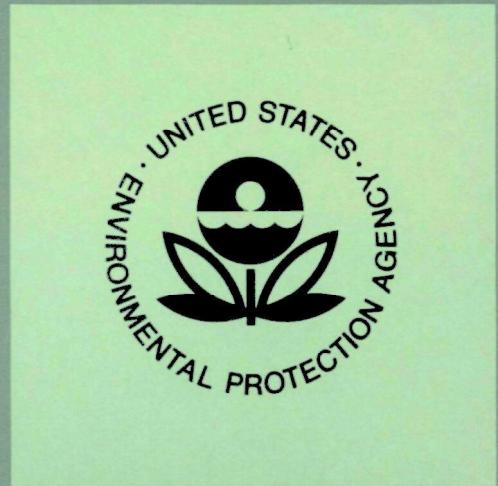


EPA-660/3-75-037
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Improving the Statistical Reliability of Stream Heat Assimilation Prediction



National Environmental Research Center
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EPA-660/3-75-037
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IMPROVING THE STATISTICAL RELIABILITY OF
STREAM HEAT ASSIMILATION PREDICTION

by

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Contract 68-03-0439
Program Element 1BA032
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ABSTRACT

In response to an increased interest in water quality by the public, a large effort has been mounted to develop mathematical models for predicting heat assimilation in bodies of water. The accuracy of these models has recently come under scrutiny due to the need for temperature predictions within 1 °C of the ambient. This work is an evaluation of existing, one-dimensional stream temperature prediction techniques for accuracy and precision. The approach is through error estimates on a general model that encompasses all of the models presently used. A sensitivity analysis of this general model is used in conjunction with statistical methods to determine the solution errors. Data taken in 1973 at the Vernon, Vermont nuclear plant are used as a data base. These data are used in conjunction with Burlington, Vermont airport weather station data to 1) gain insight into the orders-of-magnitude of the various errors and 2) carry out a detailed data analysis to establish the probabilities of meeting given error requirements. This report contains the model descriptions for the general stream model, the sensitivity analysis model, and the data analysis models; a description of the Vernon, Vermont site; the data for four problems from the Vernon nuclear plant; an order-of-magnitude error study; and the results of the four data analyses. The four appendices contain 1) a description of the input FORMAT specifications, 2) the input data for the four problems, 3) program listings, and 4) the theory of the sensitivity analysis.

This report was submitted in fulfillment of Contract 68-03-0439 by Richard W. McLay, P.E., Essex Junction, Vermont, under the partial sponsorship of the Environmental Protection Agency. Work was completed as of May 1975.

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SECTION I

CONCLUSIONS

1. One-dimensional stream temperature models are effective for predicting average temperatures over a short period of time.
2. Predictions made using site data averaged over a day will be within 2 °F (1.11 °C) of the actual average temperature of the following day over 90 percent of the time.
3. The water temperature at the Vernon site is the most important factor in the analysis. The Vernon study indicates that meteorological factors affect the Connecticut river predictions results very little. Travel time thus appears to be a major factor since a knowledge of the initial temperature is essential to accurate predictions.
4. Seasonal effects on prediction accuracy are minor.

SECTION II

RECOMMENDATIONS

The results of this study indicate that, in this case, water temperature at the site is the most important variable in the prediction of the downstream Connecticut river temperature. In order to minimize the errors of prediction, it is recommended that temperatures be monitored upstream of the site and predictions be made over as short a period of time as possible, i.e., average the previous day's data to predict the following day's average temperature. This is motivated by the need to know the initial temperature in the analysis for the entire travel time of water through that portion of the stream being simulated.

These predictions are useful to a plant operator making day-to-day decisions as opposed to a planner predicting conditions to occur several years in the future using an historical weather data base.

This work indicates that for the Vernon plant such predictions will have error within 2 °F (1.11 °C) 90 percent of the time. Smaller streams may have greater effects from meteorological parameters, which were not found from the Vernon problems. It is also recommended that similar sensitivity analyses be performed for two-dimensional models used for predicting temperatures in lakes, estuaries, and cooling ponds.

SECTION III

INTRODUCTION

PURPOSE

Stream temperature is an important factor in water quality. The temperature of the stream directly controls the types and amounts of plant and animal life native to it. In recent years there has been an increased interest in water quality by the public. In response to this interest a very large effort has been mounted to develop mathematical models for predicting heat assimilation in bodies of water.

Models have been developed for predicting temperatures in streams, cooling ponds, reservoirs, estuaries, and large lakes (See, for example, the review by Policastro and Tokar [1972]). Usually, a stream model assumes a one-dimensional problem with uniform mixing and with various modes of heat transport at the air-water interface simulated by semi-emperical expressions. In addition, the problem is generally treated as one in a steady-state condition, i.e., the formulation involves a relationship between the flow rate and the position downstream from an initial point, x , allowing the independent variable to be chosen as the variable x while the time variable becomes implicit to the problem. While the development of stream models is straight-forward, their use is subject to a great deal of interpretation and judgement (See, for example, Asbury [1970]).

The purpose of this study is to determine the effects of variations in initial temperature and meteorological data on results of mathematical models for predicting stream temperatures.

SCOPE

Three principal problems inherent in model use to predict heat assimilation are:

1. The extrapolation of weather station meteorological data to the site under study is subject to considerable variance.

2. There is usually a lack of data from which to compute the evaporation and other heat transfer rates for a stream.
3. The temporal variations of the data cause large variations in short-term predictions.

In addition to these, we find that the spatial and temporal variations of temperature in the environment without the addition of a heat load may be greater than either the requirements set by a regulatory agency or the errors inherent in the model, i.e., there is a question as to what the ambient values really are. Local variations in topography and/or tree cover can shade the stream and cause effective incoming and outgoing radiation areas to be reduced. The accuracy of instruments used to measure the various physical quantities is always subject to review. Ground water advection can be an influential transport process, but it is almost impossible to measure. Finally, the large amount of data taken for any site provides a good probability for human error in recording or transmission.

This study considered the three principal problems listed above by using a sensitivity analysis of a general, one-dimensional stream model. This was combined with data analysis techniques to compute the probabilities of meeting given error requirements. Data from the Vernon, Vermont nuclear plant and the Burlington, Vermont weather station were used to form a data base, from which four example problems were obtained and evaluated.

SECTION IV
MODEL DESCRIPTIONS

THE GENERAL STREAM MODEL

The stream model used for the study is one-dimensional with the independent variable being the distance downstream, x . This model is simple enough that a general version of it can be considered that encompasses all one-dimensional models now in existence. A discussion of this concept is given in Appendix D.

All one-dimensional models take a basic form as shown in Figure 1 and are described by the equation:

$$\frac{uA}{\lambda} \frac{dT}{dx} = [Q_{Rad} - Q_{Ref} - Q_{Back} - Q_{Evap} - Q_{Conv} + Q_{Mis}] \quad (1)$$

where the variables are as defined in Section VIII, Symbols and Variable Names, and the water is fully mixed at each cross section. Any departure from the form of equation (1) due to direct integration, approximations to the heat fluxes Q , etc., can be shown by a Taylor's expansion to be proportional to some power of the mesh size. (See Appendix D). Put simply, as the number of stations or data points in the models are increased they will all produce results converging toward the same solution, provided that total heat fluxes and the heat transfer coefficients are the same. The fundamental heat flux expressions used in this work are taken from Laevastu [1960], where the processes are linearized in T . Not all authors use linearized expressions (See for example Jaske [1971]). However, numerical experience shows that if the temperature variations are small, i.e., small with respect to absolute temperatures, and of course they always will be, it is justified to linearize the expressions, including the fourth power terms in the back radiation fluxes.

The concept of using a simple, general model was considered essential in this work, since it reduced the study from a huge data handling problem for many models to the study of a single, general model whose error analysis applies equally well to all models in question, provided a convergent mesh size (station length) is specified.

The expressions for the heat fluxes from Laevastu [1960] are:

$$\downarrow Q_{\text{Rad}} \quad \uparrow Q_{\text{Ref}} \quad \uparrow Q_{\text{Back}} \quad \uparrow Q_{\text{Evap}} \quad \uparrow Q_{\text{Conv}} \quad \downarrow Q_{\text{Misc}}$$

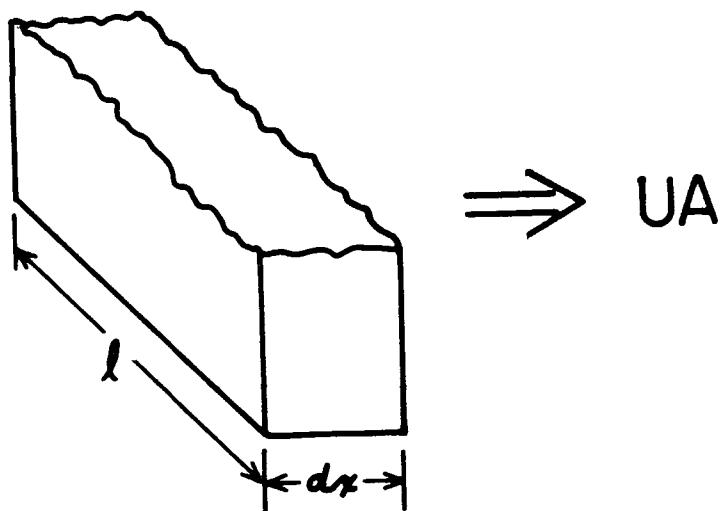


Figure 1. Control volume for stream model

$$\begin{aligned}
Q_{\text{Solar}} &= 1.9 \sin \bar{\alpha} (1 - 0.0006 C^3) (0.061) , \\
Q_{\text{Reflected}} &= \frac{3}{\bar{\alpha}} Q_{\text{Solar}} (0.061) , \\
Q_{\text{Back}} &= (1.0 - 0.765 C) (14.38 - 0.09 (\frac{5}{9} (T - 32) \\
&\quad - 0.046\phi) (\frac{1}{69.72})) , \\
Q_{\text{Evaporation}} &= \frac{\rho h}{240} f g (0.35) (1.0 + 9.8 \times 10^{-3} w_2) (e_w - e_a) , \\
Q_{\text{Convection}} &= 39.0 (T - T_a) (0.26 + 0.077 w_2) \frac{5}{9} (0.061) .
\end{aligned} \tag{2}$$

The definitions are given in Section VIII. It should be noted here that the coefficients from these terms are largely based on empirical data and in many cases will vary considerably. However, as is seen in Section VI, the sensitivity analysis reveals little change in temperature decay rates with considerable change in these flux expressions for the Connecticut River. For smaller streams, this would not be the case.

THE SENSITIVITY ANALYSIS MODEL

In order to study the errors in stream temperature produced by the errors in input data, it is necessary to develop certain error expressions from equation (1). These are developed in view of the two fundamental definitions from Rosko [1972]:

1. Accuracy is defined as conformity of fact.
2. Precision is defined as sharpness of definition.

In the case of this work then, accuracy refers to the convergence of the solution to the actual stream temperature. Similarly, precision refers to the rate of convergence.

The sensitivity, or error, analysis required for the work was developed from equation (1) by making a small change, or variation, in the variables. Equation (1) can be rewritten symbolically as

$$\frac{dT}{dx} = \frac{\lambda}{Au} Q . \tag{3}$$

A variation of both sides of this equation yields

$$\frac{d \delta T}{dx} = \frac{\lambda}{A u} \delta Q , \quad (4)$$

where it is assumed that the flow rate and stream width are known and that the process described is linear in its variation. If the error in temperature, $\delta T(0)$, is known at the initial point, it is apparent that, given the errors in the heat fluxes, δQ , the error at any given point downstream can be computed from equation (4) by a direct computation.

It is important to note that, if approximate values of the coefficients in equation (4) are obtained as constants, the equation can be solved in closed-form,

$$\delta T = A \exp[-\alpha x] + \sum_i C_i .$$

Results of an analysis of this type are presented in Section VI.

THE DATA ANALYSIS MODELS

Previous sections have described the mathematical model studied and the sensitivity analysis model. The first of these models, or close variations of it, has been used extensively to predict the mean temperatures of streams. The sensitivity analysis model has the capability of predicting the error in the mean temperature at a point downstream, given the corresponding errors in the mean initial condition for temperature and the mean meteorological conditions. Thus, the mathematical models were available for a study, setting the stage for the data analysis.

The philosophy of the data analysis emerged from the concepts of probability. As has been shown by Hogan et al. [1972], it is unrealistic to establish the error in the estimate of the mean temperature deterministically. Rather, the statement must read to the effect:

If the errors in the heat fluxes $|\delta Q|$ and the error in initial mean temperature $|\delta T(0)|$ are constrained in size to given values, then the probability that the error in mean stream temperature $|\delta T| \leq 1/n {}^{\circ}\text{C}$ will be P_1 , $|\delta T| \leq 1 {}^{\circ}\text{C}$ will be P_2 ($P_2 > P_1$) .

Put simply, for given errors in the initial mean temperature and the meteorological data, it is possible to determine the probability of meeting a given error requirement. This can be done by using the sensitivity analysis model, which appears to be a very realistic approach to assessing the effects of the introduction of a heat load.

The methods employed in the data analysis are best visualized by using Figure 2, where the six primary variables are illustrated. The effect of errors in these variables is shown schematically in the figure, where the initial error δT is seen to decrease with increasing x . By collecting a data base of these variables over a period of several months, it was possible to make use of the sensitivity analysis to compute the error in temperature for a number of trials, based on moving averages. With an increasing number of trials the probability, P , that $|\delta T|$ is less than some given error in temperature can be estimated from:

$$P \doteq \frac{\text{Number of trials with } |\delta T| < \text{given value}}{\text{Total number of trials}} . \quad (5)$$

Figures 3 and 4 illustrate the methods for utilizing the data base to evaluate equation (5). Figure 3 shows schematically the data base at an airport weather station remote to the site, in this case the Burlington, Vermont weather station. These data are collected together with the stream temperatures at the site every three hours, eight points per variable per day. These data are averaged over a specified number of previous days, then compared with the respective averages over the day following to form the errors in the input variables, $\delta \phi$, etc. The sensitivity analysis is then used to predict the errors in temperature downstream. These are then compared with the given temperature error requirement and the components of equation (5) computed. It should be noted here that this model simulates the errors of an observer at the site attempting to predict the temperature several days ahead.

Figure 4 shows schematically the second data analysis model, where the data base includes 1) the remote weather station data, 2) the stream temperatures at the site, and 3) the average daily stream temperature above the site (See Figure 5, station 7). In this case the daily average of the station 7 temperature is compared with the following day's daily average temperature at the site. Meteorological data are averaged in an analogous manner, i.e., daily averages compared for two consecutive days. These form the errors in the input variables. The sensitivity analysis is then used to predict the errors in temperature downstream, these are compared with the given temperature error requirements, and the components of equation (5) computed. This

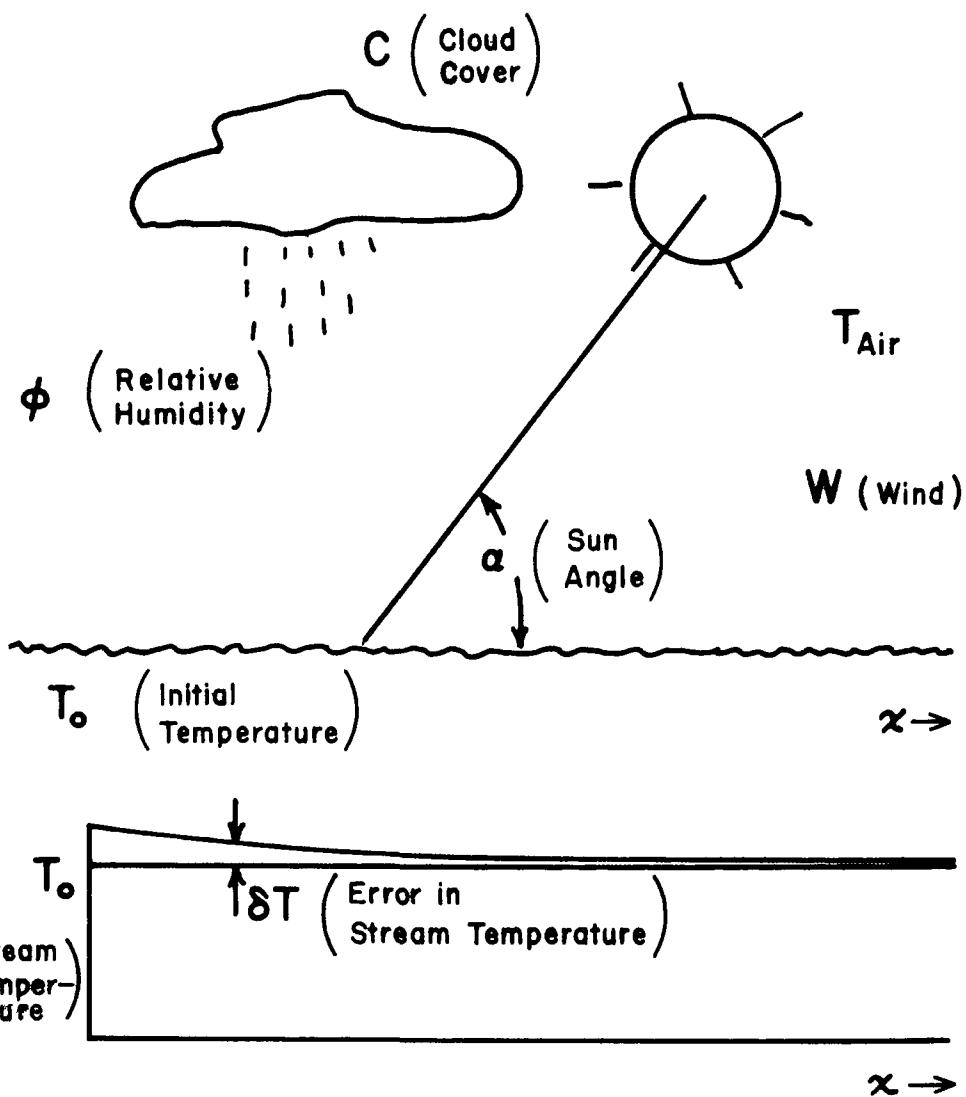


Figure 2. Six primary meteorological and site variables

Process moves through all of data

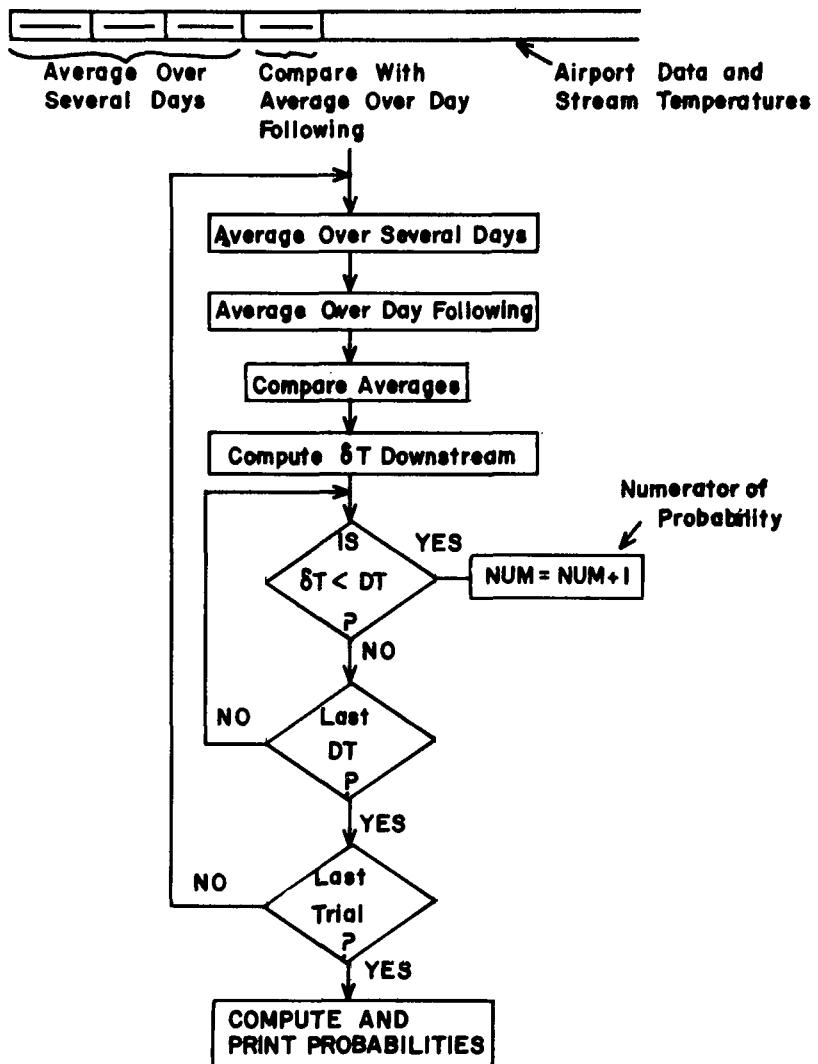


Figure 3. Model using site water temperature data

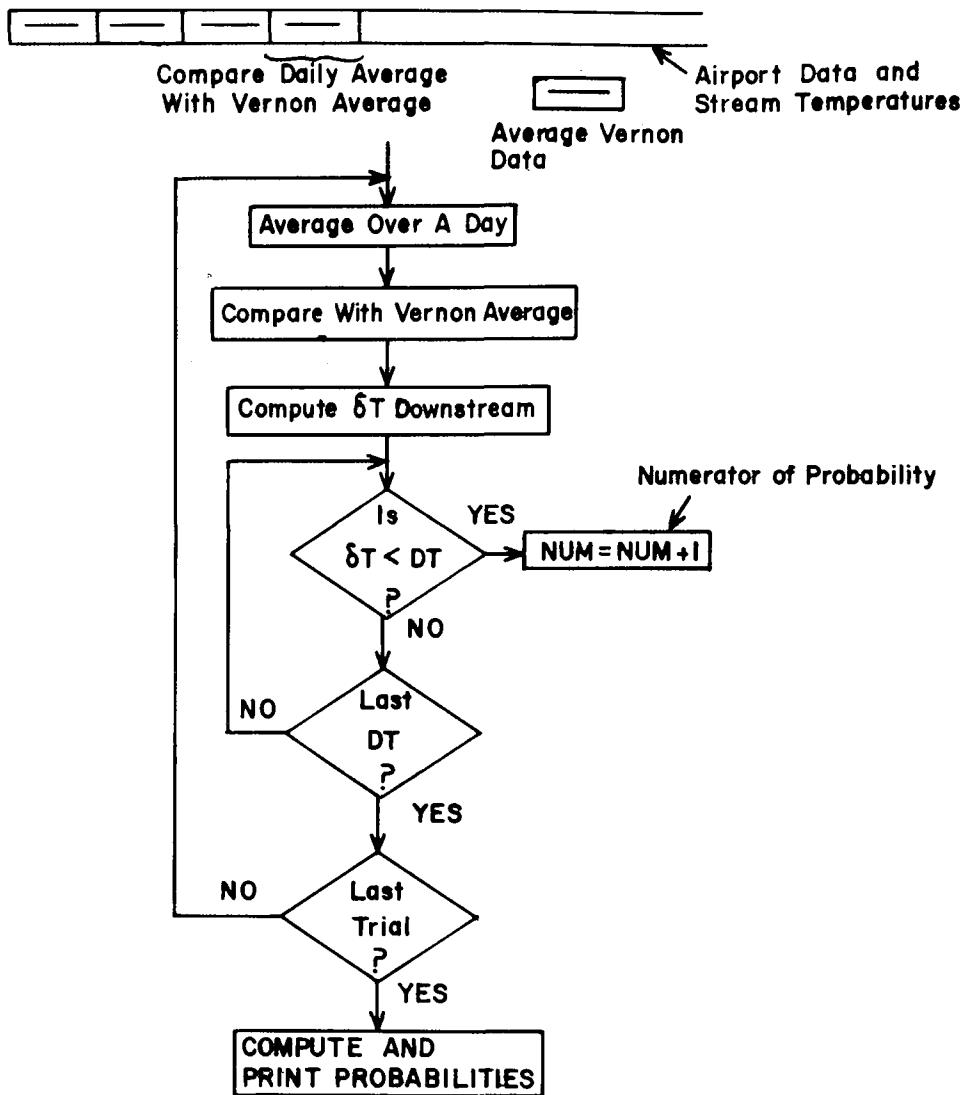


Figure 4. Model using site and station 7 temperature data

model simulates the errors of an observer remote to the site attempting to predict the site stream temperature one day ahead.

SECTION V

STUDY AREA AND METHODOLOGY

THE VERNON NUCLEAR PLANT

A program of ecological studies of the Connecticut river in the vicinity of Vernon, Vermont was initiated in 1967, prior to the operation of the Vermont Yankee Nuclear Powerplant. The preoperational studies were enlarged in scope in subsequent years and were continued after the plant became operational in October 1972. The location of the plant is shown in Figure 5, where the positions of short-term and long-term sampling stations are shown. The particulars of these sampling stations are as follows:

| <u>Station No.</u> | <u>Location Relative to Vernon Dam</u> | <u>Type</u> |
|--------------------|----------------------------------------|-------------|
| 1 | 6.45 Miles (10.4 Km) South | Short-term |
| 2 | 4.70 Miles (7.56 Km) South | Short-term |
| 3 | 0.65 Miles (1.05 KM) South | Long-term |
| 4 | 0.55 Miles (0.89 Km) North | Short-term |
| 5 | 1.25 Miles (2.01 Km) North | Short-term |
| 6 | 4.10 Miles (6.60 Km) North | Short-term |
| 7 | 4.25 Miles (6.84 Km) North | Long-term |
| 8 | 8.70 Miles (14.0 Km) North | Short-term |

Stations 3 and 7 are permanently emplaced below and above the site respectively. Stations 3 and 7 yielded the water temperature data used in the study while meteorological data were obtained from instruments at the plant and in Keene, New Hampshire.

DATA BASE DESCRIPTION

The data base used in the project was taken from four sources:

- 1) Measured water temperatures at the site
(See Aquatec [1974]),
- 2) Measured meteorological data at the site
(Personal communications),
- 3) Meteorological data from Brattleboro, Vermont
and Keene, New Hampshire (U.S. Weather Service),
- 4) Meteorological data at the Burlington, Vermont
weather station (U.S. Weather Service).

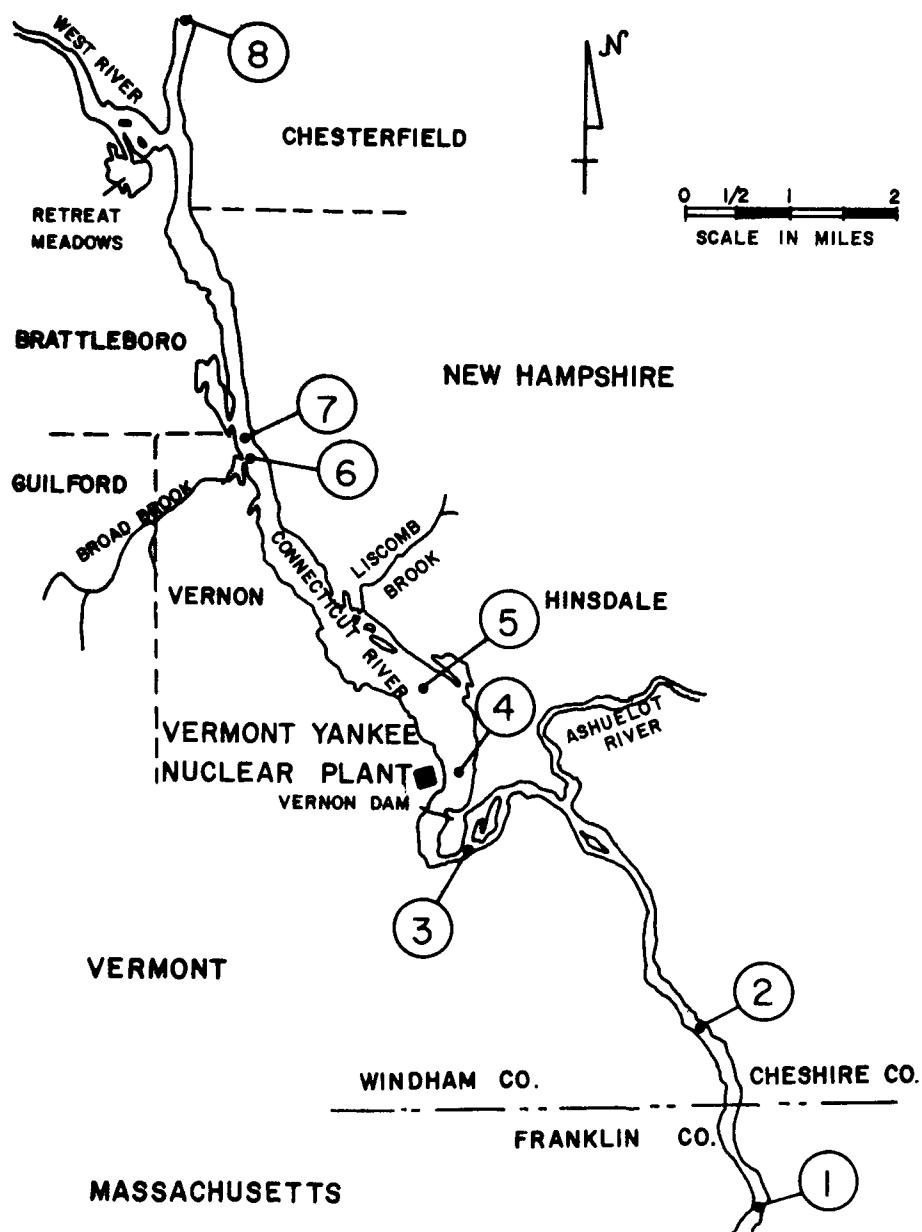


Figure 5. The Vernon nuclear plant-temperature sampling stations

The data base variables and dates for the Vernon plant example problems are as follows:

1. Burlington, Vermont Weather Station data and Vernon, Vermont water temperature data:

Variables

Cloud cover, air temperature, relative humidity, wind speed, water temperature from stations 3 and 7.

Dates of Available Data

- a) May 1, 1973 to June 20, 1973
 - b) August 15, 1973 to August 31, 1973 and September 12, 1973 to September 26, 1973.
 - c) October 1, 1973 to October 3, 1973, October 17, 1973 to October 24, 1973, and October 27, 1973 to October 29, 1973.
 - d) October 17, 1973 to October 24, 1973, October 27, 1973 to October 29, 1973, and November 1, 1973 to November 14, 1973.
2. Vernon, Vermont (and vicinity) site meteorological data:

Daily Average Variables

Cloud cover, air temperature, relative humidity, wind speed.

Dates of Available Data

June 21, 1973

September 27, 1973

October 30, 1973

November 15, 1973

EXAMPLE PROBLEMS

Four example problems were constructed from the data base previously discussed. They represented spring, summer, fall and winter conditions at the Vernon Nuclear Plant. The days studied were June 21, September 27, October 30, and November 15, 1973. The dates of the data blocks were as labeled a), b), c) and d) above in the previous section "Dates of Available Data." Computations were carried out to a point 25000 feet (7620 meters) downstream from the initial point in the model ($x = 0$).

SECTION VI

DISCUSSION OF RESULTS

In addition to the analyses described in Section IV, the Data Analysis Models, an order-of-magnitude error analysis was carried out using the closed-form solution developed from equation (4).

