FLOOD ROUTING THROUGH STORM DRAINS Part IV

NUMERICAL COMPUTER METHODS OF SOLUTION

By

## V. YEVJEVICH and A. H. BARNES

November 1970



16

HYDROLOGY PAPERS COLORADO STATE UNIVERSITY Fort Collins, Colorado

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#### ABSTRACT

This fourth part of a four-part series of hydrology papers on flood routing through storm drains presents computer-oriented numerical methods for solving the two quasi-linear hyperbolic partial differential equations known as the De Saint-Venant equations of gradually varied free-surface unsteady flow. Formulation and description of various finite-difference schemes based on explicit methods include the "unstable", diffusing, upstream differencing, leap frog, and Lax-Wendroff schemes. Stability and convergence are examined for these various schemes of the explicit method. Using various criteria of comparison, the specified intervals scheme of the method of characteristics, the Lax-Wendroff scheme, and the diffusing scheme are compared. Of the above explicit schemes in using the finite-difference ratios in the two partial differential equations, it is found that the Lax-Wendroff scheme with the secondorder interpolation for dependent variables is the most accurate stable scheme. The specified intervals scheme of the method of characteristics, using either the first-order or second-order interpolations for the dependent variables, is also discussed. It is concluded that this scheme, based on the method of characteristics and using the second-order interpolations, is the most accurate numerical integration scheme of all those studied. Flow charts, computer programs, variable conversion tables, and sample inputs and outputs, for the three numerical computer schemes, the diffusing scheme, the Lax-Wendroff scheme, and the specified intervals scheme of the method of characteristics, used in the solution of the De Saint-Venant equations, are given in appendices 1 through 3.

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#### FLOOD ROUTING THROUGH STORM DRAINS

#### Part IV

#### NUMERICAL COMPUTER METHODS OF SOLUTION

#### by

V. Yevjevich\* and A. H. Barnes\*\*

#### Chapter 1

#### INTRODUCTION

#### 1.1 General Classification of Partial Differential Equations

Partial differential equations of physical processes fall within one of three forms, depending on the character of the coefficients of the partial derivatives. The equations expressing the onedimensional gradually varied free-surface unsteady flow result in what is termed the hyperbolic form of partial differential equations. These equations are characterized by the initial conditions of the dependent variables being known, given, or independently evaluated at all distance positions for the time selected as zero, the boundary conditions being independently established at two distance locations, and the process being continued indefinitely in time within the established boundary conditions. As time increases, the effect of the initial conditions becomes less influential as the boundary conditions dominate the process.

The hyperbolic partial differential equations contrast the elliptic differential equations in which the process is not time dependent. In this case the initial conditions are the boundary conditions and are independent of time. A typical process described by this form is a two-dimensional temperature distribution in a thin plate with prescribed boundary conditions along the edges.

The third type of partial differential equations are parabolic equations, with the solution requirements being similar to the hyperbolic form. The simplest parabolic equation is the one-dimension heat-flow equation.

In subsequent text only the hyperbolic partial differential equation for gradually varied freesurface unsteady flow are discussed.

# 1.2 Continuity and Momentum Equations of Unsteady Flow

The two basic quasi-linear hyperbolic partial differential equations of gradually varied free-surface unsteady flow are derived in Chapter 3, Part I, Hydrology Paper No. 43, as Eqs. 3.23 and 3.19, and are reproduced here in their final dimensionless forms. The continuity equation is

$$\frac{A}{VB} \frac{\partial V}{\partial x} + \frac{\partial y}{\partial x} + \frac{1}{V} \frac{\partial y}{\partial t} = \frac{q}{VB} , \qquad (1.1)$$

and the momentum equation is

$$\frac{\alpha V}{g} \frac{\partial V}{\partial x} + \frac{\beta}{g} \frac{\partial V}{\partial t} + \frac{\partial y}{\partial x} = (S_o - S_f) - \beta \frac{Vq}{Ag} , \qquad (1.2)$$

in which

ß

- A = the cross-section area, V = the mean cross-section y
  - = the mean cross-section velocity as a dependent variable,
- = the water depth in the conduit as a dependent variable,
- = the length along the conduit as an independent variable,
- t = the time as an independent variable,
- B = the water surface width,
- a = the energy velocity distribution coefficient,
  - = the momentum velocity distribution coefficient,
- g = the gravitational acceleration.
- So = the slope of the conduit invert,
- $S_{f}$  = the energy gradient, and
- q = the distributed lateral inflow (or outflow) as discharge per unit length of the conduit.

The energy gradient, measuring the energy head loss along the conduit, is expressed in this study by the Darcy-Weisbach equation in the form

$$S_{f} = \frac{fV^2}{8gR} , \qquad (1.3)$$

in which f is the Darcy-Weisbach friction factor, R is the hydraulic radius of a partially full conduit, with R = A/P, and P is the wetted perimeter.

The friction factor (f) is expressed as a function of Reynolds number,  $R_e$  = VR/v, with  $\nu$  the kinematic viscosity of the water.

Equations 1.1 and 1.2 generally give the closest approximations of the actual flood movement through channels and conduits, if the basic conditions for applying the two equations are approximately satisfied. The most important condition is that of gradual variability of the flood hydrograph; this condition is nearly always fulfilled for storm floods entering into and moving along storm drains.

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#### 1.3 Methods of Solving Equations of Unsteady Flow

All methods available in literature for solving Eqs. 1.1 and 1.2 may be grouped into analytical, graphical, and numerical procedures. The numerical procedures depend on the computational devices available.

Analytical solutions. The partial differential equations 1.1 and 1.2 have a friction slope,  $S_f$ , proportional to the square of the velocity or to the square of the discharge. Because their coefficients are functions of dependent variables (V, y), they are non-linear differential equations of the hyperbolic type. Because of the inherent mathematical difficulties of these non-linear and non-homogeneous equations, there is no way to carry out the analytical integration in closed form, unless many simplifications are introduced.

The classical approach, first performed by De Saint-Venant, neglects friction resistance and assumes the channel to be horizontal with wide rectangular cross sections. These assumptions deviate so much from the reality of flood-wave movement in channels and conduits that the wave characteristics resulting from analytical integration are generally not comparable with true wave characteristics. This classical approach by means of analytical integration is an extreme; it may be considered to be a rough approximation, and, in accuracy, can be compared with some of the very simple integration procedures of flood routing that are based on the water storage ordinary differential equation.

The use of analytical integration makes it necessary to approximate and simplify both the initial conditions and the boundary conditions by analytical expressions, which are used in Eqs. 1.1 and 1.2. The inflow hydrograph as the boundary condition, and the wave profile along the conduit, as the initial condition, must be mathematically approximated by considering them to be either symmetrical or asymmetrical waves, with functions of bell-shaped curves (gammafunctions, and others). The channel conditions may be represented by the cross section area or width as functions of water depth and distance along the conduit, with a roughness coefficient usually a constant, and the bottom slope being either a constant or a function of distance. The lateral inflow and outflow are taken as constant or are approximated by simple functions of channel and lateral flow characteristics, and of time.

The great diversity in shape and roughness of natural channels, free-surface flow conditions and the complexity of the pattern of the lateral inflows and outflows tend to complicate the analytical expressions that approximate these conditions to the extent that the analytical integration of the two partial differential equations becomes impossible. In summary, the two partial differential equations for unsteady flow can be integrated analytically, with expressions for wave evolution, by rather restrictive and very simplifying conditions, which generally are not acceptable for the solution of current practical problems.

For some discussions and abstracted references about the analytical solutions of simplified conditions for flood routing through conduits and channels, as well as of graphical and numerical solutions, see the "Bibliography and Discussion of Flood-Routing Methods and Unsteady Flow in Channels" [1]\*, and the general reference list in Appendix 2 of Hydrology Paper No. 43 (Part I of this series of four papers).

<u>Graphical solutions</u>. The graphical solutions of equations for free-surface unsteady flow may be characterized by the following procedure. The celerity of the disturbance in the distance-time reference plane, (x,t) - plane, is computed from the simplified wave relation

$$\frac{dx}{dt} = V \pm \sqrt{gy}_{\star} , \qquad (1.4)$$

in which V is the mean velocity of flow,  $y_*$  is the hydraulic depth (A/B) in any cross-sectional shape, and g is the gravitational acceleration.

The term  $C = \sqrt{gy_{\star}}$  is usually referred to as the celerity of a small disturbance moving in a quiescent water of a channel. The terms  $V + \sqrt{gy_{\star}}$  and  $V - \sqrt{gy_{\star}}$  are called either the wave velocity [2, p. 540], or the celerity of a small disturbance in the moving fluid [1, p. 10]. This latter term will be used in this paper when Eq. 1.4 is discussed or used. If the first derivative, dt/dx, in the (x,t) - plane is used as the measure of the celerities of disturbances in the moving water, then the inverse of Eq. 1.4 should be used as

$$\frac{dt}{dx} = \frac{1}{V \pm \sqrt{gy_{\star}}} \qquad (1.5)$$

In case of the circular conduit in which flood waves move with gradually varied free-surface flow,  $y_*$ should be replaced by  $y_* = f(y)$ , a function of water depth.

In the discussion to follow the two directions of Eq. 1.5 will be referred to as the characteristic directions, which are first derivatives of characteristic curves, defined in Chapter 3, Part I, Hydrology Paper No. 43. Along the characteristic curves, the wave phenomenon may be expressed by the two ordinary differential equations with two dependent variables as unknowns. Thus, starting from the known values of the dependent variables (V and y) at two locations in time (t) and position (x), the direction of the characteristics may be graphically plotted. From these plots, the location of the intersections in time and position can be determined. With the known time (t) and position (x) a finite difference solution to the two ordinary differential equations gives the corresponding dependent variables (V and y). Repeating the procedure, the integration proceeds along the time scale for the given length of channel or conduit.

This procedure has been used extensively by Parmakian in his book on waterhammer analysis [3]. Akers and Harrison presented a similar analysis for free-surface unsteady flow in a circular channel in their paper on attenuation of flood waves in partially full pipes, [4].

The limitations of graphical procedures are immediately evident when one considers the effect of \*[] Reference numbers refer to the list of references at the end of this paper.

various parameters, initial and boundary conditions, in a given problem. Thus the graphical solution has limited application at present because of the labor involved, except perhaps for the visualization of the digital computer schemes and the results to be presented.

<u>Numerical solutions</u>. Various numerical procedures have been used in the past. The excessive number of calculations in order to progress the solution in time, however, has limited the application of these solutions.

The two partial differential equations, 1.1 and 1.2, are usually approximated by the two finitedifferences equations, replacing the increments (dx, dt, dV, dy) by the finite differences ( $\Delta x$ ,  $\Delta t$ ,  $\Delta V$ ,  $\Delta y$ ). At the same time the partial derivatives are replaced by ratios of finite differences:  $\partial V/\partial x$ by  $\Delta V/\Delta x$ ,  $\partial V/\partial t$  by  $\Delta V/\Delta t$ ,  $\partial y/\partial x$  by  $\Delta y/\Delta x$ , and  $\partial y/\partial t$  by  $\Delta y/\Delta t$ . With  $\Delta x$  and  $\Delta t$  given,  $\Delta V$ and  $\Delta y$  are changes of dependent variables which occur for these finite differences.

The basic characteristics of the above finitedifference approximations are: (1) the accuracy depends on the size and relation of finite differences  $\Delta t$  and  $\Delta x$ ; (2) the smaller the  $\Delta x$ , the more involved the computation work, but also the greater the accuracy may be, and (3) the values of dependent variables computed for the end of a  $\Delta t$  become the initial values for the next  $\Delta t$ .

With the development of electronic computers, which provide fast and relatively inexpensive computations, the past drawbacks in economy of performing the operations of the finite-differences method of integration are largely eliminated. The method is highly favored inasmuch as it is the most accurate of all practical methods of flood routing in channels and conduits. The advent of new numerical schemes helped this progress in the use of numerical methods of solution by digital computers.

The results of integration are given for two dependent variables as functions  $V = F_1(x, t)$  and  $y = F_2(x, t)$ . These two functions represent surfaces in the space (V, x, t) and (y, x, t). If there is any discontinuity in the four partial derivatives of Eqs. 1.1 and 1.2, these discontinuities propagate along the channel, and the projection of the position of discontinuities at surfaces  $F_1$  and  $F_2$  in the (x, t)-plane produces lines that are called "characteristics", or "characteristic lines". These lines are usually curves, but in application may be replaced by straight lines along the finite differences  $\Delta x$ and  $\Delta t$ .

The simplified characteristic lines are usually given in the form

$$dx = (V \pm \sqrt{gy}) dt,$$
 (1.6)

and

$$d(V \pm 2 \sqrt{gy_*}) = g(S_0 - S_f)dt$$
, (1.7)

which are equivalent to Eqs. 1.1 and 1.2. The hydraulic depth ( $y_{\star}$ ) should be expressed as a function of y for the free-surface flow in circular conduits.

Equations 1.6 and 1.7 are usually numerically integrated by replacing dx and dt with  $\Delta x$  and  $\Delta t$ , and  $d(V \pm 2 \sqrt{gy_*})$  with  $\Delta(V \pm 2 \sqrt{gy_*})$ . Several numerical procedures have been developed for these approximations in the finite-differences form.

Certain features of the method of numerical integration by characteristics are important for applicability in practical cases in flood routing by finite differences: (1) the long wave is assumed to be composed of many elementary waves in the form of small surges so that for the time  $\Delta t$  and the reach  $\Delta x$ , the velocity change,  $\Delta V$ , and height change,  $\Delta y$ , are considered as discontinuities traveling with celerities  $V \pm \sqrt{gy}$  (providing only a rough approximation in the case of long flood waves, where the friction forces are not negligible); (2) the straight-line characteristics for  $\Delta x$  and  $\Delta t$ , and (3) some complexity of procedure when friction factors, channel slope, sudden changes of cross section, bifurcations, junctions, and similar changes, are to be taken into consideration.

With the advent of computers and new numerical schemes, numerical integration by finite differences of Eqs. 1.6 and 1.7 has become economical. The general applicability of various electronic computers (analog, hybrid, digital) to the numerical integration either of Eqs. 1.1 and 1.2, or of Eqs. 1.6 and 1.7, is discussed in the next subchapter.

