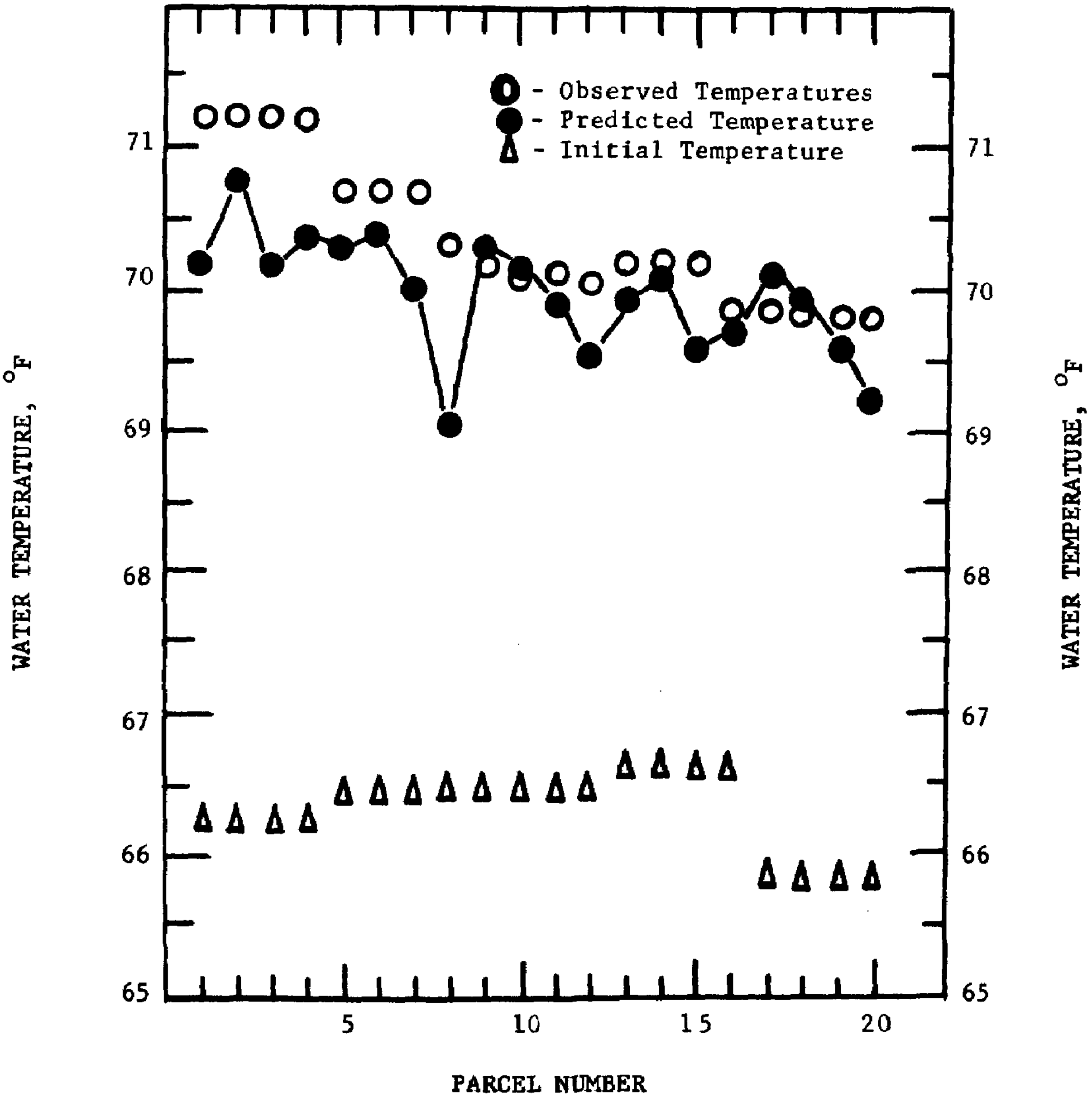

FIGURE 5.3 Analysis of Water Temperatures at Bonneville Dam for Condition 2 in Table 5.1

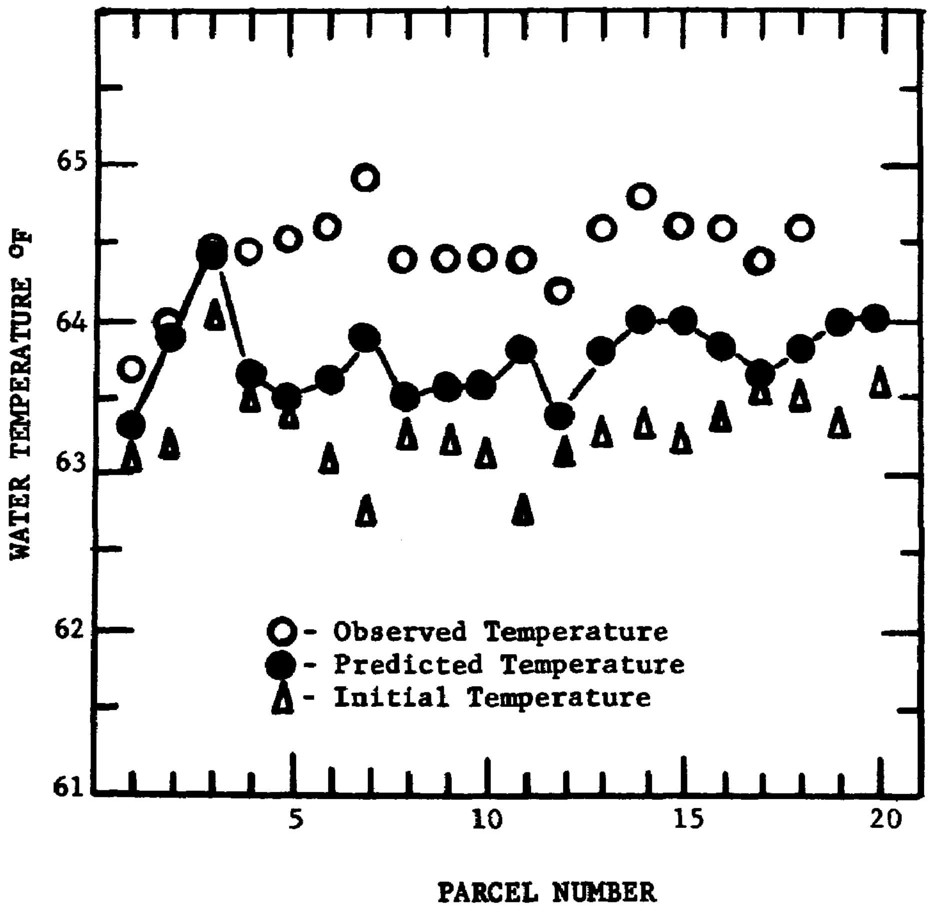

FIGURE 5.4 Analysis of Water Temperature at Rocky Reach Dam for Condition 3 in Table 5.

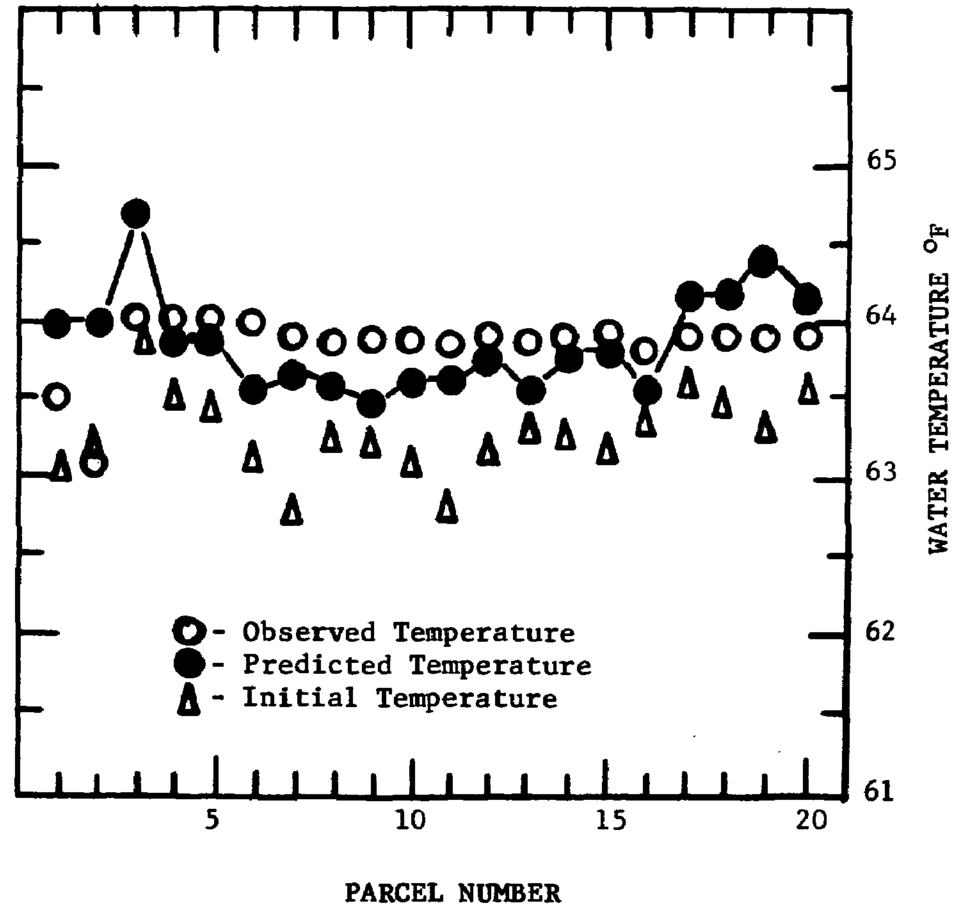

FIGURE 5.5 Analysis of Water Temperatures at Rock Island Dam For Condition 3 in Table 5.

Two subroutines are being developed which will eliminate some of the restrictions associated with the present model. One subroutine calculates solar radiation using available techniques (3) and the other subroutine calculates backwater profiles (4).

Study of other problem areas, including evaporation and sensible heat fluxes, diffusion and dispersion processes and unsteady flow, will continue.

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(1) ____________ "Water-Loss Investigations: Lake Hefner Studies, Technical Report," U.S.G.S. Professional Paper 269, U.S. Government Printing Office, Washington, D.C.:1954

(2) Raphael, J.M., "Prediction of Temperature in Rivers and Reservoirs," Journal of the Power Division, ASCE, July 1962,pp 157-181.

(3) ____________ "Heat and Mass Transfer Between a Water Surface and the Atmosphere, (Preliminary edition)", Tennessee Valley Authority, Norris, Tennessee, July, 1967.

(4) Prasad, R,____ "A Numerical Method of Computing Gradually Varied Flow Profiles", Specialty Conference of Hydraulics Division, ASCE, M.I.T. Cambridge, Massachusetts, August, 1968.

A-1. Description of the Computer Program

The computer program, which calculates water temperatures according to the principles described in the main portion of the report, has been coded in FORTRAN H. The program contains one MAIN program and nine subprograms. The MAIN program is a calling program only, the function of the other programs is as follows:

(1) HYREAD - Reads in river geometry, dam discharge and tailwater elevation and advected source discharge.

(2) MEREAD - Reads in the meteorological data and averages the data over specified periods.

(3) THREAD - Reads all temperature input, stations at which parcel temperatures are to be reinitialized, stations where temperatures are to be printed, and temperatures of advected sources.

(4) TROUT - Routes the parcels down the river, making use of subprograms TEMP and HYDRA2 for determination of parcel temperatures and travel times.

(5) HYDRA2 - Calculates parcel velocity using the method of Section 4.

(6) TEMP - Calculates the parcel temperature using equation (3.5) or (3.7), depending upon whether a linear or parabolic function relating heat budget and water temperature is desired.

(7) METEOR - Calculates the net heat flux, Q, using relationships described in Section 4. An array of heat budget versus water temperature is generated for each averaging period and the appropriate coefficients in equation (3.3) or (3.6) are calculated with the aid of CRVXZQ.

(8) CRVXZQ - A curve fitting routine using the Method of Least Squares.

(9) TWRITE - Writes out predicted, observed and initial parcel temperatures, as well as arrival times and travel times, for each parcel at specified stations.

The intention has been to design the program in modular form, so that various parts of the program, particularly input and output, can be easily modified.