ORDER-OF-MAGNITUDE ERROR ANALYSIS

In order to gain insight into the solution of equation (4), it was logical to simplify the form of the equation and obtain a closed-form solution

$$\delta T = A e^{-\alpha x} + \sum_i C_i , \quad (6)$$

where the C_i are the respective particular solutions associated with the errors $\delta\phi$, etc., and the constant A is related directly to the error in water temperature $\delta T(0)$ at the site, $x = 0$. The coefficient α then reveals the rate of decay of the error in temperature with distance. The June 21, 1973 averaged data were taken as an example problem:

| | | |
|------------------------------------|---|-------------------------------|
| uA (Rate of flow) | = | 13,503 ft ³ /sec , |
| E1 (River width) | = | 400 ft , |
| C (Cloud cover) | = | 8 tenths , |
| $\bar{\alpha}$ (Sun angle) | = | 59° , |
| ϕ (Relative humidity) | = | 71 percent , |
| w_2 (Wind speed) | = | 10 MPH , |
| T _{air} (Air temperature) | = | 75 °F . |

(7)

These data were compared with the averaged data of May 31, 1973 to obtain the errors in the variables between these two days. This was done arbitrarily to examine the order-of-magnitude of the resulting errors in temperature. The input errors are:

$$\begin{aligned}
\delta C \text{ (Error in cloud cover)} &= 2 \text{ tenths} , \\
\delta \bar{\alpha} \text{ (Error in sun angle)} &= 5^\circ , \\
\delta \phi \text{ (Error in relative humidity)} &= 29 \text{ percent} , \\
\delta w_2 \text{ (Error in wind speed)} &= 5.2 \text{ MPH} , \\
\delta T_{air} \text{ (Error in air temperature)} &= 16^\circ F . \quad (8)
\end{aligned}$$

Thus, the problem will yield approximate errors for predicting the water temperature on June 21, 1973 given the meteorological data from May 31, 1973. Of interest are the solutions C_i of equation (6), which are due to the respective errors in equation (8). They are found from equation (4) and Appendix D to be

$$\begin{aligned}
1. \quad \delta T_{CP} &= 10.2^\circ F , \\
2. \quad \delta T_{\bar{\alpha}P} &= 1.71^\circ F , \\
3. \quad \delta T_{\phi P} &= 0.357^\circ F , \\
4. \quad \delta T_{w2P} &= 1.33^\circ F , \\
5. \quad \delta T_{airP} &= 19.63^\circ F . \quad (9)
\end{aligned}$$

Similarly, from the same source the coefficient α can be found:

$$\alpha = 0.947 \times 10^6 . \quad (10)$$

The corresponding value of x where the value of δT falls below 5 percent of the original value at $x = 0$. is

$$\begin{aligned}
x &= 3,170,000 \text{ feet} , \\
&\quad (966,000 \text{ meters}) \\
&\doteq 600 \text{ miles} . \\
&\quad (966 \text{ kilometers}) \quad (11)
\end{aligned}$$

This order-of-magnitude study indicates important facts associated with the Vernon site:

1. Modeling the Connecticut river, which has a large flow rate in comparison with its width, produces a solution that will have errors decaying over a very long distance. This means that the error in temperature will remain virtually constant near $x = 0$.
2. The computations are far less sensitive to the environmental factors than thought previously.
3. Since the error in temperature is nearly constant near $x = 0$, the variable of primary concern is the initial error in temperature $\delta T(0)$. Thus, it appears that records of upstream temperatures in the Connecticut river would be useful for projecting average temperatures downstream.
4. Since α is inversely proportional to the volume flow Au it is possible to compute the value of α for the various flow rates, given a known flow-rate $A_1 U_1$ and associated α , α_1 :

$$\alpha = \alpha_1 \frac{A_1 U_1}{Au}$$

This expression will yield the stream flow for which a given decay rate will exist.

RESULTS OF DATA ANALYSES

The results of the four data analyses are presented in the form of probabilities for meeting given error requirements with the variables averaged over a given number of prior days. Tables I, II, and III contain results from all four problems. It should again be emphasized that these results relate to a plant operator making decisions as to the operating conditions of a given plant as opposed to a site planner predicting conditions several years in advance. As indicated on the tables, the river temperatures and the meteorological parameters are averaged over one and two days respectively.

Results in Table I indicate that an observer at the site attempting to predict the average stream temperature the following day at a position 25,000 feet (7,620 meters) downstream by averaging the previous day's meteorological data and stream temperature data would compute an

Table 1. PROBABILITIES OF MEETING GIVEN ERROR REQUIREMENTS BY AN OBSERVER AT THE VERNON SITE AVERAGING ONE DAY AND PREDICTING ONE DAY AHEAD AT A DISTANCE OF 25,000 FEET(7620 METERS) DOWNSTREAM

| | Error Requirement $^{\circ}\text{F}$ ($^{\circ}\text{C}$) | | | |
|--------------------|-------------------------------------------------------------|------------------------------------------------|------------------------------------------------|------------------------------------------------|
| | 1°F (0.56°C) | 2°F (1.11°C) | 3°F (1.67°C) | 4°F (2.22°C) |
| June 21, 1973 | 0.6 | 0.9 | 0.94 | 1.0 |
| September 27, 1973 | 0.613 | 0.935 | 0.963 | 0.968 |
| October 30, 1973 | 0.769 | 0.923 | 0.923 | 0.923 |
| November 15, 1973 | 0.75 | 1.0 | 1.0 | 1.0 |

Table 2. PROBABILITIES OF MEETING GIVEN ERROR REQUIREMENTS BY AN OBSERVER AT THE VERNON SITE AVERAGING TWO DAYS AND PREDICTING ONE DAY AHEAD AT A DISTANCE OF 25,000 FEET (7620 METERS) DOWNSTREAM

| | Error Requirement $^{\circ}\text{F}$ ($^{\circ}\text{C}$) | | | |
|--------------------|-------------------------------------------------------------|------------------------------------------------|------------------------------------------------|------------------------------------------------|
| | 1°F (0.56°C) | 2°F (1.11°C) | 3°F (1.67°C) | 4°F (2.22°C) |
| June 21, 1973 | 0.469 | 0.694 | 0.898 | 0.980 |
| September 27, 1973 | 0.533 | 0.867 | 0.933 | 0.967 |
| October 30, 1973 | 0.5 | 0.833 | 0.833 | 0.917 |
| November 15, 1973 | 0.522 | 0.957 | 1.0 | 1.0 |

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Table 3. PROBABILITIES OF MEETING GIVEN ERROR REQUIREMENTS BY AN OBSERVER AT STATION 7 ONE DAY AHEAD AT THE VERNON SITE (SAME POSITION AS STATED FOR TABLE 2)

| | Error Requirement $^{\circ}\text{F}$ ($^{\circ}\text{C}$) | | | |
|------------------|-------------------------------------------------------------|------------------------------------------------|------------------------------------------------|------------------------------------------------|
| | 1°F (0.56°C) | 2°F (1.11°C) | 3°F (1.67°C) | 4°F (2.22°C) |
| June 21, 1973 | 0.520 | 0.800 | 0.880 | 0.960 |
| October 30, 1973 | 0.846 | 0.923 | 0.923 | 0.923 |

approximate stream temperature within an error of 2 °F (1.11 °C) between 90 and 100 percent of the time. He would compute an approximate stream temperature within an error of 1 °F (0.56 °C) between 60 and 77 percent of the time.

Table II shows that the same observer at the site making the same prediction of an average temperature as made in Table I but using the average of two prior days' data would compute an approximate stream temperature within an error of 4 °F (2.22 °C) between 92 and 100 percent of the time. He would predict within an error of 3°F (1.67 °C) between 83 and 100 percent of the time. Similarly, a 2 °F (1.11 °C) error would be obtained between 69 and 96 percent of the time. Finally a 1 °F (0.56 °C) error would be obtained between 47 and 53 percent of the time.

Table III shows that an observer using data from station 7 above the Vernon dam, attempting to predict stream temperatures at the Vernon site by averaging a day's station 7 water temperature would compute an approximate stream temperature within an error of 4 °F (2.22 °C) between 92 and 96 percent of the time. He would predict within 3 °F (1.67 °C) between 88 and 92 percent of the time, within 2 °F (1.11 °C) between 80 and 92 percent of the time. Finally, he would predict within 1 °F (0.56 °C) between 52 and 85 percent of the time.

Thus, it is seen that predictions made at the site (with a daily average) a short period of time into the future are accurate over 90 percent of the time for a 2 °F (1.11 °C) allowable error. Averaging data over a two day period of time reduces the probability of meeting the 2 °F (1.11 °C) error to around 80 percent, which appears to be a primary influence of the travel time through this portion of the Connecticut river system, one to two days. These studies indicate that it is important to have good records of upstream temperatures from a site. With these it will be possible to predict an average temperature within 2 °F (1.11 °C). It is important to note, however, that short term fluctuations are not predictable by these methods as used in the project. Finally, the effects of season do not appear to make appreciable differences in predictions.

SECTION VII

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SECTION VIII

SYMBOLS AND VARIABLE NAMES

VARIABLE NAMES

a - General integration limit.
A - Stream cross-sectional area.
 A, \bar{A} - Amplitude of exponential decay function.
C - Cloud cover.
 C_i - Constants.
c - Specific heat.
DT - Allowable error in stream temperature.
f - Function of several variables.
 \dot{f} - Derivative of f($\dot{f} = df/dx$)/
h - Integration step.
 I_1, I_2 - Integrals.
 K_i - Kernel function.
 ℓ, EL - Stream width.
n - Integer number.
 $O(-)$ - Of order(Order of magnitude).
P, P_i - Probability of occurrence.
Q - Total heat flux.
 Q_i, Q_{ij} - Particular heat fluxes.
 Q_{Back} - Back radiation heat flux.
 $Q_{\text{Conv}}, Q_{\text{Convection}}$ - Convective heat flux.
 $Q_{\text{Evap}}, Q_{\text{Evaporation}}$ - Evaporative heat flux.
 $Q_{\text{Mis}(c)}$ - Miscellaneous heat flux.
 $Q_{\text{Rad}}, Q_{\text{Solar}}$ - Radiative solar heat flux.
 $Q_{\text{Ref}}, Q_{\text{Reflective}}$ - Reflective heat flux.
T - Stream temperature.
 T_o - Initial stream temperature.
U,u - Average stream flow velocity.
W, W_2 - Wind speed.
x - Distance downstream.
 x_i - Particular position.

\hat{x} - Particular value of x .
 x_{\max} - Maximum value of x .
 y - General function.
 \dot{y} - Derivative of general function.
 $y(0), y_0$ - Initial value of general function.
 y_i - Value of function at x_i .
 z - Dummy variable of integration.

GREEK SYMBOLS

α - Decay rate coefficient.
 $\alpha, \bar{\alpha}$ - Sun angle.
 δC - Error in cloud cover.
 δQ - Error in total heat flux.
 δT - Error in stream temperature.
 $\delta T(0)$ - Initial error in stream temperature.
 δT_{air} - Error in air temperature.
 δT_{airp} - Particular solution for air temperature error.
 δT_{cp} - Particular solution for cloud cover error.
 δT_i - Particular solution.
 δT_{W2p} - Particular solution for wind speed error.
 $\delta T_{\bar{\alpha}p}$ - Particular solution for sun angle error.
 $\delta T_{\phi p}$ - Particular solution for relative humidity error.
 $\delta W, \delta W_2$ - Error in wind speed.
 $\delta \bar{\alpha}$ - Error in sun angle.
 $\delta \phi$ - Error in relative humidity.
 Δx - Increment in downstream distance.
 ϕ - Relative humidity in percent.
 ρ - Density.
 ξ - Position.

APPENDIX A

FORMAT SPECIFICATIONS

This appendix presents the procedures required for using the three codes developed during the course of the project:

1. The general stream model code, STREAM.
2. The sensitivity analysis code, SENSIT.
3. The data analysis code, MONT.

STREAM

The digital computer code STREAM performs all the necessary computations to predict the stream water temperature at any distance downstream from a given initial station. The principle of conservation of energy is applied to the stream under steady-state, steady-flow conditions. Heat transfer to and from the water in the various heat transfer modes is computed. Numerical integration is used to compute the stream temperature, with a choice of four algorithms available to the user. A listing of the STREAM code is given in APPENDIX C.

INPUT REQUIREMENTS TO STREAM

STREAM accepts the following information:

INTC: (1, 2, 3 or 4) in 6I10 FORMAT. This parameter respectively chooses Euler, Modified Euler, Runge Kutta or Adams-Moulton integration routines.

X, DX, DXPR, XEND: in 6E10.0 FORMAT. These parameters are, respectively, the initial value of the distance downstream in feet (usually 0.), the integration interval in feet, the print interval in feet, and the final value of the distance downstream in feet.

ERROR, DXMAX: in 6E10.0 FORMAT. These parameters are used by the integration routine only and represent the error in the function in $^{\circ}$ F and the maximum integration step size in feet allowed.

TEMP, U, AREA, EL: in 6E10.0 FORMAT. These parameters are, respectively, the initial value of the temperature in $^{\circ}$ F, the average velocity of the stream in ft/sec, the cross-sectional area of the stream in ft^2 , and the stream width in feet.

RHO, WMPH, TAIR, CLD, RH, ALBAR: in 6E10.0 FORMAT. These are, respectively, the density of the water (62.4#/ft³, here), the wind speed in MPH, the air temperature in °F, the cloud cover in tenths, the relative humidity in percent, and the average sun angle in degrees.

The final information is read in a loop of 10 sets:

PTBL(I), TTBL(I), HFGTB(I) in 6E10.0 FORMAT. These tables are, respectively, the water saturation pressure table in PSI, the water temperature table in °F, and the latent heat of evaporation table in BTU/pound, all corresponding and in order. This information is extracted from standard steam tables for the temperature range 32 to 120 °F.

The code then computes the stream temperature downstream from a given point. The output proceeds at each print position with the position X itself, the integration step DX, the stream temperature TEMP, and the derivative of the stream temperature with respect to the position variable DTEMP. Following this, other auxilliary variables are printed out: EW, EVAP, HE, HFG, HQ, EBR, and HC. These are only important for diagnostics, not the solution itself.

SENSIT

The digital computer code SENSIT performs all necessary computations to predict the error in the stream water temperature (due to the difference between the actual and approximate input data) at any distance downstream from a given initial station. The variation in the original equation is coded to examine the effects of errors of the input variables. Numerical integration is used to compute the error in stream temperature, with a choice of four algorithms available to the user. A listing of the SENSIT code is given in APPENDIX C.

INPUT REQUIREMENTS TO SENSIT

SENSIT accepts the following information:

INTC: In 6I10 FORMAT. This variable is the integration routine to be used (See STREAM for description).

X, DX, DXPR, XEND: In 6E10.0 FORMAT (See STREAM for description).

ERROR, DXMAX: In 6E10.0 FORMAT (See STREAM for description).

DT, U, AREA, EL: In 6E10.0 FORMAT. The initial temperature error DT is read in at this point (other variables are described in STREAM).

RHO, WMPH, TAIR, CLD, RH, ALBAR: In 6E10.0 FORMAT (See STREAM for variable description).

PTBL(I), TTBL(I), HFGTB(I): In 6E10.0 FORMAT (See STREAM for variable description).

DALP, DCLOUD, DRH, DTAIR, DWMPH: In 6E10.0 FORMAT. These variables are the errors in the respective values of the sun angle in degrees, the cloud cover in tenths, the relative humidity in percent, the air temperature in °F, and the wind velocity in MPH.

NTEMP: In 6I10 FORMAT. This is the number of temperatures given downstream.

STTBL(I), XTBL(I): In 6E10.0 FORMAT. These tables are, respectively, the water temperature and the position downstream in NTEMP sets.

The code then computes the error in the stream temperature downstream from a given point. The output proceeds at each print position with the position X itself, the integration step DX, the stream temperature TEMP, the error in the stream temperature DT, and the derivative of the error in stream temperature DDT.

Following this some auxilliary variables are also printed out: EW, DEW, EVAP, HE, HFG, HØB, HC, HLYMN, and HD, which are important for diagnostics, not for the solution itself.

MONT

The digital computer code MONT performs all the necessary calculations to obtain the probabilities for meeting a given temperature requirement. The code takes prepared data and makes a series of trials, forming data differences, and uses the sensitivity analysis code, SENSIT, to obtain the stream temperature difference at a prescribed distance downstream (in this case 25,000 feet [7620 meters]). The code makes three studies:

1. Computes the probability of meeting given error requirements given in both initial water temperature and meteorological data at the site.
2. Computes the probabilities of meeting given error requirements given errors from water temperature and meteorological time averaged data at the site.
3. Computes the probabilities of meeting given error requirements given errors from water temperature and meteorological data at a remote site, in the case of this study, at station 7 above the nuclear plant. A list of the MONT code is given in APPENDIX C.

INPUT REQUIREMENTS TO MONT

MONT accepts the following information:

NLN, LOG1: In 6I10 FORMAT. The first variable is the number of lines of data (taken every 3 hours, 8 data points per day, each day always complete); the second variable is 0 if no time averaged data appears, not zero if time averaged data appears.

Following these integer variables the major part of the data is read for the remote airport and the site water temperature in a loop of NLN lines as follows:

C(I), TA(I), PHI(I), W(I), TW(I): In 6F10.3 FORMAT. The variables are: 1) the cloud cover in tenths, 2) the air temperature in °F, 3) the relative humidity in percent, 4) the wind speed in knots, and 5) the site water temperature in °F.

Next, the average data for the actual site and the particular day are input:

UA, EL, CC, TAIR: In 6F10.3 FORMAT. These variables are 1) the flow volumes of the river in ft³/sec, 2) the river width in ft, the cloud cover in tenths, and the air temperature in °F.

TWA, RH, WSP: In 6F10.3 FORMAT. These variables are 1) the water temperature in °F, 2) the relative humidity in percent and 3) the wind speed in knots.

If LOG1 = 0 the next two sets of data are not necessary. If LOG1 ≠ 0 the next two sets of data for the dates of past years prior to the date in question (the time-averaged data).

NTA: In 6I10 FORMAT. This value is the number of lines of time averaged data.

Following this NTA lines of data are read in as follows:

CTA(I), TATA(I), PHITA(I), WTA(I), TWTA(I): In 6F10.3 FORMAT. The variables are 1) the cloud cover in tenths, 2) the air temperature in °F, 3) the relative humidity in percent, 4) the wind speed in knots, and 5) the water temperature in °F.

Following this, the data describing the analysis are read in:

NCAS: In 6I10 FORMAT. This is the number of cases of temperature to be used in the trials.

DELT(I), I=1, NCAS: In 6E10.3 FORMAT. These are input in sequence, the first six values of allowed temperature on the first line, the second six on the second line, etc.

NDAS: In 6I10 FORMAT. This is the number of day cases to be tried.

IDAS(I), I=1, NDAS: In 6I10 FORMAT. These are the number of days of data to be averaged in each day case. They are input in sequence, six values per line.

Following this, 10 lines of data are input for the sensitivity analysis program, which is a subroutine in this case.

PTBL(I), TTBL(I), HFGTB(I): In 6E10.3 FORMAT (See STREAM for variables description).

The next data to be input are 1) the number of days since March 21 (the vernal equinox) which is required to estimate the coefficient involved with the sun heating effect, and 2) the latitude of the plant in degrees:

DM21, BETA: In 6E10.0 FORMAT.

The last data to be input are the daily average of the water temperature at the remote site:

T7(I), I=1, Number of Days in 6E10.3 FORMAT.

The code then computes the errors in the stream temperature downstream from a given point considering the days to be averaged as requested. Three sets of input errors are examined:

1. The airport meteorological data and stream temperature against itself (simulating values at a site).
2. The time-averaged meteorological and stream temperature data against the site data.
3. The airport meteorological data and the remote site water temperature data against the site data water temperatures(simulating predictions from a distance) .

These are compared to the requirements on temperature for each case. The number of cases for which the requirements are satisfied are recorded and printed out in the form of probability values.

APPENDIX B

INPUT DATA

This Appendix contains the input for the four example problems.

EXAMPLE PROBLEM INPUT

The input for the four example problems has the following format:

1. The number of lines of data, 8 lines per day (3 hour intervals).
2. The time averaged data logic parameter (1 means time averaged data appears, 0 means no time averaged data appears).
3. The data now appears by line as follows:
 - a) Cloud cover in tenths.
 - b) Air temperature in °F.
 - c) Relative humidity in percent.
 - d) Wind speed in knots.
 - e) Water temperature °F.
4. The average data (over a day) for the plant site then is:
 - a) The flow volume, UA, ft³/sec.
 - b) The river width, EL, ft.
 - c) The cloud cover at the site in tenths.
 - d) The air temperature °F
 - e) The water temperature °F.
 - f) The relative humidity in percent.
 - g) The wind speed in knots.

5. If time-averaged data appears the following then is required:
 - a) The number of time-averaged data lines.
 - b) The lines of data as follows
 - 1) Cloud cover in tenths.
 - 2) Air temperature °F.
 - 3) Relative humidity in percent.
 - 4) Wind speed in knots.
 - 5) The water temperature in °F.
6. The control data for the data analysis is next.
 - a) The number of cases of error in temperature.
 - b) The allowed errors in temperature.
 - c) The number of cases for days of data to be averaged.
 - d) The actual number of days of data to be averaged.
7. The tables of vapor pressure and latent heat (no changes except for very unusual conditions).
8. The days to the date in question past March 21.
9. The latitude of the site in degrees.
10. The daily averages of the water temperatures at the remote site. In this case station 7.

PRINTOUT FOR THE FOUR EXAMPLE PROBLEMS

JUNE 21, 1973

MAY 1 to JUNE 20, 1973

RUN

NUMBER OF DATA LINES= 408 TIME AV. LOGIC= 0

| CLD COVER | AIR TEMP | REL HUM | WIND SPD | WATER TEMP |
|-----------|----------|---------|----------|------------|
| .000 | 35.000 | 92.000 | 4.000 | 48.000 |
| 8.000 | 33.000 | 96.000 | 3.000 | 48.000 |
| 8.000 | 39.000 | 93.000 | 4.000 | 48.200 |
| 9.000 | 56.000 | 60.000 | 5.000 | 48.500 |
| 10.000 | 56.000 | 57.000 | 4.000 | 48.500 |
| 10.000 | 61.000 | 52.000 | 4.000 | 48.700 |
| 10.000 | 53.000 | 80.000 | 4.000 | 49.000 |
| 10.000 | 54.000 | 96.000 | 5.000 | 49.000 |
| 10.000 | 56.000 | 90.000 | 7.000 | 49.200 |
| 10.000 | 55.000 | 90.000 | 8.000 | 49.200 |
| 10.000 | 56.000 | 87.000 | 12.000 | 49.500 |
| 5.000 | 66.000 | 68.000 | 14.000 | 50.000 |
| 10.000 | 72.000 | 57.000 | 14.000 | 50.500 |
| 10.000 | 73.000 | 55.000 | 9.000 | 51.000 |
| 10.000 | 68.000 | 68.000 | 9.000 | 51.000 |
| 10.000 | 61.000 | 90.000 | 4.000 | 51.000 |
| 10.000 | 64.000 | 84.000 | 4.000 | 51.200 |
| 10.000 | 65.000 | 78.000 | 10.000 | 51.500 |
| 8.000 | 63.000 | 90.000 | 11.000 | 51.700 |
| 10.000 | 70.000 | 73.000 | 8.000 | 52.200 |
| 10.000 | 75.000 | 54.000 | 10.000 | 52.700 |
| 10.000 | 55.000 | 100.000 | 7.000 | 53.000 |
| 10.000 | 50.000 | 93.000 | 10.000 | 52.500 |
| 10.000 | 50.000 | 80.000 | 4.000 | 52.200 |
| 10.000 | 48.000 | 68.000 | 5.000 | 52.000 |

| | | | | |
|--------|--------|--------|--------|--------|
| 9.000 | 46.000 | 71.000 | 2.000 | 52.000 |
| 10.000 | 45.000 | 80.000 | 5.000 | 52.000 |
| 10.000 | 49.000 | 66.000 | 6.000 | 52.200 |
| 10.000 | 50.000 | 59.000 | 8.000 | 52.500 |
| 10.000 | 51.000 | 52.000 | 6.000 | 52.700 |
| 10.000 | 48.000 | 63.000 | 4.000 | 52.500 |
| 10.000 | 46.000 | 58.000 | 3.000 | 52.500 |
| 10.000 | 43.000 | 76.000 | 3.000 | 52.200 |
| 10.000 | 42.000 | 76.000 | 2.000 | 52.000 |
| 10.000 | 42.000 | 89.000 | 3.000 | 52.000 |
| 10.000 | 45.000 | 77.000 | 6.000 | 52.000 |
| 10.000 | 47.000 | 66.000 | 7.000 | 52.000 |
| 10.000 | 45.000 | 80.000 | 4.000 | 52.200 |
| 10.000 | 43.000 | 89.000 | 3.000 | 52.200 |
| 10.000 | 43.000 | 93.000 | 3.000 | 52.000 |
| 10.000 | 43.000 | 96.000 | 4.000 | 51.700 |
| 10.000 | 43.000 | 93.000 | 5.000 | 51.500 |
| 10.000 | 45.000 | 93.000 | 9.000 | 51.500 |
| 8.000 | 53.000 | 62.000 | 10.000 | 51.700 |
| 9.000 | 55.000 | 51.000 | 12.000 | 52.000 |
| 9.000 | 56.000 | 51.000 | 11.000 | 52.500 |
| 2.000 | 53.000 | 57.000 | 6.000 | 52.200 |
| 0.000 | 45.000 | 65.000 | 4.000 | 52.000 |
| 0.000 | 37.000 | 89.000 | 0.000 | 51.500 |
| 0.000 | 32.000 | 96.000 | 0.000 | 51.200 |
| 0.000 | 39.000 | 93.000 | 0.000 | 51.000 |
| 0.000 | 54.000 | 53.000 | 11.000 | 51.000 |
| 0.000 | 58.000 | 44.000 | 14.000 | 51.700 |
| 6.000 | 62.000 | 34.000 | 10.000 | 53.000 |

| | | | | |
|--------|--------|---------|--------|--------|
| 2.000 | 55.000 | 47.000 | 4.000 | 53.200 |
| .000 | 43.000 | 83.000 | 2.000 | 52.700 |
| 1.000 | 38.000 | 89.000 | 0.000 | 52.500 |
| 4.000 | 35.000 | 92.000 | 3.000 | 52.000 |
| 5.000 | 53.000 | 69.000 | 14.000 | 52.000 |
| 10.000 | 63.000 | 48.000 | 14.000 | 52.200 |
| 10.000 | 68.000 | 41.000 | 15.000 | 52.700 |
| 10.000 | 63.000 | 40.000 | 16.000 | 53.500 |
| 10.000 | 57.000 | 57.000 | 6.000 | 53.700 |
| 10.000 | 54.000 | 69.000 | 12.000 | 53.500 |
| 10.000 | 49.000 | 93.000 | 9.000 | 53.500 |
| 10.000 | 50.000 | 96.000 | 3.000 | 53.000 |
| 10.000 | 50.000 | 96.000 | 4.000 | 53.000 |
| 10.000 | 55.000 | 93.000 | 7.000 | 52.700 |
| 10.000 | 56.000 | 93.000 | 8.000 | 52.700 |
| 10.000 | 57.000 | 83.000 | 9.000 | 53.000 |
| 10.000 | 55.000 | 86.000 | 5.000 | 53.200 |
| 10.000 | 53.000 | 93.000 | 6.000 | 53.200 |
| 10.000 | 54.000 | 90.000 | 5.000 | 53.200 |
| 10.000 | 55.000 | 96.000 | 7.000 | 53.000 |
| 7.000 | 58.000 | 87.000 | 8.000 | 52.500 |
| 10.000 | 64.000 | 75.000 | 13.000 | 52.500 |
| 10.000 | 71.000 | 64.000 | 12.000 | 53.000 |
| 10.000 | 75.000 | 50.000 | 12.000 | 54.000 |
| 10.000 | 68.000 | 63.000 | 5.000 | 54.000 |
| 10.000 | 62.000 | 67.000 | 18.000 | 54.000 |
| 10.000 | 57.000 | 100.000 | 8.000 | 54.000 |
| 10.000 | 57.000 | 93.000 | 12.000 | 54.200 |

| | | | | | |
|--|--------|--------|---------|--------|--------|
| | 10.000 | 56.000 | 93.000 | 11.000 | 54.500 |
| | 10.000 | 57.000 | 93.000 | 10.000 | 54.500 |
| | 7.000 | 52.000 | 83.000 | 8.000 | 54.700 |
| | 8.000 | 56.000 | 83.000 | 5.000 | 55.000 |
| | 9.000 | 56.000 | 80.000 | 4.000 | 55.000 |
| | 7.000 | 54.000 | 72.000 | 5.000 | 55.000 |
| | 10.000 | 52.000 | 69.000 | 9.000 | 55.200 |
| | 9.000 | 46.000 | 80.000 | 3.000 | 55.000 |
| | 9.000 | 49.000 | 80.000 | 11.000 | 55.000 |
| | 10.000 | 57.000 | 69.000 | 13.000 | 55.500 |
| | 10.000 | 55.000 | 77.000 | 9.000 | 56.200 |
| | 10.000 | 51.000 | 100.000 | 4.000 | 56.700 |
| | 7.000 | 53.000 | 93.000 | 5.000 | 56.500 |
| | 9.000 | 49.000 | 86.000 | 4.000 | 56.200 |
| | 10.000 | 48.000 | 89.000 | 3.000 | 56.000 |
| | 10.000 | 45.000 | 86.000 | 5.000 | 55.700 |
| | 10.000 | 46.000 | 80.000 | 10.000 | 55.500 |
| | 10.000 | 50.000 | 69.000 | 13.000 | 56.000 |
| | 10.000 | 52.000 | 59.000 | 13.000 | 56.200 |
| | 10.000 | 51.000 | 64.000 | 10.000 | 56.700 |
| | 10.000 | 51.000 | 57.000 | 6.000 | 56.500 |
| | 8.000 | 48.000 | 66.000 | 5.000 | 56.000 |
| | 7.000 | 45.000 | 71.000 | 4.000 | 56.000 |
| | 9.000 | 42.000 | 83.000 | 5.000 | 55.500 |
| | 10.000 | 46.000 | 77.000 | 3.000 | 55.200 |
| | 10.000 | 50.000 | 69.000 | 10.000 | 55.200 |
| | 10.000 | 50.000 | 69.000 | 7.000 | 55.700 |
| | 10.000 | 51.000 | 64.000 | 8.000 | 56.000 |
| | 8.000 | 49.000 | 71.000 | 4.000 | 56.000 |

| | | | | | |
|--|--------|--------|---------|--------|--------|
| | •000 | 40•000 | 93•000 | 2•000 | 55•500 |
| | •000 | 37•000 | 96•000 | •000 | 55•000 |
| | 3•000 | 33•000 | 100•000 | 3•000 | 54•500 |
| | 5•000 | 40•000 | 96•000 | 3•000 | 54•500 |
| | 9•000 | 56•000 | 60•000 | 3•000 | 54•500 |
| | 10•000 | 55•000 | 64•000 | 10•000 | 54•700 |
| | 10•000 | 52•000 | 83•000 | 9•000 | 55•000 |
| | 10•000 | 49•000 | 96•000 | 5•000 | 55•000 |
| | 10•000 | 48•000 | 100•000 | 4•000 | 55•000 |
| | 10•000 | 46•000 | 100•000 | 4•000 | 54•700 |
| | 10•000 | 45•000 | 93•000 | 9•000 | 54•700 |
| | 7•000 | 47•000 | 71•000 | 7•000 | 54•200 |
| | 2•000 | 54•000 | 49•000 | 5•000 | 54•500 |
| | 4•000 | 60•000 | 39•000 | 13•000 | 55•000 |
| | 1•000 | 62•000 | 38•000 | 10•000 | 55•200 |
| | 1•000 | 59•000 | 42•000 | 8•000 | 55•000 |
| | 1•000 | 55•000 | 47•000 | 7•000 | 55•000 |
| | 8•000 | 54•000 | 49•000 | 11•000 | 55•000 |
| | 8•000 | 54•000 | 55•000 | 10•000 | 54•700 |
| | 5•000 | 55•000 | 57•000 | 10•000 | 54•500 |
| | 7•000 | 64•000 | 47•000 | 13•000 | 54•500 |
| | 6•000 | 68•000 | 39•000 | 10•000 | 54•700 |
| | 10•000 | 52•000 | 74•000 | 14•000 | 55•000 |
| | 10•000 | 45•000 | 86•000 | 9•000 | 54•700 |
| | 10•000 | 43•000 | 93•000 | 9•000 | 54•700 |
| | 10•000 | 42•000 | 96•000 | 5•000 | 54•700 |
| | 10•000 | 42•000 | 100•000 | 4•000 | 54•700 |
| | 10•000 | 48•000 | 83•000 | 10•000 | 54•700 |