<u>Concluding remarks</u>. All three methods -- analytical, graphical, and numerical -- by finite differences applied either to partial differential equations or to characteristic differential equations, when applicable, give sufficiently accurate results if the methods are extended to their limits of accuracy. These methods can be successfully applied to the analysis of particular waves that have been observed. The practical prediction of wave movement, however, requires a considerable amount of work, especially when the network of drains is complex.

The mathematical difficulties of analytical integration of the two partial differential equations, the need for a large amount of data for the graphical methods, the accompanying drawbacks of time-consuming procedures and the cost in applying the approximate methods of numerical integration have provided incentive for developing simpler, but generally less accurate, flood-routing methods [1]. Since the objective of this study is to produce research results that lead to practical methods in using complete Eqs. 1.1 and 1.2, or Eqs. 1.6 and 1.7, in routing flood hydrographs through storm drains, the only acceptable integration methods from both economic and accuracy standpoints are numerical methods by finite differences and the use of electronic computers. This paper is, therefore, concerned only with these latter methods.

#### 1.4 Computer Oriented Numerical Solutions

The obvious conclusion to the dilemma of excessive repetitive calculations and the limit of manual computations is the use of electronic computers. Three possibilities exist for the solution of the problem equations.

One type of computer is the analog computer in which the mathematical functions are simulated by suitable amplifiers, potentiometers or other electronic elements. The combination of these elements simulate the mathematical equations of the physical phenomenon. This technique is particularly desirable for a physical system with fixed parameters and repetitive operations. This analog system permits an evaluation of the effect of variations in boundary conditions. A disadvantage of the analog solution would be the problems of generating the geometric and hydraulic parameters at each stage in the computations.

The hybrid electronic computer permits continuous evaluation of the differential equations by analog and evaluates the required parameters by digital computation. Thus, a continuous solution can be obtained with the geometric and hydraulic parameters evaluated by direct computation. The availability of such computers is still limited, but hybrid computers may become the best computational device for unsteady flow. The programming is specialized and not readily usable by most programmers. For these reasons the more conventional digital computer has been generally used and will be discussed exclusively in this paper.

The digital computer presents the advantage of rapid arithmetical operations and a relatively simple and versatile programming capability. The basic limitation is that integration cannot be expressed as a continuous function as is done in the analog computer. This requires that any integration of an equation or a set of equations be represented by a series of discrete elements. The approximation to the correct integration would be expected to improve as the size of the discrete elements decreased and their number increased. This is an acceptable assumption for many integration processes. However, it cannot be assumed that it is correct for all cases. This is due to the effect of round-off and truncation errors within the computer. For this study it has been assumed that the functions to be integrated are "well

behaved" and may be reasonably integrated by the assumption of discrete increments of the variables of integration.

There are a large variety of numerical integration procedures available for the solution of the St-Venant partial differential equations of gradually varied free-surface unsteady flow. One method of categorization of these basic procedures is to consider solutions depending on the two partial differential equations of 1.1 and 1.2 of the phenomenon; in the other method solutions depend on the ordinary differential equation forms, Eqs. 1.6 and 1.7, of the same equations. How the forms of the ordinary differential equations are derived from the partial differential equations is shown in Chapter 3 of Part I, Hydrology Paper No. 43.

### 1.5 Objectives of Studies Presented in this Paper

The objectives of this paper are to present only the results of studies concerning the numerical solutions by various finite-differences schemes, either for the case of the two partial differential equations, 1.1 and 1.2, or for the case of the four characteristics equations, 1.6 and 1.7. Chapter 2 analyzes the applicability of various finite-difference schemes in the numerical solution of the two partial differential equations. Chapter 3 analyzes the various finitedifference schemes in the numerical solution of the four characteristic equations. The applicability of various schemes is discussed at the end of each of these two chapters. Chapter 4 is a comparison of the best finite-difference schemes in the case of numerical solution of partial differential equations and numerical solution of characteristic equations. Chapter 5 presents the conclusions and recommendations for further research.

#### Chapter 2

#### INTEGRATION OF PARTIAL DIFFERENTIAL

#### EQUATIONS BY FINITE DIFFERENCES

#### 2.1 Finite-Difference Methods

The finite-difference methods of numerical integration to be discussed refer to the partial differential equations of gradually varied freesurface unsteady flow. Because these equations do not permit a closed analytical solution, approximate numerical methods of integration must be employed. Since all numerical integration methods are fundamentally finite-difference procedures some distinctions between various methods or schemes are appropriate.

For this presentation, the term "finite-difference method" will refer to the approximation to the partial derivatives as the ratios of differences of finite values of the dependent variables at fixed uniform intervals. The ratios of finite differences will approach the partial derivatives as the intervals or differences become smaller. The basic definition of a partial derivative in x of a two-variable function, f(x, y), is

$$\frac{\partial f(x, y)}{\partial x} = \lim_{\Delta x \to 0} \left[ \frac{f(x + \Delta x, y) - f(x, y)}{\Delta x} \right] . (2.1)$$

Using the right side of this equation, the partial derivative may be approximated as nearly accurate as desired by selecting a small difference  $\Delta x$ .

For solving De Saint-Venant equations 1.1 and 1.2 difference approximations are made as follows. Since there are two independent variables and two dependent variables, designation of the time-distance locations of the variables will be based on the subscripts and superscripts of the variables. The subscript will refer to the distance (space) location, and the superscript to the time location as shown in Fig. 2.1.





Fig. 2.1. Definition graph for the finite-difference scheme.

Thus, the depth at distance location i and at time location j is designated as  $y_1^{\frac{1}{2}}$ . The four partial derivatives of Eqs. 1.1 and 1.2 may be approximated by

$$\frac{\partial V}{\partial x} \approx \frac{V_{i+1}^{j} - V_{i}^{j}}{x_{i+1}^{j} - x_{i}^{j}} , \qquad (2.2)$$

$$\frac{\partial V}{\partial t} = \frac{V_i^{j+1} - V_i^j}{t_i^{j+1} - t_i^j}, \qquad (2.3)$$

$$\frac{\partial y}{\partial x} = \frac{y_{i+1}^{j} - y_{i}^{j}}{x_{i+1}^{j} - x_{i}^{j}}$$
, (2.4)

and

$$\frac{\partial y}{\partial t} = \frac{y_i^{j+1} - y_i^j}{t_i^{j+1} - t_i^j} . \qquad (2.5)$$

The unknown quantities in these expressions are generally the values at the incremental time locations, j+1. Thus  $V_i^{j+1}$  and  $y_i^{j+1}$  are the unknown values. With the two equations of unsteady flow, these two unknowns may be solved for simultaneously. This procedure is referred to as an explicit scheme in that the conditions at a later time, j+1, are determined directly from the conditions at the preceding time, j. Other explicit schemes are presented in the next subchapter.

Another manner of expressing the partial derivatives with respect to the distance position is

$$\frac{\partial V}{\partial x} \approx \frac{V_{i+1}^{j+1} - V_{i}^{j+1}}{x_{i+1}^{j+1} - x_{i}^{j+1}} , \qquad (2.6)$$

and

$$\frac{\partial y}{\partial x} = \frac{y_{i+1}^{j+1} - y_{i}^{j+1}}{x_{i+1}^{j+1} - x_{i}^{j+1}} \quad . \tag{2.7}$$

The partial derivatives in the case of Eqs. 2.6 and 2.7 are described in terms of the independent variable x along the incremental time locations. Therefore, there are four unknowns of V and y, at two distance locations at a given incremental time location. The two equations of unsteady flow at a given point in time and distance are insufficient for the solution. However, if a system of simultaneous equations are developed for each point, there will be as many equations as the total number of unknowns. A simultaneous solution of this set then results in the desired solution. This scheme is referred to as the implicit solution since all solutions are directly interrelated. No attempt was made to use this method, however, because of the limits in solving equations for the dependent variables at an unlimited number of distance locations.

A physical and, consequently, mathematical limitation to either an explicit or implicit scheme is imposed by the direction a disturbance travels in the time-distance reference plane. The directions of a disturbance are commonly referred to as the characteristic directions and are defined by Eq. 1.5. The two expressions for dt/dx of Eq. 1.5 represent the two directions the disturbances propagate along.

If one considers these directions as emanating from a single given point in the time-distance plane, where a disturbance occurred, the region x and tbetween these two directions is affected by the disturbance. This region is the "region of influence". If one considers the disturbances as having occurred at two different locations in the time-distance plane, two of the four directions will intersect. The region bounded by this intersection is the "domain of dependence." The dependent variables in this region are functions of all their previous values within this region. As a corollary, the values of dependent variables outside this region.

Thus, the directions of the disturbance or characteristic directions in the (x, t) - plane divide the time-distance plane into a region wherein solutions from given conditions are possible, and a region in which solutions are theoretically impossible. It is necessary to consider this in any finitedifference method of integrating the two partial differential equations. The general criterion to be applied is that

$$\frac{dt}{dx} \approx \frac{1}{V \pm \sqrt{g A/B}} , \qquad (2.8)$$

in which V and A/B are the average values for the specified finite differences,  $\Delta x$  and  $\Delta t$ . The criteria of Eq. 2.8 is valid for all values of the dependent variables in the solution. The nearer the two points in the (x, t) - plane are, the more nearly the numerical solution will approach the true solution.

#### 2.2 Various Finite-Difference Schemes

Equations 2.2 through 2.5 present the simplest approximation by the finite-difference expressions to the partial derivatives. A wide variety of schemes, usually more sophisticated than Eqs. 2.2 through 2.5, have been developed by various authors to provide better accuracy and to maintain the stability of the solutions with minimum computational work.

Richtmeyer [5] presented six schemes with their corresponding truncation errors. These schemes are presented in Table 2.1. This table displays the computational template of the (x, t) - plane, the approximation to the partial derivatives, and the order of the truncation error  $O(\Delta)$ , due to the approximation where  $\Delta$  is the symbol of increment, either  $\Delta x$  or  $\Delta t$ .

Substituting these approximations into the basic equations results in a pair of equations with two unknowns, velocity and depth, at the end of the time interval.

The "unstable scheme" is inherently unstable. It is presented to demonstrate the simplest scheme, and to permit comparison of stable schemes with this basic scheme.

The diffusing scheme is the simplest stable scheme. It offers two approaches for computation. One approach consists of the staggered scheme as presented in Table 2.1. It uses known values of V and y at the i-1 and the i+1 distance positions at time t to compute the dependent variables at the distant position i, at time t +  $\Delta t$ . This approach determines values at all locations defined by i+j equal an even number. The other approach is to advance one  $\Delta x$ and thus compute the dependent variables at each intersection. This approximately doubles the computational time but produces results at one-half the intervals of the first method.

In order for the diffusing scheme to be stable, it is necessary that

$$\frac{\Delta t}{\Delta x} \leq \left| \frac{1}{V \pm \sqrt{g A/B}} \right|$$

be a condition throughout the computation. As the flow progresses into the super-critical range, this condition is less likely to be fulfilled unless an arbitrary reduction in  $\Delta t$  is made. An additional limitation of this scheme is the assumed linearity of the dependent variables within the interval from i-1 to i+1.

The upstream differencing scheme is similar to the diffusing scheme. The computer programming, however, is somewhat more involved because of the necessity of deciding which representation of the distance derivative to use for each computation. For this reason this scheme was not investigated in this study.

The leap-frog scheme is an improvement over the diffusing scheme in that the time derivative is estimated from the computed values of the dependent variables at the t -  $\Delta$ t time position. The limitation of this procedure is similar to that of the diffusing scheme. An additional limitation is the required computer storage of computed values at three successive times as compared to two successive times for the other schemes.

The previously described schemes all depend on an assumption of linearity between the time-distance junctions for the description of the partial derivatives at the pivot point (i, j). An improvement to this assumption is to recognize the rate-of-change of the derivative as defined by the known values of the dependent variables at three points. The Lax-Wendroff method provides this recognition. The procedure is described in detail in a following subchapter. The consistent reproduction of initial conditions for a constant discharge, regardless of the curvature of the water surface, is the benefit derived from this method.

The implicit scheme requires the solution of a system of simultaneous equations equal in number to the number of distance intervals plus one. Two of

	UNSTABLE	DIFFUSING	UPSTREAM DIFFERENCING	LEAP FROG	LAX WENDROFF	IMPLICIT
COMPUTATIONAL TEMPLATE × Unknown o Known t t x	j+I- j i-Ii i+I	j+1 j i-1 j j+1	j+1 j ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓	j + 1 j j j - 1 j	j+1- j i-l i i+l	j+I <b>* * *</b> j <b>← </b>
PARTIAL ∂u DERIVATIVE	$\frac{\mathtt{v}_{i+1}^{j}-\mathtt{v}_{i-1}^{j}}{2\Delta \mathtt{x}}$	$\frac{v_{i+1}^{j} - v_{i-1}^{j}}{2\Delta x}$	$\frac{\mathbf{U}_{i+1}^{j}-\mathbf{U}_{i}^{j}}{\Delta \mathbf{x}}\mathbf{or}\frac{\mathbf{U}_{i}^{j}-\mathbf{U}_{i-1}^{j}}{\Delta \mathbf{x}}$	$\frac{v_{i+1}^j - v_{i-1}^j}{2\Delta x}$	Depends on form of partial different- ial equation.	$\frac{\mathtt{v}_{i+1}^{\mathtt{j+1}} \hspace{-0.1cm} \hspace{-0.1cm} \mathtt{v}_{\mathtt{i-1}}^{\mathtt{j+1}} \hspace{-0.1cm} \hspace{-0.1cm} \hspace{-0.1cm} \hspace{-0.1cm} \hspace{-0.1cm} \mathtt{v}_{\mathtt{i-1}}^{\mathtt{j}} \hspace{-0.1cm} \hspace{-0.1cm} \hspace{-0.1cm} \mathtt{v}_{\mathtt{i-1}}^{\mathtt{j}} \hspace{-0.1cm} -0.1c$
$\frac{\partial U}{\partial t} \approx$	$\frac{\mathtt{U_i^{j+1}}-\mathtt{U_i^j}}{\Delta t}$	$\underbrace{\frac{\boldsymbol{\upsilon_i^{j+1}} - \underbrace{\boldsymbol{\upsilon_{i+1}^{j}} + \boldsymbol{\upsilon_{i-1}^{j}}}{2}}_{\Delta t}}_{\Delta t}$	$\frac{\mathtt{u_i^{j+1}}-\mathtt{u_i^{j}}}{\Delta \mathtt{t}}$	$\frac{\underline{v_{i}^{j+1}}-\underline{v_{i}^{j-1}}}{2\Delta t}$		$\frac{U_{i}^{j+1}-U_{i}^{j}}{\Delta t}$
						2
TRUNCATION ERROR	0[Δ <sup>2</sup> ]	0[Δ <sup>2</sup> ]	0[\$ <sup>2</sup> ]	0[Δ <sup>3</sup> ]	0[Δ <sup>3</sup> ]	0[Δ <sup>3</sup> ]

Table 2.1 Various finite-difference schemes

these equations involve the boundary conditions. This system was not used because of the number of equations that needed to be solved simultaneously, for an arbitrarily long conduit.