A-2. Data Requirements

Data requirements for running the program can be divided into four categories:

I. Hydraulic Data

1. Section number

2. River mile of each section

3. Distance of water surface level below the tailwater elevation of the upstream dam, in feet.

4. Cross-sectional area, in square feet, and water surface width, in feet, for various water levels at each section.

5. Dam discharges in 1000 cfs and tailwater elevations in feet above datum.

6. Discharge from advected sources, in 1000 cfs.

II. Meteorologic Data

1. Incident solar radiation in langleys or BTU/ft.^{2}/hr.

2. Cloud cover in number of tenths

3. Air pressure in inches of mercury

4. Wind speed in knots or miles per hour

5. Air temperature in ^{o}F or ^{o}C.

6. Wet-bult temperature or dew-point in ^{o}F or ^{o}C.

III. Water Temperature Data

1. Initial temperature of parcels

2. Station numbers associated with temperature input

3. Station numbers associated with output temperatures

4. Station numbers where parcel temperatures are to be reinitialized (a subset of III.2 above)

IV. Systems Information

1. Seven cards are reserved for supplying labelling information such as location of river basin, stations providing meteorology data, time period covered by analysis, etc.

APPENDIX B

B.1. Preparation of Cards

The data cards are prepared in four groups, corresponding to those described in the Appendix A-2. A sample set of data as arranged on punched cards is given in Appendix D.1. The numbers in the left edge of the sample data print-out correspond to the numbers given below.

I.1 FORMAT (6I5, F15.10)

NADV - number of advected sources

NDAMS - number of dams

NDAYS - number of days parcels are released from the first dam

NDQ - number of days of discharge

NPD - number of periods into which each day is divided

NSECT - number of sections into which river is divided

DZ - the height increment at which cross-sectional area and water surface width are specified

I.2 FORMAT (I3,F6.1,F4.1,F5.0,5(F7.0,F5.0),I1)

N - section number, beginning with one (1) at the first upstream dam and increasing consecutively downstream. The first station is at the downstream face of the first dam. Between dams the river may be divided into as many sections as are needed. At subsequent downstream dams, however, there must be a station at the upstream face and the downstream face, to account for the space taken by the dam.

X(N) - river mile of section, N

CTE(N) - distance in feet, of the water surface at station N below the tailwater of the upstream dam.

CD(N) - lowest elevation at station N for which cross-sectional area and water surface width are specified

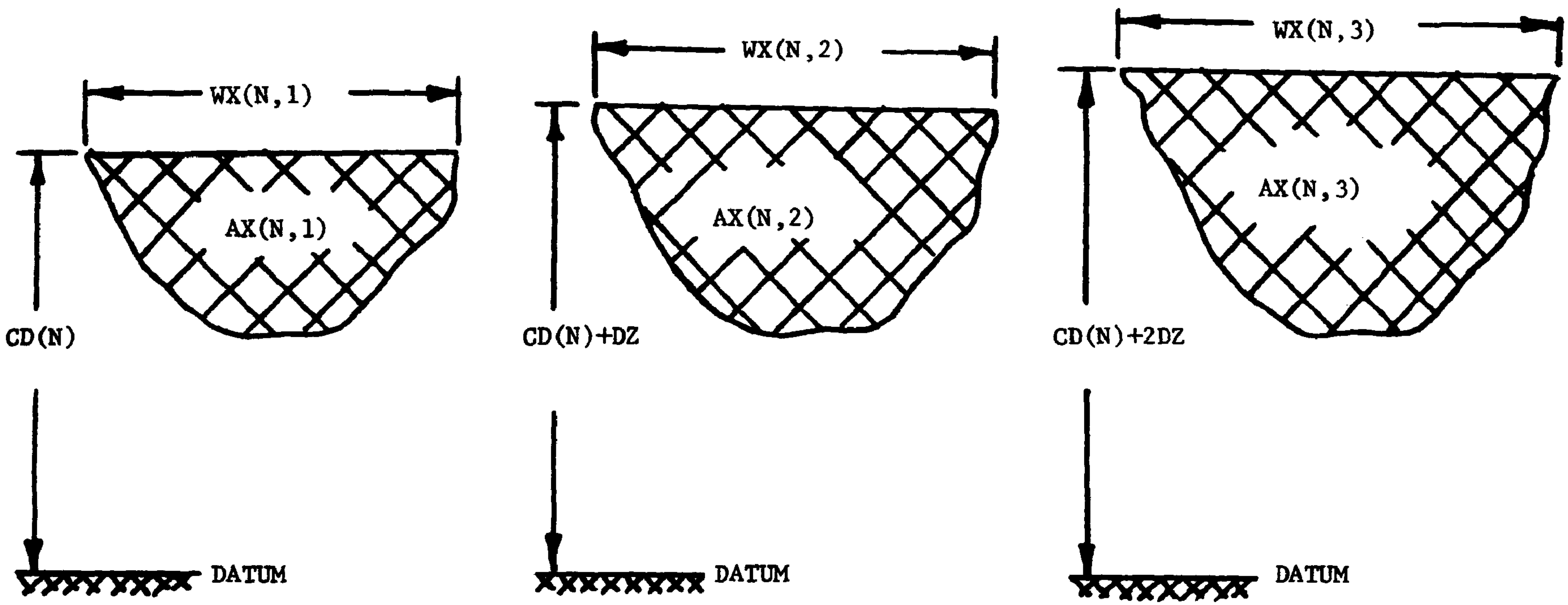

FIGURE B-2.1 Schematic Diagram Showing How Cross-Sectional Data is to be Specified at Station N.

AX(N,1) - cross-sectional area at station N for the water surface elevation, CD(N), in ft.^{2} See Figure B.2-1.

WX(N,1) - water surface width, in feet, at station N for the water surface elevation CD(N). See Figure B.2-1

AX(N,2) - as above for water surface level, CD(N)+DZ

WX(N,2) - as above for water surface level, CD(N)+DZ

AX(N,3) . . . . CD(N)+2DZ

WX(N,3) . . . . CD(N)+2DZ

AX(N,4) . . . . CD(N)+3DZ

WX(N,4) . . . . CD(N)+3DZ

AX(N,5) . . . . CD(N)+4DZ

WX(N,5) . . . . CD(N)+4DZ

ICK - an indicator for determining the last geometry card for each station. If ICK = 0, there are more cards to follow. ICK = 1 indicates the last geometry card for station N.

Continue in the above manner until all station geometry is recorded.

I.3 FORMAT (2I2, 12X,5 (F6.1,2X)

M - dam number

ID(M) - section number of dam M. Corresponds to section number at the downstream face of dam M.

ELT(M,1) - tailwater elevation of dam M, in feet on day 1 of the analysis.

QD(M,1) - discharge in 1000 cfs for first daily time period

QD(M,2) - as above for second time period, if necessary

QD(M,3) - as above for third time period, if necessary

QD(M,4) - as above for fourth time period, if necessary

Continue as above for as many days as there are dam discharges

I.4 FORMAT (2I2,20X,4(F6.1,2x)

M - advected source number

IDADV(M) - section number of advected source

QADV(M,1) - discharge of advected source, or in 1000 cfs for the first daily time period.

QADV(M,2) - as above for the second time period, if necessary

QADV(M,3) - as above for the third time period, if necessary

QADV(M,4) - as above for the fourth time period, if necessary

II.1 FORMAT (5I5)

NDMET - number of days of meteorologic data

NAVG - number of days over which meteorologic data is averaged

NMD - number of meteorologic variables per day

MAXT - maximum water temperature for heat budget calculations

MINT - minimum water temperature for heat budget calculations

II.2 FORMAT (3F5.0)

PHI - the latitude of the river system

DTSL - the difference between local time of the river system and standard time. Positive if the local meridan is greater than the standard meridian, negative otherwise (for west longitude only.)

DAY1 - first day of analysis

II.3 FORMAT (7I5)

ISI = 1 Radiation in BTU/ft^2/hr
= 2 Radiation in langleys

IS2 = 1 wind speed in MPH
2 wind speed in knots

IS3 = 1 air temperature in ^{o}C
2 air temperature in ^{o}F

IS4 = 1 wet bulb temperature is input
= 2 dew point temperature is input

IS5 = 1 solar radiation is input

IS6 = 1 write heat budget information
= 2 do not write heat budget information

IV = 1 linear heat budget relations
   = 2 parabolic heat budget relationship

II.4 FORMAT (2E10.3)

CT3 - evaporation coefficient lb./mile/ft.^{2}/^{o}F

CT4 - sensible heat conduction coefficient, lb./mile/ft.^{2}/^{o}F.

II.5 FORMAT (18A4)

FRMT - FORTRAN IV FORMAT statement for reading meteorological data

II.6 FORMAT - specified by user (see above II.5). Data must appear in the following order, however:

A9 - incident solar radiation in langleys/hr or BTU/ft.^{2}/hr

B9 - cloud cover in number of tenths

C9 - wind speed in MPH or knots

D9 - air temperature in ^{o}C or ^{o}F

E9 - wet bulb or dew point temperature in ^{o}C or ^{o}F

F9 - air pressure in in. Hg.

III.1 FORMAT (I5)

NT1 - number of stations with temperature input

III.2 FORMAT/315/(16F5.0)

IDIN(N)-station number of temperature input

NTHIN(N) - number of temperature values at station N

ICFIN = 1 if ^{o}F
      = 2 if ^{o}C

THR(N,J) - temperature at station N for time period. J=1, NTHIN(N) ^{o}F or ^{o}C

III.3 FORMAT (I5)

NCHNG - number of stations at which temperature is to be reinitialized.

III.4 FORMAT (20 A4/15)

XCHNG(N,J) - label for station N at which parcel temperatures are to be reinitialized

IDCHNG(N) - station number at which temperature is to be reinitialized

III.5 FORMAT (2I5)

NTP - number of locations at which parcel temperatures are to be predicted.

ICFOUT = 2 if output temperature is ^{o}F

III.6 FORMAT (20 A4/15)

XOUT (N,J) - label describing temperature output location

IDTP(N) - station number of the Nth temperature output location.

III.7 FORMAT (10X,15/16F5.0)

ICFIN = 1 if advected source temperature is in ^{o}C
= 2 if advected source temperature is in ^{o}F

TADV(N,J) temperature of advected source at station N.
J = 1,NPQ (NPQ=NPDxNDQ)

IV.1 FORMAT (20A4)

HOT POO (I,J) - lable such as organization performing work, area covered by analysis, and date of analysis
I = 1,7
J = 1,20

A listing of the program and a sample of the output are given in Appendix C and D.

APPENDIX C

```
      MAIN PROGRAM

      CALL HYREAD
   20 CALL MEREAD
   30 CALL THREAD
      CALL TROUT
      CALL TWRITE
      STOP
      END
```