| | | | | |
|--------|--------|---------|--------|--------|
| 10.000 | 48.000 | 86.000 | 4.000 | 54.700 |
| 10.000 | 49.000 | 89.000 | 4.000 | 54.700 |
| 10.000 | 51.000 | 77.000 | 5.000 | 54.500 |
| 10.000 | 49.000 | 83.000 | 5.000 | 54.000 |
| 10.000 | 42.000 | 96.000 | 7.000 | 53.700 |
| 10.000 | 42.000 | 100.000 | 10.000 | 53.000 |
| 10.000 | 41.000 | 100.000 | 10.000 | 52.500 |
| 10.000 | 42.000 | 96.000 | 10.000 | 52.500 |
| 10.000 | 45.000 | 93.000 | 13.000 | 52.500 |
| 10.000 | 46.000 | 93.000 | 10.000 | 52.500 |
| 10.000 | 46.000 | 93.000 | 8.000 | 52.500 |
| 10.000 | 46.000 | 93.000 | 9.000 | 52.500 |
| 10.000 | 47.000 | 86.000 | 7.000 | 52.500 |
| 10.000 | 49.000 | 77.000 | 7.000 | 51.700 |
| 10.000 | 48.000 | 80.000 | 5.000 | 51.500 |
| 6.000 | 50.000 | 80.000 | 3.000 | 51.200 |
| 5.000 | 60.000 | 62.000 | 3.000 | 51.000 |
| 9.000 | 67.000 | 49.000 | 4.000 | 51.000 |
| 10.000 | 63.000 | 50.000 | 10.000 | 51.000 |
| 10.000 | 60.000 | 65.000 | 3.000 | 51.000 |
| 10.000 | 53.000 | 90.000 | 3.000 | 51.000 |
| 10.000 | 51.000 | 100.000 | 5.000 | 51.000 |
| 10.000 | 51.000 | 100.000 | 6.000 | 51.000 |
| 10.000 | 50.000 | 100.000 | 11.000 | 50.700 |
| 10.000 | 52.000 | 100.000 | 13.000 | 50.500 |
| 10.000 | 51.000 | 96.000 | 14.000 | 50.200 |
| 10.000 | 49.000 | 96.000 | 15.000 | 50.200 |
| 10.000 | 48.000 | 96.000 | 14.000 | 50.200 |
| 10.000 | 47.000 | 100.000 | 13.000 | 50.200 |

| | | | | | |
|--|--------|--------|---------|--------|--------|
| | 10.000 | 47.000 | 100.000 | 8.000 | 50.200 |
| | 10.000 | 47.000 | 100.000 | 7.000 | 50.200 |
| | 10.000 | 47.000 | 100.000 | 9.000 | 50.000 |
| | 10.000 | 50.000 | 86.000 | 7.000 | 50.000 |
| | 10.000 | 54.000 | 75.000 | 8.000 | 50.200 |
| | 7.000 | 58.000 | 65.000 | 10.000 | 50.500 |
| | 6.000 | 56.000 | 62.000 | 4.000 | 51.000 |
| | .000 | 43.000 | 96.000 | 2.000 | 51.000 |
| | .000 | 39.000 | 100.000 | 3.000 | 50.500 |
| | .000 | 37.000 | 100.000 | 2.000 | 50.000 |
| | .000 | 45.000 | 100.000 | 3.000 | 50.000 |
| | 2.000 | 60.000 | 70.000 | 3.000 | 50.000 |
| | 8.000 | 67.000 | 40.000 | 6.000 | 50.500 |
| | 8.000 | 68.000 | 36.000 | 7.000 | 51.200 |
| | 9.000 | 63.000 | 43.000 | 7.000 | 51.500 |
| | 9.000 | 52.000 | 74.000 | 4.000 | 51.700 |
| | .000 | 47.000 | 89.000 | 7.000 | 51.500 |
| | .000 | 42.000 | 96.000 | 2.000 | 51.500 |
| | 3.000 | 51.000 | 90.000 | 6.000 | 51.500 |
| | 4.000 | 60.000 | 70.000 | 8.000 | 51.700 |
| | 4.000 | 67.000 | 55.000 | 12.000 | 52.000 |
| | 3.000 | 68.000 | 51.000 | 13.000 | 52.700 |
| | 3.000 | 63.000 | 50.000 | 6.000 | 53.500 |
| | 3.000 | 52.000 | 83.000 | 3.000 | 53.500 |
| | 2.000 | 45.000 | 96.000 | 2.000 | 53.500 |
| | 10.000 | 46.000 | 100.000 | 5.000 | 53.700 |
| | 10.000 | 47.000 | 100.000 | 5.000 | 53.700 |
| | 3.000 | 54.000 | 86.000 | 8.000 | 53.700 |

| | | | | | |
|--|--------|--------|---------|--------|--------|
| | 1.000 | 64.000 | 65.000 | 8.000 | 54.000 |
| | 2.000 | 66.000 | 51.000 | 3.000 | 54.000 |
| | 4.000 | 63.000 | 65.000 | 6.000 | 54.000 |
| | 6.000 | 55.000 | 80.000 | 7.000 | 54.000 |
| | 2.000 | 50.000 | 83.000 | 3.000 | 54.000 |
| | 8.000 | 50.000 | 86.000 | 6.000 | 54.000 |
| | 7.000 | 55.000 | 75.000 | 7.000 | 53.700 |
| | 9.000 | 58.000 | 67.000 | 7.000 | 53.700 |
| | 7.000 | 62.000 | 58.000 | 5.000 | 53.500 |
| | 2.000 | 64.000 | 54.000 | 4.000 | 53.500 |
| | 8.000 | 61.000 | 58.000 | 4.000 | 53.500 |
| | 8.000 | 55.000 | 80.000 | 7.000 | 53.500 |
| | 6.000 | 54.000 | 75.000 | 10.000 | 53.500 |
| | 10.000 | 51.000 | 80.000 | 7.000 | 53.500 |
| | 1.000 | 55.000 | 75.000 | 8.000 | 53.500 |
| | 5.000 | 60.000 | 62.000 | 15.000 | 53.700 |
| | 3.000 | 65.000 | 54.000 | 10.000 | 54.000 |
| | 1.000 | 68.000 | 49.000 | 13.000 | 54.500 |
| | 9.000 | 63.000 | 60.000 | 6.000 | 54.700 |
| | 9.000 | 57.000 | 72.000 | 7.000 | 54.700 |
| | 10.000 | 54.000 | 80.000 | 7.000 | 54.700 |
| | 10.000 | 52.000 | 90.000 | 10.000 | 54.700 |
| | 10.000 | 51.000 | 96.000 | 10.000 | 55.000 |
| | 10.000 | 54.000 | 100.000 | 11.000 | 55.200 |
| | 10.000 | 57.000 | 93.000 | 9.000 | 55.500 |
| | 10.000 | 58.000 | 90.000 | 10.000 | 55.700 |
| | 10.000 | 60.000 | 93.000 | 13.000 | 55.500 |
| | 10.000 | 61.000 | 97.000 | 10.000 | 55.200 |
| | 10.000 | 63.000 | 97.000 | 10.000 | 55.200 |

| | | | | | |
|--|--------|--------|---------|--------|--------|
| | 10.000 | 62.000 | 97.000 | 4.000 | 55.500 |
| | 10.000 | 61.000 | 100.000 | 8.000 | 55.500 |
| | 10.000 | 62.000 | 100.000 | 6.000 | 55.500 |
| | 8.000 | 69.000 | 73.000 | 9.000 | 56.500 |
| | 7.000 | 72.000 | 57.000 | 8.000 | 57.200 |
| | 10.000 | 60.000 | 87.000 | 5.000 | 57.700 |
| | 10.000 | 58.000 | 93.000 | 6.000 | 57.700 |
| | 10.000 | 57.000 | 93.000 | •000 | 57.700 |
| | 10.000 | 55.000 | 100.000 | •000 | 57.700 |
| | 10.000 | 56.000 | 96.000 | 3.000 | 57.500 |
| | 10.000 | 62.000 | 75.000 | 2.000 | 57.700 |
| | 9.000 | 68.000 | 55.000 | 5.000 | 58.000 |
| | 10.000 | 64.000 | 54.000 | 5.000 | 58.200 |
| | 3.000 | 63.000 | 65.000 | •000 | 58.200 |
| | 10.000 | 58.000 | 90.000 | 3.000 | 58.500 |
| | 10.000 | 56.000 | 96.000 | 3.000 | 58.500 |
| | 10.000 | 56.000 | 100.000 | 4.000 | 58.500 |
| | 10.000 | 56.000 | 100.000 | •000 | 59.000 |
| | 10.000 | 59.000 | 100.000 | 4.000 | 59.000 |
| | 10.000 | 60.000 | 84.000 | 10.000 | 59.500 |
| | 10.000 | 64.000 | 73.000 | 4.000 | 60.000 |
| | 10.000 | 62.000 | 73.000 | 4.000 | 60.000 |
| | 3.000 | 58.000 | 81.000 | 6.000 | 60.000 |
| | 1.000 | 56.000 | 80.000 | 10.000 | 60.200 |
| | •000 | 54.000 | 80.000 | 8.000 | 60.200 |
| | 9.000 | 60.000 | 70.000 | 13.000 | 60.700 |
| | 9.000 | 64.000 | 68.000 | 14.000 | 61.500 |
| | 10.000 | 62.000 | 75.000 | 9.000 | 62.000 |

| | | | | |
|--------|--------|---------|--------|--------|
| 9.000 | 66.000 | 65.000 | 5.000 | 61.700 |
| 10.000 | 56.000 | 90.000 | 8.000 | 61.500 |
| 10.000 | 53.000 | 96.000 | 6.000 | 61.000 |
| 2.000 | 47.000 | 83.000 | 5.000 | 61.000 |
| 6.000 | 41.000 | 96.000 | 4.000 | 61.000 |
| 3.000 | 47.000 | 68.000 | 12.000 | 60.700 |
| 2.000 | 51.000 | 46.000 | 10.000 | 60.700 |
| 1.000 | 57.000 | 44.000 | 12.000 | 61.500 |
| .00 | 59.000 | 44.000 | 10.000 | 61.700 |
| .000 | 56.000 | 45.000 | 5.000 | 61.500 |
| .000 | 43.000 | 83.000 | 3.000 | 61.200 |
| .000 | 39.000 | 93.000 | 3.000 | 61.000 |
| .000 | 36.000 | 96.000 | 0.000 | 60.700 |
| .000 | 47.000 | 83.000 | 3.000 | 60.700 |
| .000 | 62.000 | 41.000 | 10.000 | 61.000 |
| .000 | 68.000 | 33.000 | 5.000 | 61.200 |
| 4.000 | 70.000 | 36.000 | 8.000 | 61.500 |
| 8.000 | 65.000 | 52.000 | 2.000 | 61.500 |
| 6.000 | 53.000 | 86.000 | 3.000 | 61.200 |
| 6.000 | 49.000 | 89.000 | 3.000 | 61.000 |
| 10.000 | 53.000 | 86.000 | 4.000 | 61.000 |
| 10.000 | 58.000 | 84.000 | 9.000 | 61.000 |
| 10.000 | 57.000 | 96.000 | 6.000 | 61.200 |
| 10.000 | 60.000 | 100.000 | 0.000 | 61.500 |
| 10.000 | 64.000 | 97.000 | 5.000 | 62.000 |
| 10.000 | 63.000 | 100.000 | 4.000 | 62.000 |
| 10.000 | 62.000 | 100.000 | 3.000 | 61.500 |
| 10.000 | 60.000 | 100.000 | 3.000 | 61.200 |
| 10.000 | 60.000 | 100.000 | 3.000 | 61.200 |

| | | | | | |
|--|--------|--------|---------|--------|--------|
| | 8,000 | 65•000 | 100•000 | 3•000 | 61•000 |
| | 6,000 | 77•000 | 74•000 | 12•000 | 61•000 |
| | 10,000 | 80•000 | 65•000 | 12•000 | 61•500 |
| | 10,000 | 76•000 | 76•000 | 4•000 | 61•700 |
| | 9,000 | 76•000 | 76•000 | 7•000 | 61•700 |
| | 8,000 | 68•000 | 87•000 | 5•000 | 62•000 |
| | 8,000 | 67•000 | 87•000 | 8•000 | 62•000 |
| | 10,000 | 71•000 | 81•000 | 10•000 | 62•200 |
| | 10,000 | 74•000 | 76•000 | 7•000 | 62•200 |
| | 7,000 | 78•000 | 71•000 | 13•000 | 62•700 |
| | 7,000 | 85•000 | 61•000 | 12•000 | 63•000 |
| | 10,000 | 71•000 | 90•000 | 7•000 | 63•100 |
| | 7,000 | 72•000 | 84•000 | 5•000 | 63•500 |
| | 7,000 | 72•000 | 76•000 | 10•000 | 63•000 |
| | 10,000 | 72•000 | 82•000 | 13•000 | 62•700 |
| | 8,000 | 70•000 | 84•000 | 16•000 | 62•700 |
| | 10,000 | 70•000 | 84•000 | 14•000 | 62•500 |
| | 8,000 | 76•000 | 66•000 | 13•000 | 62•700 |
| | 7,000 | 79•000 | 52•000 | 8•000 | 63•000 |
| | 4,000 | 80•000 | 41•000 | 13•000 | 64•000 |
| | •000 | 75•000 | 45•000 | 8•000 | 64•500 |
| | •000 | 61•000 | 75•000 | 5•000 | 64•700 |
| | •000 | 56•000 | 93•000 | 3•000 | 64•500 |
| | 1,000 | 55•000 | 93•000 | 3•000 | 64•200 |
| | 8,000 | 68•000 | 68•000 | 10•000 | 64•000 |
| | 5,000 | 77•000 | 56•000 | 11•000 | 64•000 |
| | 8,000 | 81•000 | 51•000 | 12•000 | 64•700 |
| | 7,000 | 84•000 | 46•000 | 10•000 | 65•200 |

| | | | | | |
|--|--------|--------|--------|--------|--------|
| | 8.000 | 79.000 | 52.000 | 7.000 | 65•500 |
| | 2.000 | 71.000 | 64.000 | 8.000 | 65•700 |
| | 3.000 | 73.000 | 57.000 | 12.000 | 65•700 |
| | 5.000 | 71.000 | 61.000 | 13.000 | 65•700 |
| | 10.000 | 71.000 | 66.000 | 10.000 | 65•500 |
| | 10.000 | 72.000 | 68.000 | 11.000 | 65•500 |
| | 9.000 | 79.000 | 62.000 | 12.000 | 66•200 |
| | 3.000 | 82.000 | 43.000 | 10.000 | 67•000 |
| | 7.000 | 77.000 | 50.000 | 8.000 | 67•500 |
| | 2.000 | 72.000 | 50.000 | 8.000 | 67•500 |
| | 2.000 | 67.000 | 53.000 | 7.000 | 67•000 |
| | 2.000 | 61.000 | 67.000 | 5.000 | 67•000 |
| | 5.000 | 64.000 | 68.000 | 8.000 | 66•500 |
| | 1.000 | 71.000 | 49.000 | 6.000 | 66•700 |
| | 8.000 | 76.000 | 43.000 | 8.000 | 67•500 |
| | 6.000 | 79.000 | 41.000 | 6.000 | 68•500 |
| | 10.000 | 70.000 | 71.000 | 4.000 | 69•000 |
| | 7.000 | 63.000 | 93.000 | 3.000 | 69•000 |
| | 10.000 | 64.000 | 90.000 | 5.000 | 68•500 |
| | 10.000 | 66.000 | 78.000 | 3.000 | 68•000 |
| | 10.000 | 72.000 | 66.000 | 8.000 | 67•500 |
| | 8.000 | 79.000 | 62.000 | 10.000 | 67•700 |
| | 2.000 | 86.000 | 55.000 | 5.000 | 68•500 |
| | 6.000 | 86.000 | 50.000 | 8.000 | 69•700 |
| | 10.000 | 78.000 | 62.000 | 5.000 | 60•200 |
| | 10.000 | 67.000 | 90.000 | 4.000 | 70•200 |
| | 2.000 | 66.000 | 93.000 | 3.000 | 69•700 |
| | 8.000 | 66.000 | 93.000 | 5.000 | 69•700 |
| | 4.000 | 73.000 | 82.000 | 8.000 | 69•500 |

| | | | | | |
|--|--------|--------|---------|--------|--------|
| | 5.000 | 78.000 | 79.000 | 11.000 | 70.200 |
| | 2.000 | 85.000 | 61.000 | 11.000 | 71.000 |
| | 10.000 | 70.000 | 93.000 | 6.000 | 72.500 |
| | 10.000 | 68.000 | 100.000 | 6.000 | 72.200 |
| | 8.000 | 66.000 | 100.000 | 6.000 | 72.000 |
| | 5.000 | 64.000 | 100.000 | 3.000 | 71.700 |
| | 10.000 | 64.000 | 100.000 | 4.000 | 71.700 |
| | 10.000 | 68.000 | 93.000 | 3.000 | 72.000 |
| | 10.000 | 71.000 | 90.000 | 5.000 | 72.000 |
| | 10.000 | 66.000 | 100.000 | 6.000 | 72.000 |
| | 6.000 | 70.000 | 76.000 | 5.000 | 71.500 |
| | 4.000 | 71.000 | 68.000 | 5.000 | 72.000 |
| | 8.000 | 61.000 | 90.000 | 3.000 | 72.200 |
| | 8.000 | 61.000 | 84.000 | 5.000 | 72.000 |
| | 8.000 | 57.000 | 96.000 | 3.000 | 72.000 |
| | 2.000 | 62.000 | 87.000 | 3.000 | 71.700 |
| | 3.000 | 70.000 | 53.000 | 7.000 | 71.700 |
| | 8.000 | 73.000 | 41.000 | 11.000 | 71.700 |
| | 3.000 | 75.000 | 34.000 | 14.000 | 71.500 |
| | 5.000 | 70.000 | 38.000 | 13.000 | 71.500 |
| | 8.000 | 61.000 | 39.000 | 13.000 | 70.500 |
| | 8.000 | 53.000 | 64.000 | 8.000 | 70.000 |
| | 2.000 | 50.000 | 71.000 | 8.000 | 69.500 |
| | 9.000 | 55.000 | 51.000 | 12.000 | 68.700 |
| | 10.000 | 55.000 | 55.000 | 8.000 | 68.500 |
| | 10.000 | 57.000 | 60.000 | 6.000 | 68.700 |
| | 10.000 | 58.000 | 55.000 | 7.000 | 68.500 |
| | 10.000 | 55.000 | 59.000 | 6.000 | 68.500 |

| | | | | | |
|--|--------|--------|---------|--------|--------|
| | 10.000 | 51.000 | 80.000 | 2.000 | 68.500 |
| | 10.000 | 49.000 | 89.000 | 4.000 | 68.000 |
| | 10.000 | 48.000 | 96.000 | 4.000 | 67.500 |
| | 10.000 | 50.000 | 96.000 | 7.000 | 67.000 |
| | 10.000 | 52.000 | 96.000 | 7.000 | 67.000 |
| | 10.000 | 52.000 | 100.000 | 5.000 | 67.500 |
| | 10.000 | 53.000 | 100.000 | 6.000 | 68.500 |
| | 10.000 | 52.000 | 100.000 | 11.000 | 68.500 |
| | 10.000 | 52.000 | 100.000 | 12.000 | 68.500 |
| | 10.000 | 49.000 | 100.000 | 4.000 | 67.700 |
| | 5.000 | 45.000 | 96.000 | 5.000 | 67.500 |
| | 3.000 | 51.000 | 90.000 | 8.000 | 67.000 |
| | 6.000 | 57.000 | 72.000 | 8.000 | 67.000 |
| | 4.000 | 62.000 | 58.000 | 11.000 | 67.200 |
| | 3.000 | 65.000 | 50.000 | 10.000 | 67.700 |
| | 3.000 | 62.000 | 54.000 | 8.000 | 67.500 |
| | 5.000 | 49.000 | 93.000 | 3.000 | 66.500 |
| | 7.000 | 45.000 | 100.000 | 2.000 | 65.700 |
| | 8.000 | 43.000 | 100.000 | 3.000 | 65.000 |
| | 10.000 | 50.000 | 93.000 | 4.000 | 63.500 |
| | 10.000 | 61.000 | 75.000 | 10.000 | 62.200 |
| | 10.000 | 62.000 | 73.000 | 11.000 | 62.200 |
| | 8.000 | 65.000 | 61.000 | 12.000 | 62.700 |
| | 10.000 | 59.000 | 75.000 | 10.000 | 62.700 |
| | 2.000 | 55.000 | 90.000 | 5.000 | 62.200 |
| | 0.000 | 55.000 | 93.000 | 5.000 | 61.200 |
| | 10.000 | 55.000 | 96.000 | 2.000 | 60.200 |
| | 10.000 | 57.000 | 93.000 | 3.000 | 59.500 |
| | 10.000 | 65.000 | 78.000 | 5.000 | 59.000 |

| | | | | | |
|----|--------|--------|--------|--------|--------|
| | 10.000 | 71.000 | 66.000 | 3.000 | 59.000 |
| | 10.000 | 74.000 | 60.000 | 6.000 | 59.000 |
| | 4.000 | 72.000 | 64.000 | 3.000 | 59.000 |
| | 3.000 | 63.000 | 84.000 | 5.000 | 59.000 |
| | 7.000 | 59.000 | 93.000 | 3.000 | 58.700 |
| | 10.000 | 64.000 | 90.000 | 4.000 | 58.500 |
| 50 | 10.000 | 68.000 | 87.000 | 10.000 | 58.200 |
| | 2.000 | 76.000 | 66.000 | 12.000 | 58.500 |
| | 8.000 | 83.000 | 46.000 | 16.000 | 59.500 |
| | 8.000 | 83.000 | 51.000 | 11.000 | 60.000 |
| | 3.000 | 78.000 | 62.000 | 8.000 | 60.200 |
| | 3.000 | 73.000 | 76.000 | 7.000 | 60.200 |

UA= 13503.000R WIDTH= 400.000CLD COVER= 8.000TEMP AIR= 75.000

TEMP WATER= 62.000REL HUM= 71.000WIND SPEED= 8.700

NUMBER OF CASES= 4

ALLOWED DTS

- 1000000E 01
- 2000000E 01
- 3000000E 01
- 4000000E 01

NUMBER OF DAYS AVERAGED= 2

DAYS AVERAGED

1

2

PTBL1 TTBL1 HFGTB1

•885E-01 •320E 02 •108E 04
•122E 00 •400E 02 •107E 04
•178E 00 •500E 02 •107E 04
•256E 00 •600E 02 •106E 04
•363E 00 •700E 02 •105E 04

•507E 00 •800E 02 •105E 04
•698E 00 •900E 02 •104E 04
•949E 00 •100E 03 •104E 04
•127E 01 •110E 03 •103E 04
•169E 01 •120E 03 •103E 04

DAYS SINCE MARCH 21= 41.000BETA= 45.000

ADDITIONAL DATA FOR STATION 7 ABOVE THE DAM

TEMPERATURES AT STATION 7, °F, DAILY AVERAGES, MAY 1-JUNE 21

48.9, 50.7, 52.3, 52.4, 52.0, 51.8, 51.9, 52.9,
53.0, 53.1, 54.5, 55.2, 55.0, 54.5, 54.2, 54.2,
53.6, 52.4, 51.4, 50.8, 51.0, 50.6, 52.3, 53.9,
53.7, 54.1, 53.8, 54.3, 55.3, 56.3, 57.9, 59.0,
59.4, 58.8, 58.9, 60.0, 60.9, 62.3, 63.3, 64.6,
65.2, 66.8, 69.2, 69.3, 69.0, 67.3, 66.9, 66.1,
62.4, 59.3, 59.9

SEPTEMBER 27, 1973
AUGUST 15 to 31 and SEPTEMBER 12 to 26

NUMBER OF DATA LINES= 256 TIME AV. LOGIC= 0

CLD COVER AIRTEMP REL HUM WIND SPD WATER TEMP

| | | | | |
|--------|--------|---------|--------|--------|
| 5.000 | 66.000 | 87.000 | 6.000 | 78.000 |
| 5.000 | 64.000 | 90.000 | 6.000 | 77.500 |
| 10.000 | 66.000 | 90.000 | 7.000 | 77.200 |
| 10.000 | 70.000 | 84.000 | 8.000 | 77.500 |
| 9.000 | 75.000 | 69.000 | 10.000 | 77.200 |
| 10.000 | 75.000 | 66.000 | 10.000 | 77.000 |
| 10.000 | 71.000 | 76.000 | 6.000 | 77.000 |
| 4.000 | 66.000 | 87.000 | 5.000 | 77.000 |
| .000 | 62.000 | 93.000 | 3.000 | 76.700 |
| 9.000 | 62.000 | 97.000 | 3.000 | 76.700 |
| 10.000 | 62.000 | 100.000 | 4.000 | 76.000 |
| 10.000 | 67.000 | 93.000 | 4.000 | 75.700 |
| 1.000 | 77.000 | 62.000 | 5.000 | 75.700 |
| 1.000 | 79.000 | 47.000 | 9.000 | 76.500 |
| .000 | 75.000 | 58.000 | 3.000 | 77.000 |
| .000 | 65.000 | 87.000 | 3.000 | 76.500 |
| .000 | 62.000 | 93.000 | 3.000 | 76.200 |
| 1.000 | 59.000 | 97.000 | 4.000 | 76.500 |
| 8.000 | 62.000 | 97.000 | 4.000 | 76.500 |
| 8.000 | 75.000 | 71.000 | 5.000 | 76.500 |
| 8.000 | 82.000 | 55.000 | 5.000 | 76.500 |
| 7.000 | 83.000 | 51.000 | 7.000 | 77.500 |
| 9.000 | 79.000 | 65.000 | 4.000 | 77.700 |
| 9.000 | 68.000 | 93.000 | 3.000 | 77.200 |
| 5.000 | 66.000 | 93.000 | 3.000 | 76.700 |
| 5.000 | 64.000 | 97.000 | 3.000 | 76.700 |

| | | | | | |
|--|--------|--------|---------|--------|--------|
| | 3.000 | 66.000 | 97.000 | 3.000 | 76.700 |
| | 8.000 | 76.000 | 71.000 | 6.000 | 76.700 |
| | 8.000 | 85.000 | 57.000 | 4.000 | 77.200 |
| | 9.000 | 85.000 | 51.000 | 9.000 | 77.000 |
| | 10.000 | 67.000 | 87.000 | 11.000 | 77.000 |
| | 8.000 | 66.000 | 93.000 | 5.000 | 76.700 |
| | 3.000 | 65.000 | 93.000 | 5.000 | 76.500 |
| | 8.000 | 63.000 | 97.000 | 6.000 | 76.500 |
| | 5.000 | 63.000 | 100.000 | 4.000 | 75.700 |
| | 7.000 | 74.000 | 84.000 | 4.000 | 76.000 |
| | 5.000 | 80.000 | 67.000 | 4.000 | 76.700 |
| | 9.000 | 69.000 | 84.000 | 9.000 | 77.200 |
| | 9.000 | 72.000 | 84.000 | 5.000 | 77.200 |
| | 4.000 | 67.000 | 93.000 | 5.000 | 76.500 |
| | 3.000 | 63.000 | 97.000 | 3.000 | 76.200 |
| | 3.000 | 60.000 | 97.000 | 5.000 | 75.700 |
| | 6.000 | 63.000 | 97.000 | 4.000 | 75.700 |
| | 6.000 | 74.000 | 71.000 | 10.000 | 76.000 |
| | 4.000 | 79.000 | 60.000 | 5.000 | 76.200 |
| | 2.000 | 81.000 | 54.000 | 5.000 | 76.700 |
| | 1.000 | 73.000 | 69.000 | 6.000 | 77.200 |
| | 1.000 | 67.000 | 84.000 | 3.000 | 76.500 |
| | 1.000 | 63.000 | 90.000 | 6.000 | 76.200 |
| | 1.000 | 61.000 | 93.000 | 7.000 | 76.200 |
| | 1.000 | 62.000 | 97.000 | 3.000 | 75.200 |
| | 4.000 | 75.000 | 69.000 | 11.000 | 75.500 |
| | 8.000 | 80.000 | 49.000 | 10.000 | 76.000 |
| | 8.000 | 80.000 | 56.000 | 10.000 | 76.500 |

| | | | | |
|--------|--------|---------|--------|--------|
| 10.000 | 70.000 | 79.000 | 6.000 | 76.700 |
| 10.000 | 68.000 | 84.000 | 5.000 | 76.500 |
| 10.000 | 69.000 | 76.000 | 8.000 | 75.500 |
| 10.000 | 67.000 | 73.000 | 13.000 | 75.200 |
| 10.000 | 66.000 | 81.000 | 13.000 | 75.000 |
| 10.000 | 65.000 | 84.000 | 11.000 | 75.000 |
| 10.000 | 61.000 | 93.000 | 10.000 | 75.200 |
| 10.000 | 61.000 | 90.000 | 8.000 | 76.000 |
| 8.000 | 61.000 | 75.000 | 4.000 | 76.000 |
| 1.000 | 54.000 | 90.000 | 4.000 | 76.000 |
| 2.000 | 51.000 | 93.000 | 3.000 | 75.500 |
| .000 | 47.000 | 100.000 | 3.000 | 74.500 |
| .000 | 50.000 | 100.000 | 5.000 | 73.500 |
| .000 | 64.000 | 65.000 | 6.000 | 73.500 |
| 9.000 | 68.000 | 55.000 | 9.000 | 74.000 |
| 7.000 | 70.000 | 49.000 | 5.000 | 75.000 |
| 9.000 | 67.000 | 66.000 | 4.000 | 75.000 |
| 10.000 | 67.000 | 61.000 | 3.000 | 74.500 |
| 10.000 | 65.000 | 73.000 | 8.000 | 73.700 |
| 10.000 | 64.000 | 75.000 | 5.000 | 73.500 |
| 1.000 | 60.000 | 81.000 | 7.000 | 73.200 |
| .000 | 64.000 | 58.000 | 8.000 | 73.200 |
| .000 | 68.000 | 49.000 | 6.000 | 73.500 |
| .000 | 71.000 | 48.000 | 8.000 | 74.500 |
| 1.000 | 65.000 | 61.000 | 4.000 | 75.000 |
| .000 | 55.000 | 90.000 | 5.000 | 74.500 |
| .000 | 52.000 | 93.000 | 3.000 | 73.700 |
| .000 | 49.000 | 96.000 | 4.000 | 73.500 |
| .000 | 51.000 | 100.000 | 5.000 | 73.200 |

| | | | | |
|--------|--------|---------|--------|--------|
| 1.000 | 69.000 | 68.000 | 6.000 | 73.200 |
| 6.000 | 76.000 | 48.000 | 9.000 | 74.000 |
| 9.000 | 77.000 | 48.000 | 8.000 | 74.000 |
| 8.000 | 69.000 | 73.000 | 5.000 | 73.500 |
| 7.000 | 63.000 | 90.000 | 4.000 | 73.000 |
| 10.000 | 61.000 | 97.000 | 4.000 | 72.700 |
| 10.000 | 62.000 | 93.000 | 4.000 | 72.700 |
| 10.000 | 64.000 | 90.000 | 5.000 | 72.700 |
| 10.000 | 65.000 | 93.000 | 5.000 | 73.000 |
| 10.000 | 75.000 | 69.000 | 6.000 | 74.000 |
| 10.000 | 76.000 | 66.000 | 6.000 | 74.000 |
| 10.000 | 72.000 | 84.000 | 4.000 | 73.700 |
| 10.000 | 70.000 | 90.000 | 4.000 | 73.500 |
| 10.000 | 68.000 | 93.000 | 5.000 | 73.500 |
| 10.000 | 66.000 | 100.000 | 4.000 | 73.500 |
| 10.000 | 67.000 | 97.000 | 4.000 | 73.500 |
| •000 | 79.000 | 77.000 | 8.000 | 74.000 |
| 6.000 | 84.000 | 65.000 | 4.000 | 74.500 |
| 6.000 | 86.000 | 63.000 | 4.000 | 75.000 |
| 4.000 | 81.000 | 79.000 | 4.000 | 75.000 |
| 5.000 | 78.000 | 88.000 | 9.000 | 75.500 |
| 10.000 | 77.000 | 88.000 | 9.000 | 75.500 |
| 10.000 | 68.000 | 93.000 | 5.000 | 75.200 |
| 9.000 | 68.000 | 100.000 | 4.000 | 75.000 |
| 4.000 | 76.000 | 97.000 | 4.000 | 75.500 |
| 2.000 | 83.000 | 74.000 | 15.000 | 76.000 |
| •000 | 85.000 | 53.000 | 9.000 | 76.500 |
| 10.000 | 77.000 | 64.000 | 5.000 | 77.000 |