All but one of the above schemes are explicit. Two of the schemes, the diffusing scheme and the Lax-Wnedroff scheme, are used in this study to solve the De Saint Venant equations. These solutions provide good accuracy and require only reasonable computer time. The diffusing and Lax-Wendroff schemes are summarized in the following two subchapters.

#### 2.3 Diffusing Scheme

The diffusing scheme evolves from the following approximation to the partial derivatives with respect to time. The schemes in Table 2.1 is the definition graph for the location of significant variables. It is assumed that the dependent variables are known for all positions at time j. The dependent variable will be designated as U in this development, and it may refer either to the V or y dependent variables of the two partial differential equations. The objective is to represent the partial derivatives as functions of the unknown dependent variable U at distance location i and time location j+1. The partial derivative of U with respect to t is approximated by

$$\left(\frac{\partial U}{\partial t}\right)_{i} = \left(\frac{\Delta U}{\Delta t}\right)_{i} , \qquad (2.9)$$

in which

$$\Delta U_{i} = U_{i}^{j+1} - U_{i}^{j} \quad . \tag{2.10}$$

Expressing U; as an average

$$U_{i}^{j} = \frac{U_{i+1}^{j} + U_{i-1}^{j}}{2} , \qquad (2.11)$$

then

$$\Delta U_{i} = U_{i}^{j+1} - \frac{U_{i+1}^{j} + U_{i-1}^{j}}{2} , \qquad (2.12)$$

and finally the finite difference approximation to this partial derivative is

$$\left( \frac{\Delta U}{\Delta t} \right)_{i} = \frac{U_{i}^{j+1} - \frac{U_{i+1}^{j} + U_{i-1}^{j}}{\Delta t}}{t}$$

$$= \frac{2U_{i}^{j+1} - U_{i+1}^{j} - U_{i-1}^{j}}{2\Delta t} .$$

$$(2.13)$$

Similarly, the partial derivative with respect to the distance x is approximated by

$$\left(\frac{\partial U}{\partial x}\right)_{i} \approx \left(\frac{\Delta U}{\Delta x}\right)_{i}$$
, (2.14) or

in which

$$\left(\frac{\Delta U}{\Delta x}\right)_{i} = \frac{1}{2} \left[ \frac{U_{i+1}^{j} - U_{i}^{j}}{\Delta x} + \frac{U_{i}^{j} - U_{i-1}^{j}}{\Delta x} \right], \qquad (2.15)$$

so that

$$\left(\frac{\Delta U}{\Delta x}\right)_{i} = \frac{1}{2\Delta x} \left(U_{i+1}^{j} - U_{i-1}^{j}\right) \quad . \tag{2.16}$$

It is to be noted that both partial derivatives are approximated for the location i, j.

#### 2.4 Lax-Wendroff Scheme

The Lax-Wendroff finite difference scheme was investigated to eliminate some of the deficiencies of the diffusing scheme. The summary of the scheme is as follows. It is assumed that all functions are continuous and contain as many continuous derivatives as required. It is also assumed that products of first-order partial derivatives, and any derivative of  $S_f$  in x and t are negligible quantities.

The expressions  $\frac{\partial A}{\partial t} = B \frac{\partial y}{\partial t}$  and  $\frac{\partial A}{\partial x} = B \frac{\partial y}{\partial x}$ relate A, B, and y. Therefore, the equation of continuity reduces to

$$\frac{\partial y}{\partial t} = -\frac{A}{B}\frac{\partial V}{\partial x} - V \frac{\partial y}{\partial x} . \qquad (2.17)$$

The intended application of the Taylor series requires the use of second-order partial derivatives. Thus,

$$\frac{\partial^2 y}{\partial t^2} = -\frac{A}{B} \frac{\partial^2 V}{\partial x \partial t} - V \frac{\partial^2 y}{\partial x \partial t} , \qquad (2.18)$$

and

$$\frac{\partial^2 y}{\partial x \partial t} = -\frac{A}{B} \frac{\partial^2 v}{\partial x^2} - v \frac{\partial^2 y}{\partial x^2} . \qquad (2.19)$$

The momentum equation, 1.2, is rewritten here in the form

$$\frac{\partial V}{\partial t} = -\frac{\alpha}{\beta} \quad V \frac{\partial V}{\partial x} - \frac{g}{\beta} \quad \frac{\partial y}{\partial x} - \frac{g}{\beta} \quad (S_f - S_o), \quad (2.20)$$

which gives then

$$\frac{\partial^2 V}{\partial x \partial t} = -\frac{\alpha}{\beta} \quad V \quad \frac{\partial^2 V}{\partial x^2} - \frac{g}{\beta} \quad \frac{\partial^2 y}{\partial x^2} \quad . \tag{2.21}$$

Hence, Eq. 2.18 becomes

$$\frac{\partial^2 y}{\partial t^2} = \frac{A}{B} \frac{1}{\beta} \left( \alpha V \frac{\partial^2 V}{\partial x^2} + g \frac{\partial^2 y}{\partial x^2} \right) + \frac{VA}{B} \frac{\partial^2 V}{\partial x^2} + V^2 \frac{\partial^2 y}{\partial x^2}$$

$$\frac{\partial^2 y}{\partial t^2} = \left(\frac{\alpha}{\beta} + 1\right) \frac{AV}{B} \frac{\partial^2 V}{\partial x^2} + \left(\frac{g}{\beta} \frac{A}{B} + V^2\right) \frac{\partial^2 y}{\partial x^2} . \qquad (2.22)$$

Equation 2.20 then gives

$$\frac{\partial^2 V}{\partial t^2} = -\frac{\alpha}{\beta} \quad V \frac{\partial^2 V}{\partial x \partial t} - \frac{g}{\beta} \frac{\partial^2 y}{\partial x \partial t} \quad . \tag{2.23}$$

Substituting Eqs. 2.19 and 2.21 into Eq. 2.23 yields

$$\frac{\partial V^2}{\partial t^2} = -\frac{\alpha}{\beta} V(-\frac{\alpha}{\beta} V \frac{\partial^2 V}{\partial x^2} - \frac{g}{\beta} \frac{\partial^2 y}{\partial x^2}) - \frac{g}{\beta} (-\frac{A}{B} \frac{\partial^2 V}{\partial x^2} - V \frac{\partial^2 y}{\partial x^2})$$

$$\frac{\partial^2 V}{\partial t^2} = \left[ \left(\frac{\alpha}{\beta}\right)^2 V^2 + \frac{g}{\beta} \frac{A}{B} \right] \frac{\partial^2 V}{\partial x^2} + \left(\frac{\alpha}{\beta} + 1\right) \frac{g}{\beta} V \frac{\partial^2 y}{\partial x^2} . \quad (2.24)$$

Putting U as the symbol for any dependent variable V or y, then for any U(x, t) and a fixed x, a Taylor series expansion gives

$$U(t+\Delta t) = U(t) + \Delta t \frac{\partial U}{\partial t} + \frac{(\Delta t)^2}{2} \frac{\partial^2 U}{\partial t^2} + 0[(\Delta t)^3] , (2.25)$$

in which both  $\partial U/\partial t$  and  $\partial^2 U/\partial t^2$  are functions of t. Similarly, for a fixed t,

$$U(x+\Delta x) = U(x) + \Delta x \frac{\partial U}{\partial x} + \frac{(\Delta x)^2}{2} \frac{\partial^2 U}{\partial x^2} + 0[(\Delta x)^3], \quad (2.26)$$

and

$$U(\mathbf{x}-\Delta \mathbf{x}) = U(\mathbf{x}) - \Delta \mathbf{x} \frac{\partial U}{\partial \mathbf{x}} + \frac{(\Delta \mathbf{x})^2}{2} \frac{\partial^2 U}{\partial \mathbf{x}^2} - O[(\Delta \mathbf{x})^3]. \quad (2.27)$$

Subtracting Eq. 2.27 from Eq. 2.26 yields

$$\frac{\partial U}{\partial x} \approx \frac{U(x+\Delta x) - U(x-\Delta x)}{2\Delta x} + 0[(\Delta x)^3] \qquad (2.28)$$

Adding Eq. 2.27 and Eq. 2.26 yields the approximation of the second-order partial derivative of U with respect to  $\ x$ 

$$\frac{\partial^2 U}{\partial x^2} = \frac{U(x+\Delta x) - 2U(x) + U(x-\Delta x)}{(\Delta x)^2} + 0[(\Delta x)^4] . (2.29)$$

Substituting V and y for U, respectively, and using Eqs. 2.17, 2.20, 2.22, and 2.24 for the appropriate partial derivatives with respect to t in Eq. 2.25 produces

$$V(t+\Delta t) = V(t) - \frac{\Delta t}{\beta} \left[ \alpha V \frac{\partial V}{\partial x} + g \frac{\partial y}{\partial x} + g(S_{f} - S_{o}) \right]$$

$$+ \frac{(\Delta t)^2}{2} \left[ \left( \frac{\alpha^2 V^2}{\beta^2} + \frac{g}{\beta} \frac{A}{B} \right) \frac{\partial^2 V}{\partial x^2} \right] + 0[(\Delta t)^3] , \qquad (2.30)$$

and

$$y(t+\Delta t) = y(t) - \Delta t \left(\frac{A}{B} \frac{\partial V}{\partial x} + V \frac{\partial y}{\partial x}\right)$$
  
+  $\frac{(\Delta t)^2}{2} \left[ \left(\frac{\alpha}{\beta} + 1\right) \frac{AV}{B} \frac{\partial^2 V}{\partial x^2} + \left(\frac{A}{B} \frac{g}{\beta} + V^2\right) \frac{\partial^2 y}{\partial x^2} \right]$   
+  $0 \left[ (\Delta t)^3 \right] . \qquad (2.31)$ 

Let j index the t intervals and i index the x intervals. Referring to Eqs. 2.28 and 2.29, the first and second partial derivatives with respect to x are approximated by

$$\frac{\partial U}{\partial x} = \frac{U_{i+1}^{j} - U_{i-1}^{j}}{2\Delta x}$$
(2.32)

and

$$\frac{\partial^2 U}{\partial x^2} = \frac{U_{i+1}^j - 2U_i^j + U_{i-1}^j}{(\Delta x)^2}$$
(2.33)

Thus, recurrence relations for finding approximate solutions to V and y in Eqs. 2.30 and 2.31 are

$$y_{i}^{j+1} = y_{i}^{j} - \frac{\Delta t}{2\Delta x} \left[ \left( \frac{A}{B} \right)_{i}^{j} \left( V_{i+1}^{j} - V_{i-1}^{j} \right) + V_{i}^{j} \left( y_{i+1}^{j} - y_{i-1}^{j} \right) \right] \\ + \frac{1}{2} \left( \frac{\Delta t}{\Delta x} \right)^{2} \left\{ \left( \frac{\alpha}{\beta} + 1 \right) \left( \frac{A}{B_{i}^{j}} V_{i}^{j} \left( V_{i+1}^{j} - 2V_{i}^{j} + V_{i-1}^{j} \right) \right. \\ + \left[ \frac{g}{\beta} \left( \frac{A}{B_{i}^{j}} + \left( V_{i}^{j} \right)^{2} \right] \left( y_{i+1}^{j} - 2y_{i}^{j} + y_{i-1}^{j} \right) \right\}$$
(2.34)

and

$$v_{i}^{j+1} = v_{i}^{j} - \frac{\Delta t}{2\beta\Delta x} \left[ \alpha V_{i}^{j} (v_{i+1}^{j} - V_{i-1}^{j}) + g(y_{i+1}^{j} - y_{i-1}^{j}) + 2g\Delta x(S_{f} - S_{o}) \right]$$

$$+ \frac{1}{2} \left( \frac{\Delta t}{\Delta x} \right)^{2} \left\{ \left[ \left( \frac{\alpha}{\beta} \right)^{2} (v_{i}^{j})^{2} + \frac{g}{\beta} \left( \frac{A_{i}^{j}}{B_{i}^{j}} \right) \right] (v_{i+1}^{j} - 2v_{i}^{j} + v_{i-1}^{j})$$

$$+ \left( \frac{\alpha}{\beta} + 1 \right) \frac{g}{\beta} v_{i}^{j} (y_{i+1}^{j} - 2y_{i}^{j} + y_{i-1}^{j}) \right\} .$$

$$(2.35)$$

For those cases in which the products of the first order partial derivatives and the derivatives of  $S_f$  cannot be disregarded, difference equations analogous to Eqs. 2.34 and 2.35 may be derived by appropriate substitutions of relations from Table 2.2 into Eqs. 2.25, 2.26, and 2.27.