(1)

```
      SUBROUTINE HYREAD
C     SUBROUTINE HYREAD READS IN THE HYDRAULIC AND HYDROLOGIC DATA.
C     THIS INCLUDES CROSS-SECTIONAL DATA, IDEALIZED BACKWATER PROFILES,
C     AND DAM DISCHARGES AND TAILWATER ELEVATIONS.
      COMMON/NUMBER/NADV, NDAMS, NDAYS, NPD, NPER, NSECT, NT1, NCHNG,
     1 NTP, NTHIN(15), NPQ
      COMMON/GEOM/AX(100,25), WX(100,25), X(100), CTE(100), CD(100), DZ
      COMMON/IDENT/ID(15), IDIN(15), IDADV(15), IDTP(15), IDCHNG(15)
      COMMON/HYDRO/ELT(12,400), QD(12,400), QADV(5,400)
      COMMON/CHECK/JJMAX(400)
      READ(5 ,1010) NADV, NDAMS, NDAYS, NDQ, NPD, NSECT, DZ
      INSECT = NSECT + 1
      IDADV(NADV+1) = INSECT + 1
      I1 = NPD
      I2 = NDAYS
      I3 = NDQ
      NPER = I1*I2
      NPQ = I1*I3
      ND1 = NDAMS - 1
C   ******************************************************************
C   *    READ RIVER GEOMETRY(RIVER MILE, AREA, WIDTH, ETC.)           *
C   ******************************************************************
      DO 19 N = 1,NSECT
      J = 1
   10 JJ = J   4
      READ(5 ,1020) N, X(N), CTE(N), CD(N), (AX(N,K), WX(N,K), K = J,JJ)
     1, ICK
      JJMAX(N) = JJ
      J = J   5
      IF (ICK.EQ.0) GO TO 10
   19 CONTINUE
C   ******************************************************************
C   *    READ DAM NUMBER, STATION, TAILWATER, ELEV. AND DISCHARGES    *
C   ******************************************************************
   20 READ(5 ,1030) M, ID(M), ELT(M,1), (QD(M,I), I = 1,NPD)
      DO 29 K = 2,NDQ
      NSTART = (K - 1)*NPD + 1
      NSTOP = K*NPD
      READ(5 ,1040) ELT(M,K), (QD(M,L), L = NSTART,NSTOP)
   29 CONTINUE
```

```
      IF (M.LT.ND1) GO TO 20
      ID(NDAMS) = INSECT
      DO 39 M = 1,ND1
      DO 39 L = 1,NPQ
      TMPRRY = QD(M,L)
      QD(M,L) = 3.6E06*TMPRRY
   39 CONTINUE
      IF (NADV.EQ.0) GO TO 100
C    ******************************************************************
C    *    READ ADVECTED SOURCE NUMBER, STATION AND DISCHARGES         *
C    ******************************************************************
   40 READ(5 ,1050) M, IDADV(M), (QADV(M,I), I = 1,NPD)
      DO 49 K = 2,NDQ
      NSTART = (K - 1)*NPD + 1
      NSTOP = K*NPD
      READ(5 ,1060) (QADV(M,L), L = NSTART,NSTOP)
   49 CONTINUE
      IF (M.LT.NADV) GO TO 40
      DO 59 M = 1,NADV
      DO 59 L = 1,NPQ
      TMPRRY = QADV(M,L)
      QADV(M,L) = 3.6E06*TMPRRY
   59 CONTINUE
 1010 FORMAT (6I5, F15.10)
 1020 FORMAT (I3, F6.1, F4.1, F5.0, 5(F7.0, F5.0), I1)
 1030 FORMAT (2I2, 12X, 5(F6.1, 2X))
 1040 FORMAT (16X, 5(F6.1,  2X))
 1045 FORMAT (2I2)
 1050 FORMAT (2I2, 20X, 4(F6.1, 2X))
 1060 FORMAT(24X,4(F6.1,2X))
  100 RETURN
      END
```