| | | | | |
|--------|--------|---------|--------|--------|
| 5.000 | 69.000 | 81.000 | 4.000 | 76.500 |
| .000 | 64.000 | 93.000 | 3.000 | 76.000 |
| .000 | 61.000 | 97.000 | 3.000 | 75.700 |
| 3.000 | 63.000 | 100.000 | 4.000 | 75.500 |
| 4.000 | 77.000 | 74.000 | 8.000 | 75.500 |
| 2.000 | 85.000 | 61.000 | 11.000 | 76.000 |
| 2.000 | 87.000 | 57.000 | 5.000 | 77.000 |
| 5.000 | 81.000 | 79.000 | 5.000 | 77.000 |
| 3.000 | 76.000 | 82.000 | 5.000 | 77.000 |
| 3.000 | 72.000 | 93.000 | 3.000 | 76.500 |
| 9.000 | 73.000 | 87.000 | 4.000 | 76.200 |
| 10.000 | 75.000 | 85.000 | 5.000 | 76.000 |
| 8.000 | 84.000 | 67.000 | 9.000 | 76.200 |
| 9.000 | 90.000 | 56.000 | 9.000 | 77.000 |
| 5.000 | 91.000 | 50.000 | 10.000 | 77.500 |
| 10.000 | 79.000 | 69.000 | 8.000 | 77.700 |
| 4.000 | 74.000 | 82.000 | 4.000 | 77.200 |
| 2.000 | 70.000 | 93.000 | 3.000 | 76.700 |
| 9.000 | 68.000 | 100.000 | 4.000 | 77.000 |
| 5.000 | 69.000 | 100.000 | 5.000 | 77.000 |
| 2.000 | 83.000 | 67.000 | 5.000 | 77.500 |
| 4.000 | 88.000 | 61.000 | 5.000 | 77.500 |
| 10.000 | 74.000 | 82.000 | 12.000 | 78.500 |
| 10.000 | 74.000 | 82.000 | 3.000 | 79.000 |
| 10.000 | 71.000 | 90.000 | 7.000 | 79.000 |
| 10.000 | 60.000 | 67.000 | 7.000 | 71.200 |
| 5.000 | 56.000 | 75.000 | 6.000 | 70.700 |
| 8.000 | 56.000 | 75.000 | 7.000 | 70.200 |
| 7.000 | 60.000 | 62.000 | 9.000 | 70.500 |

| | | | | | |
|--|--------|--------|---------|--------|--------|
| | 10.000 | 62.000 | 48.000 | 9.000 | 70.500 |
| | 10.000 | 62.000 | 50.000 | 8.000 | 70.500 |
| | 10.000 | 60.000 | 58.000 | 6.000 | 70.500 |
| | 10.000 | 56.000 | 78.000 | 3.000 | 70.500 |
| | 10.000 | 54.000 | 83.000 | 3.000 | 70.200 |
| | 4.000 | 51.000 | 90.000 | 3.000 | 70.000 |
| | 9.000 | 51.000 | 93.000 | 3.000 | 69.500 |
| | 5.000 | 61.000 | 58.000 | 10.000 | 69.500 |
| | 9.000 | 63.000 | 46.000 | 5.000 | 70.200 |
| | 4.000 | 64.000 | 47.000 | 8.000 | 70.500 |
| | 9.000 | 57.000 | 69.000 | 3.000 | 71.000 |
| | 10.000 | 52.000 | 83.000 | 3.000 | 70.500 |
| | 10.000 | 51.000 | 86.000 | 6.000 | 70.200 |
| | 10.000 | 50.000 | 86.000 | 4.000 | 69.700 |
| | 10.000 | 51.000 | 90.000 | 7.000 | 69.500 |
| | 10.000 | 59.000 | 70.000 | 8.000 | 69.500 |
| | 10.000 | 59.000 | 75.000 | 5.000 | 68.500 |
| | 10.000 | 55.000 | 90.000 | 5.000 | 68.200 |
| | 10.000 | 54.000 | 93.000 | 8.000 | 68.000 |
| | 10.000 | 54.000 | 96.000 | 4.000 | 68.000 |
| | 10.000 | 54.000 | 96.000 | 6.000 | 68.000 |
| | 10.000 | 54.000 | 96.000 | 4.000 | 67.700 |
| | 10.000 | 54.000 | 96.000 | 6.000 | 67.500 |
| | 10.000 | 55.000 | 100.000 | 3.000 | 67.700 |
| | 10.000 | 57.000 | 96.000 | 8.000 | 67.700 |
| | 8.000 | 59.000 | 93.000 | 5.000 | 67.700 |
| | 9.000 | 57.000 | 93.000 | 5.000 | 67.700 |
| | 10.000 | 57.000 | 96.000 | 7.000 | 67.700 |

| | | | | |
|--------|--------|---------|--------|--------|
| 10.000 | 58.000 | 93.000 | 11.000 | 67.500 |
| 10.000 | 58.000 | 90.000 | 11.000 | 67.200 |
| 10.000 | 56.000 | 83.000 | 12.000 | 67.000 |
| 9.000 | 54.000 | 75.000 | 13.000 | 67.000 |
| 9.000 | 54.000 | 69.000 | 12.000 | 67.000 |
| 9.000 | 53.000 | 72.000 | 12.000 | 67.000 |
| 6.000 | 51.000 | 69.000 | 9.000 | 66.700 |
| 9.000 | 51.000 | 71.000 | 11.000 | 66.700 |
| 10.000 | 50.000 | 71.000 | 10.000 | 66.500 |
| .000 | 42.000 | 86.000 | 3.000 | 66.000 |
| .000 | 41.000 | 96.000 | 4.000 | 65.500 |
| 4.000 | 52.000 | 55.000 | 8.000 | 66.000 |
| 8.000 | 55.000 | 53.000 | 11.000 | 66.700 |
| 6.000 | 56.000 | 51.000 | 5.000 | 66.700 |
| 10.000 | 50.000 | 74.000 | 4.000 | 66.200 |
| 10.000 | 48.000 | 93.000 | 7.000 | 66.000 |
| 10.000 | 50.000 | 93.000 | 10.000 | 65.700 |
| 10.000 | 50.000 | 96.000 | 8.000 | 65.700 |
| 10.000 | 52.000 | 96.000 | 12.000 | 65.000 |
| 10.000 | 52.000 | 96.000 | 4.000 | 65.000 |
| 10.000 | 54.000 | 96.000 | 6.000 | 65.500 |
| 10.000 | 51.000 | 96.000 | 13.000 | 65.200 |
| 10.000 | 51.000 | 93.000 | 13.000 | 64.700 |
| 2.000 | 47.000 | 93.000 | 4.000 | 64.200 |
| 8.000 | 41.000 | 96.000 | 3.000 | 64.000 |
| 4.000 | 39.000 | 100.000 | 3.000 | 63.500 |
| 9.000 | 40.000 | 100.000 | 3.000 | 63.700 |
| 2.000 | 54.000 | 90.000 | 8.000 | 64.500 |
| .000 | 61.000 | 72.000 | 10.000 | 64.700 |

| | | | | | |
|--|--------|--------|---------|--------|--------|
| | 2.000 | 63.000 | 60.000 | 13.000 | 64.200 |
| | 1.000 | 55.000 | 69.000 | 7.000 | 63.700 |
| | 6.000 | 55.000 | 62.000 | 12.000 | 63.700 |
| | 10.000 | 54.000 | 64.000 | 11.000 | 63.500 |
| | 10.000 | 54.000 | 67.000 | 13.000 | 63.500 |
| | 10.000 | 54.000 | 69.000 | 16.000 | 63.500 |
| | 10.000 | 55.000 | 75.000 | 14.000 | 64.000 |
| | 10.000 | 55.000 | 80.000 | 8.000 | 64.200 |
| | 9.000 | 51.000 | 90.000 | 12.000 | 64.000 |
| | 5.000 | 47.000 | 74.000 | 9.000 | 63.500 |
| | .000 | 43.000 | 73.000 | 6.000 | 63.000 |
| | .000 | 35.000 | 85.000 | 4.000 | 63.000 |
| | 5.000 | 33.000 | 92.000 | 4.000 | 62.700 |
| | .000 | 34.000 | 96.000 | 4.000 | 63.000 |
| | 2.000 | 48.000 | 66.000 | 4.000 | 63.500 |
| | 5.000 | 53.000 | 45.000 | 6.000 | 63.200 |
| | 4.000 | 54.000 | 42.000 | 7.000 | 62.700 |
| | 3.000 | 44.000 | 71.000 | 5.000 | 62.500 |
| | .000 | 38.000 | 86.000 | 5.000 | 62.200 |
| | .000 | 35.000 | 89.000 | 4.000 | 62.200 |
| | .000 | 34.000 | 92.000 | 4.000 | 62.000 |
| | 10.000 | 41.000 | 86.000 | 10.000 | 61.700 |
| | 10.000 | 44.000 | 80.000 | 7.000 | 61.500 |
| | 10.000 | 48.000 | 93.000 | 12.000 | 61.500 |
| | 10.000 | 51.000 | 93.000 | 23.000 | 61.500 |
| | 10.000 | 54.000 | 100.000 | 17.000 | 61.000 |
| | 10.000 | 57.000 | 100.000 | 10.000 | 61.000 |
| | 9.000 | 58.000 | 100.000 | 8.000 | 60.700 |

| | | | | |
|--------|--------|---------|--------|--------|
| 7.000 | 56.000 | 100.000 | 3.000 | 60.700 |
| 10.000 | 53.000 | 100.000 | 3.000 | 61.000 |
| 1.000 | 61.000 | 97.000 | 9.000 | 61.500 |
| 10.000 | 64.000 | 75.000 | 6.000 | 62.000 |
| 10.000 | 57.000 | 93.000 | 7.000 | 61.500 |
| 10.000 | 55.000 | 96.000 | 6.000 | 61.500 |
| 10.000 | 52.000 | 100.000 | 8.000 | 61.200 |
| 10.000 | 50.000 | 100.000 | 8.000 | 61.200 |
| 10.000 | 50.000 | 100.000 | 7.000 | 61.200 |
| 10.000 | 50.000 | 100.000 | 6.000 | 61.000 |
| 10.000 | 50.000 | 100.000 | 7.000 | 60.500 |
| 10.000 | 51.000 | 100.000 | 7.000 | 60.000 |
| 10.000 | 53.000 | 100.000 | 4.000 | 59.500 |
| 10.000 | 53.000 | 100.000 | 4.000 | 59.200 |
| 5.000 | 50.000 | 93.000 | 6.000 | 59.500 |
| 7.000 | 49.000 | 93.000 | 4.000 | 59.500 |
| .000 | 46.000 | 89.000 | 4.000 | 59.500 |
| 1.000 | 43.000 | 100.000 | 3.000 | 60.000 |
| 3.000 | 56.000 | 78.000 | 1.000 | 60.700 |
| 3.000 | 63.000 | 65.000 | 10.000 | 60.700 |
| 7.000 | 65.000 | 59.000 | 10.000 | 60.000 |
| 8.000 | 54.000 | 83.000 | 7.000 | 59.500 |
| 4.000 | 50.000 | 89.000 | 5.000 | 59.200 |
| .000 | 47.000 | 96.000 | 5.000 | 59.000 |
| .000 | 44.000 | 96.000 | 3.000 | 59.000 |
| 8.000 | 45.000 | 100.000 | 4.000 | 58.700 |
| 2.000 | 60.000 | 87.000 | 14.000 | 59.200 |
| 7.000 | 66.000 | 68.000 | 12.000 | 59.500 |
| 7.000 | 68.000 | 63.000 | 10.000 | 59.000 |

•000 61.000 78.000 6.000 59.000

4.000 61.000 78.000 7.000 58.700

UA= 7718.000R WIDTH= 400.000CLD COVER= 2.000TEMP AIR= 62.000

TEMP WATER= 60.000REL HUM= 72.000WIND SPEED= 8.700

NUMBER OF CASES= 4

ALLOWED DTS

•1000000E 01

•2000000E 01

•3000000E 01

•4000000E 01

NUMBER OF DAYS AVERAGED= 2

62

DAYS AVERAGED

1

2

PTBL1 TTBL1 HFGBTB1

•885E-01 •320E 02 •108E 04
•122E 00 •400E 02 •107E 04
•178E 00 •500E 02 •107E 04
•256E 00 •600E 02 •106E 04
•363E 00 •700E 02 •105E 04
•507E 00 •800E 02 •105E 04
•698E 00 •900E 02 •104E 04
•949E 00 •100E 03 •104E 04
•127E 01 •110E 03 •103E 04
•169E 01 •120E 03 •103E 04

DAYS SINCE MARCH 21= 75.000BETA= 45.000

OCTOBER 30 , 1974
OCTOBER 1 to 3 , 17 to 24, and 27 to 29, 1973

NUMBER OF DATA LINES= 112 TIME_AV. LOGIC= 0

CLOUD COVER AIRTEMP REL HUM WIND SPD WATER TEMP

| | | | | |
|--------|--------|---------|--------|--------|
| .000 | 38.000 | 96.000 | 4.000 | 60.000 |
| .000 | 37.000 | 100.000 | 3.000 | 60.000 |
| .000 | 38.000 | 100.000 | 3.000 | 60.000 |
| .000 | 56.000 | 72.000 | 6.000 | 60.700 |
| 3.000 | 65.000 | 47.000 | 8.000 | 61.000 |
| 8.000 | 66.000 | 37.000 | 8.000 | 60.700 |
| 5.000 | 59.000 | 56.000 | 9.000 | 60.500 |
| 5.000 | 55.000 | 67.000 | 5.000 | 60.500 |
| 5.000 | 54.000 | 75.000 | 11.000 | 60.200 |
| 3.000 | 54.000 | 75.000 | 7.000 | 60.200 |
| 10.000 | 53.000 | 74.000 | 9.000 | 60.200 |
| 10.000 | 58.000 | 72.000 | 10.000 | 60.500 |
| 10.000 | 60.000 | 84.000 | 10.000 | 60.500 |
| 10.000 | 58.000 | 96.000 | 9.000 | 60.700 |
| 10.000 | 58.000 | 100.000 | 8.000 | 60.500 |
| 10.000 | 59.000 | 97.000 | 7.000 | 60.500 |
| 10.000 | 61.000 | 97.000 | 8.000 | 60.500 |
| 10.000 | 60.000 | 100.000 | 4.000 | 60.500 |
| 10.000 | 62.000 | 100.000 | 4.000 | 60.500 |
| 10.000 | 65.000 | 97.000 | 6.000 | 60.700 |
| 10.000 | 64.000 | 100.000 | 7.000 | 61.000 |
| 10.000 | 65.000 | 100.000 | 3.000 | 60.700 |
| 10.000 | 62.000 | 100.000 | 5.000 | 60.500 |
| 10.000 | 58.000 | 100.000 | 3.000 | 60.500 |
| 10.000 | 44.000 | 65.000 | 9.000 | 54.700 |
| 10.000 | 45.000 | 65.000 | 6.000 | 54.700 |

| | | | | |
|--------|--------|---------|--------|--------|
| 10.000 | 45.000 | 68.000 | 10.000 | 54.500 |
| 10.000 | 45.000 | 77.000 | 10.000 | 54.700 |
| 10.000 | 45.000 | 80.000 | 14.000 | 55.000 |
| 10.000 | 47.000 | 56.000 | 10.000 | 55.500 |
| 10.000 | 45.000 | 58.000 | 7.000 | 55.500 |
| 10.000 | 45.000 | 60.000 | 7.000 | 55.500 |
| 10.000 | 43.000 | 73.000 | 4.000 | 55.000 |
| 10.000 | 42.000 | 76.000 | 4.000 | 55.000 |
| 9.000 | 38.000 | 82.000 | 5.000 | 54.700 |
| 8.000 | 46.000 | 66.000 | 7.000 | 54.700 |
| 10.000 | 47.000 | 61.000 | 6.000 | 54.500 |
| 10.000 | 46.000 | 66.000 | 6.000 | 54.500 |
| 10.000 | 45.000 | 71.000 | 4.000 | 54.200 |
| 10.000 | 43.000 | 73.000 | 3.000 | 54.200 |
| 1.000 | 37.000 | 89.000 | 3.000 | 54.000 |
| 3.000 | 32.000 | 96.000 | 3.000 | 54.000 |
| 5.000 | 32.000 | 100.000 | 3.000 | 53.700 |
| 1.000 | 43.000 | 100.000 | 0.000 | 53.700 |
| 5.000 | 48.000 | 63.000 | 3.000 | 53.700 |
| 10.000 | 50.000 | 50.000 | 5.000 | 54.200 |
| 10.000 | 44.000 | 68.000 | 6.000 | 54.000 |
| 10.000 | 45.000 | 58.000 | 8.000 | 54.000 |
| 10.000 | 44.000 | 80.000 | 11.000 | 53.700 |
| 10.000 | 44.000 | 86.000 | 11.000 | 53.500 |
| 10.000 | 44.000 | 86.000 | 7.000 | 53.200 |
| 10.000 | 44.000 | 100.000 | 3.000 | 53.000 |
| 10.000 | 46.000 | 100.000 | 6.000 | 53.000 |
| 10.000 | 46.000 | 100.000 | 7.000 | 53.500 |

| | | | | |
|--------|--------|---------|--------|--------|
| 10.000 | 46.000 | 96.000 | 10.000 | 53.200 |
| 10.000 | 44.000 | 100.000 | 7.000 | 53.000 |
| 10.000 | 44.000 | 100.000 | 6.000 | 53.000 |
| 9.000 | 41.000 | 100.000 | 7.000 | 52.700 |
| 8.000 | 39.000 | 89.000 | 6.000 | 52.500 |
| 2.000 | 43.000 | 71.000 | 9.000 | 52.200 |
| .000 | 47.000 | 56.000 | 4.000 | 52.700 |
| .000 | 49.000 | 50.000 | 4.000 | 53.200 |
| .000 | 40.000 | 86.000 | 3.000 | 53.000 |
| .000 | 37.000 | 89.000 | 3.000 | 52.700 |
| .000 | 34.000 | 92.000 | 5.000 | 52.500 |
| .000 | 33.000 | 96.000 | 4.000 | 52.200 |
| 4.000 | 32.000 | 100.000 | 3.000 | 52.000 |
| .000 | 47.000 | 93.000 | 10.000 | 52.000 |
| 3.000 | 56.000 | 64.000 | 6.000 | 52.000 |
| 5.000 | 58.000 | 60.000 | 7.000 | 52.500 |
| .000 | 45.000 | 93.000 | 5.000 | 52.500 |
| .000 | 44.000 | 86.000 | 5.000 | 52.500 |
| .000 | 40.000 | 96.000 | 3.000 | 52.000 |
| .000 | 38.000 | 100.000 | 3.000 | 52.000 |
| .000 | 35.000 | 100.000 | 5.000 | 51.500 |
| 4.000 | 56.000 | 72.000 | 11.000 | 51.700 |
| 3.000 | 62.000 | 58.000 | 10.000 | 52.000 |
| 7.000 | 63.000 | 54.000 | 6.000 | 52.500 |
| 8.000 | 55.000 | 69.000 | 5.000 | 52.500 |
| 4.000 | 50.000 | 86.000 | 3.000 | 52.200 |
| 5.000 | 47.000 | 93.000 | 3.000 | 52.000 |
| 5.000 | 44.000 | 96.000 | 3.000 | 51.500 |
| 4.000 | 39.000 | 96.000 | 3.000 | 51.200 |

| | | | | | |
|--|--------|--------|---------|--------|--------|
| | 7.000 | 50.000 | 96.000 | 3.000 | 51.000 |
| | 4.000 | 61.000 | 67.000 | 6.000 | 51.500 |
| | .000 | 62.000 | 67.000 | 5.000 | 52.000 |
| | .000 | 52.000 | 93.000 | 3.000 | 52.000 |
| | .000 | 43.000 | 100.000 | 3.000 | 52.000 |
| | 10.000 | 54.000 | 96.000 | 10.000 | 52.000 |
| | 10.000 | 47.000 | 96.000 | 9.000 | 51.700 |
| | 10.000 | 45.000 | 83.000 | 10.000 | 51.500 |
| | 10.000 | 44.000 | 80.000 | 11.000 | 51.700 |
| | 10.000 | 44.000 | 74.000 | 13.000 | 52.000 |
| | 10.000 | 44.000 | 71.000 | 9.000 | 52.000 |
| | 10.000 | 40.000 | 76.000 | 7.000 | 51.700 |
| | 4.000 | 38.000 | 67.000 | 3.000 | 51.500 |
| | 2.000 | 31.000 | 92.000 | 3.000 | 51.000 |
| | 5.000 | 30.000 | 96.000 | 3.000 | 51.000 |
| | 8.000 | 27.000 | 96.000 | 5.000 | 50.700 |
| | 8.000 | 39.000 | 79.000 | 4.000 | 50.500 |
| | 10.000 | 42.000 | 63.000 | 8.000 | 50.700 |
| | 9.000 | 43.000 | 63.000 | 5.000 | 50.700 |
| | 10.000 | 37.000 | 82.000 | 3.000 | 50.500 |
| | 10.000 | 41.000 | 73.000 | 6.000 | 50.200 |
| | 10.000 | 42.000 | 71.000 | 9.000 | 50.000 |
| | 8.000 | 40.000 | 62.000 | 12.000 | 50.000 |
| | 5.000 | 36.000 | 79.000 | 3.000 | 50.000 |
| | 8.000 | 45.000 | 68.000 | 11.000 | 50.000 |
| | 10.000 | 49.000 | 59.000 | 12.000 | 50.000 |
| | 10.000 | 49.000 | 59.000 | 13.000 | 50.000 |
| | 10.000 | 47.000 | 74.000 | 11.000 | 50.000 |

10.000 47.000 93.000 8.000 50.000
UA= 6240.000R WIDTH= 400.000CLD COVER= 1.000TEMP AIR= 45.000
TEMP WATER= 50.000REL HUM= 68.000WIND SPEED= 000

NUMBER OF CASES= 4

ALLOWED DTS

- 1000000E 01
- 2000000E 01
- 3000000E 01
- 4000000E 01

NUMBER OF DAYS AVERAGED= 2

DAYS AVERAGED

1

2

PTBL1 TTBL1 HFGTB1

•885E-01 •320E 02 •108E 04
•122E 00 •400E 02 •107E 04
•178E 00 •500E 02 •107E 04
•256E 00 •600E 02 •106E 04
•363E 00 •700E 02 •105E 04
•507E 00 •800E 02 •105E 04
•698E 00 •900E 02 •104E 04
•949E 00 •100E 03 •104E 04
•127E 01 •110E 03 •103E 04
•169E 01 •120E 03 •103E 04

DAY S SINCE MARCH 21= 108.000BETA= 45.000

ADDITIONAL DATA FOR STATION 7 ABOVE THE DAM

TEMPERATURES AT STATION 7, °F, DAILY AVERAGES,
OCTOBER 1-3, 17-24, AND 27-29

60.4, 60.0, 59.8, 55.8, 55.0, 54.5, 53.6, 53.4,
53.0, 52.6, 52.9, 52.7, 51.9, 51.0

NOVEMBER 15, 1973
OCTOBER 17 to 24 and 27 to 29, 1973
NOVEMBER 1 to 14, 1973

NUMBER OF DATA LINES= 200 TIME AV. LOGIC= 0

CLD COVER AIRTEMP REL HUM WIND SPD WATER TEMP

| | | | | |
|--------|--------|---------|--------|--------|
| 10.000 | 44.000 | 65.000 | 9.000 | 54.700 |
| 10.000 | 45.000 | 65.000 | 6.000 | 54.700 |
| 10.000 | 45.000 | 68.000 | 10.000 | 54.500 |
| 10.000 | 45.000 | 77.000 | 10.000 | 54.700 |
| 10.000 | 45.000 | 80.000 | 14.000 | 55.000 |
| 10.000 | 47.000 | 56.000 | 10.000 | 55.500 |
| 10.000 | 45.000 | 58.000 | 7.000 | 55.500 |
| 10.000 | 45.000 | 60.000 | 7.000 | 55.500 |
| 10.000 | 43.000 | 73.000 | 4.000 | 55.000 |
| 10.000 | 42.000 | 76.000 | 4.000 | 55.000 |
| 9.000 | 38.000 | 82.000 | 5.000 | 54.700 |
| 8.000 | 46.000 | 66.000 | 7.000 | 54.700 |
| 10.000 | 47.000 | 61.000 | 6.000 | 54.500 |
| 10.000 | 46.000 | 66.000 | 6.000 | 54.500 |
| 10.000 | 45.000 | 71.000 | 4.000 | 54.200 |
| 10.000 | 43.000 | 73.000 | 3.000 | 54.200 |
| 1.000 | 37.000 | 89.000 | 3.000 | 54.000 |
| 3.000 | 32.000 | 96.000 | 3.000 | 54.000 |
| 5.000 | 32.000 | 100.000 | 3.000 | 53.700 |
| 1.000 | 43.000 | 100.000 | •.000 | 53.700 |
| 5.000 | 48.000 | 63.000 | 3.000 | 53.700 |
| 10.000 | 50.000 | 50.000 | 5.000 | 54.200 |
| 10.000 | 44.000 | 68.000 | 6.000 | 54.000 |
| 10.000 | 45.000 | 58.000 | 8.000 | 54.000 |
| 10.000 | 44.000 | 80.000 | 11.000 | 53.700 |
| 10.000 | 44.000 | 86.000 | 11.000 | 53.500 |

| | | | | | |
|--|--------|--------|---------|--------|--------|
| | 10,000 | 44.000 | 86.000 | 7.000 | 53.200 |
| | 10,000 | 44.000 | 100.000 | 3.000 | 53.000 |
| | 10,000 | 46.000 | 100.000 | 6.000 | 53.000 |
| | 10,000 | 46.000 | 100.000 | 7.000 | 53.500 |
| | 10,000 | 46.000 | 96.000 | 10.000 | 53.200 |
| | 10,000 | 44.000 | 100.000 | 7.000 | 53.000 |
| | 10,000 | 44.000 | 100.000 | 6.000 | 53.000 |
| | 9.000 | 41.000 | 100.000 | 7.000 | 52.700 |
| | 8.000 | 39.000 | 89.000 | 6.000 | 52.500 |
| | 2.000 | 43.000 | 71.000 | 9.000 | 52.200 |
| | 0.000 | 47.000 | 56.000 | 4.000 | 52.700 |
| | 0.000 | 49.000 | 50.000 | 4.000 | 53.200 |
| | 0.000 | 40.000 | 86.000 | 3.000 | 53.000 |
| | 0.000 | 37.000 | 89.000 | 3.000 | 52.700 |
| | 0.000 | 34.000 | 92.000 | 5.000 | 52.500 |
| | 0.000 | 33.000 | 96.000 | 4.000 | 52.200 |
| | 4.000 | 32.000 | 100.000 | 3.000 | 52.000 |
| | 0.000 | 47.000 | 93.000 | 10.000 | 52.000 |
| | 3.000 | 56.000 | 64.000 | 6.000 | 52.000 |
| | 5.000 | 58.000 | 60.000 | 7.000 | 52.500 |
| | 0.000 | 45.000 | 93.000 | 5.000 | 52.500 |
| | 0.000 | 44.000 | 86.000 | 5.000 | 52.500 |
| | 0.000 | 40.000 | 96.000 | 3.000 | 52.000 |
| | 0.000 | 38.000 | 100.000 | 3.000 | 52.000 |
| | 0.000 | 35.000 | 100.000 | 5.000 | 51.500 |
| | 4.000 | 56.000 | 72.000 | 11.000 | 51.700 |
| | 3.000 | 62.000 | 58.000 | 10.000 | 52.000 |
| | 7.000 | 63.000 | 54.000 | 6.000 | 52.500 |

| | | | | |
|--------|--------|---------|--------|--------|
| 8.000 | 55.000 | 69.000 | 5.000 | 52.500 |
| 4.000 | 50.000 | 86.000 | 3.000 | 52.200 |
| 5.000 | 47.000 | 93.000 | 3.000 | 52.000 |
| 5.000 | 44.000 | 96.000 | 3.000 | 51.500 |
| 4.000 | 39.000 | 96.000 | 3.000 | 51.200 |
| 7.000 | 50.000 | 96.000 | 3.000 | 51.000 |
| 4.000 | 61.000 | 67.000 | 6.000 | 51.500 |
| 0.000 | 62.000 | 67.000 | 5.000 | 52.000 |
| 0.000 | 52.000 | 93.000 | 3.000 | 52.000 |
| 0.000 | 43.000 | 100.000 | 3.000 | 52.000 |
| 10.000 | 54.000 | 96.000 | 10.000 | 52.000 |
| 10.000 | 47.000 | 96.000 | 9.000 | 51.700 |
| 10.000 | 45.000 | 83.000 | 10.000 | 51.500 |
| 10.000 | 44.000 | 80.000 | 11.000 | 51.700 |
| 10.000 | 44.000 | 74.000 | 13.000 | 52.000 |
| 10.000 | 44.000 | 71.000 | 9.000 | 52.000 |
| 10.000 | 40.000 | 76.000 | 7.000 | 51.700 |
| 4.000 | 38.000 | 67.000 | 3.000 | 51.500 |
| 2.000 | 31.000 | 92.000 | 3.000 | 51.000 |
| 5.000 | 30.000 | 96.000 | 3.000 | 51.000 |
| 8.000 | 27.000 | 96.000 | 5.000 | 50.700 |
| 8.000 | 39.000 | 79.000 | 4.000 | 50.500 |
| 10.000 | 42.000 | 63.000 | 8.000 | 50.700 |
| 9.000 | 43.000 | 63.000 | 5.000 | 50.700 |
| 10.000 | 37.000 | 82.000 | 3.000 | 50.500 |
| 10.000 | 41.000 | 73.000 | 6.000 | 50.200 |
| 10.000 | 42.000 | 71.000 | 9.000 | 50.000 |
| 8.000 | 40.000 | 62.000 | 12.000 | 50.000 |
| 5.000 | 36.000 | 79.000 | 3.000 | 50.000 |

| | | | | | |
|--|--------|--------|--------|--------|--------|
| | 8.000 | 45.000 | 68.000 | 11.000 | 50.000 |
| | 10.000 | 49.000 | 59.000 | 12.000 | 50.000 |
| | 10.000 | 49.000 | 59.000 | 13.000 | 50.000 |
| | 10.000 | 47.000 | 74.000 | 11.000 | 50.000 |
| | 10.000 | 47.000 | 93.000 | 8.000 | 50.000 |
| | 10.000 | 39.000 | 93.000 | 3.000 | 49.000 |
| | 10.000 | 48.000 | 80.000 | 5.000 | 49.000 |
| | 10.000 | 46.000 | 83.000 | 6.000 | 49.000 |
| | 10.000 | 47.000 | 93.000 | 6.000 | 49.000 |
| | 10.000 | 49.000 | 93.000 | 9.000 | 49.200 |
| | 10.000 | 50.000 | 69.000 | 12.000 | 50.000 |
| | 10.000 | 49.000 | 63.000 | 14.000 | 50.000 |
| | 10.000 | 49.000 | 61.000 | 20.000 | 49.200 |
| | 10.000 | 49.000 | 56.000 | 13.000 | 49.000 |
| | 6.000 | 49.000 | 50.000 | 14.000 | 48.200 |
| | 4.000 | 48.000 | 48.000 | 16.000 | 48.200 |
| | 5.000 | 49.000 | 48.000 | 8.000 | 48.500 |
| | 8.000 | 54.000 | 43.000 | 9.000 | 48.700 |
| | 10.000 | 52.000 | 45.000 | 9.000 | 48.700 |
| | 10.000 | 50.000 | 50.000 | 5.000 | 48.500 |
| | 10.000 | 45.000 | 74.000 | 5.000 | 48.500 |
| | 10.000 | 43.000 | 76.000 | 6.000 | 48.700 |
| | 3.000 | 42.000 | 71.000 | 14.000 | 48.700 |
| | 3.000 | 42.000 | 60.000 | 14.000 | 49.000 |
| | 3.000 | 44.000 | 47.000 | 15.000 | 49.000 |
| | 9.000 | 44.000 | 40.000 | 17.000 | 49.200 |
| | 9.000 | 42.000 | 41.000 | 12.000 | 49.000 |
| | 4.000 | 41.000 | 40.000 | 15.000 | 49.000 |