#### TABLE 2.2

#### Substitutions

The substitutions in the following equations are:

$$M = \frac{(1 - \frac{2y}{D})}{\sqrt{\frac{y}{D}(1 - \frac{y}{D})}}, \text{ with } D \text{ the conduit diameter;}$$

$$N = \frac{1}{D} \left\{ \frac{B}{\cos^{-1}(1 - \frac{2y}{D})} - \frac{A}{\frac{D}{D} \sqrt{\frac{y}{D}(1 - \frac{y}{D})} \left[\cos^{-1}(1 - \frac{2y}{D})\right]^{2}} \right\};$$
  

$$\frac{\partial B}{\partial x} = M \frac{\partial y}{\partial x}, \quad \frac{\partial B}{\partial t} = M \frac{\partial y}{\partial t}, \quad \frac{\partial R}{\partial x} = N \frac{\partial y}{\partial x}, \quad \text{and} \quad \frac{\partial R}{\partial t} = N \frac{\partial y}{\partial t};$$
  

$$\frac{\partial^{2} y}{\partial x \partial t} = \frac{\partial V}{\partial x} \left(-2 \frac{\partial y}{\partial x} + \frac{A}{B^{2}} \frac{\partial B}{\partial x}\right) - \frac{A}{B} \frac{\partial^{2} V}{\partial x^{2}} - V \frac{\partial^{2} y}{\partial x^{2}};$$
  

$$\frac{\partial^{2} y}{\partial t^{2}} = - \frac{\partial V}{\partial x} \left(\frac{\partial y}{\partial t} - \frac{A}{B^{2}} \frac{\partial B}{\partial t}\right) - \frac{A}{B} \frac{\partial^{2} V}{\partial x \partial t} - V \frac{\partial^{2} y}{\partial t^{2}} - \frac{\partial V}{\partial t} \frac{\partial y}{\partial t};$$
  

$$\frac{\partial^{2} V}{\partial x \partial t} = - \frac{\alpha}{\beta} \left(\frac{\partial V}{\partial x} \frac{\partial V}{\partial x} + V \frac{\partial^{2} V}{\partial x^{2}}\right) - \frac{g}{\beta} \frac{\partial^{2} y}{\partial x^{2}} - \frac{\alpha}{\beta} \frac{f}{8} \left(\frac{2RV \frac{\partial V}{\partial x} - V^{2}}{R^{2}} - \frac{\partial R}{\partial x}\right)$$
  
and

$$\frac{\partial^2 V}{\partial t^2} = -\frac{\alpha}{\beta} (\frac{\partial V}{\partial x} \frac{\partial V}{\partial t} + V \frac{\partial^2 V}{\partial x \partial t}) - \frac{g}{\beta} \frac{\partial^2 y}{\partial x \partial t} - \frac{\alpha}{\beta} \frac{f}{8} (\frac{2RV \frac{\partial V}{\partial t} - V^2 \frac{\partial R}{\partial t}}{R^2}).$$

#### 2.5 Comparison of Solutions by the Two Schemes

Comparing the solutions of both water depth and water velocity at various times and distances would be redundant. Since the analytical and physical waves will be compared by their water depths at a given position, solutions of y alone are considered. In this analysis, comparison is made for the theoretical dimensions of the experimental conduit, approximately 3 feet in diameter and 822 feet long. In the subsequent plots of these solutions of y iet A be the solutions with all the derivative terms, and A be the solutions without the terms consisting of the product of the first order derivatives and the derivatives of the energy slope, and D the solutions based on the diffusing scheme.

An important criterion of any numerical solution is the ability to repeat the values of y given at the initial conditions as best as possible over a period of time under a constant discharge. Under this steady flow, a critical x position is that which is near the downstream end of the pipe. Figure 2.2 shows the plots of y versus t at x = 796.7ft using the Lax-Wendroff Scheme developed in the previous subchapter, and the method based on the diffusing scheme. In these two methods the total number n of x intervals used was 160, or  $\Delta x = L/n = 822/160$ . It is to be noted that after 175 seconds the maximum drops are about 0.01 and 0.07 ft for A<sub>w</sub> and D<sub>i</sub> schemes, respectively.

Another important criterion in a numerical solution is stability. Paraphrasing material from the Journal of Mathematics and Physics [6] stability is related to the difference between the exact solution of the difference equations and the numerical solution of these equations. This difference may be called the round-off error. In the Journal stability is defined in terms of the growth of round-off errors. That is, strong stability exists if the over-all error due to round-off errors does not grow, and weak stability exists if single round-off errors do not grow. Strong and weak instability occurs if neither of the above is true. Also stated is the assumption that weak stability implies strong stability. Thus, stability is a measure of error propagation.

The first series of tests studying the measure of error propagation was that of strong stability under a constant discharge or steady flow. That is, for both the Lax-Wendroff method and the method based on the diffusing scheme, an error of 0.001 feet was added to the initial condition at each x partition point. Simultaneously, these schemes were run over a period of time using the correct initial conditions, and these same conditions, plus the induced error were used as the starting lines. In both cases the induced error did not grow but approached zero with the developed scheme tending to zero at a faster rate.

Some effects were observed in the second series of tests with reference to weak stability, as the induced error was added only to the middle partition point. Using 81 partition points and observing the solutions of y at x = 4n - 3 and t = 2n - 1, it was found that the developed solution took 225.3 seconds to zero out to five decimal places, and the diffusing scheme took 520.9 seconds.

Of more importance in the matter of stability is the third series of tests studied. This time the constant discharge input hydrograph was replaced by a varying hypothetical input hydrograph. An error of 0.001 feet was added to the initial conditions at the 81st point of a total of 160 partition points in both the Lax-Wendroff scheme and the diffusing scheme. The solutions of y for the same t and x partition points were the same as those observed for the second series of tests. After 180.9 seconds the error at point i = 5 was 0.00001, and the error at the other points has zeroed out to 5 decimal places using the Lax-Wendroff scheme. The diffusing scheme solutions did not show an induced error growth either; this time the error did not stop at zero but became negative.

Thus, these series of tests indicate that both the diffusing scheme and the Lax-Wendroff scheme are stable with the latter showing the greater stability.

The next consideration regarding comparisons of solutions using the hypothetical flood input hydrograph, is that of the effect of interval size. In both the Lax-Wendroff scheme and the diffusing scheme  $\Delta t = \Delta x/4z$ , where z is the initial discharge (Q) divided by the initial area (A). This is done to insure that  $\Delta t$  will be small enough to fall within the domain of dependence. Figure 2.3 shows the plots



Fig. 2.2. Comparison of Lax-Wendroff scheme  $(A_w)$  and the diffusing scheme  $(D_i)$  in reproducing the steady initial conditions along the conduit, at the distance x = 796.7 ft.

of y in feet at x = 735.8 ft versus the number n of  $\Delta x$  intervals used (n = 80, n = 160, and n = 320) for both schemes and for three different The entire length of 822 ft of the conduit was times. divided by n to obtain the corresponding  $\Delta x$ . From top to bottom in Fig. 2.3, the given times t represent y rising (upper graph), y near maximum (central graph), and y falling (lower graph). effects of the size of the  $\Delta x$  intervals are noticeable, and, thus, the corresponding size of At intervals are also noticeable, when comparing the diffusing scheme to the Lax-Wendroff scheme. Since the error in the Taylor series expansion is on the order of  $(\Delta t)^3$ , in which  $\Delta t$  is a function of  $\Delta x$ , the difference in y due to different  $\Delta x$  sizes is not as profound in the Lax-Wendroff scheme solutions as in the diffusing scheme. Figure 2.3 also shows the underestimation by the diffusing scheme similarly shown before in Fig. 2.2 in the study of ability of this scheme to repeat the initial condition under a constant input discharge.

The last consideration in this comparison of solutions involves the Lax-Wendroff scheme but with the assumption  $(A_{WO})$ , or without this assumption  $(A_W)$ , that all products of first-order partial derivatives and any derivative of  $S_f$  are negligible.

Using the same hypothetical input hydrograph, Figs. 2.4 and 2.5 show plots of the depth y versus time t at positions x = 409.1 ft, and x = 797.8 ft, respectively. These figures give the comparisons of results for the developed Lax-Wendroff scheme (A<sub>W</sub>) and the simplified scheme with the above assumption (A<sub>WO</sub>). The difference occurs in the computed hydrographs when the first-order partial derivatives are such that the assumption becomes less valid. That is for example,  $\partial y/\partial t$  is negligible only until the computed water wave reaches a particular x position and causes an increase in y.

#### 2.6 Concluding Remarks

Among the finite-difference schemes, the Lax-Wendroff scheme is considered as superior not only to the diffusing scheme but to all others investigated for the purpose of flood routing through storm drains under the conditions of application of Eqs. 1.1 and 1.2. Taking into account all six schemes, either discussed briefly or analyzed, it is concluded that the Lax-Wendroff scheme is an optimal scheme between the accuracy in the results produced and the computer time necessary for the corresponding numerical solutions. It is, therefore, considered as the feasible numerical computational scheme whenever a gradually varied free-surface unsteady flow is computed directly by numerically integrating the two partial differential equations stated in Chapter 1 as Eqs. 1.1 and i.2.

For benefit to other investigators and users, the computational procedures and programs are reproduced here in the two appendices.

Appendix 1 gives the computation details of the diffusing scheme and Appendix 2 gives the computation details of the Lax-Wendroff scheme. Each appendix contains the following items, (1) Flow chart; (2) Computer program, (3) Definition of variables; this gives the conversion table between the mathematical symbols used in this paper and the symbols used in Fortran language for a CDC 6600 or CDC 6400 digital computer; and (4) Sample input and output.







Fig. 2.5. The same comparison as in Fig. 2.4, except at the position x = 797.8 ft.

#### INTEGRATION OF CHARACTERISTIC DIFFERENTIAL EQUATIONS BY FINITE DIFFERENCES

#### 3.1 Statement of Characteristic Equations

The two partial differential equations of gradually varied free-surface unsteady flow, Eqs. 1.1 and 1.2, when transformed give the four ordinary characteristics differential equations. Their development is shown in Chapter 3, Part I, Hydrology Paper No. 43. The equations with  $\alpha = \beta = 1$ , and q = 0 (Eqs. 3.50 to 3.53 of Part I), are the starting equations and are given here as:

$$\xi_{+} = \left(\frac{dt}{dx}\right)_{+} = \frac{1}{V + \sqrt{gA/B}} , \qquad (3.1)$$

$$\xi_{-} = \left(\frac{dt}{dx}\right)_{-} = \frac{1}{V - \sqrt{gA/B}} , \qquad (3.2)$$

$$\left\{ \left( \frac{A}{VB} - \frac{V}{g} \right) \xi_{+} + \frac{1}{g} \right\} \frac{dy}{dx} + \frac{A}{gVB} \frac{dV}{dx} + \frac{A}{VB} \left( S_{O} - S_{f} \right) \xi_{+} = 0, (3.3)$$

and

$$\left\{ \left| \frac{A}{VB} - \frac{V}{g} \right| \xi_{-} + \frac{1}{g} \right\} \frac{dy}{dx} + \frac{A}{gVB} \frac{dV}{dx} + \frac{A}{VB} (S_o - S_f) \xi_{-} = 0 \quad . \quad (3.4)$$

These four dependent equations form the basis for numerical solutions in the method of characteristics. There are a variety of procedures that may be used and these procedures may be broadly divided into two categories, the grid system and the specified intervals system.

#### 3.2 Various Schemes

The first category uses the grid system generated by the intersecting characteristics curves in the timedistance plane. In this case, solutions to the problem are made at the intersections. These intersections occur at the nonuniform spacings in both x and t directions, thus, interpolations are required in order to develop time or distance relations. These relations are commonly referred to as the Lagragian description for the distance relations at an instant of time, and the Eulerian description for the time relations at a fixed position. This method of using grids of characteristics is based on establishing the initial characteristic curves from the initial conditions. The receding characteristic curves emanate from it. In Fig. 3.1 the initial characteristic first determined from the inflow hydrocurve &, first determined from the inflow hydro-graph and the initial steady conditions, is drawn from x = 0 and t = 0. By introducing the values of the dependent variables V and y along the initial characteristic curve  $\xi$ , at the appropriate points in the computational scheme, the values of V and y as functions of the independent variables x and t are obtained at successive points. For example, the values of the depths and velocities at points  $Q_1$ , and  $Q_{\chi}$  in Fig. 3.1 are obtained from the values of

depths, velocities, and coordinates (x, t) of the points  $Q_0$ ,  $P_1$ ,  $P_2$  and  $P_3$ , respectively. In the same manner, all values of the dependent variables V and y as functions of the independent variables x and t can be computed.



Fig. 3.1. Network of characteristics in the method of grid system for the solution of unsteady flow equations.

It is evident from the preceding brief description that the values in the solution at each intersection of characteristics must be retained in the computer for the later interpolation for fixed times and positions. No attempt was made in this study to use the method of characteristics curves. The principal reason was the need for excessive computer storage of solutions at each intersection.

The second category is the specified intervals system for independent variables. In this approach, the dependent variables V and y are known functions of the independent variables x and t either as initial conditions of t = 0 or as the results of previous time computations. For example, it is assumed that V and y are known along distance x at time t. Figure 3.2 represents the rectangular grid in the (x, t)-plane with intervals  $\Delta x$  and  $\Delta t$  in x and t coordinates, respectively. In this case, V and y at points  $M_j$ ,  $A_j$ ,  $B_j$ ,..., $N_j$  are known. The values of V and y at time t +  $\Delta t$ , and particularly' at points  $M_{j+1}$ ,  $A_{j+1}$ ,  $B_{j+1}$ ,..., $N_{j+1}$ , can then be computed from equations 3.1 through 3.4 and from the boundary conditions. In this manner, V and y at time t + At at various points along distance x can also be computed. This process can be continued as far as desired or meaningful. This method was selected and used in this study because the values of x and t at points  $M_{j+1}$ ,  $A_{j+1}$ ,  $B_{j+1}$ ,..., $N_{j+1}$  are exactly known, and only the values of V and y at these points must be determined.





This method has the advantage that it gives results directly and in the form most needed and useable, such as the hydrograph at each position along the channel and also the water surface profile at any given time. From the view of computer programming, arrangement of the steps of computation for the methods of the second category appears to offer advantages over the methods of the first category. Since the values of the dependent variables at time t in the second category are known at predetermined points, the only information needed to be stored in the computer is the values of the dependent variables at time t + At. Therfore, this category needs computer storage of only two time lines as indicated in Fig. 3.2 and designated by j and j+1 rows, respectively. Values of the dependent variables and y of row j are known and stored while the values of V and y of row j+1 are being computed for the next time interval. After completion of this time interval, the values of V and y of row j+1 are stored for computation at the next time interval; the values of V and y of row j are then printed out and the storage space is replaced by the values of row j+1.