(2)

```
      SUBROUTINE MEREAD
C     SUBROUTINE MEREAD READS IN AND AVERAGES METEOROLOGY DATA.
C     AVERAGING PERIODS ARE SPECIFIED BY THE USER.
      COMMON/CONST/ NDMET, NAVG, NMD, IS1, IS2, IS3, IS4, IS5, IS6, IV,
     1MAXT, MINT
      COMMON/EVAP/CT3, CT4
      COMMON/ROOTS/ALPHA(40,24), BETA(40,24), GAMMA(40,24)
      COMMON/WEATHR/QS(100), CC(100), W(100), TA(100), TAW(100), AP(100)
      COMMON/NUMBER/NADV, NDAMS, NDAYS, NPD, NPER, NSECT, NT1, NCHNG,
     1 NTP, NTHIN(15), NPQ
      COMMON/ALMNAC/PHI, DTSL, DAY1
      DIMENSION FRMT(18)
      READ(5 ,1000) NDMET, NAVG, NMD, MAXT, MINT
      READ(5 ,1001) PHI, DTSL, DAY1
      READ(5 ,1002) IS1, IS2, IS3, IS4, IS5, IS6, IV
      READ(5 ,1005) CT3, CT4
      READ(5 ,1010) FRMT
      XNPD = NPD
      NDIV = NMD/NPD
      T1 = NDIV
      NLOOPS = (NDMET-1)/NAVG + 1
      DO 49 I = 1,NLOOPS
      NDAYL = NAVG
      NCHECK = NDMET - NAVG*I
      IF (NCHECK.LT.0) NDAYL = NDMET - NAVG*(I-1)
      XDL = NDAYL
      DO  9 J = 1,NPD
      QS(J) = 0.0
      CC(J) = 0.0
      W(J) = 0.0
      TA(J) = 0.0
      TAW(J) = 0.0
      AP(J) = 0.0
    9 CONTINUE
      DO 39 J = 1,NDAYL
      DO 39 K = 1,NPD
      DO 39 L = 1,NDIV
      READ(5 ,FRMT) A9, B9, C9, D9, E9, F9
      QS(K) = A9/T1 + QS(K)
      CC(K) = B9/T1 + CC(K)
```

```
      W(K) = C9/T1 + W(K)
      TA(K) = D9/T1 + TA(K)
      TAW(K) = E9/T1 + TAW(K)
      AP(K) = F9/T1 + AP(K)
   39 CONTINUE
      DO 48 M = 1,NPD
      QS(M) = QS(M)/XDL
      IF (IS1.EQ.2) QS(M) = 3.6866431*QS(M)
      CC(M) = CC(M)/XDL
      W(M) = W(M)/XDL
      IF (IS2.EQ.2) W(M) = 1.1515*W(M)
      TA(M) = TA(M)/XDL
      IF (IS3.EQ.2) TA(M) = 1.8*TA(M) + 32.
      TAW(M) = TAW(M)/XDL
      IF (IS3.EQ.2) TAW(M) = 1.8*TAW(M) + 32.
      AP(M) = AP(M)/XDL
   48 CONTINUE
      ITRANS = I
      CALL METEOR(ITRANS)
   49 CONTINUE
 1000 FORMAT (5I5)
 1001 FORMAT (3F5.0)
 1002 FORMAT (7I5)
 1005 FORMAT (2E10.3)
 1010 FORMAT (18A4)
      RETURN
      END
```

```
 (3)   SUBROUTINE THREAD
C      SUBROUTINE THREAD READS IN TEMPERATURE DATA.  THIS INCLUDES
C      INPUT TEMPERATURE LOCATIONS, STATIONS WHERE TEMPERATURES ARE
C      REINITIALIZED, TEMPERATURES FROM ADVECTED SOURCES, AND LOCATIONSS
C      OF OUTPUT TEMPERATURES.
       COMMON/TEMPER/THETA(5,365), THR(5,365), TADV(5,365)
       COMMON/NUMBER/NADV, NDAMS, NDAYS, NPD, NPER, NSECT, NT1, NCHNG,
      1 NTP, NTHIN(15), NPQ
       COMMON/IDENT/ID(15), IDIN(15), IDADV(15), IDTP(15), IDCHNG(15)
       COMMON/NAME/XCHNG(5,40), XOUT(10,40)
       INSECT = NSECT
       READ(5 ,1000) NT1
       DO 9 I = 1,NT1
       READ(5 ,1005) IDIN(I), NIN, ICFIN, (THR(I,J), J = 1,NIN)
       NTHIN(I) = NIN
       IF (ICFIN.EQ.2) GO TO 9
       DO 8 M = 1,NIN
       TMPRRY = THR(I,M)
       THR(I,M) = 1.8*TMPRRY   32.0
     8 CONTINUE
     9 CONTINUE
       READ(5 ,1000) NCHNG
       IDCHNG(NCHNG+1) = INSECT + 1
       IF (NCHNG.EQ.0) GO TO 20
       DO 19 K = 1,NCHNG
       READ(5 ,1025) ((XCHNG(K,L), L = 1,20), IDCHNG(K))
    19 CONTINUE
    20 READ(5 ,1027) NTP, ICFOUT
       WRITE(6,1027) NTP, ICFOUT
       DO 29 K = 1,NTP
       READ(5 ,1030) ((XOUT(K,L), L = 1,20), IDTP(K))
    29 CONTINUE
    45 CONTINUE
       IF (NADV.EQ.0) GO TO 100
       DO 49 I = 1,NADV
       READ(5 ,1045) ICFIN, (TADV(I,J), J = 1,NPQ)
       IF (ICFIN.EQ.2) GO TO 49
       DO 48 M = 1,NPQ
       TMPRRY = TADV(I,M)
       TADV(I,M) = 1.8*TMPRRY   32.0
```

```
   48 CONTINUE
   49 CONTINUE
 1000 FORMAT (I5)
 1005 FORMAT (/3I5/(16F5.0))
 1025 FORMAT (20A4/I5)
 1027 FORMAT (2I5)
 1030 FORMAT (20A4/I5)
 1045 FORMAT (/10X, I5/(16F5.0))
  100 RETURN
      END
```

```
(4)     SUBROUTINE TROUT
C       SUBROUTINE TROUT ROUTES THE PARCELS DOWN THE RIVER.  SUBROUTINE
C       TEMP IS USED IN CONJUNCTION WITH TROUT TO DETERMINE PARCEL
C       TEMPERATURES.
        COMMON/NUMBER/NADV, NDAMS, NDAYS, NPD, NPER, NSECT, NT1, NCHNG,
       1 NTP, NTHIN(15), NPQ
        COMMON/IDENT/ID(15), IDIN(15), IDADV(15), IDTP(15), IDCHNG(15)
        COMMON/HOWLNG/TIME(10,400)
        COMMON/TEMPER/THETA(5,365), THR(5,365), TADV(5,365)
        COMMON/GEOM/AX(100,25), WX(100,25), X(100), CTE(100), CD(100), DZ
        DIMENSION T(20), DELTAT(20)
        T(1) = 24.0/NPD
        DO 99 I = 1,NPER
        II = I
        IQ = I
        L = 1
        MADV = 1
        M = 1
        N = 0
        TH1 = THR(1,I)
        NNEW = 2
     15 N = N   1
     20 DX = (X(N) - X(N+1))*5280.
     25 CALL HYDRA2(II, IQ, M, MADV, N, U, Z)
        DIST = T(L)*U
        DTEST = DIST - DX
        IF (DTEST) 30,35,45
     30 DX = DX - DIST
        DT = T(L)
        DELTAT(L) = DT
        CALL TEMP(IQ, II, MADV, M, N, DT, Z, TH1)
        II = II   1
        IF (II.GT.NPQ) GO TO 75
        L = 1
        GO TO 25
     35 DT = T(L)
        DELTAT(L) = DT
        CALL TEMP(IQ, II, MADV, M, N, DT, Z, TH1)
        N = N   1
        IF (N.GT.IDADV(MADV)) MADV = MADV + 1
```

```
      IF (N.NE.IDCHNG(NNEW)) GO TO 36
      TH1 = THR(NNEW,II)
      NNEW = NNEW + 1
   36 CONTINUE
      GO TO 46
   45 L = L   1
      T(L) = DX/U
      DT = T(L)
      DELTAT(L) = DT
      CALL TEMP(IQ, II, MADV, M, N, DT, Z, TH1)
      T(L) = T(L-1) - T(L)
      N = N   1
      IF (N.GT.IDADV(MADV)) MADV = MADV + 1
      IF (N.NE.IDCHNG(NNEW)) GO TO 46
      TH1 = THR(NNEW,II)
      NNEW = NNEW + 1
   46 CONTINUE
      DO 49 K = 1,NTP
      IF (N.NE.IDTP(K)) GO TO 49
      THETA(K,I) = TH1
      SUM = 0.0
      DO 48 KL = 2,L
      SUM = SUM + DELTAT(KL)
   48 CONTINUE
      TIME(K,I) = (II - 1)*T(1) + SUM
   49 CONTINUE
      IF (DTEST.EQ.0.0) L = 1
      IF (DTEST.EQ.0.0) II = II + 1
      IF (II.GT.NPQ) GO TO 75
      N1 = N + 1
      IF (N1.LT.ID(M+1)) GO TO 20
      M = M + 1
      IF (M.GE.NDAMS) GO TO 99
      IQ = II
      GO TO 15
   75 NDUM = 0
   80 NDUM = NDUM   1
      IF (N.GE.IDTP(NDUM)) GO TO 80
      ND1F = NTP - NDUM + 1
      DO 89 ID1F = 1,ND1F
```

```
      NDUG = NDUM + IDIF - 1
      THETA(NDUG,I) = -999.99
   89 CONTINUE
   99 CONTINUE
      RETURN
      END
```

```
(5)    SUBROUTINE HYDRA2(II, IQ, M, MADV, N, U, Z)
C      SUBROUTINE HYDRA2 CALCULATES DEPTH AND VELOCITY OF THE PARCEL AS
C      REQUIRED BY SUBROUTINE TROUT.
       COMMON/NUMBER/NADV, NDAMS, NDAYS, NPD, NPER, NSECT, NT1, NCHNG,
      1 NTP, NTHIN(15), NPQ
       COMMON/HYDRO/ELT(12,400), QD(12,400), QADV(5,400), QZ
       COMMON/IDENT/ID(15), IDIN(15), IDADV(15), IDTP(15), IDCHNG(15)
       COMMON/CHECK/JJMAX(400)
       COMMON/GEOM/AX(100,25), WX(100,25), X(100), CTE(100), CD(100), DZ
       DIMENSION AR(2), WR(2), QDUMMY(10)
       IDAY = (IQ - 1)/NPD + 1
       DO 20 L = 1,2
       NL1 = N + L - 1
       EL = ELT(M,IDAY) - CTE(NL1)
    10 DELTA = (EL - CD(NL1))/DZ + 1.0
       K = DELTA
       K1 = K + 1
       HK = K
       WR(L) = WX(NL1,K) + (DELTA - HK)*(WX(NL1,K1) - WX(NL1,K))
       AR(L) = AX(NL1,K) + (DELTA - HK)*(AX(NL1,K1) - AX(NL1,K))
    20 CONTINUE
       WA = (WR(1) + WR(2))/2.0
       AA = (AR(1) + AR(2))/2.0
       IF (N.NE.ID(M)) GO TO 25
       QADD = 0.0
       MTEST2 = MADV
       NTEST = IDADV(MADV)
    25 CONTINUE
       IF (N.LT.IDADV(MTEST2)) GO TO 40
       IF (N.NE.NTEST) GO TO 35
       IQADV = II
       NTEST = IDADV(MADV)
       GO TO 40
    35 CONTINUE
       SUM1 = 0.0
       SUM2 = 0.0
       DO 38 I = IQADV,II
       MAD1 = MADV - 1
       RATIO = QADV(MAD1,I)/QADV(MAD1,IQADV)
       SUM1 = SUM1 + RATIO
```

```
      SUM2 = SUM2 + RATIO*QADV(MAD1,I)
   38 CONTINUE
      ITEMP = MADV - MTEST2
      QDUMMY(ITEMP) = SUM2/SUM1
      QADD = 0.0
      DO 39 I = 1,ITEMP
      QADD = QADD + QDUMMY(I)
   39 CONTINUE
   40 CONTINUE
      SUM1 = 0.0
      SUM2 = 0.0
      DO 49 I = IQ,II
      RATIO = QD(M,I)/QD(M,IQ)
      SUM1 = SUM1 + RATIO
      SUM2 = SUM2 + RATIO*QD(M,I)
   49 CONTINUE
      Q = SUM2/SUM1 + QADD
   55 U = Q/AA
      Z = AA/WA
      QZ = Q
      RETURN
      END
```

```
(6)    SUBROUTINE TEMP(IQ, II, MADV, M, N, DT, Z, TH1)
C      SUBROUTINE TEMP CALCULATES PARCEL TEMPERATURES AS REQUIRED BY
C      SUBROUTINE TROUT.
       COMMON/ROOTS/ALPHA(40,24), BETA(40,24), GAMMA(40,24)
       COMMON/IDENT/ID(15), IDIN(15), IDADV(15), IDTP(15), IDCHNG(15)
       COMMON/HYDRO/ELT(12,400), QD(12,400), QADV(5,400), Q
       COMMON/TEMPER/THETA(5,365), THR(5,365), TADV(5,365)
       COMMON/NUMBER/NADV, NDAMS, NDAYS, NPD, NPER, NSECT, NT1, NCHNG,
      1 NTP, NTHIN(15), NPQ
       COMMON/CONST/ NDMET, NAVG, NMD, IS1, IS2, IS3, IS4, IS5, IS6, IV,
      1MAXT, MINT
       NPDAVG = NAVG*NPD
       INDMET = (NDMET - 1 ) / NAVG + 1
       IAVG = ( II-1 )/NPDAVG + 1
       IF (IAVG.GT.INDMET) IAVG = INDMET
       INPD = II -((II - 1)/NPD)*NPD
       EX = GAMMA(IAVG,INPD)*DT/(62.43*Z)
       GO TO (10,20), IV
    10 TAV = TH1   BETA(IAVG, INPD)
       TAV = TAV*EXP(EX)
       TAV = -BETA(IAVG, INPD) + TAV
       GO TO 25
    20 TAV = (TH1 + ALPHA(IAVG,INPD))/(TH1 + BETA(IAVG,INPD))
       TAV = TAV*EXP(-EX)
       TAV = (-ALPHA(IAVG,INPD) + BETA(IAVG,INPD)*TAV)/(1.0 - TAV)
    25 TH1 = TAV
       IF (N.NE.IDADV(MADV)) GO TO 100
       TMAIN = TH1*Q
       TTRIB = TADV(MADV,II)*QADV(MADV,II)
       QTOT = Q + QADV(MADV,II)
       TH1 = (TMAIN+TTRIB)/QTOT
   100 RETURN
       END
```

```
(7)    SUBROUTINE METEOR(IAVG)
C      SUBROUTINE METEOR CALCULATES THE HEAT BUDGET AS A FUNCTION OF
C      WATER TEMPERATURE, USING THE INPUT METEOROLOGY DATA.  .
C      THIS INFORMATION IS PASSED TO SUBROUTINE CRVXZQ WHERE A FIRST
C      OR SECOND ORDER POLYNOMIAL RELATING THE HEAT BUDGET TO WATER
C      TEMPERATURE IS GENERATED.

       COMMON/CONST/ NDMET, NAVG, NMD, IS1, IS2, IS3, IS4, IS5, IS6, IV,
      1MAXT, MINT
       COMMON/WEATHR/QS(100), CC(100), W(100), TA(100), TAW(100), AP(100)
       COMMON/ROOTS/ALPHA(40,24), BETA(40,24), GAMMA(40,24)
       COMMON/HEATBG/TW(50), QT(50), C(10), MDTH
       COMMON/NUMBER/NADV, NDAMS, NDAYS, NPD, NPER, NSECT, NT1, NCHNG,
      1 NTP, NTHIN(15), NPQ
       COMMON/EVAP/CT3, CT4
       COMMON/ALMNAC/FHI, DTSL, DAY1
       DIMENSION A1(2,11), GOFGRA(30)
       REAL*4 LHA
       MM = MAXT - MINT + 1
       MDTH = MM
       XNPD = NPD
       T1 = 24.0/XNPD
       DO 9 J = 1,MM
       J1 = J - 1
       TW(J) = MINT + J1
     9 CONTINUE
       DO 99 I = 1,NPD
       TAI = TA(I)
       TAC = 5.*(TA(I)-32.)/9.
       TAWC = 5.*(TAW(I)-32.)/9.
       TAWC2 = TAWC/2.
       NGG = TAWC2 + 1
       XNGG = NGG - 1.
       EA = GOFGRA(NGG) + (TAWC2-XNGG)*(GOFGRA(NGG+1)-GOFGRA(NGG))
       IF (IS4.EQ.2) GO TO 70
       D1 = 0.00066*(1.+0.0015*TAWC)
       D2 = TAC - TAWC
       P = AP(I)*33.8639
       EA = EA - D1*P*D2
    70 IC1 = (CC(I) + 1.5)
```

```
      EA = EA/33.8639
   80 BATA = A1(1,IC1) + A1(2,IC1)*EA
      IF (IS6.NE.1) GO TO 90
   85 WRITE(6 ,1000)IAVG, I, BATA, EA, RH, ES
      WRITE(6 ,1010) W(I), AP(I), TA(I), TAW(I), CC(I), QS(I)
      WRITE(6 ,1020)
   90 QB1 = SQRT(BATA)
      QB1 = QB1*(TAI + 459.4)**2
C    ******************************************************************
C    *    COMPUTING REFLECTED SOLAR RADIATION                         *
C    ******************************************************************
      DAY = DAY1   (IAVG - 1)*NAVG   NAVG/2.0
      PI = 3.14159
      PHI = FHI*PI/180.
      DELTA = 23.45*PI/180.0
      DELTA = DELTA*COS(2.0*PI*(194.0-DAY)/365.0)
      XI = I
      T2 = T1*(2.0*XI-1.0)/2.0
      LHA = T2 - 12.0 - DTSL
      LHA = LHA*PI/12.0
      ALPSN = SIN(PHI)*SIN(DELTA)   COS(PHI)*COS(DELTA)*COS(LHA)
      ALPHR = ARSIN(ALPSN)
      ALPHR = 180.0*ALPHR/PI
      ALPHR = ABS(ALPHR)
      IF (ALPHR.LT.0.01) ALPHR = 0.01
      CLOUD = CC(I)
      IF (CLOUD.LT.1.0) RS = 1.18*ALPHR**(-0.77)
      IF (CLOUD.GE.1.0.AND.CLOUD.LT.6.0) RS = 2.20*ALPHR**(-0.97)
      IF (CLOUD.GE.6.0.AND.CLOUD.LT.9.0) RS = 0.95*ALPHR**(-0.75)
      IF (CLOUD.GT.9.0) RS = 0.35*ALPHR**(-0.45)
C    ******************************************************************
C    *    GENERATE ARRAY OF HEAT FLUX AS A FUNCTION OF WATER          *
C    *    TEMPERATURE, FOR EACH DAILY TIME PERIOD                     *
C    ******************************************************************
      DO 96 J = 1,MM
      TWC = 5.0*(TW(J) - 32.0)/9.0
      HV = -0.545*TWC + 595.85
      HV = 1.8*HV
      TWC2 = TWC/2.
      NGG = TWC2 + 1
```

```
      XNGG = NGG - 1.
      EW = GOFGRA(NGG) + (TWC2-XNGG)*(GOFGRA(NGG+1)-GOFGRA(NGG))
      EW = EW/33.8639
      CT1 = 0.97
      CT2 = 1.72E-09
      QE = HV*CT3*W(I)*(EW - EA)
      QH = HV*CT4*W(I)*AP(I)*(TAI - TW(J))
      QB = (TW(J) + 459.4)**2
      QB = (QB - QB1)*(QB + QB1)*CT1*CT2
   91 QT(J)   QS(I)*(1.0-RS)-QB-QE QH
      GO TO 95
   95 CONTINUE
      IF (IS6.EQ.1) WRITE(6 ,1030) TW(J), QT(J), QS(I), QR, QB, QE, QH,
     1 EW, TW(J)
   96 CONTINUE
      IVP = IV
      CALL CRVXZQ(IVP)
      GO TO (97,98), IV
   97 GAMMA(IAVG,I) = C(2)
      BETA(IAVG,I) = C(1)/C(2)
      WRITE(6 ,1040) IAVG, I, BETA(IAVG,I), IAVG, I, GAMMA(IAVG,I)
      GO TO 99
   98 GAM = C(2)*C(2) - 4.0*C(1)*C(3)
      GAMMA(IAVG,I) = SQRT(GAM)
      ALPHA(IAVG,I) = (C(2) + GAMMA(IAVG,I))/(2.0*C(3))
      BETA(IAVG,I) = (C(2) - GAMMA(IAVG,I))/(2.0*C(3))
      WRITE(6 ,1047) C(1), C(2), C(3)
      WRITE (6 ,1050) IAVG, I, ALPHA(IAVG,I), IAVG, I, BETA(IAVG,I),
     1IAVG, I, GAMMA(IAVG,I)
   99 CONTINUE
 1000 FORMAT (23H ENERGY BUDGET PERIOD  ,I3,//14H DAILY PERIOD ,I3/////
     132H ATMOSPHERIC RADIATION FACTOR = ,F8.3, 2X, 6H EA = , F8.3, 2X,
     26H RH = ,F8.3, 2X, 6H ES = ,F8.3//)
 1010 FORMAT (20H         WIND SPEED = ,F8.3/
     1         20H     AIR PRESSURE = ,F8.3/
     2         20H  AIR TEMPERATURE = ,F8.3/
     3         20H   WET BULB TEMP. = ,F8.3/
     4         20H      CLOUD COVER = ,F8.3/
     5         20H  SOLAR RADIATION = ,F8.3)
 1020 FORMAT (1HO//10X, 3H TW, 9X, 3H QT, 9X, 3H QS, 9X, 3H QR, 9X,
```

```
     13H QB, 9X, 3H QE, 9X, 3H QH, 9X, 3H EW, 9X, 3H TW//)
1030 FORMAT (1H , 9F12.3)
1040 FORMAT (1H0//7H  BETA(,I3, 1H,, I2, 4H) = F8.3/
     1              7H GAMMA(,I3, 1H,, I2, 4H) = F8.3)
1047 FORMAT(//10X,4HQ    ,F7.3,4H    (,F9.6,6H)T    (,F9.7,5H)T**2)
1050 FORMAT (1H0//7H ALPHA(,I3, 1H,, I2, 4H) = F8.3/
     1              7H  BETA(,I3, 1H,, I2, 4H) = F8.3/
     2              7H GAMMA(,I3, 1H,, I2, 4H) = F8.3)
1060 FORMAT(1X,2F4.2,F6.1,F3.2)
      DATA A1/0.740, 0.154, 0.750, 0.151, 0.761, 0.145, 0.770, 0.143,
     10.781, 0.137, 0.791, 0.134, 0.800, 0.132, 0.810, 0.129, 0.827,
     20.117, 0.845, 0.105, 0.868, 0.087/,
     3GOFGRA/6.108, 7.055, 8.129, 9.347, 10.72, 12.27, 14.02, 15.98,
     418.17, 20.63, 23.37, 26.43, 29.83, 33.61, 37.80, 42.43, 47.55,
     553.20, 59.42, 66.26, 73.78, 82.02, 91.03, 100.89, 111.66, 123.40/
      RETURN
      END
```