| | | | | |
|--------|--------|--------|--------|--------|
| 9.000 | 40.000 | 39.000 | 14.000 | 48.500 |
| 9.000 | 39.000 | 38.000 | 18.000 | 48.500 |
| 6.000 | 37.000 | 39.000 | 12.000 | 48.500 |
| 8.000 | 36.000 | 40.000 | 14.000 | 48.200 |
| 9.000 | 36.000 | 40.000 | 17.000 | 48.200 |
| 9.000 | 38.000 | 37.000 | 11.000 | 48.200 |
| 6.000 | 39.000 | 36.000 | 11.000 | 48.200 |
| 9.000 | 37.000 | 41.000 | 8.000 | 47.500 |
| 1.000 | 33.000 | 44.000 | 8.000 | 47.000 |
| 2.000 | 31.000 | 47.000 | 6.000 | 47.000 |
| 2.000 | 32.000 | 43.000 | 7.000 | 46.700 |
| 3.000 | 31.000 | 43.000 | 7.000 | 46.700 |
| 5.000 | 34.000 | 42.000 | 12.000 | 47.000 |
| 9.000 | 35.000 | 37.000 | 9.000 | 47.000 |
| 6.000 | 38.000 | 31.000 | 10.000 | 46.700 |
| 5.000 | 35.000 | 32.000 | 11.000 | 46.500 |
| 8.000 | 34.000 | 37.000 | 7.000 | 45.700 |
| 10.000 | 32.000 | 33.000 | 11.000 | 45.500 |
| 10.000 | 31.000 | 36.000 | 10.000 | 45.200 |
| 10.000 | 30.000 | 41.000 | 12.000 | 45.000 |
| 7.000 | 28.000 | 53.000 | 14.000 | 45.000 |
| 9.000 | 31.000 | 40.000 | 10.000 | 45.000 |
| 10.000 | 32.000 | 38.000 | 17.000 | 45.000 |
| 10.000 | 29.000 | 58.000 | 8.000 | 44.700 |
| 10.000 | 28.000 | 61.000 | 12.000 | 44.500 |
| 7.000 | 27.000 | 55.000 | 7.000 | 44.500 |
| 7.000 | 25.000 | 60.000 | 9.000 | 44.500 |
| 8.000 | 27.000 | 61.000 | 5.000 | 44.500 |
| 8.000 | 30.000 | 58.000 | 4.000 | 44.500 |

| | | | | | |
|--|--------|--------|--------|--------|--------|
| | 7.000 | 36.000 | 52.000 | 6.000 | 44.700 |
| | 9.000 | 38.000 | 46.000 | 12.000 | 44.700 |
| | 9.000 | 38.000 | 46.000 | 10.000 | 44.200 |
| | 10.000 | 38.000 | 53.000 | 7.000 | 44.000 |
| | 10.000 | 36.000 | 57.000 | 8.000 | 44.000 |
| | 10.000 | 36.000 | 62.000 | 7.000 | 44.000 |
| | 10.000 | 36.000 | 62.000 | 10.000 | 43.500 |
| | 10.000 | 36.000 | 57.000 | 15.000 | 43.500 |
| | 10.000 | 38.000 | 50.000 | 15.000 | 43.500 |
| | 9.000 | 40.000 | 45.000 | 14.000 | 43.500 |
| | 10.000 | 41.000 | 45.000 | 13.000 | 43.500 |
| | 7.000 | 38.000 | 57.000 | 8.000 | 43.500 |
| | 9.000 | 36.000 | 42.000 | 12.000 | 43.200 |
| | 9.000 | 35.000 | 42.000 | 7.000 | 43.000 |
| | 6.000 | 32.000 | 45.000 | 7.000 | 43.000 |
| | 7.000 | 32.000 | 43.000 | 12.000 | 43.000 |
| | 7.000 | 34.000 | 38.000 | 12.000 | 43.000 |
| | 9.000 | 33.000 | 45.000 | 12.000 | 43.000 |
| | 9.000 | 31.000 | 43.000 | 15.000 | 42.500 |
| | 10.000 | 29.000 | 45.000 | 13.000 | 42.200 |
| | 9.000 | 26.000 | 46.000 | 14.000 | 42.000 |
| | 10.000 | 25.000 | 46.000 | 12.000 | 41.700 |
| | 10.000 | 25.000 | 53.000 | 12.000 | 41.500 |
| | 10.000 | 25.000 | 66.000 | 10.000 | 41.500 |
| | 8.000 | 30.000 | 56.000 | 9.000 | 41.500 |
| | 7.000 | 33.000 | 42.000 | 9.000 | 41.200 |
| | 5.000 | 31.000 | 43.000 | 10.000 | 41.200 |
| | 10.000 | 31.000 | 45.000 | 11.000 | 41.000 |

| | | | | |
|--------|--------|--------|--------|--------|
| 10.000 | 29.000 | 51.000 | 6.000 | 41.000 |
| 10.000 | 27.000 | 55.000 | 6.000 | 41.000 |
| 9.000 | 27.000 | 53.000 | 6.000 | 41.000 |
| 8.000 | 29.000 | 49.000 | 9.000 | 41.000 |
| 8.000 | 33.000 | 48.000 | 4.000 | 42.000 |
| 10.000 | 36.000 | 42.000 | 7.000 | 42.000 |
| 10.000 | 34.000 | 44.000 | 6.000 | 41.500 |
| 10.000 | 33.000 | 50.000 | 0.000 | 41.200 |
| 10.000 | 34.000 | 52.000 | 7.000 | 41.200 |
| 10.000 | 34.000 | 64.000 | 7.000 | 41.200 |
| 10.000 | 35.000 | 59.000 | 10.000 | 41.200 |
| 10.000 | 37.000 | 59.000 | 12.000 | 41.500 |
| 10.000 | 39.000 | 53.000 | 14.000 | 41.500 |
| 10.000 | 39.000 | 51.000 | 15.000 | 41.500 |
| 10.000 | 39.000 | 48.000 | 14.000 | 41.500 |
| 10.000 | 41.000 | 43.000 | 14.000 | 41.500 |
| 10.000 | 41.000 | 43.000 | 13.000 | 41.500 |
| 10.000 | 41.000 | 43.000 | 13.000 | 41.500 |
| 10.000 | 41.000 | 45.000 | 10.000 | 41.500 |
| 10.000 | 43.000 | 47.000 | 13.000 | 41.500 |
| 10.000 | 45.000 | 49.000 | 10.000 | 41.500 |
| 10.000 | 46.000 | 50.000 | 8.000 | 41.500 |
| 10.000 | 46.000 | 52.000 | 5.000 | 41.500 |
| 10.000 | 46.000 | 52.000 | 8.000 | 41.500 |
| 10.000 | 48.000 | 48.000 | 13.000 | 41.500 |
| 10.000 | 51.000 | 48.000 | 14.000 | 41.500 |
| 10.000 | 54.000 | 51.000 | 14.000 | 41.500 |
| 10.000 | 55.000 | 57.000 | 10.000 | 41.500 |
| 8.000 | 61.000 | 46.000 | 13.000 | 42.000 |

8.000 57.000 42.000 12.000 42.000
6.000 48.000 63.000 4.000 42.000
8.000 45.000 71.000 4.000 42.000
UA= 7640.000R WIDTH= 400.000CLD COVER= 1.000TEMP AIR= 50.000
TEMP WATER= 41.700REL HUM= 68.000WIND SPEED= 4.400
NUMBER OF CASES= 4

ALLOWED DTS

- 1000000E 01
- 2000000E 01
- 3000000E 01
- 4000000E 01

NUMBER OF DAYS AVERAGED= 2

DAYS AVERAGED

1

2

PTBL1 TTBL1 HFTBL1

•885E-01 •320E 02 •108E 04
•122E 00 •400E 02 •107E 04
•178E 00 •500E 02 •107E 04
•256E 00 •600E 02 •106E 04
•363E 00 •700E 02 •105E 04
•507E 00 •800E 02 •105E 04
•698E 00 •900E 02 •104E 04
•949E 00 •100E 03 •104E 04
•127E 01 •110E 03 •103E 04
•169E 01 •120E 03 •103E 04

APPENDIX C

PROGRAM LISTINGS

This appendix presents complete program listings for the STREAM, SENSIT, and MONT codes.

1.000 C
2.000 C
3.000 C STREAM
4.000 C
5.000 C
6.000 C STREAM THERMAL MDFL
7.000 C
8.000 C
9.000 COMM8N DTEMP,TEMP,XPR,XEND,DXPR,X,DX, INT,INTC,IN,I8,EL,AREA,U
10.000 COMM8N ERR8R,DXMAX
11.000 COMM8N RH, WMD,HD,TATR,CLD,RH,ALBAR,TWS,TA, EW,EA,H8S,HS
12.000 COMM8N HSR,HAB,EFR,EVAP,HE,HC,HLYMN,PTBL(10),TTBL(10),WMS,CONST
13.000 COMM8N HFG,CLD1,HFGTB(10),CONS1
14.000 IN=5
15.000 I8=6
16.000 CALL INPUT
17.000 IF(INTC = 4) 4,105,105
18.000 4 XPR = DXPR
19.000 5 CONTINUE
20.000 D9 100 JE= 1,INT
21.000 CALL DIFQ
22.000 G9 T8 (10,10,20), INTC
23.000 10 CALL EULFR(DTEMP,TEMP,DX,1,JE,X)
24.000 G9 T8 100
25.000 20 CALL RK4(DTEMP,TEMP,DX,1,JE,X)
26.000 100 CONTINUE
27.000 IF(X = XPR) 5,250,250
28.000 250 CALL Supt

```
29.000      XPR = XPR + DXPR
30.000      IF(X = XFND) 5,300,300
31.000 105"  CONTINUE
32.000      JJMP = -1
33.000 110"  CONTINUE
34.000      XPR = X + DXPR
35.000 120"  CONTINUE
36.000      CALLNBRD(DTEMP,X,XPR,TEMP,ERRBR,t,DX,DXMAX,JUMP,KSTR,KC,1.E-6,IB)
37.000      IF(JUMP)130,140,150
38.000 130"  WRITE(IB,131) X
39.000 131"  FORMAT(//! X =E14.5! INTEGRATION FAILURE!)
40.000      CALL EXIT
41.000 140"  CONTINUE
42.000      CALL DIFFQ
43.000      G3 TO 120
44.000 150"  CALL BUPT
45.000      IF(X = XFND) 110,300,300
46.000 300"  CALL EXIT
47.000      END
48.000      SJBRBUTINE INPUT
49.000      CMMBN DTEMP,TEMP, XPR,XEND,DXPR,X,DX, INT,INTC,
50.000      1 IN,IB,EL,ARFA,U,ERRBR,DXMAX
51.000      CMMENRHS, WMD,HD,TAIR,CLD,RH,ALBAR,TWS,TA, EW,EA,HBS,HS
52.000      CMMBN HSR,HBS,FBR,EVAP,HE,HC,HLYMN,PTBL(10),TTBL(10),WMS,CONST
53.000      CMMBN HFG,CLD1,HFGTB(10),CONST
54.000 10"   FORMAT(6F10.0)
55.000 20"   FORMAT(6I10)
56.000 C     CHOICE OF INTEGRATION SUBROUTINE
```

```
57.000      READ(IN,20)      INTC
58.000      IF(INTC = 3) 30,40,50
59.000 30    INT = INTC
60.000      GO TO 60
61.000 40    INT = 4
62.000      GO TO 60
63.000 50    CONTINUE
64.000 60    CONTINUE
65.000      GO TO (110,120,130,140), INTC
66.000 110   WRITE(10,115)
67.000 115   FORMAT('1      ****  FULFR INTEGRATION      *****!//')
68.000      GO TO 150
69.000 120   CONTINUE
70.000      WRITE(10,125)
71.000 125   FORMAT('1      *****  MBD. EULER INTEGRATION  *****!//')
72.000      GO TO 150
73.000 130   WRITE(10,135)
74.000 135   FORMAT('1      *****  4 TH ORDER RUNGE-KÜTTA      *****!//')
75.000      GO TO 150
76.000 140   WRITE(10,145)
77.000 145   FORMAT('1      *****  ADAMS MBDLBN INTEG.  *****!//')
78.000 150   CONTINUE
79.000 C
80.000 C      INTEGRATION CONTROL PARAMETERS.
81.000      READ(IN,10) X,DX,DXPR,XEND
82.000      WRITE(10,160)X,DX,DXPR,XEND
83.000 160   FORMAT('1      X ='F6.2'      DX ='E10.3'      DXPR ='E10.3
1      XEND ='E10.3,/)
84.000      READ(IN,10) ERROR,DXMAX
```

```
85.000      WRITE(I0,180) ERR8R,DXMAX
87.000 180  F9RMAT('  ERROR =1E10.3!  DXMAX =1E10.3,/ )
88.000      READ(IN,10) TEMP,U,AREA,EL
89.000      READ(IN,10) RH0,WMPH,TAIR,CLD,RH,ALBAR
90.000      DB .185 I=1,10
91.000 185  READ(IN,10) PTBL(I), TTBL(I), HFTB(I)
92.000      TA = (TAIR - 32.)*5./9.
93.000      W = WMPH*22./15.
94.000      WMS = W * .3048
95.000      WMD = WMPH * .24.
96.000      C8NST = FL/(RH0*U*AREA)
97.000      C8NS1 = (RH0*0.00328)/(24.*3600.*0.0644)
98.000      SINA = SIN(ALBAR*3.14159/180.)
99.000      CLD1 = 1. - .0745*CLD
100.000 C    INCIDENT SOLAR RADIATION
101.000      H0S = 1.9*SINA
102.000      HS = H0S*(1. - .0006*CLD**3)
103.000 C    REFLECTED SOLAR RADIATION
104.000      HSR = HS*3./ALBAR
105.000      EA = RH*(1013./1470.)*SI(TTBL,PTBL,TAIR,10)
106.000      WRITE(10,200) TEMP
107.000 200  F9RMAT('  INITIAL STREAM TEMPERATURE ='F6.2! DEG F'/ )
108.000      WRITE(10,210) U,AREA,EL
109.000 210  F9RMAT('  STREAM VELOCITY ='F6.3! FT/SEC  CR. SEC. AREA ='1
110.000      F10.2'  SQ. FT.  SURFACE WIDTH ='F6.1'  FT'/ )
111.000      WRITE(10,220) RH0,CLD,RH,ALBAR
112.000 220  F9RMAT('  RH0='F5.2! LB/CU.FT.  CLD='F4.1' TENTHS',
113.000      F1'  RH='F5.1' PCT!/ ALBAR ='F4.1' DEGRFES'/ )
```

```

114.000      WRITE(10,230) TAIR,TA,CNST, C8NS1
115.000 230  FORMAT(' AIR TEMP. =F5.1' DFG F'F8.1' DFG C',
115.000      1' CNST ='E10.3' C8NS1 ='E10.3')
117.000      WRITE(10,240) W,WMPH,WMS,WMD
118.000 240  FORMAT(' WIND VELOCITY =F6.2' FT/SEC'F8.2'MPH'F8.2' METERS',
119.000      1'/SEC'F8.2' MILES/DAY')
120.000      WRITE(10,260)
121.000 260  FORMAT(1,T20!TTBL!T40!PTBL!T60!HFGTB!)
122.000      DB 270 I =1,10
123.000 270  WRITE(10,280) TTBL(I), PTBL(I), HFGTB(I)
124.000 280  FORMAT(10X,3F20.5)
125.000      WRITE(10,300) EA,H8S,HS,HSR
126.000 300  FORMAT(1, FA ='E12.4' H8S ='E12.4' HS ='E12.4',
127.000      1' HSR ='E12.4' LY/MIN)
128.000      WRITE(10,310)
129.000 310  FORMAT(11)
130.000      RETURN
131.000      END
132.000      SUBROUTINE QUPUT
133.000      COMMON DTEMP, TFMP,          XPR,XFND,DXPR,X,DX, INT,INTC,
134.000      1 IN,10,EI ,ARFA,U,ERRR,R,DXMAX
135.000      COMMON NRHB, WMD,HD,TAIR,CLD,RH,ALBAR,TWS,TA, EW,EA,H8S,HS
136.000      COMMON HSR,H8B,FBR,EVAP,HE,HC,HLYMN,PTBL(10),TTBL(10),WMS,CNST
137.000      COMMON HFG,CLD1,HFGTB(10),C8NS1
138.000      WRITE(10,10) X,DX
139.000 10   FORMAT(1 X ='F7.1' FT      DX ='F6.1' )
140.000      WRITE(10,20) TEMP,DTEMP
141.000 20   FORMAT(1 STREAM TEMP =F6.2' DFG F      DTEMP ='E10.3',
142.000      1' DEG F/FT)

```

```

143.000      WRITE(10,30) EW, EVAP, HE, HFG
144.000 30   FORMAT(' EW =',F12.5)
145.000      WRITE(10,50) HOB, EBR, HC
146.000      FORMAT(' HBR =',E12.5, ' EBR =',F12.5, ' HC =',E12.5, ' LY/MIN')
147.000 50   WRITE(10,60) HLYMN, HD
148.000      FORMAT(' TOTAL HEAT TRANSFER =',E12.5, ' LY/MIN',E15.5,
149.000 60   ' BTU/SEC-FT2')
150.000      WRITE(10,70)
151.000      FORMAT(////)
152.000 70   RETURN
153.000      END
154.000      SUBROUTINE DIFEQ
155.000      C9MM9NDTFMP, TFMP, XPR, XEND, DXPR, X, DX, INT, INTC,
156.000      1 IN, 10, FI, ARFA, U, ERR9R, DXMAX
157.000      C9MM9NRH9, WMD, HD, TAIR, CLD, RH, ALBAR, TWS, TA, EW, EA, HBS, HS
158.000      C9MM9N HSR, HAB, FBR, EVAP, HE, HC, HLYMN, PTBL(10), TTBL(10), WMS, CONST
159.000      C9MM9N HFG, CLD1, HFGTB(10), CONS1
160.000      THERMAL EXCHANGE WITH ENVIRONMENT.
161.000 C     TWS = (TFMP - 32.) * 5./9.
162.000      EW = (1013./14.7) * SI(TTBL, PTBL, TFMP, 10)
163.000      EFFECTIVE BACK RADIATION.
164.000 C     HOB = (14.38 - .09*TWS - .046*RH)/69.72
165.000      EBR = HBR * CLD1
166.000      EVAPORATION HEAT TRANSFER.
167.000 C     EVAP = .35 * (EW-EA) * (1. + .009R* WMD)
168.000      HFG = SI(TTBL, HFGTB, TEMP, 10)
169.000      HE = EVAP*HFG*C9NS1
170.000

```

171.000 C CONVECTION HEAT TRANSFER
172.000 HC = 39.*(.26 + .077*WMS)*(TWS - TA)/1440.
173.000 C TOTAL HEAT TRANSFER TO WATER, LY/MIN
174.000 HLYMN = HS - (EBR + HSR + HC + HE)
175.000 C TOTAL HEAT TRANSFER, BTU/SEC-FT²
176.000 HD = HLYMN * .0614
177.000 C DERIVATIVE CALCULATION
178.000 DTEMP = CONST*HD
179.000 RETURN
180.000 END
181.000 CCCCC
182.000 CCCCC
183.000 CCCCC
184.000 CCCCC
185.000 FUNCTION SI(XTBL,YTBL,X,N)
186.000 C LINEAR INTERPOLATION OR EXTRAPOLATION OF SINGLE VARIABLE FUNCTION
187.000 C XTBL = INDEPENDENT VARIABLE TABLE
188.000 C YTBL = DEPENDENT VARIABLE TABLE
189.000 C IND = INDICATOR OF EXTRAPOLATION
190.000 C 0=NO EXTRAPOLATION, 1=LOWER EXTRAPOLATION, 2=UPPER EXTRAPOLATION
191.000 DIMENSION XTBL(40),YTBL(40)
192.000 C CHECK TO SEE IF EXTRAPOLATION IS NEEDED.
193.000 IF(X>XTBL(1)) 120,130,150
194.000 120 IND = 1
195.000 130 II = 2
196.000 G9 TO 254
197.000 150 IF(XTBL(N)=X) 160,180,210
198.000 160 IND = ?
199.000 180 II = N

```
200.000      G0 T0 254
201.000 C   FIND X IN TABLE.S IN TABLE
202.000 210 D0 220 IK=2,N
203.000     II = IK
204.000     IF(XTBL(IK)-X) >20,254,254
205.000 220 C0NT1NUF
206.000 254 X1 = XTBL(II-1)
207.000     X2 = XTBL(II)
208.000     Y1 = YTBL(II-1)
209.000     Y2 = YTBL(II)
210.000     SI = Y1+(Y2-Y1)*(X-X1)/(X2-X1)
211.000     RETURN
212.000     END
213.000 CCCCCC
214.000 CCCCCC
215.000 C   EULER AND MODIFIED EULER INTEGRATION
216.000 CCCCCC
217.000 CCCCCC
218.000 CCCCCC
219.000     SUBROUTINE EULER(YP,Y,DT,NE,J,T)
220.000     DIMENSION YP(20),Y(20), SY(20),SYP(20)
221.000     G0 T0(10,20),J
222.000 10  C0NT1NUF
223.000     D0 100 I=1,NF
224.000     SY(I)= Y(I)
225.000     SYP(I)= YP(I)
226.000     Y(I)= Y(I)+DT*YP(I)
227.000 100 C0NT1NUF
```

```
228•000      T=T+DT
229•000      RETURN
230•000  20  CONTINUE
231•000      D9 200 I=1,NF
232•000      Y(I)= SY(I)+(YP(I)+SYP(I))*DT/2.
233•000  200  CONTINUE
234•000      RETURN
235•000      END
236•000  CCCCCC
237•000  CCCCCC
238•000  CCCCCC
239•000  C  FOURTH ORDER RUNGE-KUTTA INTEGRATION
240•000  CCCCCC
241•000  CCCCCC
242•000  CCCCCC
243•000      SUBROUTINE RK4(YP,Y,DT,NE,J,T)
244•000      DIMENSION YP(5),Y(5),AK(5,4),SY(5)
245•000      G0 T0(10,20,30,40),J
246•000  10  CONTINUE
247•000      D9 100 I=1,NF
248•000      SY(I) = Y(I)
249•000      AK(I,1) = DT*YP(I)
250•000      Y(I) = Y(I) + AK(I,1)*.5
251•000  100  CONTINUE
252•000      ST = T
253•000      T = T + DT*.5
254•000      RETURN
255•000  20  CONTINUE
256•000      D9 200 I=1,NF
```

```
257.000      AK(I,2) = DT*YP(I)
258.000      Y(I) = SY(I) + AK(I,2)*.5
259.000 200  CONTINUE
260.000      RETURN
261.000 30   CONTINUE
262.000      DO 300 I = 1,NE
263.000      AK(I,3) = DT*YP(I)
264.000      Y(I) = SY(I) + AK(I,3)
265.000 300  CONTINUE
266.000      T = ST + DT
267.000      RETURN
268.000 40   CONTINUE
269.000      DO 400 I = 1,NE
270.000      AK(I,4) = DT.*YP(I)
271.000      Y(I)=SY(I)+(AK(I,1)+AK(I,4)+2.**(AK(I,2)+AK(I,3)))/6.
272.000 400  CONTINUE
273.000      RETURN
274.000      END
275.000 CCCCC
276.000 CCCCC
277.000 CCCCC
278.000 C   ADAMS-Moulton INTEGRATION
279.000 CCCCC
280.000 CCCCC
281.000 CCCCC
282.000      SUBROUTINE NORD(F,T,TLIM,Y,ERROR,NF,H,HMAX,JUMP,KSTP,KC0N,CLIF,IB)
283.000      DIMENSION STARY(5),Y(5),SY(5),SAVEY(5),F(5),FP(5),DELTA(5),DALTA(5)
284.000      1,A(5),B(5),C(5),D(5),AA(5),BB(5),CC(5),DD(5),SF(5)
```

285.000 IF(KSTP=32767)993,991,991
286.000 991 KSTP=28
287.000 C TEST FOR TYPE OF ENTRY
288.000 993 IF(JUMP)1,998,999
289.000 998 G9 T8 (1000,11,21,802,803),IA
290.000 C JUMP P8S. RESTORE VALUES
291.000 999 T=SAVET
292.000 992 JUMP=0
293.000 D8 901 I=1,NF
294.000 F(I)=SF(I)
295.000 901 Y(I)=SAVFY(I)
296.000 G9 T8 102
297.000 C JUMP NEG. INITIALIZE
298.000 1 D9 5 I=1,NE
299.000 STARY(I)=Y(I)
300.000 A(I)=0.001
301.000 B(I)=0.001
302.000 C(I)=0.001
303.000 5 D(I)=0.001
304.000 KSTP=0
305.000 KDELY=0
306.000 KCBN=0
307.000 XT=95.0/(288.*64.)
308.000 U=853.0/(12.*5040.)
309.000 V=95.0/288.0
310.000 P=25.0/24.0
311.000 Q=35.0/72.0
312.000 R=5.0/48.0
313.000 S=1.0/120.0

```
314.000      IA=1
315.000      JUMP=0
316.000      G9 T8 1101
317.000 C    BEGIN INTEGRATION STEP
318.000 1000 D9 1111 I=1,NE
319.000      SF(I)=F(I)
320.000 1111 SAVFY(I)=Y(I)
321.000 C    H T88 SMALL RETURN WITH JUMP NFG.
322.000 600 IF(ABS(T+H)-ABS(T),605,601,605
323.000 601 JUMP=-1
324.000      G9 T8 1101
325.000 605 T=T+H
326.000      D9 10 I=1,NE
327.000      Y(I)=Y(I)+H*(F(I)+A(I)+B(I)+C(I)+D(I))
328.000 10 FP(I)=F(I)+2.0*A(I)+3.0*B(I)+4.0*C(I)+5.0*D(I)
329.000      IA=2
330.000      G9 T8 1101
331.000 11 D9 12 I=1,NE
332.000 12 SY(I)=Y(I)
333.000      D9 20 I=1,NE
334.000      DELTA (I)=F(I)-FP(I)
335.000 20 Y(I)=Y(I)+V*DELTA (I)*H
336.000      IA=3.
337.000      KCBN=1
338.000      G9 T8 1101
339.000 21 KCBN=0
340.000      D9 30 I=1,NE
341.000      DALTA (I)=F(I)-FP(I)
```

```
342.000    29 Y(I)=SY(I)+V*DALTA(I)*H
343.000    30 CONTINUE
344.000 C   TEST FOR STARTING SEQUENCE
345.000    31 IF(KSTP=28)35,40,40
346.000 C   APPLY TEST 2 ON ZEROTH STEP
347.000    35 IF(KSTP)50,50,60
348.000 C   HALVING TESTS
349.000    40 DO 45 I=1,NE
350.000      IF(ABS(DALTA(I))-ERROR/ABS(H))45,45,55
351.000    45 CONTINUE
352.000    50 IF(V*H*CLIF=0.125)60,60,55
353.000    55 T=T-H
354.000 C   FAIL TESTS, HALVE H
355.000    223 H=H/2.0
356.000      KDEL(Y)=0
357.000      DO 56 I=1,NE
358.000      A(I)=A(I)/2.0
359.000      B(I)=B(I)/4.0
360.000      C(I)=C(I)/8.0
361.000      F(I)=SF(I)
362.000      Y(I)=SAVFY(I)
363.000    56 D(I)=D(I)/16.0
364.000      G9 T8 1000
365.000 C   PASS TESTS, CORRECT A,B,C,D
366.000    60 KSTP=KSTP+1
367.000      DO 65 I=1,NE
368.000      A(I)=A(I)+3.0*B(I)+6.0*C(I)+10.0*D(I)+P*DALTA(I)
369.000    62 B(I)=B(I)+4.0*C(I)+10.0*D(I)+Q*DALTA(I)
370.000    64 C(I)=C(I)+5.0*D(I)+R*DALTA(I)
```

371.000 67 D(I)=D(I)+S*DALTA(I)
372.000 65 CONTINUE
373.000 C IF IN STARTING SEQUENCE, BRANCH
374.000 IF(KSTP=24)70,90,100
375.000 70 G9 T0 (1000,1000,1000,74,1000,1000,1000,78,1000,1000,1000,1000,74,1000,
376.000 11000,1000,86,1000,1000,1000,74,1000,1000,1000,1000),KSTP
377.000 C 4TH, 12TH, 20TH STEP, GO BACK
378.000 74 H=-H
379.000 DO 75 I=1,NE
380.000 A(I)=-A(I)
381.000 75 C(I)=-C(I)
382.000 G9 T0 1000
383.000 C 8TH STEP GO FORWARD
384.000 78 H=-H
385.000 DO 79 I=1,NE
386.000 Y(I)=STARY(I)
387.000 A(I)=-A(I)
388.000 79 C(I)=-C(I)
389.000 G9 T0 1000
390.000 C 16TH STEP, HALVE H, APPLY TEST 1
391.000 86 H=H/2.0
392.000 DO 87 I=1,NE
393.000 A(I)=A(I)/2.0
394.000 B(I)=B(I)/4.0
395.000 C(I)=C(I)/8.0
396.000 87 D(I)=D(I)/16.0
397.000 DO 88 I=1,NE
398.000 IF(ABS(DALTA(I))-ERROR/ABS(H))88,88,89

399.000 88 CONTINUE
400.000 C PASS TEST G0 FORWARD WITH HALVFD H
401.000 G0 T0 78
402.000 C FAIL TEST BEGIN AGAIN WITH HALVFD H
403.000 89 H=-H
404.000 D8 92 I=1,NE
405.000 92 Y(I)=STARY(I)
406.000 G0 T0 1
407.000 C 24TH STEP, DOUBLE H, STARTING SEQUENCE ENDS
408.000 90 H=H*2.0
409.000 D9 91 I=1,NE
410.000 A(I)=A(I)*2.0
411.000 B(I)=B(I)*4.0
412.000 C(I)=C(I)*8.0
413.000 91 D(I)=D(I)*16.0
414.000 G0 T0 78
415.000 100 KDELY=KDFLY+1
416.000 C WILL NEXT STEP MOVE PAST TLIM
417.000 102 IF(ABS(TLIM-T)=ABS(H))103,103,110
418.000 C YES.....SAVF T AND Y, INTEGRATE TO TLIM, RETURN.
419.000 103 ENDH=TLIM-T
420.000 D9 105 I=1,NF
421.000 AA(I)=ENDH*A(I)/H
422.000 BB(I)=ENDH**2*B(I)/H**2
423.000 CC(I)=ENDH**3*C(I)/H**3
424.000 105 DD(I)=ENDH**4*D(I)/H**4
425.000 SAVFT=T
426.000 D9 800 I=1,NF
427.000 SF(I)=F(I)

```
428.000 800 SAVEY(I)=Y(I)
429.000 806 T=TLIM
430.000   DS 106 I=1,NF
431.000     Y(I)=Y(I)+ENDH*(F(I)+AA(I)+BB(I)+CC(I)+DD(I))
432.000 106 FP(I)=F(I)+2.0*AA(I)+3.0*BB(I)+4.0*CC(I)+5.0*DD(I)
433.000   IA=4
434.000   G9 T8 1101
435.000 802 DS 805 I=1,NF
436.000 805 SY(I)=Y(I)
437.000   DS 107 I=1,NF
438.000     DELTA(I)=F(I)-FP(I)
439.000 107 Y(I)=Y(I)+V*DELTA(I)*ENDH
440.000   IA=5
441.000   G9 T8 1101
442.000 803 DS 108 I=1,NF
443.000     DALTA(I)=F(I)-FP(I)
444.000 108 Y(I)=SY(I)+V*DALTA(I)*ENDH
445.000   JUMP=1
446.000   G9 T8 1101
447.000 C   N8.....TEST FOR DOUBLING. IF OK, BEGIN NEXT STE- AFTER DOUBLING
448.000 110 IF(ABS(TLIM-T)-ABS(2.0*H))1000,1000,111
449.000 111 IF(KDELY=4)1000,120,120
450.000 120 IF(ABS(2.0*H)-ABS(HMAX))121,121,1000
451.000 121 DS 125 I=1,NF
452.000   IF(ABS(DALTA(I))-ERRR/(128.0*ABS(H)))125,125,1000
453.000 125 C0NTINUE
454.000   IF(V*H*CLIF=0.0625)130,1000,1000
455.000 130 C0NTINUE
```

```
456•000 335 H=2•0•H
457•000      D9 135 T=1,NF
458•000      A(I)=2•0•A(I)
459•000      B(I)=4•0•B(I)
460•000      C(I)=8•0•C(I)
461•000 135 D(I)=16•0•D(T)
462•000      KDELY=0
463•000      G9 T8 1000
464•000 1101 C9NTINUE
465•000 1150 F9RMAT(1,2X,'HH =1,2X,F10•6,14X,'KSTP =1,2X,I3,10X,'DAL3A(I)',/)
466•000 1151 F9RFORMAT(5(2X,12,1X,E14•7))
467•000      RETURN
468•000      END
```