#### 3.3 Numerical Solution by the Specified Intervals <u>System</u>

This section discusses the numerical solution of the equations of free-surface unsteady flow by the method of characteristics with the specified time interval,  $\Delta t$ , and the specified distance interval  $\Delta x$ . In this method, V and y at point P on the (x, t)-plane of Fig. 3.3 are to be computed from the initial conditions or from previous values of V and y at points A, B, and C using two assumptions: (a)  $\Delta t$  is sufficiently small so that the parts of the characteristics between P and R and between P and S may be considered as straight lines, and

(b) The slope of the straight line PR at point P is the positive characteristic direction of the position C,  $(\xi_{+})_{C}$ , and the slope of the straight line PS at point P is the negative characteristic direction of the position C,  $(\xi_{-})$ .





Fig. 3.3. Rectangular grid for the solution by the system of specified intervals, Δt and Δx: subcritical flow (upper graph), critical flow (center graph), and supercritical flow (lower graph).

Since  $x_p$  and  $t_p$  are known, the velocity at point P, V<sub>p</sub>, and the depth at point P, y<sub>p</sub>, are then computed. The computations proceed as follows. (1) The coordinates of R and S are deter-

(1) The coordinates of R and S are determined from the relations of  $(\xi_{+})_{C}$ ,  $(\xi_{-})_{C}$ , and the geometry of the grid by

$$t_p - t_R = (\xi_+)_C (x_p - x_R)$$
, (3.5)

and

$$t_p - t_s = (\xi_-)_c (x_p - x_s)$$
, (3.6)

in which  $(\xi_+)_C$  and  $(\xi_-)_C$  are computed from Eqs. 3.1 and 3.2, respectively, at point C.

3.1 and 3.2, respectively, at point C. (2) The values of  $V_R$ ,  $V_S$ ,  $y_R$ , and  $y_S$  are determined by interpolation from the Taylor expansion, with h the symbol of either  $\Delta x$  or  $\Delta h$ , as

 $f(x+h) = f(x) + hf'(x) + \frac{h^2}{2!} f''(x) + \dots + 0(h^n), \quad (3.7)$ and  $f(x-h) = f(x) - hf'(x) + \frac{h^2}{2!} f''(x) + \dots + 0(h^n), \quad (3.8)$ 

For a first order interpolation, the second and higher derivatives are neglected. The first derivative of Eq. 3.7 becomes, in finite difference form,

$$f'(x) = \frac{f(x + \Delta x) - f(x)}{\Delta x}$$

and that of Eq. 3.8 becomes, in finite-difference form,

$$f'(x) = \frac{f(x) - f(x - \Delta x)}{\Delta x}$$

The value of the function (U = V or y) at points R and S are then, from Eq. 3.8 and Eq. 3.7, respectively,

$$U_{\rm R} = U_{\rm C} - \frac{U_{\rm C}^{-U_{\rm A}}}{\Delta x} (x_{\rm C}^{-x_{\rm R}})$$
 (3.9)

$$U_{\rm S} = U_{\rm C} + \frac{U_{\rm C} - U_{\rm B}}{\Delta x} (x_{\rm C} - x_{\rm S})$$
 (3.10)

For the second order interpolation, the third and higher derivatives of Eq. 3.7 and Eq. 3.8 are neglected, the first and second derivatives in these two equations become, in finite-difference form,

 $f'(x) = \frac{f(x+\Delta x) - f(x-\Delta x)}{2\Delta x}$ 

and

$$f''(x) = \frac{f(x+\Delta x) - 2f(x) + f(x-\Delta x)}{(\Delta x)^2}$$

The value of the function (U = V or y) at points R and S are then

$$U_{R} = U_{C} - \frac{U_{B}^{-}U_{A}}{2\Delta x} (x_{C}^{-}x_{R}^{-}) + \frac{U_{B}^{-}2U_{C}^{+}U_{A}^{-}}{2(\Delta x)^{2}} (x_{C}^{-}x_{R}^{-})^{2} , \quad (3.11)$$

$$U_{S} = U_{C} - \frac{U_{B}^{-}U_{A}}{2\Delta x} (x_{C}^{-}x_{S}) + \frac{U_{B}^{-}2U_{C}^{+}U_{A}}{2(\Delta x)^{2}} (x_{C}^{-}x_{S})^{2} , \quad (3.12)$$

from which  $V_R$ ,  $V_S$ ,  $y_R$  and  $y_S$  may be computed knowing the V and y at points A, C, and B.

(3) Then  $\rm V_p$  and  $\rm y_p$  are obtained by solving simultaneously the finite-difference forms of Eqs. 3.3 and 3.4, or by

$$(F_{+})_{C}(y_{p}-y_{R}) + (G_{+})_{C}(V_{p}-V_{R}) + (S_{+})_{C}(x_{p}-x_{R}) = 0$$
 (3.13)

and

$$(F_{-})_{C}(y_{p}-y_{S}) + (G_{-})_{C}(V_{p}-V_{S}) + (S_{-})_{C}(x_{p}-x_{S}) = 0$$
 (3.14)

in which the above values of F, G, and S at point C are defined as

$$(F_{+})_{C} = (A_{1}C_{2}-A_{2}C_{1})_{C}(\xi_{+})_{C} - (B_{1}C_{2}-B_{2}C_{1})_{C} ;$$

$$(G_{+})_{C} = (A_{1}B_{2}-A_{2}B_{1})_{C} ;$$

$$(S_{+})_{C} = (A_{1}E_{2}-A_{2}E_{1})_{C}(\xi_{+})_{C} - (B_{1}A_{2}-B_{2}A_{1})_{C} ;$$

$$(F_{-})_{C} = (A_{1}C_{2}-A_{2}C_{1})_{C}(\xi_{-})_{C} - (B_{1}C_{2}-B_{2}C_{1})_{C} ;$$

$$(G_{-})_{C} = (A_{1}B_{2}-A_{2}B_{1})_{C} , \text{ and}$$

$$(S_{-})_{C} = (A_{1}E_{2}-A_{2}E_{1})_{C}(\xi_{-})_{C} - (B_{1}E_{2}-B_{2}E_{1})_{C} ,$$

in which the above coefficients of the two general partial differential equations (Eqs. 3.24 and 3.25, Part I, Hydrology Paper No. 43) are: A<sub>1</sub> = A/VB, A<sub>2</sub> = V/g, B<sub>1</sub> = 0, B<sub>2</sub> = 1/g, C<sub>1</sub> = C<sub>2</sub> = 1, D<sub>1</sub> = 1/V, D<sub>2</sub> = 0, E<sub>1</sub> = 0, and E<sub>2</sub> = S<sub>f</sub>-S<sub>o</sub>. Solving equations 3.13 and 3.14 simultaneously,

$$y_{p} = \frac{\begin{vmatrix} (T_{+})_{C} & (G_{+})_{C} \\ (T_{-})_{C} & (G_{-})_{C} \end{vmatrix}}{\begin{vmatrix} (F_{+})_{C} & (G_{+})_{C} \\ (F_{-})_{C} & (G_{-})_{C} \end{vmatrix}}$$
(3.15)

and

$$V_{P} = \frac{\begin{vmatrix} (F_{+})_{C} & (T_{+})_{C} \\ (F_{-})_{C} & (T_{-})_{C} \end{vmatrix}}{\begin{vmatrix} (F_{+})_{C} & (G_{+})_{C} \\ (F_{-})_{C} & (G_{-})_{C} \end{vmatrix}}$$
(3.16)

in which

$$(T_{+})_{C} = (F_{+})_{C} y_{R} + (G_{+})_{C} V_{R}^{-} (S_{+})_{C} (x_{P}^{-}x_{R})$$
, (3.17)

and

$$(T_)_{C} = (F_)_{C} y_{S} + (G_)_{C} V_{S} - (S_)_{C} (x_{p} - x_{S})$$
. (3.18)

By these computations, velocities and depths at time  $t + \Delta t$  are obtained for all points along the channel, except for the two boundary points. The values for the boundary points are provided by previous computations of the known boundary conditions.

The procedure in the solution requires first the determination of the intervals within which the points R and S lie. A linear interpolation is then performed within the appropriate interval for the dependent variables at time t. This linear interpolation has the same effect as the linear interpolation in the diffusing finite-difference scheme, namely a systematic positive or negative shift in the computed values V and y.

In an attempt to eliminate this deficiency, a second-order interpolation was developed. Referring again to Fig. 3.3 (upper graph), a second-degree polynomial of the form

$$U = a + bx + cx^2$$
 (3.19)

is assumed to fit the function of V and y through points A, C, and B. This is the same interpolation as in Eqs. 3.9 and 3.10, except in a different way of implementing it. If the function is centered on the location of C, then the constants are

$$a = U_{C}, b = \frac{U_{B}^{-}U_{A}}{2\Delta x}$$
, and  $c = \frac{U_{B}^{-}2U_{C}^{+}U_{A}}{2\Delta x^{2}}$ . (3.20)

Thus, the value of the function of the location of R is

$$U_{R} = U_{C} - \frac{1}{2}(UP)(U_{B}-U_{A}) + \frac{1}{2}(UP)^{2}(U_{B}-2U_{C}+U_{A})$$
(3.21)

in which

$$UP = -\frac{\Delta t}{\Delta x} \left/ \left( \frac{dt}{dx} \right)_{+} \right.$$
(3.22)

The ratio of  $\Delta t$  to  $\Delta x$  is the selected grid mesh ratio and  $(dt/dx)_{+}$  is the direction of the positive characteristic estimated from the conditions at location C.

Similarly, the value of the function at location  ${\rm S}$  is

$$U_{S} = U_{C} - \frac{1}{2}(UN)(U_{B}-U_{A}) + \frac{1}{2}(UN)^{2}(U_{B}-2U_{C}+U_{A})$$
 (3.23)

in which

$$UN = -\frac{\Delta t}{\Delta x} \left/ \left( \frac{dt}{dx} \right) \right|_{-}$$
(3.24)

This interpolation scheme offers two advantages. First, the curvature of the function at a given time is approximated. Second, it is not necessary to compute within which interval the intersection of the characteristic and the x-axis falls. The assumptions in this scheme are that the functions of velocity and depth are continuous and may be approximated by a parabolic relation within the interval. Any other similar non-linear interpolation scheme may be designed if it suits the general types of the V(x) and y(x) functions for various values of t.

#### 3.4 Initial Conditions

The necessary initial conditions for the unsteady free-surface flow are that all velocities and depths of water along the channel must be known at a given time. In this study, it was assumed that at the initial time the discharge was constant throughout the reach. Thus, the problem can be treated as a steady non-uniform flow. Velocities and depths along the channel were then determined by computations of conventional backwater or drawdown surface profiles, depending on the downstream control conditions. This procedure uses the standard step method [2, p. 265].

#### 3.5 Boundary Conditions

The two governing partial differential equations for unsteady flow require two independent boundary conditions relating velocity and depth at certain locations along the channel. One of these conditions is the discharge-time relation existing at the inlet end to the section of channel under study. This relation can be either expressed in a mathematical form, or given as discrete points of discharge at selected intervals of time.

The other boundary condition imposed on the problem is that of a discharge-versus-depth relation at the downstream end, characterized either by a control structure or by the critical depth at a free outfall. This is the boundary condition that must exist for subcritical flow of the base discharge.

If the base discharge is in the supercritical range or on a supercritical slope the boundary condition must be expressed at the inlet end. This function takes the form of a discharge-versus-depth relation. This condition, in combination with the condition of a discharge-versus-time relation, is somewhat difficult to visualize physically; however, it is a necessary condition because the characteristic directions both have a positive slope and thus there is no influence of the downstream conditions on the upstream conditions.

The following discussion presents a detailed analysis of these boundary conditions. Arbitrary inflow hydrographs were investigated to test and verify the computer program and also to provide results for evaluating the significance of variations in the hydraulic parameters.

Upstream boundary conditions - The boundary condition at the upstream inlet is given by an inflow hydrograph, Q(t), with no limitation on the shape of the hydrograph. A hypothetical hydrograph, having a Pearson Type III distribution with four parameters, was selected for evaluating the effect of variations in the parameter and is shown by Fig. 3.4. Thus, the inflow Q at time t designated by Q(t) may be described by

$$Q(t)=Q_{b} + Q_{o}e^{-(t-t_{p})/(t_{g}-t_{p})}(t/t_{p})^{t/(t_{g}-t_{p})},$$
 (3.25)



Fig. 3.4. Hypothetical inflow hydrograph of the Pearson Type III function, Eq. 3.25, with the selected parameters:  $Q_b = 6.21$  cfs,  $Q_o = 8.00$  cfs, t = 100.00 sec, and t g 150.0 sec.

in which  $Q_b$  is the constant base flow,  $Q_o$  is the peak flow,  $t_p$  is the time from the beginning of storm runoff to peak discharge and  $t_g$  is the time from the beginning of the storm runoff to the center of mass of storm runoff, G. One hydrograph with arbitrary values of  $Q_b$ ,  $Q_o$ ,  $t_p$ , and  $t_g$  were used in this study. The shape and these arbitrary values of parameters are shown in Fig. 3.4.

The depth and the velocity at the upstream boundary point P in Fig. 3.5, which is at x = 0and at the time t +  $\Delta t$ , can be computed from initial conditions at C and B, with the boundary conditions given by the inflow hydrograph

$$AV = Q(t)$$
, (3.26)

in which A is the cross-sectional area and V is the velocity at P.

Using the previously discussed assumptions and procedure of computing velocities and depths at other points along the channel the negative characteristic direction at point C is also given by the initial conditions. The relation between the depth yp and velocity  $V_p$  at point P can be determined from Eq. 3.4. Substituting the boundary condition of Eq. 3.26 into Eq. 3.14 gives

$$y_{p} = y_{s} - \frac{(G_{-})_{c} \left\{\frac{Q(t)}{A} - V_{s}\right\} + (S_{-})_{c} \left(x_{p} - x_{s}\right)}{(F_{-})_{c}},$$
 (3.27)

....

in which A is the cross-sectional area at P and

A is a function of  $y_p$ . Solving for  $y_p$  from Eq. 3.27 and substituting  $y_p$  into Eq. 3.26 makes it possible to determine  $V_p$ . Since Eq. 3.27 is not linear in  $y_p$ , a Newton-Rhapson interation was used for its solution.