(8)

```
      SUBROUTINE CRVXZQ(IV)
C     SUBROUTINE CRVXZQ IS A CURVE FITTING ROUTINE USING THE METHOD OF
C     LEAST SQUARES.
      COMMON/HEATBG/X(50), Y(50), C(10), MDTH
      REAL*8 A(11,11), B(11), P(20)
      IV2 = IV*2
      DO 9 I = 1,IV2
      P(I) = 0.0
      DO 9 J = 1,MDTH
      P(I) = P(I) + X(J)**I
    9 CONTINUE
      N = IV + 1
      DO 19 I = 1,N
      DO 19 J = 1,N
      K = I + J - 2
      IF (K) 15,15,10
   10 A(I,J) = P(K)
      GO TO 19
   15 A(1,1) = MDTH
   19 CONTINUE
      B(1) = 0.0
      DO 29 J = 1,MDTH
      B(1) = B(1) + Y(J)
   29 CONTINUE
      DO 39 I = 2,N
      B(I) = 0.0
      DO 39 J = 1,MDTH
      B(I) = B(I) + Y(J)*X(J)**(I-1)
   39 CONTINUE
      NM1 = N - 1
      DO 89 K = 1,NM1
      KP1 = K + 1
      L = K
      DO 49 I = KP1,N
      AIK = ABS(A(I,K))
      ALK = ABS(A(L,K))
      IF (AIK - ALK) 49,49,45
   45 L = I
   49 CONTINUE
      K2 = K
```

```
      IF (L - K2) 60,60,50
   50 DO 59 J = K2,N
      TEMP = A(K,J)
      A(K,J) = A(L,J)
      A(L,J) = TEMP
   59 CONTINUE
      TEMP = B(K)
      B(K) = B(L)
      B(L) = TEMP
   60 DO 89 I = KP1,N
      FACTOR = A(I,K)/A(K,K)
      A(I,K) = 0.0
      DO 69 J = KP1,N
      A(I,J) = A(I,J) - FACTOR*A(K,J)
   69 CONTINUE
      B(I) = B(I) - FACTOR*B(K)
   89 CONTINUE
      C(N) = B(N)/A(N,N)
      I = NM1
   90 IP1 = I + 1
      SUM = 0.0
      DO 99 J = IP1,N
   99 SUM = SUM + A(I,J)*C(J)
      C(I) = (B(I) - SUM)/A(I,I)
      I = I - 1
      IF (I) 100,100,90
  100 RETURN
      END
```

```
(9)    SUBROUTINE TWRITE
C      SUBROUTINE TWRITE WRITES OUT PREDICTED INFORMATION AS A FUNCTION
C      OF PARCEL NUMBER AND LOCATION.
       COMMON/IDENT/ID(15), IDIN(15), IDADV(15), IDTP(15), IDCHNG(15)
       COMMON/TEMPER/THETA(5,365), THR(5,365), TADV(5,365)
       COMMON/HOWLNG/TIME(10,400)
       COMMON/NAME/XCHNG(5,40), XOUT(10,40)
       COMMON/NUMBER/NADV, NDAMS, NDAYS, NPD, NPER, NSECT, NT1, NCHNG,
      1 NTP, NTHIN(15), NPQ
       COMMON/EVAP/CT3, CT4
       DIMENSION HOTPOO(10,20)
       READ(5 ,1001) ((HOTPOO(I,J), J = 1,20), I = 1,7)
       WRITE(6 ,1002) ((HOTPOO(I,J), J = 1,20), I = 1,7)
       XNPD = NPD
       T1 = 24.0/XNPD
       DO 29 J = 1,NTP
       XMEAN = 0.0
       STDV = 0.0
       NADD = 0
       WRITE(6 ,1004) (XOUT(J,L), L = 1,20)
       IK = 0
       DO 9 K = 1,NT1
       IF (IDTP(J).EQ.IDIN(K)) IK = K
     9 CONTINUE
       JK = 0
       DO 19 K = 1,NCHNG
       IF (IDTP(J).GT.IDCHNG(K)) JK = K
    19 CONTINUE
       IF (JK.NE.0) WRITE(6 ,1005) (XCHNG(JK,L), L = 1,20)
       WRITE(6 ,1010)
       DO 28 L = 1,NPER
       IF (THETA(J,L).GT.-999.0) GO TO 20
       WRITE(6 ,1020) L
       GO TO 28
    20 II = TIME(J,L)/T1 + 1
       IDAY = TIME(J,L)/24.0 + 1
       IHOUR = TIME(J,L) - IDAY*24 + 24
       IHOUR = IHOUR*100
       IDAYEL = (TIME(J,L) - (L - 1)*T1)/24
       IHOURE = TIME(J,L) - (L - 1)*T1 - 24*IDAYEL
```

```
      IF (II.GT.NTHIN(IK)) GO TO 25
      IF (IK.EQ.0) GO TO 25
      WRITE(6 ,1030) L, IDAY, IHOUR, IDAYEL, IHOURE, THETA(J,L),
     1THR(IK,II), THR( 1,L), L
      DIFF = THETA(J,L) - THR(IK,II)
      XMEAN = DIFF + XMEAN
      STDV = DIFF**2 + STDV
      NADD = NADD + 1
      GO TO 28
   25 CONTINUE
      WRITE(6 ,1040) L, IDAY,IHOUR, IDAYEL, IHOURE, THETA(J,L), THR(1,L)
     1, L
   28 CONTINUE
      WRITE(6 ,1041)
      WRITE(6 ,1050) CT3, CT4
      IF (NADD.EQ.0) GO TO 29
      XMEAN = XMEAN/NADD
      STDV = STDV/(NADD - 1)
      STDV = SQRT(STDV)
      WRITE(6 ,1045) XMEAN, STDV
   29 CONTINUE
 1001 FORMAT (20A4)
 1002 FORMAT (1H1,(/////11X, 20A4))
 1004 FORMAT (1H1, 10X, 20A4/11X, 20A4//)
 1005 FORMAT (1H0, 10X, 20A4/11X, 20A4//)
 1010 FORMAT (1H0, 2X, 105H---------------------------------------------
     1------------------------------------------------------------/3X,
     22H--, 9X, 2H--, 15X, 2H--, 15X, 2H--, 14X, 2H--, 14X, 2H--, 14X,
     32H--, 8X, 2H--/3X, 105H--          -- ARRIVAL TIME  --  TRAVEL TIME
     4 --  PREDICTED   --  OBSERVED    --   INITIAL    --          --/3X,
     5105H-- PARCEL  ------------------------------------ TEMPERATURE  -
     6- TEMPERATURE  -- TEMPERATURE  -- PARCEL --/3X,  105H-- NUMBER  --
     7 DAY  -  TIME  -- DAYS - HOURS  --   (FAHR.)   --   (FAHR.)    --
     8   (FAHR.)    -- NUMBER --/3X, 2H--, 9X, 2H-- 6X, 1H-, 8X, 2H--,
     96X, 1H-, 8X, 2H--, 14X, 2H--,  14X, 2H--, 14X, 2H--, 8X, 2H--/3X,
     A105H--------------------------------------------------------------
     B-------------------------------------------)
 1020 FORMAT (3X, 2H--, 2X, I3, 4X, 2H--, 2X, 3HDNR,  1X, 1H-- 8X, 2H--,
     16X, 1H-- 8X, 2H--, 14X, 2H--, 14X, 2H--, 14X, 2H-- 8X, 2H--/3X,
     2105H--------------------------------------------------------------
```

```
    3---------------------------------------)
1030 FORMAT (3X, 4H--  , I3, 7H    -- , I3, 5H  -  , I4, 5H  -- , I3,
    14H  - , I4, 9H   --     , F5.1, 11H     --    , F5.1, 11H     --
    2 , F5.1, 9H    --  , I3, 5H   --/, 3X, 105H---------------------
    3-----------------------------------------------------------------
    4----------------)
1040 FORMAT (3X, 4H--  , I3, 7H    -- , I3, 5H  -  , I4, 5H  -- , I3,
    14H  - , I4, 9H   --     , F5.1, 11H     --    , 5H-----,  11H    -
    2-    , F5.1, 9H    --  , I3, 5H   --/3X, 105H-------------------
    3-----------------------------------------------------------------
    4------------------)
1041 FORMAT (1HO, 5X, 32HDNR - DID NOT REACH THIS STATION /
    112X, 25HDURING COMPUTATION PERIOD//)
1045 FORMAT (1HO//6X, 53HMEAN VALUE OF PREDICTED MINUS OBSERVED TEMPERA
    1TURES -, F5.1//6X, 61HSTANDARD DEVIATION OF PREDICTED MINUS OBSERV
    2ED TEMPERATURES -, F5.1//)
1050 FORMAT (1HO, 5X, 25HEVAPORATION COEFFICIENT -, 1PE10.2, 1X, 23HLB.
    1/MILE/FT.**2/IN. HG.//6X, 38HSENSIBLE HEAT CONDUCTION COEFFICIENT
    2-, 1PE10.2, 1X, 23HLB./MILE/FT.**2/DEG. F.)
     RETURN
     END
```

APPENDIX D

D.1 SAMPLE DATA

I.1

```
    1    4   24   24    4   36  2.0
```

I.2

```
001 397.100.0 382.000090.0160.000686.0470.001776.0640.002600.0660.004420.0680.01
0010397.100.00382.005100.0700.006400.0810.008500.0860.010800.0955.012700.0980.02
0010397.100.00382.014800.1050.016900.1300.018800.1700.021000.1095.023200.1110.03
0010397.100.00382.026000.1135.028200.1160.030800.1180.033000.1200.035300.1230.14
0020392.405.60380.000300.0185.000700.0300.001700.0490.002700.0610.014000.0760.01
0020392.405.60380.005470.0840.007230.0930.009000.1000.011200.1075.013400.1100.02
0020392.405.60380.015600.1150.018000.1240.020600.1320.023300.1400.026000.1490.13
0030386.712.50380.005700.0880.007620.1070.009920.1225.012800.1275.015000.1330.01
0030386.712.50380.017200.1380.020000.1450.023000.1550.026100.1650.029700.1750.02
0030386.712.50380.033700.1850.033200.1940.037200.2040.041000.2140.045700.2240.13
0040382.119.60360.002300.0500.003960.0520.004200.0570.006200.0600.006900.0640.01
0040382.119.60360.008200.0680.010100.0710.011900.0850.013900.1000.015900.1150.02
0040382.119.60360.018000.1180.020500.1210.023000.1250.025500.1300.028500.1390.03
0040382.119.60360.031200.1470.031500.1580.034800.1670.037900.1760.041200.1850.14
0050377.425.80370.002470.0450.003780.0880.006450.1700.010020.1800.013630.1820.01
0050377.425.80370.017000.1860.020800.1890.024200.1930.028000.1960.032000.2000.02
0050377.425.80370.036700.2040.040500.2080.044700.2110.049000.2150.053800.2200.13
0060371.635.60360.004980.1230.007750.1470.010830.1600.014180.1730.017890.1960.01
0060371.635.60360.022600.4000.030000.4050.037900.4100.046100.4130.055500.4180.02
0060371.635.60360.063710.4250.073200.4280.082000.4310.090700.4370.000000.0000.13
0070364.447.00350.008400.1460.011200.1510.014480.1590.017900.1630.021200.1695.01
0070364.447.00350.024400.1740.028200.1800.032000.1840.035700.1890.039200.1930.02
0070364.447.00350.043000.1990.047200.2040.051300.2090.055900.2140.060000.2195.13
0080358.354.40340.012500.0880.014300.0950.016200.1000.018300.1020.020500.1050.01
0080358.354.40340.022200.1090.024700.1105.027000.1150.029200.1190.031500.1220.02
0080358.354.40340.034000.1260.036500.1300.039000.1330.031500.1370.044500.1400.13
0090353.658.30340.006855.1240.009483.1388.012407.1536.015613.1657.019017.1748.01
0090353.658.30340.022605.1840.026397.1952.030413.2064.034652.2174.000000.0000.12
0100346.365.90334.008077.1416.011143.1656.014707.1908.018775.2160.023121.2186.01
0100346.365.90334.027519.2212.031968.2237.036466.2261.041012.2285.045616.2319.02
0100346.365.90334.050288.2353.055024.2378.000000.0000.000000.0000.000000.0000.13
 11 339.569.0 324.  6400. 850. 10400. 850. 14400. 850. 18400.1150. 22400.1450.00
0110339.569.00324.026426.1747.030411.2278.035163.2474.040307.2670.045759.2782.01
```