1.000 C
2.000 C
3.000 C SENSIT
4.000 C
5.000 C
6.000 C SENSITIVITY ANALYSIS
7.000 C
8.000 C
9.000 C
10.000 COMMNDDT,DT,XPR,XEND,DXPR,X,DX,INT,INTC,IN,IB,EL,AREA,U
11.000 COMMEN ERRBR,DXMAX,TMP,HFGTB(10),CNS1
12.000 COMMEN RH,B,WMD,HD,TAIR,CLDRH,AIRBAR,TWS,TA,EW,EA,HBS,HS
13.000 COMMEN HSR,HOB,EVR,EVAP,HE,HC,HLYMN,PTBL(10),TTBL(10),WMS,CONST
14.000 COMMEN HFG,HAC,CLD1,CLDP,CLD3,DALP,DALPR,DCLDS,DRH,DTAIR,
15.000 DTA,DW,DWMS,DWMD,DEA,DEW,DLYMN,DBTUS,NTEMP,STTBL(10),XTBL(10)
16.000 IN=5
17.000 IB=6
18.000 CALL INPUT
19.000 IF(INTC = 4) 4,105,105
20.000 4 XPR = DXPR
21.000 5 CONTINUE
22.000 G9 100 JF= 1,INT
23.000 CALL DIFFQ
24.000 G9 T8 (10,10,20), INT
25.000 10 CALL EULFR(DDT,DT,DX,1,JE,X)
26.000 G9 T8 100
27.000 20 CALL RK4(DDT,DT,DX,1,JE,X)
28.000 100 CONTINUE
29.000 IF(X = XPR) 5,250,250
30.000 250 CALL SUPT
31.000 XPR = XPR + DXPR
32.000 IF(X = XFND) 5,300,300
33.000 105 CONTINUE
34.000 JUMP = -1
35.000 110 CONTINUE
36.000 XPR = X + DXPR

```

37.000 120  CONTINUE
38.000  CALLLN8RD(DDT,X,XPR,DT,ERR8R,1,DX,DXMAX,JUMP,KS,KC,1.E-6,I8)
39.000  IF(JUMP)130,140,150
40.000 130  WRITE(I8,131) X
41.000 131  FORMAT(//1 X *'E14.5' INTEGRAT,8N FAILURE!)
42.000  CALL EXIT
43.000 140  C9NTINUF
44.000  CALL DIFFQ
45.000  G9 T8 120
46.000 150  CALL SUPT
47.000  IF(X = XFND) 110,300,300
48.000 300  CALL EXIT
49.000  END
50.000  SUBROUTINE INPUT
51.000  COMM8N DDT, DT, XPR,XEND,DXPR,X,DX,INT,INTC,
52.000 1 IN,I9,EL,ARFA,U,ERR8R,DXMAX,TEMP,HFGTB(10),CONS1
53.000  COMM8NRHA,WMD,HD,TAIR,CLD,RH,ALBAR,TWS,TA,EW,EA,H8S,HS
54.000  COMM8N HSR,H8B,FBR,EVAP,HE,HC,HLYMN,PTBL(10),TTBL(10),WMS,CONST
55.000  COMM8N HFG,HAC,CLD1,CLD2,CLD3,DALP,DALPR,DCLD,DRH,DTAIR,
56.000 1 DTA,DW,DWMS,DWMD,DEA,DEW,DLYMN,DBTUS,NTEMP,STTBL(10),XTBL(10)
57.000 10   FORMAT(6F10.0)
58.000 20   FORMAT(6I10)
59.000  RAT18 = 3.14159/180.
60.000  C    CHOICE OF INTEGRATION SUBROUTINE
61.000  READ(IN,P0) INT
62.000  IF(INTC = 3) 30,40,50
63.000 30   INT = INTC
64.000  G9 T8 60

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```
55.000 40      INT = 4
56.000          GO TO 60
57.000 50      CONTINUE
58.000 60      CONTINUE
59.000          GO TO (110,120,130,140), INTC
60.000 110      WRITE(I8,115)
61.000 115      FORMAT(11      **** EULER INTEGRATION      *****'//)
62.000          GO TO 150
63.000 120      CONTINUE
64.000          WRITE(I8,125)
65.000 125      FORMAT(11      ***** MOD. EULER INTEGRATION      *****'//)
66.000          GO TO 150
67.000 130      WRITE(I8,135)
68.000 135      FORMAT(11      ***** 4 TH ORDER RUNGE-KUTTA      *****'//)
69.000          GO TO 150
70.000 140      WRITE(I8,145)
71.000 145      FORMAT(11      ***** ADAMS Moulton INTEG. *****'//)
72.000 150      CONTINUE
73.000 C
74.000 C      INTEGRATION CONTROL PARAMETERS
75.000          READ(IN,10) X,DX,DXPR,XEND
76.000          WRITE(I8,160) X,DX,DXPR,XEND
77.000 160      FORMAT(' X =1F6.2!    DX =1E10.3!    DXPR =1E10.3
78.000          1 !    XEND =1E10.3,/)
79.000          READ(IN,10) FRRAR,DXMAX
80.000          WRITE(I8,180) ERROR,DXMAX
81.000 180      FORMAT('    ERROR =1E10.3!    DXMAX =1E10.3,/)
82.000          READ(IN,10) DT,U,AREA,EL
83.000          READ(IN,10) RHO,WMPH,TAIR,CLD,RH,ALBAR
```

```
94.000      DS 185 I=1,10
95.000 185  READ(IN,10) PTBL(I), TTBL(I), HFTTB(I)
96.000      TA = (TAIR - 32.)*5./9.
97.000      W = WMPH*22./15.
98.000      WMS = W * .3048
99.000      WMD = WMPH * 24.
100.000     CONST = FL/(RH0*U*ARFA)
101.000     C0NS1 = (RH0*0.00328)/(24.*3600.*0.0614)
102.000     READ(IN,10) DALP,DCLD,DRH,DTAIR,DWMPH
103.000     DTA = DTAIR*5./9.
104.000     H9S = 1.9*SIN(ALBAR*RATIO)
105.000     H9C = 1.9*COS(ALBAR*RATIO)
106.000     CLD1 = 1. - .0765*CLD
107.000     CLD2 = -.0018*CLD**2
108.000     CLD3 = 1. - .0006*CLD**3
109.000     DALPR = DALP * RATIO
110.000     DW = DWMPH*22./15.
111.000     DWMS = DW * .3048
112.000     DWMD = DWMPH*24.
113.000 C    INCIDENT SOLAR RADIATION
114.000     HS = H9S * CI D3
115.000 C    REFLECTED SOLAR RADIATION
116.000     HSR = HS * 3./ALBAR
117.000     FTA = SI(TTBL,PTBL,TAIR,10)
118.000     EA = RH*(1013./1470.)*FTA
119.000     TAIRP = TAIR+DTAIR
120.000     FTAP = SI(TTBL,PTBL,TAIRP,10)
121.000     DEA = (1013./1470.)*(DRH*FTA + RH*(FTAP - FTA))
122.000     WRITE(10,200) DT
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```
123.000 200  FORMAT(1, INITIAL DT ='E12.4           !      DEG F')  
124.000          WRITE(I0,210) U,AREA,EL  
125.000 210  FORMAT(1, STREAM VELOCITY ='F6.3' FT/SEC   CR. SEC. AREA ='  
126.000          1F10.2' SQ. FT. SURFACE WIDTH ='F6.1' FT')  
127.000          WRITE(I0,220) RH0,CLD,RH,ALBAR  
128.000 220  FORMAT(1, RH='F5.2' LB/CU.FT. CLD='F4.1' TENTHS'  
129.000          1' RH='F5.1' PCT! ALBAR ='F4.1' DEGREES')  
130.000          WRITE(I0,230) TAIR,TA,CNST,CNS1  
131.000 230  FORMAT(1, AIR TEMP. ='F5.1' DFG F!F8.1' DEG C'  
132.000          1' CNST ='E10.3' CNS1 ='F10.3')  
133.000          WRITE(I0,240) W,WMPH,WMS,WMD  
134.000 240  FORMAT(1, WIND VELCITY ='F6.2' FT/SEC'F8.2'MPH'F8.2' METERS'  
135.000          1'/SEC'F8.2' MILES/DAY')  
136.000          WRITE(I0,260)  
137.000 260  FORMAT(1,T20!TTBL!T40!PTBL!T60!HFGTB!)  
138.000          D8 270 I =1,10  
139.000 270  WRITE(I0,280) TTBL(I), PTBL(I), HFGTB(I)  
140.000 280  FORMAT(10X,3F20.5)  
141.000          WRITE(I0,300)DCLD,DRH,DTAIR  
142.000 300  FORMAT(1, DCLD ='F6.3' DRH ='F5.3' DTAIR ='F6.2')  
143.000          WRITE(I0,310) DALP,DWMPH  
144.000 310  FORMAT(1, DALP ='F6.2' DWMPH ='F6.2')  
145.000          WRITE(I0,320) H8S,H8C,HS,HSR  
146.000 320  FORMAT(1, H8S='E12.4' H8C='E12.4' HS='E12.4' HSR='E12.4' LY/MIN)  
147.000          1N!  
148.000          WRITE(I0,330) EA,DEA  
149.000 330  FORMAT(1, EA ='E12.4' DEA ='E12.4')  
150.000          WRITE(I0,340)
```

```
151.000 340 FORMAT(/,T20!STTBL!T40!XTBL/)
152.000 READ(IN,20) NTEMP
153.000 D9 350 I =1,NTEMP
154.000 READ(IN,10) STTBL(I),XTBL(I)
155.000 WRITE(10,280) STTBL(I),XTBL(I)
156.000 350 CONTINUE
157.000 WRITE(10,360)
158.000 360 FORMAT('1')
159.000 RETURN
160.000 END
161.000 SUBROUTINE SUPT
162.000 C9MM8N DDT, DT,XPR,XEND,DXPR,X,Dx,INT,
163.000 1INTC, IN,I0,FL,AREA,U,ERRR,DXMAX,TEMP,HFGTB(10),CONS1
164.000 C9MM8NRH,WND,HD,TAIR,CLD,RH,AIRBAR,TWS,TA,EW,EA,HSS,HS
165.000 C9MM8N HSR,HAB,EVR,EVAP,HE,HC,HLYMN,PTBL(10),TTBL(10),WMS,CONST
166.000 C9MM8N HFG,HBC,CLD1,CLD2,CLD3,DALP,DALPR,DCLD,DRH,DTAIR,
167.000 1DTA,DW,DWMS,DWMD,DEA,DEW,DLYMN,DBTUS,NTEMP,STTBL(10),XTBL(10)
168.000 WRITE(10,10) X,DX
169.000 10 FORMAT(' X ='F7.1' FT      DX ='F6.1'      //)
170.000 WRITE(10,20) TEMP
171.000 20 FORMAT(' STREAM TEMP ='E12.4' DEG F')
172.000 WRITE(10,70) DT,DDT
173.000 WRITE(10,30) EW,DEW,FVAP,HE,HFG
174.000 30 FORMAT(' EW ='F12.5'  DEW ='F12.5'  EVAP ='E12.5'  HE ='E
175.000 1E12.5'  LY/MIN  HFG ='E12.5',/ )
176.000 WRITE(10,50) HBR,EVR,HC
177.000 50 FORMAT(' HBR ='E12.5'  EBR='F12.5'  HC ='E12.5'  LY/MIN')
178.000 WRITE(10,60) HLYMN,HD
179.000 60 FORMAT(' TOTAL HEAT TRANSFER ='E12.5'  LY/MIN'E15.5,
```

180.000 1! BTU/SEC-FT21/)
181.000 70 FORMAT(1! DT *!E12.5! DDT *!E12.5,/)
182.000 WRITE(18,80) DLVMN,DBTUS
183.000 80 FORMAT(1! DLVMN *!E12.5! DBTUS *!E12.5,/)
184.000 WRITE(18,90)
185.000 90 FORMAT(1X,60(1*!),//)
186.000 RETURN
187.000 END
188.000 SUBROUTINE DIFEQ
189.000 C9MMBN DDT,DT, XPR, XFND, DXPR, X, Dx,
190.000 1INT, INT, IN, IS, EL, AREA, U, ERR8R, DXMAX, TEMP, HFGTB(10), C0NS1.
191.000 C9MMBNRHA, WMD, HD, TAIR, C, RH, ALBARS, TWS, TA, EW, FA, HBS, HS
192.000 C9MMBN HSR, HBS, EBR, EVAP, HE, HC, HLYMN, PTBL(10), TTBL(10), WMS, CONST
193.000 C9MMBN HFG, HAC, CLD1, CLD2, CLD3, DALP, DALPR, DCILD, DRH, DTAIR,
194.000 1DTA, DW, DWMS, DWMD, DEA, DEW, DLVMN, DBTUS, NTEMP, STTBL(10), XTB(10)
195.000 C THERMAL FXCHANGE WITH ENVIRONMFNT.
196.000 TEMP = S1(XTB(1),STTBL,X,NTEMP)
197.000 TWS = (TEMP-32.)*5./9.
198.000 DTWS = DT*5./9.
199.000 FTA = S1(TTBL,PTBL,TEMP,10)
200.000 TTW = TFMP + DT
201.000 FTB = S1(TTBL,PTBL,TTW,10)
202.000 EW = (1013./14.7)*FTA
203.000 DEW = (1013./14.7)*(FTB - FTA)
204.000 C EFFECTIVE BACK RADIATION.
205.000 HBR = (14.38-.09*TWS-.046*RH)/69.72
206.000 EBR = HBR*CLD1
207.000 C EVAPORATION HEAT TRANSFER.

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208•000      EVAP = .35* (EW-EA)*(1. + .0098* WMD)
209•000      HFG = SI(TTBI ,HFGTB,TEMP,10)
210•000      HE = EVAP*HFG*C9NS1
211•000 C    CONVECTION HEAT TRANSFER
212•000      HC = 39.*(.26 + .077*WMS)*(TWS - TA )/1440.
213•000 C    TOTAL HEAT TRANSFER TO WATER, LY/MIN
214•000      HLYMN = HS = (EBR + HSR + HC + HE)
215•000 C    TOTAL HEAT TRANSFER, BTU/SEC-FT2
216•000      HD = HLYMN * .0614
217•000      F1 = CLD2*DCI D*HBS
218•000      F2 = CLDR*HSC*DALPR
219•000      F3 = .0765*DCLD*HBR
220•000      F4 = -(CLD1*(-.09*DTWS - .046*DRH)/69.72
221•000      F5 = -(F1+F2)*3./ALBAR
222•000      F6 = HS*3.*DALP/ALBAR**2
223•000      F7 = -( .35*HFG/14400.)*( (1. + .0098*WMD)*(DEW - DEA) +
224•000      1 .0098*DwMD*(EW - EA))
225•000      F8 = -(39./1440.)*( (.26 + .077*WMS)*(DTWS - DTA) +
226•000      1 .077*DwMS*(TWS - TA))
227•000      DLYMN = F1 + F2 + F3 + F4 + F5 + F6 + F7 + F8
228•000      DBTUS = DLYMN*.0614
229•000      DDT = CONST*DBTUS
230•000      RETURN
231•000      END
232•000 CCCCCC
233•000 CCCCCC
234•000 CCCCCC
235•000 CCCCCC

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```
236.000      FUNCTION SI(XTBL,YTBL,X,N).
237.000 C      LINEAR INTERPOLATION OR EXTRAPOLATION OF SINGLE VARIABLE FUNCTION
238.000 C      XTBL = INDEPENDENT VARIABLE TABLE
239.000 C      YTBL = DEPENDENT VARIABLE TABLE
240.000 C      IND = INDICATOR OF EXTRAPOLATION
241.000 C      0=NO EXTRAPOLATION, 1=LOWER EXTRAPOLATION, 2=UPPER EXTRAPOLATION
242.000      DIMENSION XTBL(40),YTBL(40)
243.000 C      CHECK TO SEE IF EXTRAPOLATION IS NEEDED.
244.000      IF(X>XTBL(1)) 120,130,150
245.000      120 IND = 1
246.000      130 II = 2
247.000      G8 TO 254
248.000      150 IF(XTBL(N)=X) 160,180,210
249.000      160 IND = 2
250.000      180 II = N
251.000      G9 TO 254
252.000 C      FIND X IN TABLES IN TABLE
253.000      210 D9 P20 IK=2,N
254.000      II = IK
255.000      IF(XTBL(1K)=X) 220,254,254
256.000      220 CONTINUE
257.000      254 X1 = XTBL(II-1)
258.000      X2 = XTBL(II)
259.000      Y1 = YTBL(II-1)
260.000      Y2 = YTBL(II)
261.000      SI = Y1+(Y2-Y1)*(X-X1)/(X2-X1)
262.000      RETURN
263.000      END
264.000 CCCCC
```

```
265.000 CCCCCC
266.000 C      EULER AND MODIFIED EULER INTEGRATION
267.000 CCCCCC
268.000 CCCCCC
269.000 CCCCCC
270.000      SUBROUTINE EULER(YP,Y,DT,NE,J,T)
271.000      DIMENSION YP(20),Y(20), SY(20),SYP(20)
272.000      G9 T@(10,20),J
273.000      10 C9NTINUE
274.000      D9 100 I=1,NF
275.000      SY(I)= Y(I)
276.000      SYP(I)= YP(I)
277.000      Y(I)= Y(I)+DT*YP(I)
278.000      100 C9NTINUE
279.000      T=T+DT
280.000      RETURN
281.000      20 C9NTINUE
282.000      D9 200 I=1,NF
283.000      Y(I)= SY(I)+(YP(I)+SYP(I))*DT/2.
284.000      200 C9NTINUE
285.000      RETURN
286.000      END
287.000 CCCCCC
288.000 CCCCCC
289.000 CCCCCC
290.000 C      FOURTH ORDER RUNGE-KUTTA INTEGRATION
291.000 CCCCCC
292.000 CCCCCC
293.000 CCCCCC
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294.000      SUBROUTINE RK4(YP,Y,DT,NE,J,T)
295.000      DIMENSION YP(5),Y(5),AK(5,4),SY(5)
296.000      G0 T0(10,20,30,40),J
297.000 10    C9NTINUE
298.000      D8 100 I=1,NE
299.000      SY(I) = Y(I)
300.000      AK(I,1) = DT*YP(I)
301.000      Y(I) = Y(I) + AK(I,1)*.5
302.000 100   C9NTINUE
303.000      ST = T
304.000      T = T + DT*.5
305.000      RETURN
306.000 20    C9NTINUE
307.000      D9 200 I=1,NE
308.000      AK(I,2) = DT*YP(I)
309.000      Y(I) = SY(I) + AK(I,2)*.5
310.000 200   C9NTINUE
311.000      RETURN
312.000 30    C9NTINUE
313.000      D9 300 I = 1,NE
314.000      AK(I,3) = DT*YP(I)
315.000      Y(I) = SY (I) + AK(I,3)
316.000 300   C9NTINUE
317.000      T = ST + DT
318.000      RETURN
319.000 40    C9NTINUE
320.000      D8 400 I = 1,NE
321.000      AK(I,4) = DT *YP(I)
```

```
322.000      Y(I)=SY(T)+(AK(I,1)+AK(I,4)+2.*(AK(I,2)+AK(I,3)))/6.
323.000 400  CONTINUE
324.000  RETURN
325.000  END
326.000 CCCCCC
327.000 CCCCCC
328.000 CCCCCC
329.000 C ADAMS-Moulton INTEGRATION
330.000 CCCCCC
331.000 CCCCCC
332.000 CCCCCC
333.000      SUBROUTINE NORD(F,T,TLIM,Y,ERROR,NF,H,HMAX,JUMP,KSTP,KCBN,CLIF,I0)
334.000      DIMENSION STARY(5),Y(5),SY(5),SAVEY(5),F(5),FP(5),DELTA(5),DALTA(5
335.000      1),A(5),B(5),C(5),D(5),AA(5),BB(5),CC(5),DD(5),SF(5)
336.000      IF(KSTP=32767)993,991,991
337.000 991 KSTP=28
338.000 C TEST FOR TYPE OF ENTRY
339.000 993 IF(JUMP)1,998,999
340.000 998 G0 T0 (1000,11,21,802,803),IA
341.000 C JUMP PSS. RESTORE VALUES
342.000 999 T=SAVET
343.000 992 JUMP=0
344.000 D0 901 I=1,NE
345.000 F(I)=SF(I)
346.000 901 Y(I)=SAVFY(I)
347.000 G0 T0 102
348.000 C JUMP NEG. INITIALIZE
349.000 1 D0 5 I=1,NE
350.000      STARY(I)=Y(I)
```

```
351.000      A(I)=0.001
352.000      B(I)=0.001
353.000      C(I)=0.001
354.000      5 D(I)=0.001
355.000      KSTP=0
356.000      KDELY=0
357.000      KCBN=0
358.000      XT=95.0/(288.0*64.0)
359.000      U=863.0/(12.0*5040.0)
360.000      V=95.0/288.0
361.000      R=25.0/24.0
362.000      Q=35.0/72.0
363.000      R=5.0/48.0
364.000      S=1.0/120.0
365.000      IA=1
366.000      JUMP=0
367.000      G9 T8 1101
368.000 C    BEGIN INTEGRATION STEP
369.000 1000  D9 1111 I=1,NE
370.000      SF(I)=F(I)
371.000 1111  SAVEY(I)=Y(I)
372.000 C    H TOO SMALL RETURN WITH JUMP NEG.
373.000 600   IF(ABS(T+H)-ABS(T))605,601,605
374.000 601   JUMP=-1
375.000      G9 T8 1101
376.000 605   T=T+H
377.000      D9 10 I=1,NE
378.000      Y(I)=Y(I)+H*(F(I)+A(I)+B(I)+C(I)+D(I))
```

379.000 10 FP(I)=F(I)+2.0*A(I)+3.0*B(I)+4.0*C(I)+5.0*D(I)
380.000 IA=2
381.000 G9 T8 1101
382.000 11 D8 12 I=1,NE
383.000 12 SY(I)=Y(I)
384.000 D9 P0 I=1,NE
385.000 DELTA (I)=F(I)-FP(I)
386.000 20 Y(I)=Y(I)+V*DELTA (I)*H
IA=3
388.000 KC0N=1
389.000 G9 T8 1101
390.000 21 KC0N=0
391.000 D8 30 I=1,NE
392.000 DALTA (I)=F(I)-FP(I)
393.000 29 Y(I)=SY(I)+V*DALTA (I)*H
394.000 30 C0NTINUE
395.000 C TEST FOR STARTING SEQUENCE
396.000 31 IF(KSTP=28)35,40,40
397.000 C APPLY TFST 2 ON ZERO TH STEP
398.000 35 IF(<STP)50,50,60
399.000 C HALVING TESTS
400.000 40 D9 45 I=1,NE
401.000 IF(ABS(DALTA (I))-ERR0R/ABS(H))45,45,55
402.000 45 C0NTINUE
403.000 50 IF(V*4*CLIF=0.125)60,60,55
404.000 55 T=T-H
405.000 C FAIL TESTS, HALVE H
406.000 P23 H=H/2.0
407.000 KDELY=0

408.000 D8 56 I=1,NE
409.000 A(I)=A(I)/2.0
410.000 B(I)=B(I)/4.0
411.000 C(I)=C(I)/8.0
412.000 F(I)=SF(I)
413.000 Y(I)=SAVFY(I)
414.000 56 D(I)=D(I)/16.0
415.000 G8 T8 1000
416.000 C PASS TESTS, CORRECT A,B,C,D
417.000 60 KSTP=KSTP+1
418.000 D8 65 I=1,NE
419.000 A(I)=A(I)+3.0*B(I)+6.0*C(I)+10.0*D(I)+P*DALTA(I)
420.000 62 B(I)=B(I)+4.0*C(I)+10.0*D(I)+Q*DALTA(I)
421.000 64 C(I)=C(I)+5.0*D(I)+R*DALTA(I)
422.000 67 D(I)=D(I)+S*DALTA(I)
423.000 65 CONTINUE
424.000 C IF IN STARTING SEQUENCE, BRANCH
425.000 IF(KSTP=24)70,90,100
426.000 70 G8 T8 (1000,1000,1000,74,1000,1000,1000,78,1000,1000,1000,74,1000,
427.000 11000,1000,86,1000,1000,1000,74,1000,1000,1000),KSTP
428.000 C 4TH, 12TH, 20TH STEP, G8 BACK.
429.000 74 H=-H
430.000 D8 75 I=1,NE
431.000 A(I)=-A(I)
432.000 75 C(I)=-C(I)
433.000 G8 T8 1000
434.000 C 8TH STEP G8 FORWARD
435.000 78 H=-H

436.000 D9 79 I=1,NE
437.000 Y(I)=STARY(I)
438.000 A(I)=-A(I)
439.000 79 C(I)=-C(I)
440.000 G9 T8 1000
441.000 C 16TH STEP, HALVFD H, APPLY TEST 1
442.000 86 H=H/2.0
443.000 D9 87 I=1,NE
444.000 A(I)=A(I)/2.0
445.000 B(I)=B(I)/4.0
446.000 C(I)=C(I)/8.0
447.000 87 D(I)=D(I)/16.0
448.000 D9 88 I=1,NE
449.000 IF(ABS(DALTA -(I))-ERR8R/ABS(H))88,88,89
450.000 88 CONTINUE
451.000 C PASS TEST G9 FORWARD WITH HALVFD H
452.000 G9 T8 78
453.000 C FAIL TEST BEGIN AGAIN WITH HALVFD H
454.000 89 H=-H
455.000 D9 92 I=1,NE
456.000 92 Y(I)=STARY(I)
457.000 G9 T8 1
458.000 C 24TH STEP, DOUBLE H, STARTING SEQUENCE ENDS
459.000 90 H=H*2.0
460.000 D9 91 I=1,NE
461.000 A(I)=A(I)*2.0
462.000 B(I)=B(I)*4.0
463.000 C(I)=C(I)*8.0
464.000 91 D(I)=D(I)*16.0

1
1

465.000 G8 T8 78
466.000 100 KDELY=KDFLY+1
467.000 C WILL NEXT STEP MOVE PAST TLIM
468.000 102 IF(ABS(TI IM-T)=ABS(H))103,103,110
469.000 C YES.....SAVE T AND Y, INTEGRATE TO TLIM, RETURN.
470.000 103 ENDH=TLIM-T
471.000 D9 105 I=1,NF
472.000 AA(I)=ENDH*A(I)/H
473.000 BB(I)=ENDH**2*B(I)/H**2
474.000 CC(I)=ENDH**3*C(I)/H**3
475.000 105 DD(I)=ENDH**4*D(I)/H**4
476.000 SAVET=T
477.000 D9 800 I=1,NF
478.000 SF(I)=F(I)
479.000 800 SAVFY(I)=Y(I)
480.000 806 T=TLIM
481.000 D9 106 I=1,NF
482.000 Y(I)=Y(I)+ENDH*(F(I)+AA(I)+BB(I)+CC(I)+DD(I))
483.000 106 FP(I)=F(I)+2.0*AA(I)+3.0*BB(I)+4.0*CC(I)+5.0*DD(I)
484.000 IA=4
485.000 G8 T8 1101
486.000 802 D9 805 I=1,NF
487.000 805 SY(I)=Y(I)
488.000 D9 107 I=1,NF
489.000 DELTA(I)=F(I)-FP(I)
490.000 107 Y(I)=Y(I)+V*DELTA(I)*ENDH
491.000 IA=5
492.000 G8 T8 1101

1.000 CCCCCC C(1000)=CLBUD CAVER
2.000 CCCCCC TA(1000)=AIR TEMP.
3.000 C PHI(1000)= RFL HUMIDITY
4.000 C W(1000)= WIND SPEED
5.000 C TW(1000)= WATER TEMP
6.000 C NCAS= NO. OF CASES
7.000 C NDA= NO. OF DAYS TO BE TRIED
8.000 C DELT(50)= ERROR CRITERION TO BE SATISFIED
9.000 C IDAS(50)= NO. OF DAYS IN TRIAL
10.000 C NLN= NO. OF LINES
11.000 C DT= FRRSR CRITERION FOR THE SPECIFIC CASE
12.000 C NTA= NO. OF TIME AVERAGED DATA PRINTS
13.000 C UA,EL,CC,.....,WSP= ACTUAL DATA AT VERNON
14.000 C INT2,INTR= DATA PRINT NUMBERS
15.000 C DC,DTA,....,DTW= FRRSR IN VARIABLES
16.000 C C9MMBN YP1(5),Y1(5),XPR1,XE,HD1,DXPR1,X1,DX1,NE1,INT1,INTC1,IN1,I81
17.000 C ,EL1,AREA1,U1
18.000 C C9MMBN ERR8R1,DXMAX1,TEMP1,HFGTB1(10),C8NS11
19.000 C C9MMBN RH81,W1,WMD1,HD1,TAIR1,CLD1,RH1,ALBAR1,TWS1,TA1,TWSA1,EW1,
20.000 C 1EA1,HS81,HS1
21.000 C C9MMBN HSR1,HBB1,FBR1,EVAP1,HE1,HC1,HLYMN1,PTBL1(10),TTBL1(10),
22.000 C 1WMS1,C8NST1
23.000 C C9MMBN CI,IF1,HFG1,HBC1,CLD11,CI,D21,CLD31,DALP1,DALPR1,DCLD1,DRH1,
24.000 C 1DTAIR1,DTA1,DW1,DWMS1,DWMD1,DEA1,DEW1,DLYMN1,DBTUS1,NTEMP1,
25.000 C 2STTB1L1(10),XTBL1(10)
26.000 C C9MMBN C(1000),TA(1000),PHI(1000),W(1000),TW(1000)
27.000 C C9MMBN NCAS, NDA, DELT(50), IDAS(50)
28.000 C C9MMBN VI,N,IN,IAU,DT,NTA,IDA
29.000 C C9MMBN CTA(50),TATA(50),PHITA(50),WTA(50),TWTA(50)

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30.000      COMMON UAF,EL,CC,TAIR,TWA,RH,WSP
31.000      COMMON INT2,INTR,DC,DTA,DPHI,DW,DTW,INVS,IFLAG
32.000      COMMON DM21,BETA
33.000      COMMON LAG1,NDAS
34.000      COMMON ICAS,PRP(50,10)
35.000      CCCCCC
36.000      CCCCCC
37.000      CCCC
38.000      CCCCCC
39.000      CALL RFFAD
40.000      DT=1.
41.000      DA .20 IDA=1,NDAS
42.000      CALL PRB
43.000      20 CONTINUE
44.000      CALL PRB
45.000      CALL VERN9N
46.000      CALL EXIT
47.000      END
48.000      C SUBROUTINE FOR READING IN DATA
49.000      CCCCCC
50.000      CCCCCC
51.000      CCCCCC
52.000      CCCCCC
53.000      CCCCCC
54.000      SUBROUTINE RFEAD
55.000      COMMON YP1(5),Y1(5),XPR1,XEND1,DXPR1,X1,DX1,NE1,INT1,INTC1,IN1,I0,1
56.000      1,EL1,AREA1,U1
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57.000 C9MM8N ERR8R1,DYMAX1,TEMP1,HFGTR1(10),C0NS11
58.000 C9MM8N RH01,W1,WMD1,HD1,TAIR1,CLD1,RH1,ALBAR1,TWS1,TA1,TWSA1,EW1,
59.000 1EA1,H9S1,HS1
60.000 C9MM8N HSR1,HBB1,EBR1,EVAP1,HE1,HC1,HLVMN1,PTBL1(10),TTBL1(10),
61.000 1WMS1,C8NST1
62.000 C9MM8N CI IF1,HFG1,H0C1,CLD11,CI D21,CLD31,DALP1,DALPR1,DCLD1,DRH1,
63.000 1DTAIR1,DTA1,DW1,DWMS1,DWMD1,DEA1,DEW1,DLYMN1,DBTUS1,NTEMP1,
64.000 2STTBL1(10),XTBL1(10)
65.000 C9MM8N C(1000),TA(1000),PHI(1000),W(1000),TW(1000)
66.000 C9MM8N NCAS, NDA, DELT(50), IDAS(50)
67.000 C9MM8N NI N,IN,I8U,DT,NTA,IDA
68.000 C9MM8N CTA(50),TATA(50),PHITA(50),WTA(50),TWTA(50)
69.000 C9MM8N UA,EL,CC,TAIR,TWA,RH,WSP
70.000 C9MM8N INT2,INT3,DC,DTA,DPHI,DW,DTW,INV\$,IFLAG
71.000 C9MM8N DM21,RETA
72.000 C9MM8N LAG1,NDAS
73.000 C9MM8N ICAS,PRP(50,10)
74.000 IN=101
75.000 I8U=102
76.000 1000 F9RMAT(6F10.3)
77.000 1001 F9RMAT(6T10)
78.000 READ (IN,1001) NLN,LAG1
79.000 WRITE(I8U,2000)NLN,LAG1
80.000 2000 F9RMAT(1H0,2X,1NUMBER OF DATA !,INFS=!,IS,ITIME AV, LOGIC=!,IS)
81.000 WRITE(I8U,2001)
82.000 2001 F9RMAT(1H0,2X,1CLD CVER AIRTFMP REL HUM WIND SPD WATER TEMP!)
83.000 DS 10 I= 1,NLN
84.000 READ(IN,1000) C(I),TA(I),PHI(I),W(I),TW(I)
85.000 WRITE(I8U,2002)C(I),TA(I),PHI(I),W(I),TW(I)