Downstream boundary conditions - The boundary conditions at the downstream outlet may generally be given by a stage-discharge relation. In this portion of the study only a free outfall at the end of conduit was assumed. Therefore, a critical flow at the downstream end exists

$$\frac{V}{\sqrt{g_{\overline{B}}^{A}}} = 1 \quad , \tag{3.28}$$

where A is the cross-sectional area and B is the top width of the downstream boundary.



Fig. 3.5. Upstream boundary conditions: subcritical flow (upper graph), critical flow (central graph), and supercritical flow (lower graph).

Figure 3.6 shows the downstream boundary where the critical depth occurs. For the free outfall, it was assumed that critical depth occurred at a distance of 4.5 times the critical depth from the end. This assumption was also applied to the unsteady case, with critical depth computed from the base discharge,  ${\rm Q}_{\rm h}.$  Therefore, the total distance  ${\rm x}_{\rm L}$  from the inlet to the downstream boundary is determined by

$$x_{\rm L} = x_{\rm F} - 4.5 y_{\rm c}$$
, (3.29)

in which  $x_F$  is the total length of the channel and  $y_c$  is the critical depth for discharge  $Q_b$ .





The depth and velocity at the downstream boundary point P at time t +  $\Delta$ t can be computed from the initial conditions at A and C, and from the boundary conditions given by Eq. 3.28.

Using the same assumptions and computational procedures, the initial conditions also give the relation between the depth  $y_p$  and the velocity  $V_p$  by applying Eq. 3.3. Substituting the boundary conditions of Eq. 3.28 into Eq. 3.13 results in

$$y_p = y_R - \frac{(G_+)_C(\sqrt{gA/B} - V_R) + (S_+)_C(x_p - x_R)}{(F_+)_C},$$
 (3.30)

in which A is the cross-sectional area and B is the top width at P, with both A and B functions of  $y_p$ .

Solving  $y_p$  from Eq. 3.30 and substituting  $y_p$  into Eq. 3.16 makes it possible to determine  $V_p$ . Since Eq. 3.30 is not linear in  $y_p$ , a Newton-Rhapson iteration was again used for a solution.

#### 3.6 Summary of Computational Procedures

In solving the equations of free-surface unsteady flow, Eqs. 1.1 and 1.2 and Eqs. 3.1 and 3.4, by the system of specified intervals, the steps of computing velocity V and depth y at various times and positions along the conduit are as follows.

(1) Values of V and y at various positions along the channel for the steady-state condition of constant base flow,  $Q_{\rm p}$ , are determined from a computation of the backwater curve.

(2) The upstream boundary conditions are evaluated.

(3) The downstream boundary conditions are evaluated.

(4) Values of V and y at time  $t + \Delta t$ along the channel are computed from the known values of V and y at time t.

(5) Steps (2), (3), and (4) are repeated as long as desired or meaningful.

To benefit other investigators, the computational procedures and programs are reproduced in Appendix 3. Appendix 3 gives the computation details of the numerical integration method using the specified interval scheme of the method of characteristics. It includes (1) flow chart, (2) computer program, (3) definitions of variables and (4) sample input and output. Additional subroutines were developed to compute the boundary conditions for supercritical regime and for lateral inflow at specified locations.\*

#### 3.7 Effect of Variations in Computational Parameters

The discrepancy between a computed value and the observed value from a physical experiment is attributable to numerous sources of errors. These errors are generally the result of systematic and random errors in the observational system and possible systematic errors in computational procedures. Random errors are a result of unavoidable accidental variations in the physical systems. The discussion that follows will be concerned with errors in the computational procedure.

Computational errors emanating from procedures in this study are the result of:

(1) The approximation of infinitesimal variations by finite values. This is a result of assuming in general, linear relations rather than the true curvilinear relations. This is a systematic error. However, the propogation of this error is not readily determined since it may be positive or negative during different stages of the computations.

(2) Truncation of numerical values. This is due to the limited precision of any discrete-element calculator.

(3) Round off in the printed output. The printed output of any computed value from a digital computer differs from the internally generated value by the amount the value is rounded off in conversion to numeric form. The computer used for these calculations rounds off in a manner similar to manual calculators.

The following discussion evaluates the significance of the controllable variables in the solution of the unsteady flow equations. These equations are considered under the computational parameters of incremental length and incremental time interval during which the integration process proceeds.

The effect of variations in the hydraulic parameters of roughness and the velocity distribution coefficients is discussed in Part I, Hydrology Paper No. 43.

Determination of computational parameter  $\Delta t$ . The grid sizes of  $\Delta x$  and  $\Delta t$  in the computational scheme, Fig. 3.2, is limited by the characteristic directions  $\xi_{\perp}, \xi_{\perp}$ , encountered during the integration.

Referring to Fig. 3.3, in order for R to lie in the interval A-C for all conditions of flow, it is necessary that the ratio of  $\Delta t/\Delta x$  be less than the value of dt/dx assumed at the location R. This condition must exist throughout the integration solution.

In order to assure that this condition exists, it is necessary that  $\Delta t$  be computed from

 $\Delta t = \Delta x / [V + \sqrt{gA/B}]$ 

\* Originals of all computer-program and punched-card decks are deposited with the Office of Research, Federal Highway Administration, U.S. Department of Transportation, Washington, D.C. in which

(1) V is the maximum anticipated velocity, and (2) A/B is a maximum for free surface flow.

Effect of computational parameter  $\Delta x$ . The method of characteristics using a specified intervals system gives the complete numerical solution of the free-surface unsteady flow. The accuracy of the results depends on the size of the rectangular grids  $\Delta x$  and  $\Delta t$  of Fig. 3.2. In this section only the effect of  $\Delta x$  is discussed;  $\Delta t$  will be discussed in the next section.

If n is the number of intervals along the conduit and  $x_{I_{\rm c}}$  is the length of the conduit, then

$$\Delta x = \frac{x_{\rm L}}{n} \quad . \tag{3.32}$$

Since  $x_L$  is assumed to be fixed, n is arbitrarily selected as any even number, thus  $\Delta x$ is determined. The smaller the  $\Delta x$ , presumably the more accurate are the results. But also, the smaller the  $\Delta x$ , the greater the required computing time. In compromising these two conditions to satisfy the objectives of this study, several values of n for the fixed  $x_L$  were tried.

Figure 3.7 shows the effect of the size of  $\Delta x$ on the depth hydrographs at three positions along the conduit. The upper graph is the depth hydrograph at a position 50.0 feet downstream from the inlet and for a  $\Delta x$  of 40.91, 20.45, 10.23, and 5.12 feet corresponding to n values of 20, 40, 80, and 160, respectively. The center and lower graphs are the depth hydrographs at 410.0 feet from the inlet, and 771.7 feet from the inlet, respectively. The initial condition for each computation is the steady-state water surface for a free outfall.



Fig. 3.7. Effect of  $\Delta x$  on hydrographs at various positions along the conduit; (1)  $\Delta x = 40.91$  ft, (2)  $\Delta x = 20.45$  ft, (3)  $\Delta x = 10.23$  ft, and (4)  $\Delta x = 5.12$  ft, at three locations of conduit x = 50.0 ft (upper graph), x = 410.0 ft (center graph) and x = 771.7 ft (lower graph).

Comparing the depth hydrographs of Fig. 3.7 with the given inflow discharge hydrograph of Fig. 3.4, it was found that:

(1) The critical portion of the conduit for computing depth hydrographs is near the outlet where there is the greatest curvature of the water surface profile. The maximum differences between the computed depths, with  $\Delta x$  being 40.91 and 5.12 feet, are approximately 0.3, 0.6, and 1.0 percent of the conduit diameter at 50.0, 410.0, and 771.7 feet from the inlet, respectively.

(2) There is no significant increase in accuracy over 0.005 feet or 0.15 percent of the conduit diameter when  $\Delta x$  is less than 10.23 feet. Therefore, a  $\Delta x$  equal to 10.23 feet, or n equal to 80, was selected for computation in the other portions of this study.

The peak depth  $y_p$  and the time to peak depth  $T_p$  are two important parameters describing a depth hydrograph. These two parameters are defined and shown graphically in Fig. 3.8. The required accuracy of a computed hydrograph at various positions along the conduit can be measured by the peak depth,  $y_p$ , relative to the diameter, D of the conduit, for various lengths  $\Delta x$ . Also, the accuracy can be measured by the time to peak depth,  $T_p$ , relative to the time to peak depth,  $T_p$ , relative to the time to peak depth,  $T_p$ , relative to the time to peak depth,  $T_p$ , relative to the time to peak depth,  $T_p$ , relative to the time to peak discharge,  $t_p$ , of the inflow discharge hydrograph of Fig. 3.4, for various lengths  $\Delta x$  and the same positions, x.



Fig. 3.8. Characteristics of the depth hydrograph with  $T_p$  the time at peak depth, and  $y_p$  the peak depth.

From the selected criteria for defining the accuracy of a computed hydrograph for a given  $\Delta x$ , it was found that the percentage differences of  $y_{\rm p}$ ,

 $(y_p)_{min} \times 100$ 

in which the index "min" refers to the depth  $y_p$  of the smallest difference used,  $\Delta x = 5.12$  ft, and the index "i" refers to depths of any other  $\Delta x > 5.12$  ft, ranged from 0.0 percent to 2.1 percent for  $\Delta x$ ranging from 5.12 ft to 40.91 ft, and at various positions x, as shown in Table 3.1. At the upstream part of the conduit there was no significant difference between  $y_p/D$  measure for different values of  $\Delta x$ , as expected. At the approximate middle of the conduit there was a 0.2 percent difference. At the downstream end, the difference was 2.1 percent. No significant change in the percentage difference of  $y_p$  to D was found when  $\Delta x$  was reduced below 10.23 ft.

In using the other parameter,  $T_p$ , to define the accuracy of computed depth hydrographs with different values of  $\Delta x$  and various positions x, the measure of accuracy was

$$\frac{\left(\frac{T_{p}}{p}\right)_{i}-\left(\frac{T_{p}}{p}\right)_{min}}{t_{p}} \times 100,$$

in which the indices "min" and "i" refer to the  $\Delta x = 5.12$  ft and all others  $\Delta x$ , respectively. It was found that there were no significant percentage differences for values  $\Delta x > 5.12$  ft, and various positions x. The percentages were about 1.2 percent at the upstream, 2.0 percent at the middle, and 8.5 percent at the downstream part of the conduit. It was also found that there was no significant change of the percentages of T<sub>p</sub> to t<sub>p</sub> (which was about 1.9 percent) when  $\Delta x$  was reduced below 10.23 ft, as shown in Table 3.2.

Tables 3.1 and 3.2 show the percentage differences of  $y_p$  to the diameter D of the conduit, and  $T_p$  to  $t_p$ , respectively, with different values of  $\Delta x$  and various positions, x. These values at even distances (0, 50, 100,...ft) were computed by linear interpolation from the values in the grid system of Fig. 3.2; therefore, some error may have been introduced. However, the change in shape of the depth hydrograph due to varying  $\Delta x$  was considered to be small. Larger  $\Delta x$  produced a lower and later peak depth.

As previously mentioned, the smaller the  $\Delta x$ , the longer the computing time required. For these particular values in the hydrograph and the specified grid system computer program, the relation between the time required for the CDC 6600 computer and the various  $\Delta x$  or n values is shown in Fig. 3.9. This relation is approximately a power function because the number of computational locations in the (x, t)plane is proportional to the square of the x-positions for a constant time position.

Table 3.1. Difference in  $y_p$  computed from various sizes of  $\Delta x$  (in percent of conduit diameter D)

Δx								DISTAN	KCE, ft								
(ft)	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800
40.91	0	-0.02	-0.16	-0.04	-0.06	-0.08	-0.11	-0.16	-0.24	-0.31	-0.41	-0.50	-0.59	-0.70	-0.94	-1.43	-2.07
20.45	0	-0.01	-0.02	-0.02	-0.03	-0.04	-0.04	-0.06	-0.10	-0.13	-0.18	-0.22	-0.27	-0.39	-0.42	-0.66	-0.99
10.23	0	0	-0.01	0	-0.01	-0.01	-0.01	-0.02	-0.03	-0.04	-0.06	-0.08	-0.09	-0.11	-0.14	-0.23	-0.39

Table 3.2. Difference in  $T_{\rm p}$  computed from various sizes of  $\Delta x$  (in percent of  $t_{\rm p})$ 

۵x								DISTAN	WCE, ft								
(ft)	0	50	100	150	200	250	300	350	400	450	500	550	600	650	700	750	800
40.91	1.23	-0.09	0.18	0.14	-1.21	-0.36	-1.62	-2.04	-2.02	-1.81	-1.09	1.21	-0.96	-1.43	-8.47	-7.32	-3.48
20.45	-0.40	-0.09	0	0.14	0.05	-0.06	0	-0.40	-0.40	-1.81	-2.73-	-0.42	-0.40	0	-3.58	-4.07	-2.04
10.23	0.41	0	0	0.14	0.05	0	0	-0.22	-0.40	0	-1.90-	-0.24	-0.42	o	-1.49	-1.62	-0.41



Fig. 3.9. Relations between n and  $\Delta x$  and the computer time, T, required for CDC 6600 computer.

### COMPARISON OF THREE FINITE DIFFERENCE SCHEMES OF NUMERICAL INTEGRATION

#### 4.1. Criteria for Comparison

The comparison of three finite-difference schemes for numerical integration and numerical computer solution and the eventual selection of the most desirable scheme for particular applications depend on simplicity, stability, accuracy, flexibility, and resulting computer time. The three schemes to be compared are: diffusing, Lax-Wendroff, and specified intervals scheme in the method of characteristics.

The simplicity of a particular scheme is related to both the algebraic description of its numerical algorithm and the computer programming involved. Generally, if the algebra is kept simple for understanding the computer programming is usually also simplified. Frequently, however, this may lead to numerous programming decisions to insure that conditions outside the range of the simplified assumptions are either included or deliberately excluded. Thus, simplified algebra does not necessarily infer simplicity in the computer algorithm.