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0110339.569.00324.051435.2894.057571.3218.064023.3234.070507.3250.077103.3346.02
0110339.569.00324.083891.3442.090888.3572.000000.0000.000000.0000.000000.0000.13
 12 333.669.8 324. 15000.2200. 20000.2300. 25000.2400. 30000.2500. 35000.2600.00
0120333.669.80324.040073.2673.045451.2723.050983.2809.056687.2895.062497.2915.01
0120333.669.80324.068347.2935.074243.2966.080217.3008.086275.3050.092763.3438.02
0120333.669.80324.100027.3826.108230.4320.000000.0000.000000.0000.000000.0000.13
 13 329.470.1 324. 27700.3000. 31700.3000. 37700.3000. 43700.3000. 49700.3000.00
0130329.470.10324.055753.3024.061823.3046.067937.3068.074095.3090.080743.3448.01
0130329.470.10324.087887.3696.095645.4180.104725.4900.115245.5620.126817.5952.02
0130329.470.10324.139053.6284.151915.6540.000000.0000.000000.0000.000000.0000.13
 14 324.370.4 324. 37000.3250. 46000.3350. 55000.3450. 64000.3550. 73000.3650.00
0140324.370.40324.081700.3748.090347.4904.100243.4992.110315.5080.121079.5424.01
0140324.370.40324.132011.5508.143130.5630.154550.5790.166290.5950.000000.0000.12
 15 324.070.4 324.109679.6700.111335.6800.113654.6900.115774.7100.115232.7200.01
0150324.070.40324.119679.7302.134961.7872.150829.7996.166945.8120.183229.8164.02
0150324.070.40324.199601.8208.216061.8252.232609.8296.249245.8340.000000.0000.13
0160319.570.50324.268849.8581.286442.8999.304808.9367.323910.9735.351738.9999.01
0160319.570.50324.268849.8581.286442.8999.304808.9367.323910.9735.351738.9999.02
0160319.570.50324.380222.9999.409473.9999.439977.9999.471785.9999.000000.0000.13
 17 311.870.5 324.187563.5150.197662.5160.207334.5170.217882.5200.228101.5210.01
0170311.870.50324.237884.5251.248404.5268.258956.5284.269540.5300.280168.5328.02
0170311.870.50324.290852.5356.301592.5384.312388.5412.323240.5440.000000.0000.13
 18 303.570.6 324.296501.6055.305551.6072.309886.6082.318524.6102.326441.6130.01
0180303.570.60324.339738.6162.352092.6184.364470.6192.376862.6200.389535.6343.02
0180303.570.60324.402234.6356.414961.6373.427728.6394.440537.6415.000000.0000.13
 19 292.370.7 324.356773.6025.361228.6100.375212.6150.389520.6160.392110;6200.01
0190292.370.70324.401801.6288.414924.6828.428613.6860.442367.6893.456185.6925.02
0190292.370.70324.470070.6958.484016.6983.497999.7000.000000.0000.000000.0000.13
0200292.000.00240.009000.0670.010500.0750.012000.0820.013800.0950.016000.1180.01
0200292.000.00240.018000.1440.021700.1710.025000.1940.029000.2160.033000.2360.02
0200292.000.00240.037000.2520.043000.2780.049000.2990.055000.3140.061500.3270.13
0210283.015.70230.014500.1290.018000.1570.022000.1860.026000.2130.030000.2400.01
0210283.015.70230.034000.2620.039000.2690.044500.2750.050000.2810.055500.2840.02
0210283.015.70230.061000.2880.067000.2980.072500.3000.078500.3050.084500.3110.13
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0220273.526.00220.037000.2190.044000.2650.050500.3100.058000.3630.065000.4200.02
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I.2 (Cont.)

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I.3

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I.4

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II. 1

24 10 24 75 50

II.2

46.0 232

II.3

2 1 1 1 1 2 2

II.4

1.09E-02 3.71E-06

II.5

(16X, F5.0, 5X, F2.0, F3.0, 8X, F4.1, F4.1, 4X, F5.2)

II.6

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196708200200	000	0020.029282.778.758.0	29.2026.0
196708200300	000	0020.029281.477.858.0	29.2029.0
196708200400	000	0019.029279.475.057.0	29.2032.0
196708200500	000	0414.029280.069.552.0	29.2028.0

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196708200700	004	09 5.029278.474.655.0	29.2025.0
196708200800	007	09 8.029277.777.757.0	29.2026.0
196708200900	037	04 5.027080.085.061.0	29.2022.0
196708201000	043	02 4.000082.887.061.0	29.2020.0
196708201100	066	03 3.009087.391.262.0	29.2018.0
196708201200	070	01 2.009090.894.764.0	29.2016.0
196708201300	067	01 2.006893.797.765.0	29.2014.0
196708201400	059	09 2.015896.999.965.0	29.2013.0
196708201500	056	09 3.015898.099.965.0	29.2012.0
196708201600	030	09 5.022598.399.965.0	29.2011.0
196708201700	023	0919.031593.996.162.0	29.2012.0
196708201800	008	1028.031588.989.962.0	29.2017.0
196708201900	002	1038.031583.885.060.0	29.2020.0
196708202000	000	1039.029281.882.859.0	29.2022.0
196708202100	000	1035.029279.380.361.0	29.2031.0
196708202200	000	1034.029278.979.960.0	29.2030.0
196708202300	000	0628.029276.177.059.0	29.2033.0
196708202400	000	0424.029274.073.958.0	29.2036.0
196708210100	000	0021.029272.671.856.0	29.2036.0
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196708210300	000	0015.029270.667.155.0	29.2045.0
196708210400	000	0013.029269.666.155.0	29.2048.0
196708210500	000	0015.029269.766.057.0	29.2057.0
196708210600	004	0220.029268.069.158.0	29.2053.0
196708210700	004	0011.029271.472.758.0	29.2042.0
196708210800	007	01 7.020273.476.460.0	29.2039.0
196708210900	037	0010.031576.683.262.0	29.2029.0
196708211000	043	0016.031576.283.062.0	29.2030.0
196708211100	066	0015.031578.284.562.0	29.2028.0
196708211200	070	0515.031580.888.063.0	29.2023.0
196708211300	067	0617.031582.389.762.0	29.2019.0
196708211400	059	0722.029283.690.162.0	29.2017.0
196708211500	055	0423.031585.591.761.0	29.2014.0
196708211600	030	0017.029286.492.261.0	29.2014.0
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196708211900	002	0022.031582.182.059.0	29.2024.0
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196708212100	000	0024.031577.976.758.0	29.2031.0

II.6 (Cont.)

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196708220700	017	00 5.029268.071.158.0	29.2043.0
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196708220900	047	00 4.033873.778.160.0	29.2035.0
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196708221100	066	00 3.004579.384.361.0	29.2025.0
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196708221900	002	0010.011287.484.660.0	29.2021.0
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196708222300	000	0020.029278.176.560.0	29.2038.0
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196708230200	000	0017.029275.474.359.0	29.2040.0
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196708230600	003	0014.029273.570.658.0	29.2045.0
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196708232000	000	0031.031570.471.153.0	29.2028.0
196708232100	000	0036.031568.269.655.0	29.2037.0
196708232200	000	0032.031567.268.254.0	29.2038.0
196708232300	000	0022.029266.467.254.0	29.2042.0
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196708240100	000	0025.029266.465.953.0	29.2041.0
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196708242200	000	00 5.029276.667.550.0	29.2022.0
196708242300	000	0016.029275.265.248.0	29.2024.0
196708242400	000	0019.029279.067.850.0	29.2024.0
196708250100	000	0020.031573.365.751.0	29.2035.0
196708250200	000	0020.031572.466.052.0	29.2036.0
196708250300	000	0020.031570.862.350.0	29.2041.0
196708250400	000	0019.031570.264.851.0	29.2038.0
196708250500	000	0016.031569.462.451.0	29.2043.0

196708250600	003	0012.033869.265.352.0	29.2041.0
196708250700	016	0013.031569.470.454.0	29.2033.0
196708250800	032	00 9.031571.074.855.0	29.2023.0
196708250900	046	00 8.033872.877.855.0	29.2018.0
196708251000	058	00 9.002274.279.855.0	29.2017.0
196708251100	065	0011.002277.183.056.0	29.2015.0
196708251200	070	0011.004580.185.257.0	29.2014.0
196708251300	069	0010.004581.687.859.0	29.2014.0
196708251400	064	0010.004582.687.258.0	29.2013.0
196708251500	054	0011.002283.789.960.0	29.2013.0
196708251600	043	0011.002285.291.060.0	29.2013.0
196708251700	029	00 9.002285.288.659.0	29.2013.0
196708251800	013	0011.000084.486.558.0	29.2013.0
196708251900	002	0012.000083.178.854.0	29.2015.0
196708252000	000	0012.000083.072.952.0	29.2018.0
196708252100	000	0011.033881.668.750.0	29.2021.0
196708252200	000	0010.033881.668.850.0	29.2022.0
196708252300	000	0011.031580.768.250.0	29.2022.0
196708252400	000	0012.031579.067.850.0	29.2024.0
196708260100	000	0011.033878.265.749.0	29.2027.0
196708260200	000	0311.031577.567.049.0	29.2023.0
196708260300	000	0112.031576.367.650.0	29.2024.0
196708260400	000	0014.029276.065.549.0	29.2024.0
196708260500	000	0013.031573.664.549.0	29.2030.0
196708260600	004	01 8.031572.766.450.0	29.2030.0
196708260700	015	04 9.031571.770.152.0	29.2026.0
196708260800	031	06 9.031572.176.154.0	29.2021.0
196708260900	042	09 6.033874.778.255.0	29.2019.0
196708261000	041	09 5.033876.881.957.0	29.2018.0
196708261100	064	10 6.033879.985.058.0	29.2016.0
196708261200	054	10 3.024882.585.057.0	29.2014.0
196708261300	030	10 1.006883.485.357.0	29.2014.0
196708261400	017	10 1.009084.387.158.0	29.2014.0
196708261500	020	10 5.013585.087.859.0	29.2014.0
196708261600	022	10 5.013584.888.660.0	29.2014.0
196708261700	023	0812.013585.888.859.0	29.2013.0
196708261800	010	10 7.015886.287.559.0	29.2014.0
196708261900	001	10 9.022583.782.856.0	29.2015.0
196708262000	000	10 8.022583.280.956.0	29.2016.0
196708262100	000	10 4.018082.478.655.0	29.2017.0

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196708270200	000	1012.027080.777.858.0	29.2027.0
196708270300	000	1010.027080.079.560.0	29.2028.0
196708270400	000	10 8.022580.378.859.0	29.2028.0
196708270500	000	1012.022579.374.558.0	29.2035.0
196708270600	001	10 6.027078.875.457.0	29.2030.0
196708270700	005	10 5.029278.977.058.0	29.2029.0
196708270800	010	10 5.024878.379.358.0	29.2027.0
196708270900	017	09 2.004578.281.059.0	29.2026.0
196708271000	034	09 1.004580.282.360.0	29.2026.0
196708271100	052	07 1.022584.288.562.0	29.2021.0
196708271200	071	06 4.022587.493.965.0	29.2019.0
196708271300	068	07 5.024888.894.065.0	29.2018.0
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196708271600	012	10 7.031589.293.064.0	29.2018.0
196708271700	011	10 8.033888.891.663.0	29.2019.0
196708271800	010	10 7.029288.991.463.0	29.2019.0
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196708280500	000	0017.029272.864.352.0	29.2041.0
196708280600	002	0016.029271.966.354.0	29.2044.0
196708280700	013	0115.029271.372.056.0	29.2035.0
196708280800	029	0214.031573.377.359.0	29.2032.0
196708280900	041	0714.031575.881.260.0	29.2028.0
196708281000	040	0810.031577.882.061.0	29.2028.0
196708281100	061	09 7.033881.186.462.0	29.2025.0
196708281200	066	08 6.033884.888.963.0	29.2023.0
196708281300	062	08 4.002287.493.265.0	29.2020.0