```
36.000 2002 FORMAT(1H0,2X,5(F10.3,1X))
87.000 10 CONTINUE
88.000 C PLANT DATA
89.000 C UA=VEL, FL=RIVER WIDTH, CL=CLOUD COVER, TAIR=OBVIOUS
90.000 C TWA=WATER TEMP, RH=REL HUMIDITY, WSP=WIND SPEED(KNOTS)
91.000 READ(IN,1000)UA,EL,CC,TAIR
92.000 WRITE(1AU,2003)UA,EL,CC,TAIR
93.000 2003 FORMAT(1H0,2X,'UA=',1X,F10.3,'R WIDTH=',1X,F10.3,'CLD COVER=',
94.000 '1X,F10.3,'TEMP AIR=',1X,F10.3)
95.000 READ(IN,1000)TWA,RH,WSP
96.000 WRITE(1AU,2004)TWA,RH,WSP
97.000 2004 FORMAT('0',2X,'TEMP WATER=',1X,F10.3,'REL HUM=',1X,F10.3,'WIND
98.000 '1SPEED=',1X,F10.3)
99.000 IF(LB31)15,16,15
100.000 15 CONTINUE
101.000 READ(IN,1001)NTA
102.000 WRITE(1AU,2005)NTA
103.000 2005 FORMAT(1H0,2X,'NUMBER OF TIME AV. DATA POINTS=',1X,I5)
104.000 WRITE(1AU,2005)
105.000 2006 FORMAT('0',2X,'CLD COVER TA AIR TEMP TA REL HUM TA WIND TA
106.000 '1 TEMP WATER TA')
107.000 D9 20 I=1,NTA
108.000 READ(IN,1000) CTA(I),TATA(I),PHITA(I),WTA(I),TWTA(I)
109.000 WRITE(1AU,2007)CTA(I),TATA(I),PHITA(I),WTA(I),TWTA(I)
110.000 2007 FORMAT(1H0,2X,5(F10.3,1X))
111.000 20 CONTINUE
112.000 16 CONTINUE
113.000 READ(IN,1001)NCAS
```

```
114.000      WRITE(I8U,2008)NCAS
115.000      2008 F9RMAT(1HO,2X,'NUMBER OF CASES=1,1X,I4)
115.000      READ(IN,3000)(DFLT(I), I=1,NCAS)
117.000      3000 F9RMAT(6F10.3)
118.000      WRITE(I8U,3010)
119.000      3010 FORMAT(1HO,2X,'ALLOWED DTS')
120.000      WRITE(I8U,2009)(DELT(I),I=1,NCAS)
121.000      2009 FORMAT(1HO,2X,E14.7)
122.000      READ(IN,1001)NDAS
123.000      WRITE(I8U,2010)NDAS
124.000      2010 F9RMAT(1O!,2X,'NUMBER OF DAYS AVERAGED=1,2X,I4)
125.000      READ(IN,1001)(IDAS(I), I=1,NDAS)
126.000      WRITE(I8U,3011)
127.000      3011 F9RMAT(1HO,2X,'DAYS AVERAGED')
128.000      WRITE(I8U,2050)(IDAS(I),I=1,NDAS)
129.000      2050 F9RMAT(1HO,2X,I5)
130.000      WRITE(I8U,2011)
131.000      2011 F9RMAT(1HO,2X,'PTBL1    TTBL1    HFGTB1',//,2X,60(*1))
132.000      D9 185 I=1,10
133.000      READ(IN,1002) PTBL1(I),TTBL1(I),HFGTB1(I)
134.000      WRITE(I8U,2012)PTBL1(I),TTBL1(I),HFGTB1(I)
135.000      2012 F9RMAT(6F10.3)
136.000      1002 F9RMAT(6F10.3)
137.000      185 CONTINUE
138.000      READ(IN,1000) DM21,BETA
139.000      WRITE(I8U,2013)DM21,BETA
140.000      BETA=BETA/57.296
141.000      2013 F9RMAT(1HO,2X,'DAYS SINCE MARCH 21=1,2X,F10.3,IBETA=1,2X,F10.3)
142.000      D9 30 IDA=1,NDAS
```

143.000 D9 40 ICAS=1,NCAS
144.000 PRP(IDA,ICAS)=0.
145.000 40 CONTINUE
146.000 30 CONTINUE
147.000 RETURN
148.000 END
149.000 CCCCC
150.000 CCCCC
151.000 CCCCC
152.000 CCCCC
153.000 CCCCC
154.000 SUBROUTINE PRB
155.000 C9MM8N YP1(5),Y1(5),XPR1,XEND1,DXPR1,X1,DX1,NE1,INT1,INTC1,IN1,I81
156.000 1,EL1,AREA1,U1
157.000 C9MM8N ERR8R1,DXMAX1,TEMP1,HFGTR1(10),C9NS11
158.000 C9MM8N RH01,W1,WMD1,HD1,TAIR1,CLD1,RH1,ALBAR1,TWS1,TA1,TWSA1,EW1,
159.000 EA1,H9S1,HS1
160.000 C9MM8N HSR1,H9B1,EPR1,EVAP1,HE1,HC1,HLYMN1,PTEL1(10),TTBL1(10),
161.000 1W1S1,C9NST1
162.000 C9MM8N CI IF1,HFG1,H9C1,CLD11,CI D21,CLD31,DALP1,DALPR1,DCLD1,DRH1,
163.000 1DTAIR1,DTA1,DW1,DWMS1,DWMD1,DEA1,DEW1,DLYMN1,DBTUS1,NTEMP1,
164.000 2STBL1(10),XTBL1(10)
165.000 C9MM8N C(1000),TA(1000),PHI(1000),W(1000),TW(1000)
166.000 C9MM8N NCAS, NDA, DELT(50), IDAS(50)
167.000 C9MM8N NI N,IN,IAU,DT,NTA,IDA
168.000 C9MM8N CTA(50),TATA(50),PHITA(50),WTA(50),TWTA(50)
169.000 C9MM8N UA,EL,CC,TAIR,TWA,RH,WSP
170.000 C9MM8N INT2,INT3,DC,DTA,DPHI,DW,DTW,INV\$,IFLAG

171.000 CMMEN DM21,BETA
172.000 CMMEN LAG1,NDA
173.000 CMMEN ICAS,PRP(50,10)
174.000 DIMENSION PR(10)
175.000 C NDA= NUMBER OF DAYS IN THE CASE
176.000 ID=IDA
177.000 NDA=IDAS(ID)
178.000 NC1=NLN/8
179.000 FNDA=NDA*3
180.000 FNDA=1/FNDA
181.000 IF(NDA-Nc1) 10,999,999
182.000 10 CONTINUE
183.000 NDIF=NC1-NDA
184.000 ENUM=0.
185.000 DEN=0.
186.000 DENP=0.
187.000 D9 20 IPO=1,NDIF
188.000 CS=0.
189.000 TAS=0.
190.000 PHIS=0.
191.000 WSE=0.
192.000 TWS=0.
193.000 D9 30 I=1,NDA
194.000 D9 40 J=1,8
195.000 INT=S*(IPO+I-1)+J-8
196.000 CS=CS + C(INT)
197.000 TAS=TAS + TA(INT)
198.000 PHIS=PHIS + PHI(INT)

199.000 WS= VS + W(INT)
200.000 TWS= TWS + TW(INT)
201.000 40 CONTINUE
202.000 30 CONTINUE
203.000 CS= CS*FNDA
204.000 TAS= TAS*FNDA
205.000 PHIS=PHIS*FNDA
206.000 WS= WS*FNDA
207.000 TWS= TWS*FNDA
208.000 C INT2= FOLLOWING DAY
209.000 INT2= I20+NDA
210.000 C1S=0.
211.000 TA1S=0.
212.000 PHI1S=0.
213.000 W1S=0.
214.000 TW1S=0.
215.000 D9 '50 I=1,8
216.000 C INT3= THE ACTUAL POSITION IN THE DAY
217.000 INT3=INT2*8-8+I
218.000 C1S=C1S+C(INT3)
219.000 TA1S=TA1S+TA(INT3)
220.000 PHI1S=PHI1S+PHI(INT3)
221.000 W1S=W1S+W(INT3)
222.000 TW1S=TW1S+TW(INT3)
223.000 50 CONTINUE
224.000 C1S=C1S*.125
225.000 TA1S=TA1S*.125
226.000 PHI1S=PHI1S*.125
227.000 W1S=W1S*.125

228.000 TW1S=TW1S*.125
229.000 DC=C1S-CS
230.000 DTA=TA1S-TA3
231.000 DPHT=PH11S-PH1S
232.000 DW=V1S-VS
233.000 DTW=TW1S-TWS
234.000 STTRL1(1)=TW1S
235.000 STTBL1(2)=TW1S
236.000 Xtbl1(1)=0.
237.000 Xtbl1(2)=25000.
238.000 NTEMP1=?
239.000 INV\$=INT2*8-4
240.000 CALL C94P(ENUM,DEN)
241.000 D9 60 ICAS=1,NCAS
242.000 IF(ABS(Y1(1))-DELT(ICAS)) 65,65,70
243.000 65 CONTINUE
244.000 PRP(IDA,ICAS)=PRP(IDA,ICAS)+1.
245.000 70 CONTINUE
246.000 60 CONTINUE
247.000 20 CONTINUE
248.000 DENP=NDIF
249.000 D9 75 ICAS=1,NCAS
250.000 PRP(IDA,ICAS)=PRP(IDA,ICAS)/DENP
251.000 75 CONTINUE
252.000 IF(L831)200,201,200
253.000 200 CONTINUE
254.000 ENUM=0.
255.000 DEN=0.
256.000 DENP=0.

257.000 C(1000)=FC
258.000 TA(1000)=TAIR
259.000 PHI(1000)=RH
260.000 W(1000)=WSP
261.000 TW(1000)=TWA
262.000 D9 205 ICAS=1,NCAS
263.000 PR(ICAS)=0.
264.000 205 C9NTINUE
265.000 D9 210 I=1,NTA
266.000 DC=CTA(I)-CC
267.000 DTA=TATA(I)-TAIR
268.000 DPHI=PHITA(I)-RH
269.000 DW=WTA(I)-WSP
270.000 DTW=WTWA(I)-TWA
271.000 STTBL1(1)=TW(1000)
272.000 STTBL1(2)=TWA(1000)
273.000 XTBL1(1)=0.
274.000 XTBL1(2)=25000.
275.000 NTEMP1=?.
276.000 INV5=1000
277.000 CALL CBMP(ENUM,DEN)
278.000 D9 40 ICAS=1,NCAS
279.000 IF(ABS(Y1(1))=DELT(ICAS))85,85,80
280.000 85 CANTINUE
281.000 PR(ICAS)=PR(ICAS)+1.
282.000 80 C9NTINUE
283.000 210 C9NTINUE
284.000 FNTA=NTA

```
285.000      D9 90 ICAS=1,NCAS
286.000      PR(ICAS)=PR(ICAS)/FNTA
287.000      CALL BUTT(I8U,PR(ICAS),IDA)
288.000      90 CONTINUE
289.000      201 CONTINUE
290.000      RETURN
291.000      999 CONTINUE
292.000      WRITE(I8U,4000)
293.000      4000 FORMAT(1H0,2X,'IT00 SMALL')
294.000      CALL EXIT
295.000      END
296.000      CCCCCC
297.000      CCCCCC
298.000      CCCCCC
299.000      CCCCCC
300.000      CCCCCC
375.000      SUBROUTINE BUTT(I8U,P,I)
376.000      WRITE(I8U,2000)I,P
377.000      2000 FORMAT(1H0,2X,'CASE1,I4,PX,'PRABILITY',E14.7)
378.000      RETURN
379.000      END
380.000      CCCCCC
381.000      CCCCCC
382.000      CCCCCC
383.000      CCCCCC
384.000      SUBROUTINE C8MP(ENUM,DEN)
385.000      COMMON YP1(5),Y1(5),XPR1,XEND1,DXPR1,X1,DX1,NE1,INT1,INTC1,IN1,I81
386.000      1,EL1,AREA1,U1
387.000      COMMON ERR8R1,DXMAX1,TEMP1,HFGTB1(10),C9NS11
```

388.000 C9MMEN RH81,W1,WMD1,HD1,TAIR1,CLD1,RH1,ALBAR1,TWS1,TA1,TWSA1,EW1,
389.000 1EA1,H9S1,HS1
390.000 C9MMEN HSR1,H8B1,ERR1,EVAP1,HE1,HC1,HLYMN1,PTBL1(10),TTBL1(10),
391.000 1WMS1,C9NST1
392.000 C9MMEN CI IF1,HFG1,H8C1,CLD11,CLD21,CLD31,DALP1,DALPR1,DCLD1,DRH1,
393.000 1DTAIR1,DTA1,DW1,DWMS1,DWMD1,DEA1,DEW1,DLYMN1,DBTUS1,NTEMP1,
394.000 2STTBL1(10),XTBL1(10)
395.000 C9MMEN C(1000),TA(1000),PHI(1000),W(1000),TW(1000)
396.000 C9MMEN NCAS, NDAS, DELT(50), IDAS(50)
397.000 C9MMEN NIN,IN,I9U,DT,NTA,IDA
398.000 C9MMEN CTA(50),TATA(50),PHITA(50),WTA(50),TWTA(50)
399.000 C9MMEN UA,EL,CC,TAIR,TWA,RH,WSP
400.000 C9MMEN INT2,INT3,DC,DTA,DPHI,DW,DTW,INV\$,IFLAG
401.000 C9MMEN DM21,BETA
402.000 C9MMEN LAG1,NDAS
403.000 C9MMEN ICAS,PRP(50,10)
404.000 RH81=62.4
405.000 X1=0.
406.000 Y1(1)=DTW
407.000 XEND1=25000.
408.000 DXPR1=XEND1
409.000 DX1=1000.
410.000 NE1=1
411.000 IN1=J4
412.000 I91=I9U
413.000 EL1=EL
414.000 AREA1=UA
.415.000 U1=1.

```
416.000    ERROR1=.01
417.000    DXMAX1=25000.
418.000    TEMP1=TW(INVS)
419.000    W1=N(INVS)*6080./3600.
420.000    WMS1=W1*.3048
421.000    WMD1=W1*3600.*24./5280.
422.000    WMPH1=WMD1/24.
423.000    TAIR1=TA(INVS)
424.000    CLDI=C(INVS)
425.000    RH1=PHI(INVS)
426.000    ALBAR1=A(NAP(DMP1,RETA))
427.000    ALBAR1=ALBAR1*57.296
428.000    TWS1=5.* (TEMP1-32.)/9.
429.000    TA1=5.* (TAIR1-32.)/9.
430.000    DALP1=5.
431.000    DALPR1=DALP1/57.296
432.000    DCLO1=DC
433.000    DRH1=DPH1
434.000    DTAIR1=DTA
435.000    DW1=DW*6080./3600.
436.000    DWMS1=DW1*.3048
437.000    DWMD1=DW1*3600.*24./5280.
438.000    CCCCC
439.000    CCCCC
440.000    CCCCC
441.000    CCCCC
442.000    CALL HUNDL
443.000    CCCCC
444.000    CCCCC
```

```
445.000 CCCCCC
446.000      IFLAG=0
447.000      IF(ABS(Y1(1))-DT)10,10,20
448.000      .10 CONTINUE
449.000      ENUM=ENUM+1.
450.000      IFLAG=1
451.000      20 CONTINUE
452.000      DEN=DEN+1.
453.000      RETURN
454.000      END
455.000 CCCCCC
456.000 CCCCCC
457.000 CCCCCC
458.000 CCCCCC
459.000      FUNCTION ALNAP(DM21,BETA)
460.000      SN1=SIN(BETA)
461.000      TH1= 6.28*DM21/ 365.
462.000      DEL= ASIN(SIN((23.45/57.296))*SIN(TH1))
463.000      PHY=ACOS(TAN(DEL)*TAN(BETA))
464.000      T0=24.*PHY/6.28
465.000      T1=T0-T0
466.000      AV=(T1-T0)*SIN(DEL)*SN1/24.
467.000      AV=AV-COS(DEL)*COS(BETA)*(SIN(6.28*T1/24.)-SIN(6.28*T0/24.))/6.28
468.000      ALNAP=ASIN(AV)
469.000      RETURN
470.000      END
471.000 CCCCCC
472.000 CCCCCC
```

473.000 CCCCC
474.000 CCCCC
475.000 CCCCC
476.000 SJBRROUTINE HUNDI
477.000 C STREAM THERMAL M8DFL *** SFNSITIVITY ANALYSIS ***
478.000 C9MM8V YP(5),Y(5),XPR,XEND,DXPR,X,DX,NE,INT,INTC,IN,IS,EL,AREA,U
479.000 C9MM8V ERR6R,DXMAX,TEMP,HFGTB(10),CANS1
480.000 C9MM8VRHA,W,WMD,HD,TAIR,CLD,RH,ALBAR,TWS,TA,TWSA,EW,EA,HOS,HS
481.000 C9MM8V HSR,HAB,FBR,EVAP,HE,HC,HLYMN,PTBL(10),TTBL(10),WMS,CNST
482.000 C9MM8V CI IF,HFG,H2C,CLD1,CLD2,CLD3,DALP,DALPR,DCLD,DRH,DTAIR,
483.000 1DTA,DN,DWMS,DWMD,DEA,DEW,DLYMN,DBTUS,NTEMP,STTBL(10),XTBL(10)
484.000 CLIF = 1.E-6
485.000 CALL INPUT
486.000 IF(INTC = 4) 4,105,105
487.000 4 XPR = DXPR
488.000 5 C9NTINUF
489.000 G9 100 JE= 1,INT
490.000 CALL DIFF0
491.000 G9 TB (10,10,20), INTC
492.000 10 CALL EULFR(YP,Y,DX,NE,JE,X)
493.000 G9 TB 100
494.000 20 CALL RK4(YP,Y,DX,NE,JE,X)
495.000 100 C9NTINUE
496.000 IF(X = XPR+ DX/4.1 5,250,250
497.000 250 C9NTINUE
498.000 XPR = XPR + DXPR
499.000 IF(X = XFND) 5,300,300
500.000 105 C9NTINUE
501.000 JUMP = *1

```

502.000 110  CONTINUE
503.000      XPR = X + DXPR
504.000 120  CONTINUE
505.000      CALLN3RD(YP,X,XPR,Y,ERRR,NE,DX,DXMAX,JUMP,KSTP,KCON,CLIF,I0)
506.000      IF(JUMP)130,140,150
507.000 130  WRITE(I0,131) X
508.000 131  FORMAT(//'* X ='E14.5! INTEGRATION FAILURE!')
509.000      RETURN
510.000 140  CONTINUE
511.000      CALL DIFFQ
512.000      G9 T8 120
513.000 150  CONTINUE
514.000      IF(X = XFND) 110,300,300
515.000 300  CONTINUE
516.000      RETURN
517.000      END
518.000 CCCCCC
519.000 CCCCCC
520.000 CCCCCC
521.000 CCCCCC
522.000      SUBROUTINE INPUT
523.000      DIMENSION PTBL(10),TTBL(10)
524.000      COMMON YP(5), DT, DUM(4), XPR, XFND, DXPR, X, DX, NE, INT, INTC,
525.000      1 IN, I0, EI, ARFA, U, EERR, R, DXMAX, TFMP, HFGTB(10), C0NS1
526.000      C0MM0N RHA, W, WMD, HD, TAIR, CLD, RH, ALBAR, TWS, TA, TWSA, EW, EA, HBS, HS
527.000      C0MM0N HSR, HBR, FBR, EVAP, HE, HC, HLYMN, PTBL, TTBL, WMS, C0NST
528.000      C0MM0N CLIF, HFG, HBC, CLD1, CLD2, CLD3, DALP, DALPR, DCLD, DRH, DTAIR,
529.000      1DTA, DW, DWMS, DWMD, DEA, DEW, DLYMN, DBTUS, NTEMP, STTBL(10), XTBL(10)

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```
530.000 10  F9RFORMAT(6F10.0)
531.000 20  F9RFORMAT(6I10)
532.000      RAT18 = 3.14159/180.
533.000 C    NUMBER OF EQUATIONS AND CHOICE OF INTEGRATION SUBROUTINE
534.000      NE=1
535.000      INTc=1
536.000      IF(INTC = 3) 30,40,50
537.000 30  INT = INTc
538.000      GO TO 60
539.000 40  INT = 4
540.000      GO TO 60
541.000 50  CONTINUE
542.000 60  CONTINUE
543.000      JFLA=1
544.000      IF(JFLA=1)65,150,65
545.000 65  CONTINUE
546.000      GO TO (110,120,130,140), INTc
547.000 110  WRITE(18,115)
548.000 115  F9RFORMAT(11      **** EULER INTEGRATION      *****1//)
549.000      GO TO 150
550.000 120  CONTINUE
551.000      WRITE(18,125)
552.000 125  F9RFORMAT(11      ***** MOD. EULER INTEGRATION      *****1//)
553.000      GO TO 150
554.000 130  WRITE(18,135)
555.000 135  F9RFORMAT(11      ***** 4 TH ORDER RUNGE-KUTTA      *****1//)
556.000      GO TO 150
557.000 140  WRITE(18,145)
558.000 145  F9RFORMAT(11      ***** ADAMS Moulton INTEG.      *****1//)
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```
539.000 150  C9NTINUE
540.000 C
541.000 C      INTEGRATION CONTROL PARAMETERS
542.000 CANST = FL/(RH0*U*AREA)
543.000 C9NS1 = (RH0*0.00328)/(24.*3600.*0.0614)
544.000 DTA = DTAIR*5./9.
545.000 H9S = 1.9*SIN(ALBAR*RATI0)
546.000 H9C = 1.9*COS(ALBAR*RATI0)
547.000 CLD1 = 1. - .0745*CLD
548.000 CLD2 = -.0018*CLD**2
549.000 CLD3 = 1. - .0006*CLD**3
550.000 DALPR = DALP * RATI0
551.000 D1 = DWMPH*22./15.
552.000 DWMS = DW * .3048
553.000 DWMD = DWMPH*24.
554.000 C      INCIDENT SOLAR RADIATION
555.000 HS = H9S * C103
556.000 C      REFLECTED SOLAR RADIATION
557.000 HSR = HS * 3./ALBAR
558.000 FTA = SI(TTBL,PTBL,TAIR,10)
559.000 EA = RH*(1013./1470.)*FTA
560.000 TAIRP = TAIR+DTAIR
561.000 FTAP = SI(TTBL,PTBL,TAIRP,10)
562.000 DEA = (1013./1470.)*(DRH*FTA + RH*(FTAP - FTA))
563.000 IFLA=1
564.000 IF(IFLA-1) 198,199,198
565.000 198 C9NTINUE
566.000 WRITE(I0,200) DT
```

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537.000 200  FORMAT(' INITIAL DT ='F12.4           '      DEG F')
538.000          WRITE(I9,210) J,AREA,EL
539.000 210  FORMAT(' STREAM VELOCITY ='F6.3' FT/SEC   CR. SEC. AREA ='F10.2'
540.000          SQ. FT. SURFACE WIDTH ='F6.1' FT')
541.000          WRITE(I9,220) RH0,CLD,RH,ALBAR
542.000 220  FORMAT(' RH='F5.2' LB/CU.FT.    CLD='F4.1' TENTHS',
543.000          ' RH='F5.1' PCT'/' ALBAR ='F4.1' DEGREES')
544.000          WRITE(I9,230) TAIR,TA,CNST,CNS1
545.000 230  FORMAT(' AIR TEMP. ='F5.1' DFG F'F8.1' DEG C',
546.000          ' CNST ='E10.3' CNS1 ='E10.3')
547.000          WRITE(I9,240) W,WMPH,WMS,WMD
548.000 240  FORMAT(' WIND VELOCITY ='F6.2' FT/SEC'F8.2'MPH'F8.2' METERS',
549.000          ' /SEC'F8.2' MILES/DAY')
550.000          WRITE(I9,260)
551.000 260  FORMAT(/,T20!TTBL!T40!PTBL!T60!HGBTB!)
552.000          D9 270 I =1/10
553.000 270  WRITE(I9,280) TTBL(I), PTBL(I), HGBTB(I)
554.000 280  FORMAT(10X,3F20.5)
555.000          WRITE(I9,300) DCLD,DRH,DTAIR
556.000 300  FORMAT(/' DCLD ='F6.3' DRH ='F6.3' DTAIR ='F6.2')
557.000          WRITE(I9,310) DALP,DWMPH
558.000 310  FORMAT(/' DALP ='F6.2' DWMPH ='F6.2')
559.000          WRITE(I9,320) H9S,H9C,HS,HSR
560.000 320  FORMAT(/' H9S='E12.4' H9C='E12.4' HS='E12.4' HSR='E12.4' LY/MIN')
561.000          1N1)
562.000          WRITE(I9,330) EA,DEA
563.000 330  FORMAT(/' EA ='E12.4' DEA ='F12.4)
564.000          WRITE(I9,340)
565.000 340  FORMAT(/,T20!STTBL!T40!XTBL!)

```

```

616.000 199  CONTINUE
617.000      RETURN
618.000      END
619.000 CCCCC
620.000 CCCCC
621.000 CCCCC
622.000 CCCCC
623.000      SUBROUTINE SPUT
624.000      C9MM8N DDT,YP(4), DT,DUM(4),XPR,XEND,DXPR,X,DX,NE,INT,
625.000      1INTC, IN,IB,FL,AREA,U,ERR8R,DXMAX,TEMP,HFGTB(10),C0NS1,
626.000      C9MM8NVRH,A,W,WMD,HD,TAIR,CLD,RH,ALPAR,TWS,TA,TWSA,EW,EA,H0S,HS
627.000      C9MM8N HSR,HAB,FBR,EVAP,HE,HC,HLYMN,PTBL(10),TTBL(10),WMS,CONST
628.000      C9MM8N CI,IF,HFG,HBC,CLD1,CLD2,CLD3,DALP,DALPR,DCLD,DRH,DTAIR,
629.000      1DTA,DW,DWMS,DWMD,DEA,DEW,DLYMN,DBTUS,NTEMP,STTBL(10),XTBL(10)
630.000      WRITE(IB,10) X,DX
631.000 10      FORMAT(1 X ='F7.1' FT    DX ='F6.1'      ,/)
632.000      WRITE(IB,20) TEMP-
633.000 20      FORMAT(1 STREAM TEMP ='E12.4' DEG F/)
634.000      WRITE(IB,70) DT,DDT
635.000      WRITE(IB,30) EW,DEW,EVAP,HE,HFG
636.000 30      F9R4AT(1 EW ='E12.5' DEW ='F12.5' EVAP ='E12.5' HE ='E12.5' LY/MIN HFG ='E12.5',/)
637.000      1E12.5 LY/MIN HFG ='E12.5',/
638.000      WRITE(IB,50) HSR,ERR,HC
639.000 50      FORMAT(1 HSR ='E12.5' EBR='F12.5' HC ='E12.5' LY/MIN/,)
640.000      WRITE(IB,60) HLYMN,HD
641.000 60      FORMAT(1 TOTAL HEAT TRANSFER ='E12.5' LY/MIN'E15.5,
642.000      1' BTU/SEC-FT2/,)
643.000 70      FORMAT(1 DT ='E12.5' DDT ='E12.5',)

```

```

644.000      WRITE(18,30) DLYMN,DBTUS
645.000 80    FORMAT(' DLYMN =1E12.5' DBTUS =1E12.5,/)
646.000      WRITE(18,90)
647.000 90    FORMAT(1X,60('*'),//)
648.000      RETURN
649.000      END
650.000 CCCCCC
651.000 CCCCCC
652.000 CCCCCC
653.000 CCCCCC
654.000      SUBROUTINE: DIFFER
655.000      C9MMEN DDT,YP(4), DT,          DUM(4), XPR,XEND,DXPR,X,DX,NE,
656.000      1INT,I4TC, IN,IS,EL,AREA,U,ERR8R,DXMAX,TEMP,HFGTB(10),C9NS1
657.000      C9MM8NRH,W,WMD,HD,TAIR,C,RH,AIRBAR,TWS,TA,TWSA,EW,EA,HBS,HS
658.000      C9MM8N,HSR,HBS,FBR,EVAP,HE,HC,HLYMN,PTBL(10),TTBL(10),WMS,C9NST
659.000      C9MM8N CI IF,HFG,HAC,CLD1,CLD2,CLD3,DALP,DALPR,DCLD,DRH,DTAIR,
660.000      1DTA,DW,DWMS,DWMD,DEA,DEW,DLYMN,DBTUS,NTEMP,STTBL(10),XTBL(10)
661.000 C      THERMAL EXCHANGE WITH ENVIRONMENT.
662.000      TEMP = SI(XTRL,STTBL,X,NTEMP)
663.000      TWS= (TEMP-32.)*5./9.
664.000      TWSA = TWS + 273.
665.000      DTWS = DT*5./9.
666.000      FTA = SI(TTBL,PTBL,TEMP,10)
667.000      TTW = TEMP + DT
668.000      FTB = SI(TTBL,PTBL,TTW,10)
669.000      EW = (1013./14.7)*FTA
670.000      DEW = (1013./14.7)*(FTB - FTA)
671.000 C      EFFECTIVE BACK RADIATION.
672.000      H9B = (14.38-.09*TWS-.046*RH)/69.72