The stability of a solution infers that the process will coverge to a real solution. This criterion is satisfied in the case of solving the De Saint Venant equations if the mesh size  $\Delta t/\Delta x$  ratio is less than dt/dx, for any part of the (x,t)-plane used in the integration solutions. If this condition is not satisfied, the solution will fluctuate about the correct value with increasing amplitude. Eventually, the results may exceed the capacity of computer.

The accuracy of a solution method in this study infers that the algorithm will reproduce the initial conditions for the steady state boundary conditions. As a corollary, the algorithm should be able to compute the steady state conditions from any arbitrary initial conditions. If the algorithm satisfies this criterion, it may be inferred that there will be good agreement between the computed and the observed quantities. The difference between these two can then be attributed to the limitations of the underlying assumptions of the theoretical equations and the limitations of accurately estimating the geometric and hydraulic parameters.

The flexibility of a computer algorithm depends on the range of conditions the algorithm will accommodate. For the unsteady flow solutions, it is desirable that the algorithm provide for all conditions of depth, velocity, and discharge within the expected physical ranges. Generally, this must include both the subcritical and the supercritical conditions. Since numerical procedures at some stage require interpolations, a computer decision is required to determine the appropriate interpolation.

#### 4.2 Properties of Diffusing Scheme

The diffusing scheme is the simplest of the three compared schemes to develop and represent in algebraic form. This can be seen from Table 2.1, wherein the partial derivatives are represented as ratios of finite differences. This simplicity, of algebraic form, however, limits accuracy and flexibility.

The stability of the diffusing scheme is assured provided the ratio of  $\Delta t/\Delta x$  does not exceed the

absolute maximum value of dt/dx at any point in the (x, t)-plane during the integration process.

The accuracy of the scheme may suffer during eventual periods of supercritical flow. This is because the characteristics intersect at a relatively great distance from the solution point. Figure 4.1 graphically presents this relationship. The accuracy of the diffusing scheme is further limited because the dependent variables are assumed to vary linearly within the interval of  $2\Delta x$ . Thus, if the actual value of a dependent variable at a given x-position is more than the interpolated value, the computed value at the same position for a later time will be less than it should be. This effect produces a dampening effect in time at a fixed location. Figure 4.1 demonstrates this effect for the depth at a location near the free-fall outlet. The greater the curvature of the free surface the more pronounced is this effect

To reduce this effect the physical size of  $\Delta x$ may be reduced but this results in an increase of the computer time needed. The computer time increases by the square of the number n of distance intervals,  $\Delta x$ . Subsequent comparison indicate that the diffusing scheme requires more computer time than the other two schemes.

#### 4.3 Properties of Lax-Wendroff Scheme

The Lax-Wendroff scheme is an improvement over the diffusing scheme in that it accommodates the curvature in the variation of dependent variables. This, however, involves a more complicated numerical algorithm.





The Lax-Wendroff scheme results in a more accurate solution in comparison with the diffusing scheme for the same  $\Delta x$  and  $\Delta t$  intervals without a significant increase in computer time. An indication of this improved accuracy is demonstrated in Fig. 4.2 The Lax-Wendroff method consistently produces the same depth over a very large period of time, whereas, the diffusing produces a consistent change.

With regard to its flexibility in accommodating a wide range of flow conditions, the Lax-Wendroff scheme possesses the same inherent limitations as the diffusing scheme. Thus, by the Lax-Wendroff scheme the further the intersection of the two characteristic curves from the solution point, the less accurate the solution.

#### 4.4 Properties of Specified Intervals Scheme of the Method of Characteristics

The complications inherent in the specified intervals scheme of the method of characteristics are justified because of its inherent accuracies. The basis for this is that the points of solutions are at the intersections of characteristic curves, rather than at any point within the domain of dependence.

The linear interpolation of this scheme is made without the need of a computer decision. All flow conditions can be accommodated by this scheme.

The accuracy of this scheme is demonstrated in Fig. 4.2, and is very good when compared to the diffusing and Lax-Wendroff schemes.

It is apparent that this finite-difference scheme of the method of characteristics produces a rapidly convergent and stable value. It is comparable to the same property of the Lax-Wendroff scheme.

The non-linear interpolation of the method of characteristics for dependent variables along distances for a given time is an improvement over the linear interpolation. However, linear interpolation is used in producing results (C) of Fig. 4.2 for this method of characteristics.



Fig. 4.2. Comparison of diffusing scheme  $(D_i)$ , Lax-Wendroff scheme  $(A_k)$ , and the specified intervals scheme of method of characteristics (C) in reproducing the steady initial conditions along the conduit, at the distance x = 796.7 ft.

#### CONCLUSIONS AND RECOMMENDATIONS

#### 5.1 Conclusions

1. Numerical integration solutions to the differential equations of gradually varied free-surface unsteady flow in prismatic channels and conduits have been reviewed, evaluated, and compared, both by the integration of the two partial differential equations and by their equivalent, four ordinary characteristic differential equations.

2. Numerical integration schemes, their solutions and their resulting computer programs are compared on the basis of their simplicity, stability, accuracy, flexibility, and the resulting computer time needed under given physical conditions.

3. Second-order or non-linear interpolations for dependent variables in the finite-difference schemes, for both the Lax-Wendroff scheme and the specified intervals scheme of the method of characteristics, were found to be necessary if maximum accuracy is to be obtained.

4. Solutions by the specified intervals scheme of the method of characteristics, with the secondorder or non-linear interpolations for dependent variables, do not significantly require more computer time for a given accuracy comparable to the accuracy of solutions by any other scheme.

5. The Lax-Wendroff finite-difference scheme requires some particular programming considerations and adjustments in the case of supercritical flow.

6. The finite-difference specified intervals scheme of the method of characteristics with the

second-order of non-linear interpolations of dependent variables is sufficiently flexible to accommodate a large range of flow conditions.

7. Numerical integration by the specified intervals scheme of the method of characteristics with the second-order or non-linear interpolations of dependent variables in the writers' opinion should be used in general for studies of gradually varied free-surface unsteady flow.

#### 5.2 Recommendations

Four recommendations for further studies are present in the following:

1. Other numerical integration finite-difference schemes, periodically appearing in the literature or not studied in this paper, should be investigated and compared with the recommended finite-difference specified intervals scheme of the method of characteristics. This should be done to find whether improvements in overall applicability can be attained.

2. The finite-difference specified intervals scheme of the method of characteristics may be further improved by considering the curvilinear nature of the characteristic curves. Thus, a better method of interpolation may be designed.

3. For the integration of gradually varied freesurface unsteady flow equations the use of a hybrid computer should be particularly investigated.

 Computer times and computer costs should be systematically investigated for the most popular digital computers and for various finite-difference schemes.

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### A.I.2. FORTRAN IV COMPUTER PROGRAM

### MAIN PROGRAM FOR UNSTEADY FLOW BY DIFFUSING SCHEME

PROGRAM NSTDY(INPUT,OUTPUT,TAPE5=INPUT,TAPE6=00TPUT)	NST	1
DIMENSION DEALER (1200) PALIADO, PALIADO, PALIADO, PALIADO	NSI	4
DIMENSION GLADUT, HIACOT, VIADOT	NST	4
DIMENSION G(330)	NoT	2
COMMON DNIN1IAIAPIOPIALICLIULIELIDZIAZICZIEZIVPIJTAIUTINXIOC	Nol	•
COMMON DIADIAFIORIALFIAIDETAISDIFINIVUGDASLIITITOITFINIFDIFCI	No1	1
	Not	3
COMMON THETAMP HE NUEPIN VC	Nal	10
COMMON GMAX(400),VMAX(400),HMAX(400)	NST	11
COMMEN TEMAX(400),TVMAX(400),THMAX(400)	NST	14
INTEGER RUN	NoT	13
	NoT	14
VAAX (I)=G	NST	10
QMAX(I)=C	hal	11
1 CONTINUE	Nat	10
CINPUT WHICH MAY DE ALTERED	hal	17
	Nol	- 6
XF=521.70	No.T	41
$F = \sigma \cdot \sigma 12$	Nol	23
ALPHA=1.000	NOI	24
BETA=1.CCG	NST	60
GR=32.175	NoT	26
H1=0.4*D	NST	27
CCOEFICIENTS	NoT	60
	Nol	29
B2=DETA/GR	ast	31
C2=1.0	NoT	36
CENU OF CUEFICIENTS	NOI	دد
CREAD INPUT NYDROGRAPH	Nol	24
READ (5,12) NGCD	NoT	35
	ICM	30
100=0	hol	20
TO=C	NaT	37
T=10	NST	40
TF=2UC	NST	41
S0=6-601	NaT	46
N1=N+1	NOI	43
NPG=6	NaT	45
1 XOX = 1	NoT	40
PEKD=120.	NaT	47
FNU=C.0000141	NST	40
F8=0-03	NST	49
PERD=120	NST	20
MINDO	A DI	21
10=1	NJI	22
CCALCULATION OF CRITICAL AND NORMAL DEPTH AT DASE FLOW	Nol	24
CALL DIGRM	Nol	20
DX=UN	Nol	20
CALL DCRIT	NoT	57
	hol	20
M=Z=N	NoT	50
FM=M	NoT	61
MM=M+1	NST	62
MMM=M-1	NST	63
DX=XL/	NST	04
RA=1.C/(2.C*VC)	NST	00
DT=RA+DX+G.5	NOT	61
WRITE (6,14) UN, UC	NST	00
WRITE (6.15) M.DX. UT. XO. XF. TU. IF. SU. U.F	NST	67
WRITE (0+16) RA+HI+PERD+FB+FC	NST	70
CCALCULATION OF INITIAL CONSTITIONS	NOT	71
CHEIGHTS AT PARTICULAR DISTANCES FROM INLET END	NST	73
FALL INCOND	NST	74

	DTA+DT D0 2 1=2.M.2		75
c	CALCULATION OF COEFFICIENTS AND SOLUTION OF VIFFERENCE EQUATIONS	hal	77
	CALL CUEU	Nul	70
	CALL COMPTE	nol	7,
4	CONTINUE	14.31	00
	K=1	No1	01
3	1F (NPO-NT) 4+4+6	hal	02
4	WRITE (6.17) T	NoT	04
	WRITE (6.16)	AST	65
	DO 5 I=1+N1+IXGX	Not	66
	WRITE (0119) INCIDENTING(I)	NoT	67
-	NT=0	Noi	00
	PN1(K)=H(10)*03.0	Nol	46
	PN2(K)=H(00)*05.0	NoT	91
	PN3(K)=H(150)*05+0	hal	72
	K=K+1	Nat	23
•	T=T+DTA	NSI	94
	T1=T1+DTA	NST	95
	QA=G(3)	NoT	97
	HA=H[3]	NST	50
	VA=V[3]	NST	99
	Hotel ( Mon )	Nal	100
	VK=V(MMN)	Nat	101
	DU 7 1=3. main +2	Nat	162
	CALL COED	NoT	104
	CALL COMPTE	NoT	160
1	CONTINUE	Not	100
C	CALL BOW	NST	107
		NSI	100
C	CALCULATION OF CUTLET DOUNDARY CONDITIONS	NST	109
-	CALL BON2	Nat	111
	DO 6 1=2.X.2	Nol	
	CALL COMPTE	Nal	114
8	CUNTINUE	ASI	112
	1F (1F-T) 9+3+3	NaT	110
9	CONTINUE	Not	117
	NPG=N1/50+1	Nol	110
	DO 10 111=1+NPG	NST	119
	IL=II+49	NST	1/1
	WRITE (6.20)	NST	144
	WRITE (6,21)	Not	143
		421	144
	WRITE (6.27) X.HHAY(1).THWAY(1).VWAY(1).IVWAY(1)	Not	142
	IF (1.EQ.N1) GO TO 11	AST	141
10	CUNTINUE	NoT	100 3
11	CALL EXIT	Nol	147
	FORMAT (13)	Val	130
13	FORMAT (BELO.C)	NOT	131
14	FORMAT (* DNGB = *E16.8//* DCOB = *E16.8/)	NST	133
15	FORMAT (* M = +15//	NST	134
	1 * DX = *E16.8//	Tch	135
	2 * DI = *L16.d//	hal	130
	4 * XF = *F16.d//	NoT	137
	5 * TO = *E16+0//	hal	137
	6 * TF = *E16.8//	NST	140
	7 * SO = *E16.0//	Nal	141
	8 * D = *E16.8//	NoT	142
6	9 F = *C10+0/1 FORMAT /# DA = #E16.3//	NoT	143
	1 * H1 = *E16.8//	NOT	144
	2 * PERD = *E16.0//	NaT	146
	3 * FB = *E16.8//	NoT	147
	4 * FC = *E16.8)	NST	140
-	FORMAT (INI+/HI ME IS+E16+0+0 SEC+)	NoT	147
9	FORMAT (1X+14+2X+616+0+2X+610+0+2X+616+0)	TCM	120
0	FORMAT (//*1 MAXIMUM VALUES AND TIMES AT EACH LUCATION*//1	NST	124
1	FORMAT (* DISTANCE MAX DEPTH TIME MAX VEL TIME MAA W	Ice	125
	1 TINE*)	NoT	124
4	FURMAT (F8.2+3(4X+F6+2+2X+F7+2))	hol	135
	END	NoT .	120-