196708281400	054	08 5.002290.094.465.0	29.2018.0
196708281500	052	08 5.004591.695.165.0	29.2018.0
196708281600	032	10 6.004592.696.665.0	29.2017.0
196708281700	022	09 9.004592.294.264.0	29.2017.0
196708281800	012	09 8.002291.692.563.0	29.2017.0
196708281900	001	1011.002290.085.460.0	29.2021.0
196708282000	000	1011.000090.880.058.0	29.2024.0
196708282100	000	10 9.000088.178.458.0	29.2025.0
196708282200	000	1010.031587.879.958.0	29.2025.0
196708282300	000	10 8.000086.076.257.0	29.2030.0
196708282400	000	10 6.000084.475.557.0	29.2031.0
196708290100	000	10 5.033884.276.358.0	29.2030.0
196708290200	000	1011.031584.579.359.0	29.2028.0
196708290300	000	1013.031580.975.257.0	29.2032.0
196708290400	000	0013.031580.674.057.0	29.2033.0
196708290500	000	0015.031579.674.157.0	29.2034.0
196708290600	002	0715.031579.175.058.0	29.2034.0
196708290700	013	0912.031577.579.359.0	29.2029.0
196708290800	026	09 8.033878.882.560.0	29.2026.0
196708290900	043	09 7.033881.186.362.0	29.2024.0
196708291000	055	09 7.033882.987.963.0	29.2023.0
196708291100	062	09 8.000086.190.664.0	29.2021.0
196708291200	056	10 9.000090.194.966.0	29.2020.0
196708291300	046	0911.002292.096.266.0	29.2019.0
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196708291500	052	0911.002295.899.967.0	29.2016.0
196708291600	038	0911.002296.899.967.0	29.2016.0
196708291700	025	0612.002296.699.966.0	29.2015.0
196708291800	010	0614.002295.696.464.0	29.2016.0
196708291900	001	0414.000094.888.161.0	29.2019.0
196708292000	000	0515.000094.682.959.0	29.2021.0
196708292100	000	0215.002291.280.958.0	29.2022.0
196708292200	000	0012.002290.082.258.0	29.2022.0
196708292300	000	00 9.002287.177.356.0	29.2024.0
196708292400	000	00 5.004586.576.555.0	29.2024.0
196708300100	000	00 4.004586.575.055.0	29.2024.0
196708300200	000	00 8.031586.573.454.0	29.2026.0
196708300300	000	0011.031582.874.255.0	29.2027.0
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196708300500	000	0212.031579.073.756.0	29.2029.0

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196708300700	011	0611.031577.579.158.0	29.2026.0
196708300800	028	0710.031580.083.860.0	29.2022.0
196708300900	041	06 8.033883.089.062.0	29.2020.0
196708301000	053	04 8.000084.189.463.0	29.2020.0
196708301100	060	00 7.002287.992.964.0	29.2018.0
196708301200	062	00 7.002291.996.064.0	29.2015.0
196708301300	061	00 8.002295.599.968.0	29.2016.0
196708301400	058	00 8.002298.099.968.0	29.2015.0
196708301500	049	00 6.006899.399.968.0	29.2013.0
196708301600	039	00 8.006899.999.967.0	29.2013.0
196708301700	025	00 6.006899.999.967.0	29.2013.0
196708301800	010	00 8.004599.499.966.0	29.2014.0
196708301900	001	0015.004597.289.361.0	29.2017.0
196708302000	000	0016.004593.887.161.0	29.2019.0
196708302100	000	0013.006890.583.159.0	29.2021.0
196708302200	000	00 5.004589.983.759.0	29.2020.0
196708302300	000	00 2.031589.181.358.0	29.2022.0
196708302400	000	00 2.031587.279.858.0	29.2024.0
19670831010000000		0009.033787.377.858.0	29.2027.0
196708310200	00	0010.031584.576.256.0	29.2027.0
196708310300	00	0013.031584.275.856.0	29.2027.0
196708310400	00	0014.029284.275.856.0	29.2026.0
196708310500	00	0214.029282.874.256.0	29.2029.0
196708310600	02	0211.031580.774.356.0	29.2031.0
196708310700	13	0312.031581.180.559.0	29.2026.0
196708310800	30	0309.031580.984.860.0	29.2022.0
196708310900	40	0408.031582.588.362.0	29.2020.0
196708311000	52	0108.031584.289.962.0	29.2018.0
196708311100	60	0006.029287.893.263.0	29.2017.0
196708311200	64	0003.031591.195.264.0	29.2016.0
196708311300	62	0003.002393.398.065.0	29.2015.0
196708311400	56	0306.004596.8101.66.0	29.2014.0
196708311500	35	0605.018098.0103.67.0	29.2012.0
196708311600	39	0705.018098.3103.67.0	29.2013.0
196708311700	28	0409.022599.3103.66.0	29.2012.0
196708311800	11	061 .022598.298.964.0	29.2011.0
196708311900	01	0512.022596.589.059.0	29.2014.0
196708312000	00	0415.024793.485.359.0	29.2018.0
196708312100	00	0417.024788.384.061.0	29.2023.0

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196708312300	00	0418.027086.881.963.0		29.2033.0
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19670901010000000		0616.0	75.560.0	29.20
19670901020000000		0610.0	72.958.0	29.20
19670901030000000		0403.0	70.356.0	29.20
19670901040000000		0402.0	66.554.0	29.20
19670901050000000		0200.0	64.552.0	29.20
19670901060000002		0504.0	66.855.0	29.20
19670901070000012		1004.0	70.257.0	29.20
19670901080000018		1011.0	73.958.0	29.20
19670901090000032		1008.0	86.761.0	29.20
19670901100000048		0514.0	89.661.0	29.20
19670901110000058		0820.0	93.263.0	29.20
19670901120000064		0617.0	94.764.0	29.20
19670901130000064		0015.0	95.865.0	29.20
19670901140000060		0620.0	95.262.0	29.20
19670901150000040		0825.0	93.063.0	29.20
19670901160000030		0826.0	93.163.0	29.20
19670901170000022		0931.0	91.064.0	29.20
19670901180000007		0933.0	83.863.0	29.20
19670901190000001		0826.0	82.062.0	29.20
19670901200000000		0727.0	79.660.0	29.20
19670901210000000		0517.0	77.259.0	29.20
19670901220000000		0420.0	76.458.0	29.20
19670901230000000		0227.0	73.658.0	29.20
19670901240000000		0232.0	72.158.0	29.20
19670902010000000		0128.0	71.658.0	29.20
19670902020000000		0323.0	69.459.0	29.20
19670902030000000		0415.0	67.757.0	29.20
19670902040000000		0417.0	67.256.0	29.20
19670902050000000		0317.0	65.156.0	29.20
19670902060000002		0217.0	67.958.0	29.20
19670902070000014		0013.0	70.058.0	29.20
19670902080000030		0010.0	72.660.0	29.20
19670902090000031		0006.0	76.061.0	29.20
19670902100000051		0006.0	75.060.0	29.20
19670902110000060		0103.0	80.061.0	29.20
19670902120000066		0608.0	81.663.0	29.20
19670902130000066		0810.0	84.463.0	29.20

19670902140000062	0912.0	85.963.0	29.20
19670902150000047	0314.0	85.262.0	29.20
19670902160000040	0313.0	85.362.0	29.20
19670902170000025	0014.0	82.261.0	29.20
19670902180000010	0014.0	78.760.0	29.20
19670902190000001	0023.0	73.257.0	29.20
19670902200000000	0027.0	70.657.0	29.20
19670902210000000	0027.0	69.456.0	29.20
19670902220000000	0026.0	68.455.0	29.20
19670902230000000	0020.0	67.655.0	29.20
19670902240000000	0011.0	64.553.0	29.20
19670903010000000	0012.0	64.054.0	29.20
19670903020000000	0010.0	59.450.0	29.20
19670903030000000	0002.0	59.651.0	29.20
19670903040000000	0001.0	58.751.0	29.20
19670903050000000	0001.0	56.249.0	29.20
19670903060000002	0001.0	60.853.0	29.20
19670903070000014	0003.0	66.756.0	29.20
19670903080000030	0005.0	68.156.0	29.20
19670903090000043	0003.0	70.857.0	29.20
19670903100000055	0001.0	73.058.0	29.20
19670903110000062	0001.0	77.459.0	29.20
19670903120000066	0002.0	80.060.0	29.20
19670903130000065	0004.0	82.461.0	29.20
19670903140000060	0005.0	84.761.0	29.20
19670903150000052	0004.0	86.162.0	29.20
19670903160000040	0005.0	87.862.0	29.20
19670903170000025	0003.0	88.562.0	29.20
19670903180000008	0006.0	85.562.0	29.20
19670903190000001	0109.0	78.259.0	29.20
19670903200000000	0208.0	77.359.0	29.20
19670903210000000	0319.0	78.159.0	29.20
19670903220000000	0410.0	72.957.0	29.20
19670903230000000	1004.0	70.757.0	29.20
19670903240000000	1015.0	73.457.0	29.20
19670904010000000	1016.0	74.660.0	29.20
19670904020000000	1020.0	74.160.0	29.20
19670904030000000	1018.0	73.860.0	29.20
19670904040000000	0714.0	72.859.0	29.20
19670904050000000	0307.0	66.355.0	29.20

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1967090407000012	0105.0	72.659.0	29.20
1967090408000027	0001.0	74.559.0	29.20
1967090409000040	0001.0	80.261.0	29.20
1967090410000052	0003.0	82.062.0	29.20
1967090411000060	0004.0	87.164.0	29.20
1967090412000063	0005.0	90.665.0	29.20
1967090413000063	0006.0	91.464.0	29.20
1967090414000058	0007.0	93.065.0	29.20
1967090415000049	0005.0	94.565.0	29.20
1967090416000038	0003.0	95.066.0	29.20
1967090417000023	0203.0	93.364.0	29.20
1967090418000008	0102.0	90.363.0	29.20
1967090419000001	0704.0	85.261.0	29.20
1967090420000000	0708.0	82.360.0	29.20
1967090421000000	1012.0	86.963.0	29.20
1967090422000000	0910.0	83.261.0	29.20
1967090423000000	1008.0	81.261.0	29.20
1967090424000000	0812.0	80.162.0	29.20
1967090501000000	1013.0	79.962.0	29.20
1967090502000000	1019.0	79.862.0	29.20
1967090503000000	1016.0	78.762.0	29.20
1967090504000000	1015.0	79.062.0	29.20
1967090505000000	1015.0	76.162.0	29.20
1967090506000000	1015.0	76.361.0	29.20
1967090507000001	1007.0	75.060.0	29.20
1967090508000002	1009.0	75.462.0	29.20
1967090509000010	1011.0	77.163.0	29.20
1967090510000010	1011.0	77.862.0	29.20
1967090511000022	1008.0	81.964.0	29.20
1967090512000013	1005.0	80.663.0	29.20
1967090513000014	1006.0	81.263.0	29.20
1967090514000016	1010.0	79.963.0	29.20
1967090515000005	1011.0	77.062.0	29.20
1967090516000003	1011.0	76.063.0	29.20
1967090517000004	1007.0	74.363.0	29.20
1967090518000002	0903.0	74.863.0	29.20
1967090519000001	0503.0	72.562.0	29.20
1967090520000000	0006.0	69.462.0	29.20
1967090521000000	0004.0	65.759.0	29.20

19670905220000000	0005.0	62.158.0	29.20
19670905230000000	0011.0	62.159.0	29.20
19670905240000000	0123.0	66.258.0	29.20
19670906010000000	0126.0	65.857.0	29.20
19670906020000000	0124.0	66.157.0	29.20
19670906030000000	0020.0	63.655.0	29.20
19670906040000000	0016.0	63.055.0	29.20
19670906050000000	0213.0	59.953.0	29.20
19670906060000001	0211.0	58.653.0	29.20
19670906070000011	0011.0	65.356.0	29.20
19670906080000027	0009.0	71.858.0	29.20
19670906090000041	0009.0	74.559.0	29.20
19670906100000053	0006.0	76.460.0	29.20
19670906110000057	0002.0	78.761.0	29.20
19670906120000066	0103.0	81.162.0	29.20
19670906130000059	0005.0	81.860.0	29.20
19670906140000060	0105.0	82.961.0	29.20
19670906150000049	0003.0	84.062.0	29.20
19670906160000038	0302.0	83.662.0	29.20
19670906170000023	0401.0	83.861.0	29.20
19670906180000008	0205.0	81.658.0	29.20
19670906190000001	0005.0	74.157.0	29.20
19670906200000000	0009.0	70.055.0	29.20
19670906210000000	0009.0	68.354.0	29.20
19670906220000000	0007.0	64.052.0	29.20
19670906230000000	0004.0	61.651.0	29.20
19670906240000000	0006.0	62.952.0	29.20
19670907010000000	0009.0	62.351.0	29.20
19670907020000000	0008.0	63.152.0	29.20
19670907030000000	0011.0	59.651.0	29.20
19670907040000000	0014.0	57.750.0	29.20
19670907050000000	0014.0	53.446.0	29.20
19670907060000001	0014.0	53.045.0	29.20
19670907070000011	0011.0	64.552.0	29.20
19670907080000025	0110.0	70.557.0	29.20
19670907090000040	0012.0	74.958.0	29.20
19670907100000051	0009.0	76.458.0	29.20
19670907110000059	0108.0	80.459.0	29.20
19670907120000063	0306.0	83.360.0	29.20
19670907130000062	0705.0	85.161.0	29.20

II.6 (Cont.)