```

673.000 EBR = HBR*CLD1
674.000 C EVAPORATION HEAT TRANSFER.
675.000 EVAP = .35* (EW-EA)*(1. + .0098* WMD)
676.000 HFG = SI(TTBL,HFGTB,TEMP,10)
677.000 HE = EVAP*HFG*C9NS1
678.000 C CONVECTION HEAT TRANSFER
679.000 HC = 39.*(.26 + .077*WMS)*(TWS - TA)/1440.
680.000 C TOTAL HEAT TRANSFER TO WATER, LY/MIN
681.000 HLYMN = HS - (EBR + HSR + HC + HE)
682.000 C TOTAL HEAT TRANSFER, BTU/SEC-FTP
683.000 HD = HLYMN * .0614
684.000 F1 = CLD2*DCLD*48S
685.000 F2 = CLD2*HSC*DALPR
686.000 F3 = .0765*DCLD*HBR
687.000 F4 = -(CLD1*(-.09*DTWS - .046*DRH)/69.72
688.000 F5 = -(F1+F2)*3./ALBAR
689.000 F6 = .HS*3.*DALP/ALBAR**2
690.000 F7 = -(.35*HFG/1440.)*((1. + .0098*WMD)*(DEW - DEA) +
1 *0098*DWMDS*(EW - FA))
692.000 F8 = -(39./1440.)*((.26 + .077*WMS)*(DTWS - DTA) +
1 *077*DWMDS*(TWS - TA))
694.000 DLYMN = F1 + F2 + F3 + F4 + F5 + F6 + F7 + F8
695.000 DBTUS = DLYMN*.0614
696.000 DDT = CONST*DBTUS
697.000 RETURN
698.000 END
699.000 CCCCC
700.000 CCCCC

```
701.000 CCCCCC
702.000 CCCCCC
703.000 FUNCTION SI(XTBL,YTBL,X,N)
704.000 C LINEAR INTERPOLATION OR EXTRAPOLATION OF SINGLE VARIABLE FUNCTION
705.000 C XTBL = INDEPENDENT VARIABLE TABLE
706.000 C YTBL = DEPENDENT VARIABLE TABLE
707.000 C IND = INDICATOR OF EXTRAPOLATION
708.000 C 0=NO EXTRAPOLATION, 1=LOWER EXTRAPOLATION, 2=UPPER EXTRAPOLATION
709.000 DIMENSION XTBL(40),YTBL(40)
710.000 C CHECK TO SEE IF EXTRAPOLATION IS NEEDED.
711.000 IF(X>XTBL(1)) 120,130,150
712.000 120 IND = 1
713.000 130 II = 2
714.000 G9 TB 254
715.000 150 IF(XTBL(N)-X) 160,180,210
715.000 160 IND = 2
716.000 180 II = N
717.000 G9 TB 254
718.000 C FIND X IN TABLES IN TABLE
719.000 210 D9 220 IK=2,N
720.000 220 II = IK
721.000 254 IF(XTBL(IK)-X) 220,254,254
722.000 220 CONTINUE
723.000 254 X1 = XTBL(II-1)
724.000 X2 = XTBL(II)
725.000 Y1 = YTBL(II-1)
726.000 Y2 = YTBL(II)
727.000 SI = Y1+(Y2-Y1)*(X-X1)/(X2-X1)
728.000 RETURN
```

```
730,000      END
731,000  CCCCCC
732,000  CCCCCC
733,000  CCCCCC
734,000  CCCCCC
735,000      SUBROUTINE EULER(YP,Y,DT,NE,J,T)
736,000      DIMENSION YP(20),Y(20), SY(20),SYP(20)
737,000      G3 TE(10,20),J
738,000  10  CONTINUE
739,000      D9 100 I=1,NF
740,000      SY(I)= Y(I)
741,000      SYP(I)= YP(I)
742,000      Y(I)= Y(I)+DT*YP(I)
743,000  100 CONTINUE
744,000      T=T+DT
745,000      RETURN
746,000  20  CONTINUE
747,000      D9 200 I=1,NF
748,000      Y(I)= SY(I)+(YP(I)+SYP(I))*DT/2.
749,000  200 CONTINUE
750,000      RETURN
751,000      END
752,000  CCCCCC
753,000  CCCCCC
754,000  CCCCCC
755,000  CCCCCC
756,000      SUBROUTINE RK4(YP,Y,DT,NE,J,T)
757,000      DIMENSION YP(5),Y(5),AK(5,4),SY(5)
```

```
758.000      G9 T0(10,20,30,40),J
759.000 10    C9NTINUE
760.000      D9 100 I=1,NF
761.000      SY(I) = Y(I)
762.000      AK(I,1) = DT*YP(I)
763.000      Y(I) = Y(I) + AK(I,1)*.5
764.000 100   C9NTINUE
765.000      ST = T
766.000      T = T + DT*.5
767.000      RETURN
768.000 20    C9NTINUE
769.000      D9 200 I=1,NF
770.000      AK(I,2) = DT*YP(I)
771.000      Y(I) = SY(I) + AK(I,2)*.5
772.000 200   C9NTINUE
773.000      RETURN
774.000 30    C9NTINUE
775.000      D9 300 I = 1,NE
776.000      AK(I,3) = DT*YP(I)
777.000      Y(I) = SY(I) + AK(I,3)
778.000 300   C9NTINUE
779.000      T = ST + DT
780.000      RETURN
781.000 40    C9NTINUE
782.000      D9 400 I = 1,NE
783.000      AK(I,4) = DT *YD(I)
784.000      Y(I)=SY(I)+(AK(I,1)+AK(I,4)+2.*(AK(I,2)+AK(I,3)))/6.
785.000 400   C9NTINUE
786.000      RETURN
```

```
787.000      END
788.000      CCCCC
789.000      CCCCC
790.000      CCCCC
791.000      CCCCC
792.000      SUBROUTINE NERD(F,T,TLIM,Y,ERRBR,NF,H,HMAX,JUMP,KSTP,KCBN,CLIF,I0)
793.000      DIMENSION STARY(5),Y(5),SY(5),SAVFY(5),F(5),FP(5),DELTA(5),DALTA(5,
794.000      1),A(5),B(5),C(5),D(5),AA(5),BB(5),CC(5),DD(5),SF(5)
795.000      IF(KSTP=32767)993,991,991
796.000      991 KSTP=28
797.000      C TEST FOR TYPE OF ENTRY
798.000      993 IF(JUMP),998,999
799.000      998 G9 T0 (1000,11,21,802,803),IA
800.000      C JUMP POS.    RESTORE VALUES
801.000      999 T=SAVET
802.000      992 JUMP=0
803.000      D0 901 I=1,NE
804.000      F(I)=SF(I)
805.000      901 Y(I)=SAVFY(I)
806.000      G9 T0 102
807.000      C JUMP NEG.    INITIALIZE
808.000      1 D0 5 I=1,NE
809.000      STARY(I)=Y(I)
810.000      A(I)=0.001
811.000      B(I)=0.001
812.000      C(I)=0.001
813.000      5 D(I)=0.001
814.000      KSTP=0
```

815.000 K0E1Y=0
816.000 KCBN=3
817.000 XT=95.0/(288.*5040.)
818.000 U=863.0/(12.*5040.)
819.000 V=95.0/288.0
820.000 P=25.0/24.0
821.000 Q=35.0/72.0
822.000 R=5.0/48.0
823.000 S=1.0/120.0
824.000 IA=1
825.000 JUMP=0
826.000 G9 T8 1101
827.000 C BEGIN INTEGRATION STEP.
828.000 1000 D9 1111 I=1,NE
829.000 SF(I)=F(I)
830.000 1111 SAVEY(I)=Y(I)
831.000 C H T88 SMALL RETURN WITH JUMP NEG.
832.000 600 IF(ABS(T+H)-ABS(T)>605,601,605
833.000 601 JUMP=-1
834.000 G9 T8 1101
835.000 605 T=T+H
836.000 D9 10 I=1,NE
837.000 Y(I)=Y(I)+H*(F(I)+A(I)+B(I)+C(I)+D(I))
838.000 10 FP(I)=F(I)+2.0*A(I)+3.0*B(I)+4.0*C(I)+5.0*D(I)
839.000 IA=2
840.000 G9 T8 1101
841.000 11 D9 12 I=1,NE
842.000 12 SY(I)=Y(I)
843.000 D9 20 I=1,NE

```
844.000      DELTA  (I)=F(I)-FP(I)
845.000      20 Y(I)=Y(I)+V*DELTA  (I)*H
846.000      IA=3
847.000      KCBN=1
848.000      G9 T9 1101
849.000      21 KCBN=0
850.000      D9 30 I=1,NE
851.000      DALTA  (I)=F(I)-FP(I)
852.000      29 Y(I)=SY(I)+V*DALTA  (I)*H
853.000      30 CONTINUE
854.000 C    TEST FOR STARTING SEQUENCE
855.000      31 IF(KSTP=28)35,40,40
856.000 C    APPLY TEST 2 ON ZEROTH STEP
857.000      35 IF(KSTP)50,50,60
858.000 C    HALVING TESTS
859.000      40 D9 45 I=1,NE
860.000      IF(ABS(DALTA  (I))-ERROR/ABS(H))45,45,55
861.000      45 CONTINUE
862.000      50 IF(V*4*CI.IF=0.125)60,60,55
863.000      55 T=T-H
864.000 C    FAIL TESTS, HALVE H
865.000      223 H=H/2.0
866.000      KDELY=0
867.000      D9 56 I=1,NE
868.000      A(I)=A(I)/2.0
869.000      B(I)=B(I)/4.0
870.000      C(I)=C(I)/8.0
871.000      F(I)=SF(I)
```

1#L

```
872.000      Y(I)=SAVFY(I)
873.000      56 D(I)=D(I)/16.0
874.000      G9 T8 1000
875.000 C    PASS TESTS, CORRECT A,B,C,D
876.000      60 KSTP=KSTP+1
877.000      D9 65 I=1,NE
878.000      A(I)=A(I)+3.0*B(I)+6.0*C(I)+10.0*D(I)+P*DALTA(I)
879.000      62 B(I)=B(I)+4.0*C(I)+10.0*D(I)+Q*DALTA(I)
880.000      64 C(I)=C(I)+5.0*D(I)+R*DALTA(I)
881.000      67 D(I)=D(I)+S*DALTA(I)
882.000      65 CONTINUE
883.000 C    IF IN STARTING SEQUENCE, BRANCH
884.000      IF(KSTP=24)7.0,90,100
885.000      70 G9 T8 (1000,1000,1000,74,1000,1000,1000,78,1000,1000,1000,74,1000,
886.000      11000,1000,86,1000,1000,1000,74,1000,1000,1000),KSTP
887.000 C    4TH, 12TH, 20TH STEP, G9 BACK
888.000      74 H=-H
889.000      D9 75 I=1,NE
890.000      A(I)=-A(I)
891.000      75 C(I)=-C(I)
892.000      G9 T8 1000
893.000 C    8TH STEP G9 FORWARD
894.000      78 H=-H
895.000      D9 79 I=1,NE
896.000      Y(I)=STARY(I),
897.000      A(I)=-A(I)
898.000      79 C(I)=-C(I)
899.000      G9 T8 1000
900.000 C    16TH STEP, HALVE H, APPLY TEST 1
```

901.000 86 H=H/2.0
902.000 D9 87 I=1,NE
903.000 A(I)=A(I)/2.0
904.000 B(I)=B(I)/4.0
905.000 C(I)=C(I)/8.0
906.000 87 D(I)=D(I)/16.0
907.000 D9 88 I=1,NE
908.000 IF(ABS(DALTA(I))-ERROR/ABS(H))88,88,89
909.000 88 CONTINUE
910.000 C PASS TEST GO FORWARD WITH HALVFD H
911.000 GO TO 78
912.000 C FAIL TEST BEGIN AGAIN WITH HALVFD H
913.000 89 H=-H
914.000 D9 92 I=1,NE
915.000 92 Y(I)=STARY(I)
916.000 GO TO 1
917.000 C 24TH STEP, DOUBLE H, STARTING SEQUENCE ENDS
918.000 90 H=H*2.0
919.000 D9 91 I=1,NE
920.000 A(I)=A(I)*2.0
921.000 B(I)=B(I)*4.0
922.000 C(I)=C(I)*8.0
923.000 91 D(I)=D(I)*16.0
924.000 GO TO 78
925.000 100 KDFLY=KDFLY+1
926.000 C WILL NEXT STEP MOVE PAST TLIM
927.000 102 IF(ABS(TLIM-T)-ABS(H))103,103,110
928.000 C YES.....SAVE T AND Y, INTEGRATE TO TLIM, RETURN.

929.000 103 ENDH=TLIM-T
930.000 DB 105 I=1,NF
931.000 AA(I)=ENDH*A(I)/H
932.000 BB(I)=ENDH**2*B(I)/H**2
933.000 CC(I)=ENDH**3*C(I)/H**3
934.000 105 DD(I)=ENDH**4*D(I)/H**4
935.000 SAVET=T
936.000 DS 800 I=1,NF
937.000 SF(I)=F(I)
938.000 800 SAVEY(I)=Y(I)
939.000 806 T=TLIM
940.000 DS 105 I=1,NF
941.000 Y(I)=Y(I)+ENDH*(F(I)+AA(I)+BB(I)+CC(I)+DD(I))
942.000 106 FP(I)=F(I)+2.0*AA(I)+3.0*BB(I)+4.0*CC(I)+5.0*DD(I)
943.000 IA=4
944.000 GO TO 1101
945.000 802 DS 805 I=1,NF
946.000 805 SY(I)=Y(I)
947.000 DS 107 I=1,NF
948.000 DELTA(I)=F(I)-FP(I)
949.000 107 Y(I)=Y(I)+V*DELTA(I)*FNDH
950.000 IA=5
951.000 GO TO 1101
952.000 803 DS 108 I=1,NF
953.000 DALTA(I)=F(I)-FP(I)
954.000 108 Y(I)=SY(I)+V*DALTA(I)*ENDH
955.000 JUMP=1
956.000 GO TO 1101
957.000 C NS.....TEST FOR DOUBLING. IF '8K, BEGIN NEST STE- AFTER DOUBLING

```
958.000 110 IF(ABS(TI IM-T)-ABS(2.0*H))1000,1000,111
959.000 111 IF(KDELY=4)1000,120,120
960.000 120 IF(A8S(2.0*H)-ABS(HMAX))121,121,1000
961.000 121 D9 125 I=1,NE
962.000   IF(ABS(DALTA(I))-ERROR/(128.0*ABS(H)))125,125,1000
963.000 125 C9NTINUE
964.000   IF(V*H*CLIF=0.0625)130,1000,1000
965.000 130 C9NTINUE
966.000 335 H=2.0*H
967.000   D9 135 I=1,NE
968.000   A(I)=2.0*A(I)
969.000   B(I)=4.0*B(I)
970.000   C(I)=3.0*C(I)
971.000 135 D(I)=16.0*D(I)
972.000   KDELY=0
973.000   G9 T8.1000
974.000 1101 C9NTINUE
975.000 1150 F9RFORMAT(/,2X,14H =1,2X,F10.6,14X,'KSTP =1,2X,I3,10X,'DAL3A(I)'),/
976.000 1151 F9RFORMAT(5(2X,I2,1X,E14.7))
977.000   RETURN
978.000   END
979.000 CCCCCC
980.000 CCCCCC
981.000 CCCCCC
982.000 CCCCCC
983.000 CCCCCC
984.000   SUBROUTINE DFBUG(A,N)
985.000   I9U#102
```

946.000 WRITE(I8U,1000)4,N
987.000 1000 F9RFORMAT(1H0,2X,'A=1,E14.7,1X,IN=1,I4)
988.000 RETURN
989.000 END
990.000 SUBROUTINE PR8U
991.000 C9MM8N YP1(5),Y1(5),XPR1,XEND1,DXPR1,X1,DX1,NE1,INT1,INTC1,IN1,I01
992.000 1,EL1,ARFA1,U1
993.000 C9MM8N ERR0R1,DXMAX1,TEMP1,HFGTB1(10),C8NS11
994.000 C9MM8N RH91,W1,WMD1,HD1,TAIR1,CLD1,RH1,ALBAR1,TWS1,TA1,TWSA1,EW1,
995.000 1EA1,H9S1,HS1
996.000 C9MM8N HSR1,H9B1,E8R1,EVAP1,HE1,HC1,HLVMN1,PTBL1(10),TTBL1(10),
997.000 1WMS1,C8NST1
998.000 C9MM8N CI(IF1,HFG1,H0C1,CLD11,CLD21,CLD31,DALP1,DALPR1,DCLD1,DRH1,
999.000 1DTAIR1,DTA1,DW1,DWMS1,DWMD1,DEA1,DEW1,DLYMN1,DBTUS1,NTEMP1,
1000.000 2STBL1(10),XTBL1(10)
1001.000 C9MM8N C(1000),TA(1000),PHI(1000),W(1000),TW(1000)
1002.000 C9MM8N NCAS,NOA,DELT(50),IDAS(50)
1003.000 C9MM8N NIN,IN,I8U,DT,NTA,IDA
1004.000 C9MM8N CTA(50),TATA(50),PHITA(50),WTA(50),TWTA(50)
1005.000 C9MM8N UA,EL,CC,TAIR,TWA,RH,WSP
1006.000 C9MM8N INT2,INT3,DC,DTA,DPHI,DW,DTW,INVS,IFLAG
1007.000 C9MM8N DM21,BETA
1008.000 C9MM8N LAG1,NDAS
1009.000 C9MM8N ICAS,PRP(50,10)
1010.000 WRITE(I8U,2000)
1011.000 2000 F9RFORMAT(1H0,2X,'PROBABILITY CHART!',2X,60('**'))
1012.000 WRITE(I8U,2001)(DELT(I),I=1,NCAS)
1013.000 2001 F9RFORMAT(1H0,10X,10YE10.3,1X))
 D8 10 I=1,NDAS

```
1015.000      WRITE(I8U,2002) IDAS(I),(PRP(I,J),J=1,NCAS)
1016.000 2002 F9RMAT(1H0,2X,I5,1X,5(E10.3,1X))
1017.000      10 CONTINUE
1018.000      RETURN
1019.000      END
1500.000      SUBROUTINE VFRN9N
1501.000      C9MMBN YP1(5),Y1(5),XPR1,XEND1,DXPR1,X1,DX1,NE1,INT1,INTC1,IN1,I01
1502.000      1,EL1,AREA1,U1
1503.000      C9MMBN ERR8R1,DXMAX1,TEMP1,HFGTB1(10),C9NS11
1504.000      C9MMBN RH81,W1,WMD1,HD1,TAIR1,CLD1,RH1,ALBAR1,TWS1,TA1,TWSA1,EW1,
1505.000      1E41,H8S1,HS1
1506.000      C9MMBN HSR1,H8B1,ERR1,EVAP1,HE1,HC1,HLVMN1,PTBL1(10),TTBL1(10),
1507.000      1WMS1,C8NST1
1508.000      C9MMBN CI,IF1,HFG1,H8C1,CLD11,CLD21,CLD31,DALP1,DALPR1,DCLD1,DRH1,
1509.000      1DTAIR1,DTA1,DW1,DWMS1,DWMD1,DEA1,DEW1,DLVMN1,DBTUS1,NTEMP1,
1510.000      2STTB1(10),XTBL1(10)
1511.000      C9MMBN C(1000),TA(1000),PHI(1000),W(1000),TW(1000)
1512.000      C9MMBN NCAS,NOA,DELT(50),IDAS(50)
1513.000      C9MMBN NIN,IN,IAU,DT,NTA,IDA
1514.000      C9MMBN CTA(50),TATA(50),PHITA(50),WTAA(50),TWTA(50)
1515.000      C9MMBN YA,EL,CC,TAIR,TWA,RH,WSP
1516.000      C9MMBN INT2,INT3,DC,DTA,DPHI,DW,DTW,INV$,IFLAG
1517.000      C9MMBN DM21,BETA
1518.000      C9MMBN LAG1,NDAS
1519.000      C9MMBN IFAS,PRP(50,10)
1520.000      DIMENSION PR(10),T7(100)
1520.010      D9 3 I=1,NCAS
1520.020      PR(I)=0.
```

L4

```
1520.030      3 C9NTINUE
1521.000 C     NDA= NUMBER OF DAYS IN THE CASE
1522.000      NDA=1
1523.000      NC1=NLN/R
1524.000      FNDA=NDA*8
1525.000      FNDA=1./FNDA
1526.000      READ(IN,1020)(T7(I),I=1,NC1)
1527.000      1020 FORMAT(6F10.3)
1528.000      D9 5 I=1,NC1
1528.010      WRITE(18U,2001)T7(I)
1528.020      2001 FORMAT(1,2X,F14.7)
1528.030      5 C9NTINUE
1532.000      IF(NDA=NC1) 10,999,999
1532.500      10 C9NTINUE
1533.000      NDIF=NC1-NDA
1534.000      ENUM=0.
1535.000      DEN=0.
1536.000      DENP=0.
1537.000      D9 20 I20=1,NDIF
1538.000      CS=0.
1539.000      TAS=0.
1540.000      PHIS=0.
1541.000      WS=0.
1542.000      TWS=0.
1543.000      D9 30 I=1,NDA
1544.000      D9 40 J=1,8
1545.000      INT=8*(I20+I-1)+J-8.
1546.000      CS=CS + C(INT)
1547.000      TAS=TAS + TA(INT)
```

1548.000 $\text{PHIS} = \text{PHIS} + \text{PHI}(\text{INT})$
1549.000 $\text{WS} = \text{NS} + \text{W}(\text{INT})$
1551.000 40 CONTINUE
1552.000 30 CONTINUE
1553.000 $\text{CS} = \text{CS} * \text{FNDA}$
1554.000 $\text{TAS} = \text{TAS} * \text{FNDA}$
1555.000 $\text{PHIS} = \text{PHIS} * \text{FNDA}$
1556.000 $\text{WS} = \text{WS} * \text{FNDA}$
1557.000 $\text{TS} = \text{T7}(\text{IP0})$
1558.000 C $\text{INT2} = \text{F31 L8WING DAY}$
1559.000 $\text{INT2} = \text{IP0} + \text{NDA}$
1560.000 $\text{C1S} = 0.$
1561.000 $\text{TA1S} = 0.$
1562.000 $\text{PHI1S} = 0.$
1563.000 $\text{W1S} = 0.$
1564.000 $\text{TW1S} = 0.$
1565.000 D9 50 I=1,8
1566.000 C $\text{INT3} = \text{THE ACTUAL POSITION IN THE DAY}$
1567.000 $\text{INT3} = \text{INT2} * 8 - R + I$
1568.000 $\text{C1S} = \text{C1S} + C(\text{INT3})$
1569.000 $\text{TA1S} = \text{TA1S} + \text{TA}(\text{INT3})$
1570.000 $\text{PHI1S} = \text{PHI1S} + \text{PHI}(\text{INT3})$
1571.000 $\text{W1S} = \text{W1S} + \text{W}(\text{INT3})$
1572.000 $\text{TW1S} = \text{TW1S} + \text{TW}(\text{INT3})$
1573.000 50 CONTINUE
1574.000 $\text{C1S} = \text{C1S} * .125$
1575.000 $\text{TA1S} = \text{TA1S} * .125$
1576.000 $\text{PHI1S} = \text{PHI1S} * .125$

```
1577.000      W1S=W1S+.125
1578.000      TW1S=TW1S*.125
1579.000      DC=C1S-CS
1580.000      DTA=TA1S-TAS
1581.000      DPHI=PHI1S-PHIS
1582.000      DW=W1S-WS
1583.000      DTW=TW1S-TWS
1584.000      STTBL1(1)=TW1S
1585.000      STTBL1(2)=TW1S
1586.000      XTBL1(1)=0.
1587.000      XTBL1(2)=25000.
1588.000      NTEMP1=2
1589.000      INV5=INTP*8-4
1590.000      CALL C9MP(ENUM,DEN)
1591.000      D9 50 ICAS=1,NCAS
1592.000      IF(ABS(Y1(1))-DELT(ICAS)) .65,.65,.70
1593.000      65  C9NTINUF
1594.000      PR(ICAS)=PR(ICAS)+1.
1595.000      70  C9NTINUF
1596.000      60  C9NTINUE
1597.000      20  C9NTINUE
1598.000      DENP=NDIF
1599.000      D9 75 ICAS=1,NCAS
1600.000      PR(ICAS)=PR(ICAS)/DENP
1601.000      75  C9NTINUE
1601.010      WRITE(IOU,2000)(PR(I),I=1,NCAS)
1601.020      2000 FORMAT(/,2X,1STATION,7 RESULTS!,1D(F6.3,1X))
1601.025      RETURN
1601.030      999 C9NTINUE
1601.040      WRITE(IOU,4000)
1601.050      4000 FORMAT(/,2X,1T09 SMALL!)
1601.060      CALL EXIT
1602.000      RETURN
1603.000      END
```

APPENDIX D

THEORY OF THE SENSITIVITY ANALYSIS

In this appendix the development of the equation (1) is discussed together with the problems of convergence and averaging of the data. The sensitivity analysis is further discussed with the exact solution being developed for the constant coefficient equation.

THE GENERAL STREAM MODEL

The equation (1) is developed from the energy equation heat fluxes shown in Figure 1. The development of this equation is based on a Taylor's expansion of the dependent variable, T , about the position, x , downstream:

$$T(x + dx) = T(x) + \frac{dT}{dx}(x) dx . \quad (D-1)$$

Use of this Taylor's expansion together with the conservation of energy for the control volume in Figure 1 yields:

$$\begin{aligned} uA T(x) - uA [T(x) + \frac{dT}{dx}(x) dx] + \\ + l dx [Q_{Rad} - Q_{Ref} - Q_{Back} - Q_{Evap} + Q_{Conv} + Q_{Misc}] = 0 . \end{aligned} \quad (D-2)$$

The first term is the enthalpy transport into the control volume; the second term is the analogous transport out of the control volume; the third term is the total heat flux at the air/water interface. Some minor algebra on equation (D-2) yields equation (1), assuming that the quantities u , A , and l vary slowly along the stream.

The equation (1) holds between points at which flows and/or heated effluents are added to the stream. Many authors directly integrate equation (1) over a station length, Δx , assuming the fluxes and u , A , l to be constant over that distance. The result is simply

$$\int_x^{x+\Delta x} \frac{uA}{l} \frac{dT}{dx} dx = \int_x^{x+\Delta x} [Q_{Rad} - Q_{Ref} - Q_{Back} + Q_{Evap} + Q_{Conv} + Q_{Misc}] dx ,$$

$$\frac{uA}{\ell} [T(x + \Delta x) - T(x)] = [Q_{Rad} - Q_{Ref} - Q_{Back} - Q_{Evap} \\ + Q_{Conv} + Q_{Misc}] \Delta x ,$$

$$T(x + \Delta x) = T(x) + \frac{\ell}{uA} [Q_{Rad} - Q_{Ref} - Q_{Back} - Q_{Evap} \\ + Q_{Conv} + Q_{Misc}] \Delta x . \quad (D-3)$$

It is possible to then incorporate heat fluxes not covered by those at the air/water interface in the Q_{Misc} term, simplifying the coding and the model considerably. Two aspects of this concept should be emphasized: 1) all models are similar to this model and are within a small error that is a function of the mesh size, and 2) the convergence of the procedure can be shown from previous literature.

Suppose that an alternate model is used in which the fluxes are redistributed, i.e., the total flux may be the same but the model assumptions causes a difference in the flux at any position x . Then this difference can be represented as a quantity proportional to the station length, Δx . For example:

$$Q_{Rad}(x + \Delta x) = Q_{Rad}(x) + O(\Delta x) . \quad (D-4)$$

But the introduction of this expression into equation (D-3) will introduce a term of order Δx^2 ($O(\Delta x^2)$), which can be made appropriately small by a suitable choice of Δx . Thus, all correctly formulated models will be a measurable error away from the general model described by equation (1).

The question of numerical convergence of the solution is discussed in general by Salvadori and Baron [1961], p. 116. Much of the information provided by them can be directly applied to this problem.

Suppose a general problem takes the form

$$\begin{aligned}\dot{y} &= f(x, y) , \\ y(0) &= y_0 .\end{aligned}\quad (D-5)$$

If Euler's method is taken as an example the form for the integration is

$$y_{i+1} = y_i + f(x_i, y_i)h , \quad (D-6)$$

which is seen to be identical in form to equation (D-3). From p. 91 in Salvadori and Baron

$$\begin{aligned}y(x) &= \int_a^x f(z) dz , \\ \dot{y}(x) &= f(x) , \\ \ddot{y}(x) &= \cdot , \\ y^{(n)}(x) &= f^{(n-1)}(x) .\end{aligned}\quad (D-7)$$

A Taylor's expansion about x yields:

$$y(x+h) = y(x) \pm \frac{h}{1!} f(x) + \frac{h^2}{2!} \dot{f}(x) \pm \frac{h^3}{3!} \ddot{f}(x) + \dots . \quad (D-8)$$

From this the following expressions can be evaluated

$$\begin{aligned}I_1 &= \int_x^{x+h} f(z) dz = y(x+h) - y(x) , \\ &= h [f(x) + \frac{h}{2!} \dot{f}(x) + \frac{h^3}{3!} \ddot{f}(x) + \dots] ,\end{aligned}\quad (D-9)$$

and

$$\begin{aligned}
 I_2 &= \int_{x-h}^{x+h} f(z) dz = y(x+h) - y(x-h), \\
 &= [2hf(x) + \frac{2h^3}{3!} f'(x) + \frac{2h^5}{5!} f^{(IV)}(x) + \dots] .
 \end{aligned} \tag{D-10}$$

From Taylor's theorem and equation (D-6)

$$y(x+h) = y(x) + hf(x) + \frac{h^2}{2!} \dot{f}(\hat{x}) \tag{D-11}$$

and the error is proportional to the maximum value of the second derivative. With these fundamentals set down the error for the equation

$$\frac{dT}{dx} = \frac{Q\ell}{uApC} \tag{D-12}$$

can be readily found. From the general analysis the error is bounded by the expression

$$|T_{\text{Approximate}} - T_{\text{Exact}}| \leq \frac{x\ell}{uApC} \left| \frac{dQ}{dx} \right|_{\max} \Delta x \tag{D-13}$$

An expression similar to (D-13) is easily developed for bounding the station length

$$\Delta x \leq \frac{\left| \Delta T_{\text{allowable}} \right|}{\frac{x_{\max}\ell}{uApC} \left| \frac{dQ}{dx} \right|_{\max}} . \tag{D-14}$$

From experience, a convergent Δx can easily be obtained for this differential equation since the heat fluxes are generally very small and have small derivatives.

DATA AVERAGING

For small changes in temperature the equation (1) will be quasi-linear. Thus, the theory of linear equations can be applied to the problem. This is very important since average data will produce average output to such a model, while a nonlinear model will not yield results of this type.

To prove this it is necessary to examine the theory from a different viewpoint. For example, the temperature at any point x downstream from the disturbance can always be represented from the linear equation in the form

$$T(x) = \sum_i \int_0^x K_i(x, \xi) Q_i(\xi) d\xi \quad (D-15)$$

where the integral occurs over the domain of interest and the kernel function $K_i(x, \xi)$ relates the effect of the i 'th heat flux $Q_i(\xi)$ at the position ξ to the temperature $T(x)$ at the position x ; the sum produces the effects of all of the heat fluxes. Since the expression is linear, it can be summed over several sets of heat fluxes to obtain the sum of temperatures as follows

$$\sum_j^n T_j(x) = \sum_i \sum_j^n \int_0^x K_i(x, \xi) Q_{ij}(\xi) d\xi . \quad (D-16)$$

Suppose that equation (D-16) is rearranged and both sides of the equation divided by the number of temperatures n :

$$\frac{1}{n} \sum_j^n T_j(x) = \sum_i \int_0^x K_i(x, \xi) \sum_j^n \frac{Q_{ij}}{n} (\xi) d\xi . \quad (D-17)$$

This proves that the effects of the heat fluxes can be averaged and the equation used to compute an average temperature. This would not be true for a nonlinear equation and is a significant result.

THE SENSITIVITY ANALYSIS

The fundamental equation for the sensitivity analysis is developed by varying both sides of the solution equation (1):

$$\frac{d\delta T}{dx} = \frac{\lambda}{Au} \delta Q , \quad (D-18)$$

where δQ is the change in the heat fluxes and δT the resulting change in the stream temperature. The initial condition for the equation is

$$\delta T(0) = \delta T_0 , \quad (D-19)$$

i.e., an initial error in temperature δT_0 is known at a point in the stream, which allows the computation of the error at points downstream.

On closer examination of δQ the linearity of the solution emerges. The individual terms are

$$\begin{aligned} \delta Q_{\text{Solar}} &= 1.9 \sin \bar{\alpha} (-0.0018 C^2 \delta C) (0.61) \\ &\quad + (1.0 - 0.0006 C^3) (1.9 \cos \bar{\alpha} \delta \bar{\alpha}) (0.061) , \end{aligned}$$

$$\delta Q_{\text{Reflected}} = \frac{3}{\pi} \delta Q_{\text{Solar}} (0.061) - \frac{6}{\bar{\alpha}^2} Q_{\text{Solar}} \delta \bar{\alpha} (0.061) ,$$

$$\begin{aligned} \delta Q_{\text{Back}} &= (1.0 - 0.0765 C) \left(\frac{1}{69.72}\right) \left(-0.09 \left(\frac{5}{9} \delta T\right) - 0.046 \delta \phi\right) \\ &\quad - 0.0765 \delta C \left(\frac{1}{69.72}\right) (14.38 - 0.09 \left(\frac{5}{9}(T - 32)\right) - 0.046 \phi) , \end{aligned}$$

$$\delta Q_{\text{Evaporation}} = \frac{\rho h_f g}{240} (0.35) (1.0 + 9.8 \times 10^{-3} W_2) (\delta e_w - \delta e_a) \\ + \frac{\rho h_f g}{240} (0.35) (9.8 \times 10^{-3} \delta W_2) (e_w - e_a) ,$$

$$\delta Q_{\text{Convection}} = 39.0 (0.077 \delta W_2) (T - T_a) \left(\frac{5}{9}\right) (0.061) \\ + 39.0 (0.26 + 0.077 W_2) (\delta T - \delta T_a) \left(\frac{5}{9}\right) (0.061) \\ (D-20)$$

Note that small changes in the heat fluxes imply like changes in δT . Thus, the justification in linearizing the analysis. The equation (D-18) is solved in this investigation using numerical analysis procedures. However, for constant coefficients in equation (D-18), the equation can be solved in closed form. Symbolically the equation can be written as:

$$\frac{d\delta T}{dx} = \frac{\lambda}{Au} [-C_1' \delta T + C_2 + C_3 + \dots + C_m] , \quad (D-21)$$

where the C_i are constants. The solution to this equation is found in two parts, a homogeneous solution decaying with distance and particular solutions that are constant. The homogeneous solution is found by assuming it in the form

$$\delta T = \bar{A} e^{-\alpha x} , \quad (D-22)$$

where \bar{A} is an initial amplitude and α is the decay rate. Substitution into equation (D-21) yields

$$-(\alpha) \bar{A} e^{-\alpha x} = \frac{\lambda}{Au} [-C_1 \bar{A} e^{-\alpha x}] , \quad (D-23)$$

which finds α to be

$$\alpha = \frac{\lambda}{Au} C_1 . \quad (D-24)$$

The particular solutions are found from

$$\delta T_i = \frac{C_i}{C_1} , \quad (D-25)$$

where $i = 2, \dots, m$. It is on this basis that the sensitivity analysis is completed.

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