1967090714000057	0906.0	88.061.0	29.20
1967090715000049	0707.0	87.961.0	29.20
1967090716000035	0805.0	88.761.0	29.20
1967090717000018	0806.0	87.161.0	29.20
1967090718000006	0706.0	82.659.0	29.20
1967090719000001	0607.0	78.057.0	29.20
1967090720000000	0008.0	74.655.0	29.20
1967090721000000	0008.0	72.154.0	29.20
1967090722000000	0006.0	71.554.0	29.20
1967090723000000	0012.0	71.054.0	29.20
1967090724000000	0214.0	69.954.0	29.20
1967090801000000	0414.0	70.554.0	29.20
1967090802000000	0613.0	66.852.0	29.20
1967090803000000	0614.0	66.753.0	29.20
1967090804000000	0710.0	63.451.0	29.20
1967090805000000	0515.0	62.351.0	29.20
1967090806000001	0315.0	62.852.0	29.20
1967090807000011	0214.0	69.756.0	29.20
1967090808000025	0015.0	75.558.0	29.20
1967090809000040	0013.0	81.860.0	29.20
1967090810000050	0010.0	82.860.0	29.20
1967090811000058	0005.0	86.261.0	29.20
1967090812000061	0003.0	90.462.0	29.20
1967090813000061	0001.0	91.363.0	29.20
1967090814000056	0005.0	92.963.0	29.20
1967090815000046	0007.0	93.665.0	29.20
1967090816000035	0007.0	92.364.0	29.20
1967090817000020	0009.0	91.864.0	29.20
1967090818000007	0011.0	88.763.0	29.20
1967090819000000	0020.0	83.662.0	29.20
1967090820000000	0029.0	75.660.0	29.20
1967090821000000	0027.0	73.059.0	29.20
1967090822000000	0028.0	71.458.0	29.20
1967090823000000	0024.0	69.456.0	29.20
1967090824000000	0016.0	66.155.0	29.20
1967090901000000	1018.0	67.655.0	29.20
1967090902000000	0523.0	66.854.0	29.20
1967090903000000	0018.0	64.152.0	29.20
1967090904000000	0016.0	61.550.0	29.20
1967090905000000	0911.0	57.149.0	29.20

19670909060000001	1005.0	58.449.0	29.20
19670909070000010	1004.0	62.452.0	29.20
19670909080000022	1001.0	67.354.0	29.20
19670909090000036	0903.0	71.956.0	29.20
19670909100000048	1003.0	74.056.0	29.20
19670909110000061	1005.0	78.258.0	29.20
19670909120000061	1004.0	81.259.0	29.20
19670909130000060	0807.0	82.760.0	29.20
19670909140000056	0806.0	84.561.0	29.20
19670909150000047	0807.0	86.962.0	29.20
19670909160000037	0708.0	85.761.0	29.20
19670909170000022	0610.0	84.061.0	29.20
19670909180000006	0606.0	80.560.0	29.20
19670909190000000	0714.0	75.060.0	29.20
19670909200000000	0720.0	71.259.0	29.20
19670909210000000	0520.0	69.458.0	29.20
19670909220000000	0518.0	68.658.0	29.20
19670909230000000	0215.0	66.656.0	29.20
19670909240000000	0414.0	65.256.0	29.20
19670910010000000	0912.0	66.556.0	29.20
19670910020000000	0904.0	63.955.0	29.20
19670910030000000	1004.0	59.652.0	29.20
19670910040000000	1000.0	60.953.0	29.20
19670910050000000	1004.0	59.953.0	29.20
19670910060000000	1007.0	57.952.0	29.20
19670910070000002	1004.0	59.853.0	29.20
19670910080000016	0802.0	64.155.0	29.20
19670910090000034	0801.0	69.457.0	29.20
19670910100000035	0801.0	71.758.0	29.20
19670910110000026	1020.0	77.660.0	29.20
19670910120000048	0926.0	79.260.0	29.20
19670910130000037	0932.0	78.459.0	29.20
19670910140000020	1039.0	77.859.0	29.20
19670910150000014	1045.0	73.058.0	29.20
19670910160000014	1043.0	72.858.0	29.20
19670910170000011	1038.0	71.057.0	29.20
19670910180000002	1025.0	70.056.0	29.20
19670910190000000	0727.0	68.156.0	29.20
19670910200000000	0522.0	65.955.0	29.20
19670910210000000	1022.0	64.754.0	29.20

II.6 (Cont.)

19670910220000000	1022.0	65.454.0	29.20
19670910230000000	1017.0	62.754.0	29.20
19670910240000000	1012.0	61.253.0	29.20
19670911010000000	1009.0	59.752.0	29.20
19670911020000000	1006.0	59.152.0	29.20
19670911030000000	1006.0	59.851.0	29.20
19670911040000000	1011.0	59.050.0	29.20
19670911050000000	1011.0	59.350.0	29.20
19670911060000000	1014.0	58.950.0	29.20
19670911070000002	1008.0	59.351.0	29.20
19670911080000008	1003.0	60.652.0	29.20
19670911090000013	1010.0	59.654.0	29.20
19670911100000028	1011.0	62.354.0	29.20
19670911110000044	1010.0	66.255.0	29.20
19670911120000020	0907.0	63.954.0	29.20
19670911130000050	0709.0	68.954.0	29.20
19670911140000054	0518.0	72.554.0	29.20
19670911150000041	0022.0	72.054.0	29.20
19670911160000037	0029.0	71.052.0	29.20
19670911170000022	0031.0	67.051.0	29.20
19670911180000007	0029.0	63.450.0	29.20
19670911190000000	0032.0	59.749.0	29.20
19670911200000000	0027.0	57.548.0	29.20
19670911210000000	0618.0	56.347.0	29.20
19670911220000000	0718.0	58.547.0	29.20
19670911230000000	0720.0	57.147.0	29.20
19670911240000000	0417.0	53.646.0	29.20
19670912010000000	0216.0	54.846.0	29.20
19670912020000000	0013.0	54.046.0	29.20
19670912030000000	0018.0	54.446.0	29.20
19670912040000000	0016.0	53.245.0	29.20
19670912050000000	0013.0	49.943.0	29.20
19670912060000001	0012.0	49.643.0	29.20
19670912070000010	0011.0	57.046.0	29.20
19670912080000024	0007.0	60.849.0	29.20
19670912090000040	0003.0	64.850.0	29.20
19670912100000053	0004.0	65.750.0	29.20
19670912110000060	0005.0	70.552.0	29.20
19670912120000064	0004.0	71.052.0	29.20
19670912130000064	0002.0	72.053.0	29.20

II.6 (Cont.)

19670912140000059	0204.0	72.352.0	29.20
19670912150000049	0103.0	73.053.0	29.20
19670912160000036	0104.0	73.553.0	29.20
19670912170000022	0102.0	73.653.0	29.20
19670912180000007	0103.0	69.752.0	29.20
19670912190000000	0013.0	62.348.0	29.20
19670912200000000	0012.0	59.347.0	29.20
19670912210000000	0010.0	54.844.0	29.20
19670912220000000	0010.0	53.043.0	29.20
19670912230000000	0012.0	56.444.0	29.20
19670912240000000	0010.0	52.743.0	29.20

III.1

2

III.2

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TEMPERATURES AT PRIEST RAPIDS DAM (R.M. 397) AUGUST 20 - SEPTEMBER 12, 1967.
   1   96    1
 19.0 19.0 19.0 19.0 19.1 19.1 19.1 19.1 19.1 19.1 19.1 19.1 19.2 19.2 19.2 19.2
18.8 18.8 18.8 18.8 18.9 18.9 18.9 18.9 19.0 19.0 19.0 19.0 19.0 19.0 19.0 19.0
19.0 19.0 19.0 19.0 18.7 18.7 18.7 18.7 18.5 18.5 18.5 18.5 18.6 18.6 18.6 18.6
18.8 18.8 18.8 18.8 18.9 18.9 18.9 18.9 18.9 18.9 18.9 18.9 18.6 18.6 18.6 18.6
18.3 18.3 18.3 18.3 18.1 18.1 18.1 18.1 17.8 17.8 17.8 17.8 17.8 17.8 17.7 17.7
18.3 18.3 18.3 18.3 18.1 18.1 18.1 18.1 17.8 17.8 17.8 17.8 17.8 17.8 17.7 17.7
TEMPERATURES AT RICHLAND(R.M. 329) AUGUST 20 - SEPTEMBER 12, 1967
  13   96    1
20.8 20.8 20.8 20.8 20.8 20.8 20.8 20.8 20.6 20.6 20.6 20.6 20.7 20.7 20.7 20.7
20.5 20.5 20.5 20.5 20.3 20.3 20.3 20.3 20.3 20.3 20.3 20.3 20.6 20.6 20.6 20.6
20.6 20.6 20.6 20.6 20.5 20.5 20.5 20.5 20.2 20.2 20.2 20.2 20.1 20.1 20.1 20.1
20.2 20.2 20.2 20.2 19.9 19.9 19.9 19.9 20.1 20.1 20.1 20.1 20.8 20.8 20.8 20.8
19.9 19.9 19.9 19.9 19.4 19.4 19.4 19.4 18.8 18.8 18.8 18.8 18.8 18.8 18.8 18.8
19.9 19.9 19.9 19.9 19.4 19.4 19.4 19.4 18.8 18.8 18.8 18.8 18.8 18.8 18.8 18.8
```

III.3

2

III.4

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  TEMPERATURES HAVE BEEN INITIALIZED AT PRIEST RAPIDS DAM(R.M. 397)
 1                                                                        1
  TEMPERATURES HAVE BEEN INITIALIZED AT RICHLAND(R.M. 329)
13                                                                       13
```

III.5

2 2

III.6

ANALYSIS OF TMEPERATURE AT RICHLAND(R.M. 329)
12
ANALYSIS OF TEMPERATURE AT BONNEVILLE DAM(R.M. 145)
36 36

III.7

TEMPERATURES AT ICE HARBOR DAM (R.M. 324) AUGUST 20 - SEPTEMBER 12, 1967
14 96 2

76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0
76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0
76.0	76.0	76.0	76.0	76.0	76.0	76.0	76.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0
75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	75.0	74.0	74.0	74.0	74.0	74.0	74.0	74.0
73.0	73.0	73.0	73.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0
73.0	73.0	73.0	73.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0	72.0

IV.1

ONE DIMENSIONAL TEMPERATURE PREDICTION MODEL - MARK II
LOWER COLUMBIA RIVER FROM PRIEST RAPIDS(R.M. 397) TO BONNEVILLE(R.M. 145)
HYDRAULIC AND HYDROLOGIC DATA FOR THE PERIOD AUGUST 20 - SEPT. 12, 1967
RICHLAND WEATHER DATA FOR THE PERIOD AUGUST 20 - SEPT. 12, 1967
FWPCA - NORTHWEST REGIONAL OFFICE
COLUMBIA RIVER THERMAL EFFECTS STUDY GROUP
MARCH 1969