#### SUBROUTINE FOR COMPUTING UPSTREAM BOUNDARY CONDITION

4

	and the second second	601	1
	SUBROUTINE BONI	104	7
	DINENSION TG(200) 01(200)	801	5
	DINENSIGN G(400), H(400), V(400)	801	2
	DINENSION G(330)	901	4
	CHARACTER AND AND ALL CINDING ACTOCICS OF TOTAL THAT UC	201	2
	COMPONE OF THE AND THE AND THE TAS SOLF THEY HAVE AND THE TO THE IN FORFE TO	501	0
		IUG	7
	COMMON A THAT AND CITE CROTOCITE AND COMMON A THAT AND CITE AND COMMON A THAT AND COMMON A THAT AND CITE AND COMMON A THAT AND COMMON A TH	801	3
	COMMON HASHMSVMSHTSVISHPISHNSGGUII	201	5
	CONNON THETA WP &R +DEPTH +VC	DOT	
	CONMON GRAX(400), VMAX(400), HMAX(400)	801	10
	COMMEN TOMAX(400) TVMAX(400) TRMAX(400)	801	11
		801	12
1	IF TIG.GE MUCH 213	801	13
2	GT=GT (NGCD)	801	14
	GO TO 6	201	1.
3	IF (1.6E.TU(10).AND.T.LT.TQ(10+1)) >+4	BUT	
4	16=16+1	901	10
	60 10 1	BUI	.1
4	$a_{1=0}(1) + a_{1}(1) + a_{1}(1) + a_{1}(1) + (1 - T_{0}(1_{0})) / (T_{0}(1_{0}+1) - T_{0}(1_{0}))$	901	10
1		BU1	19
Б	HN=H11)	801	20
	THETA=2.0*ATANF((SURTE(D*H(2)-H(2)*2))/(0*0.5-H(2)))	201	21
	IF (THETA) 7.8.8	DOT	
7	THETA=6.26318+THETA	801	"
â	A=G-125#1THFTA-SINFITHETA11#(0*D)	B01	23
		801	24
	WP=D=0.5=THETA	HILL	25
	R=A/wP	401	16
	A2=V(2)*ALPHA/GR	001	
	SF=+125*F*62*V(2)*V(2)/K	801	41
	E2=5E=50	BU1	60
a (		DUL	67
3	Su-Sukir (U-nk-nk-nk)	601	30
	THETA=2.0*ATANF (ISURTFISUIT/10-0.5-MIT	0.01	
	1F (THETA) 10,11,11	BOI	-
10	THETA=6.20310+THETA	801	24
1.1	AX=0.125+1THETA-SINE(THETA)1+(D+D)	BUI	33
4.1	AA-0+125-110-14-0111-01/441-82#04/01+(V(3)+01/4X-VA-V(1))-C2*(H/	HU1	34
	FH=HN-A2*1V131+VA-V11-01/AA1-02-DA/01-11137-01-04	801	35
	1+H(3)-H(1))-4.0*DX*E2	801	3.6
	DAX=0.25*D*D*(1.0-COSF(THETA))/50	001	30
	FPH=1.0-(A2-H2*DX/01)*(GT*DAX/(AX*AX))	901	37
	UNIEHN-EH/EDH	801	50
		oul	39
1	IF TABSFTHAD-ANT-0.00017 ISTETIC	nul	40
12	HN=HNU		41
	GU TU 9		
13	H(1)=HNU	DOI	44
	0(1)=01	801	43
		801	44
		1CB	45
	IF (H(I).LI.HMAX(I)) 60 10 14	201	44
	HMAX(1)=H(1)	DAT	
	THMAX(1)=T	801	41
14	IE (V(1), LT, VMAX(1)) GO TO 15	301	43
•-		801	49
		801	50
	TVMAX(1)=1	HUT	51
15	IF (U(1).LT.UMAX(1)) GO TO 16		
	GHAX(1)=G(1)	201	20
	TG84X(1)=1	DUI	23
24	DETINA	dU1	54
10	RE LONG	841	22-
	ENU		
	SUBROUTINE FOR COMPUTING CRITICAL DEPTH		
	Prince States & Sectors States States	1.1	
	SUBROUTINE DCRIT	UCK	
	DIMENSION TG(200) OI(200)	DCR	4
	DIMENSION 0(400), 6(400), V(400)	NOG	3
	DIMENSION GLAGON	DCR	4
	DIMENSION OF STOP AT A TO DE CLASS AS CALLS APPOINT AND THE OF	0.02	
	COMMON DNIHITATAP ISPTATICITUTETIBETAETCETEETTPTTTTTTTTT	DCR	6
	COMMON D, XO, XF, GR, ALPHA, BETA, SO, F, H, V, G, SX, DI, T, TO, FF, RFB, FC, B	UCR	
	COMMON M+MMM+L+I+PERD+DDT+VA+IQ+TQ+QI+NGCD	DCK	1
	COMMON HA+HM+VM+HT+VT+NPT+HH+G+Q[]	DCR	0
	COMMON THETA.WP.R.DEPTH.VC	DCR	7
1	THE TA= 2 . 0 #ATANE ( 15-RTE (D*DX-DX##2) ) / (D*D-5-DX) ]	DCR	10
	Inclassion and the second second second second second	DCH	11
<u>.</u>	1F 11BEAL 21313	DCR	17
4	INE IA=0+20310+THETA	DCA	
3	A=0.125*(THETA-51NF(THETA))*(D*D)	DCH	13
	8=0*51NF(THETA*0.5)	UCH	14
	DC=DX=(6*(4**3)-4(PHA*((n*u)))**2)/uk)/(3*0*((0*A)**2)-(2*0*(4**3)	DCA	15
	The second state state state state	DCR	10
		000	17
	IF (ABSF*7C-DX)-0.00011 5+4+4	DUR	11
4	DX=DC	DCR	18
	60 10 1	DCR	19
5	VC-01124	DCR	20
·	V-VIII-	DCH	21
	RETURN	Den	
	ENC	DCK	44-

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14

#### SUBROUTINE FOR COMPUTING DOWNSTREAM BOUNDARY CONDITION

	SUBROUTINE BONZ	BOZ	3
	DIMENSION TO(2001, 01/200)	804	2
	DIMENSION 0(400). H(400). V(400)	BUL	3
	DINENSION GLADU	bu4	4
	COMMUN DN.HI.A.AP.0P.41.Cladistianceac.CorcePrulayInhauC	dU4	>
	COMMON D. XD. XF. GR AL PHA DE TA SO F HIV QUEX DI TITOIF IN FDIFCIO	DUL	
	COMMON MAMMAMAL . I.PERD.DDT.VA.LUIUIUIUIU	BUC	7
	COMMON HASHMANNAHTAVTANPTAHHAGAQII	804	ø
	COMMON THETA	804	9
	COMMON DMAX(400) . VMAX(400) .HMAX(400)	802	10
	COMMON TOMAX(400).TVMAX(400).THMAX(400)	BOZ	11
	HP=H(M)	802	12
	VP=V(M)	802	13
	THETA=2.0*ATANF((SGRTF(D*HP-HP*HP))/(0.5*0-HP))	BOZ	14
	1F (THETA) 1+1+2	auz	15
1	THETA=THETA+6.20016	DUC	16
2	AP=0.125*(THETA-SINF(THETA))*(U*U)	BUZ	17
-	BP=D*SINF(0.5*THETA)	302	10
3	THETA=2.0*ATANF((SGRTF(D*HX-HX*HX))/(D*G.5-HX))	302	15
÷.	IF (THETA) 4+5+5	302	40
4	THETA=6.28310+THETA	BUZ	£1
5	A=0+125*(THETA-SINF(THETA))*(0*0)	BOZ	22
	B=D#SINF(THETA+0.5)	802	23
	VX=SQRTF(A+GR/B)	802	44
	CIN=COSF(THETA+0.5)/SINF(THETA+0.5)	BOZ	45
	FORG=AP/(BP+DX)+(VX+V(MM)-V(MMM)-VM)+VP/JX+(HX+H(MM)-H(MMM)-HM)+	1002	26
	1X+H(MMM)-H(MM)-HM)/DT	BUZ	67
	FPR1=AP/(8P*0X*2.6*VX)*(GK-A*GK*2.0*CTN/(8*6))+VP/0A+1.6/DT	BUZ	20
	DC=HX-FORG/FPR1	buz	27
	IF (ABSF(DC-HX)-0.0001) 7.6.6	802	30
6	HX=DC	dU2	21
-	GO TO 3	002	32
7	H(MM)=DC	802	33
2	THETA=2.0*ATANF((SGRTF(D*DC-DC*DC))/(D*0.5-DC))	BOZ	34
	IF (THEIA) 8,9,9	802	35
8	THETA=6.28318+THETA	80Z	36
5	A=0.125*(THETA-SINF(THETA))*(D*D)	BOZ	37
	B=D*SINF(THETA*0.5)	BOZ	34
	V(MM)=SGRTF(A*GR/B)	BUZ	24
	G(MM)=A+V(NN)	DUZ	40
	1=384	DUC	+1
	IF (H(1).LT.HMAX(1)) GO TO 10	BUZ	42
	HMAX(1)=H(1)	BUL	43
	THMAX(I)=T	BUZ	44
10	IF (V(1).LT.VMAX(1)) GO TO 11	du2	45
	VMAX(I)=V(1)	802	46
	TVMAX(1)=T	802	47
11	IF (Q(1).LT.QMAX(1)) GO TO 12	802	48
	QMAX(1)=Q(1)	802	49
	TQMAX(I)=T	802	50
12	RETURN	BOZ	51 %
	ENU	044	26-

#### SUBROUTINE FOR COMPUTING GEOMETRIC PARAMETERS OF CIRCULAR SEGMENT

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	SUBROUTINE CIRCLE	CIR	1
	DIMENSION TG(200), QI(200)	CIR	4
	DIMENSION G(400), D(400), V(400), X(330)	CIR	3
	COMMON DNIHI + A + AP + OP + A1 + C1 + D1 + E1 + O2 + A2 + C2 + C2 + VP + UT A + UT + HX + UC	CIN	4
	COMMON DIA, XO, XF, GR, ALPHA, BETA, SO, F, D, V, Q, DX, DT, T, TO, TF, N, FB, FC, B	CIR	5
	COMMON M.MM.MMM.L.I.PERD.DDI.VA.IQ.IG.GI.NOCD	CIR	D
	COMMON HASHMSVMSHTSVTSNPTSHHSXSGB	CIR	7
	COMMON THETA: WP .R . DEPTH . VC	CIR	0
	THETA=2.0*ATANF((SGRTF(DIA*DEPTH-JEPTH*#2))/(DIA*0.5-DEPTH))	CIR	7
	1F (THETA) 1+2+2	Cla	10
1	THETA=6.20310+THETA	CIR	11
2	A=0+125*(THETA-SINF(THETA))*(01A*01A)	CIN	12
	WP=(UIA+0.5)=THETA	CIR	13
	R=A/wP	CIK	14
	d=01A*SINF(THETA/2.C)	CIN	15
	RETURN	CIR	16
	END	CIR	17-

SUBROUTINE FOR COMPUTING COEFFICIENTS IN DIFFERENCE EQUATIONS

	SUGROUTINE COEU	CUT	1
	DIMENSION TG(200), Q1(200)	CUE	2
	DIMENSION 0(400), H(400), V(400)	COF	- 3
	DIMENSION G(33C)	COF	4
	COMMON DALHIA AD DD.41.C1.01.E1.2.42.C2.E2.VD. TA.01.EX.0C	600	1
	COMMON D. YO. YE. GO. AL DETA CO. F. H.Y. O. DY. DT. T. T. T. W. E. E. C.	000	1
		CUE	
	COMMON NERMERAMEL FIFERDEDDISVASIGEGUEENGCD	CUE	- 1
	COMMON HASHMAVMAHIAVIANPIAHAGAGII	COE	
	COMMON THETA WP +R + DEPTH + VC	COE	
	VT = (V(1+1)+V(1-1))*C.5	CUE	10
	HT=(H(I+1)+H(I-1))*0.5	CUE	11
	THETA=2.0*ATANF((SGRTF(D*HT+HT**2))/(D*0.5-HT))	CUE	14
	IF (THETA) 1+2+2	CUC	13
1	InETA=6.20310+THETA	CUE	14
2	A=0+125*(THETA-SINF(IncTA))*(0*0)	CUE	12
	WP=D*L.5*THETA	CUE	16
	B=A/KP	CUE	17
	B=D+SINE/THETA+(5)	COF	1.6
		CDE	14
		COL	20
		COL	20
	AZ-VI*ALPRA/GK	CUE	21
	SF==123*F*52*V1*V1/K	COE	44
	EZ=SF-SO	CUL	63
	RETURN	CUL	24
	END	CUL	43
	SUBBOUTTNE FOR COMPLETING REDAY & VELOCITY AT END OF THE DETENDED		
	SUBACTINE FOR COMPUTING DEPTH & VELOCITY AT END OF TIME INTERVAL		
	SUBROUTINE COMPTE	COM	1
	DIMENSION TO(200), OI(200)	COM	2
	DIMENSION C(400) + H(400) + V(400)	004	3
	DIMENSION G(33.)	COL	4
	COMMON ON HILLA APADA ALCIADIALIADIAL CALLARY PROTACT HEAD	CON	
		Culm	1
		COM	~
		COM	
		CUM	•
	COMMON THETA WAY RODEPTHINC	CON	y
	CUMMUN UMAX(400), VMAX(400), HMAX(400)	CUN	10
	COMMON TWMAX(400), TVMAX(400), THMAX(400)	CUn	11
	H(1)=HT-(DT/(2.0*DX*D1))*(A1*(V(1+1)-V(1-1))+(H(1+1)-H(1-1)))	CUM	12
	V([]=VT-(DT/B2)*((A2*(V([+1)-V([-1))+H([+1)-h([-1))/(2*0*DX)+E2))	CUM	13
	VP=V(I)	CUN	14
	Q(1)=V(1)*A	COM	15
	IF (H(1)) IT-HMAX(1)) GG TO 1	COm	16
	HMAX(1)=H(1)	Cold	17
	THMAX(I)=T	COM	1.0
1		Cim	10
	Way(1)-V(1)	Cum	
	TMAAVILL-T	CUM	20
		COM	41
2	IF (G(1).CI.GMAX(1)) GO TO 3	COM	44
	QMAX(1)=Q(1)	COM	23
	TOMAX(I)=T	COM	64
3	RETURN	COM	25
	END	COM	26-
	SUBROUTINE FOR COMPUTING NORMAL DEPTH	Date	- 10 -
	SUBROUTINE DNORM	DINO	
	DIMENSION TQ(200), Q1(200)	DNO	4
	DIMENSION G(400), H(400), V(400)	DNU	3
	DIMENSION G(330)	DNU	4
	COMMON DNOHIGAGAPODFALOCIOLOCIOCOCCOCCOCCOVERTATATA	LINU	2
	COMMUN D, XO, XF, GR + ALPHA + BETA + SO, F + H + V + Q + DX + DT + T + T + T + F + F + F + F + F	DNU	U
	COMMON M.MM.MMM.L.I.PERD.DDT.VA.IQ.TU.QI.NGCO	DNU	7
	COMMON HA, HM, VM, HT, VT, NPT, HH, G, QII	DNU	8
	COMMON THETA . WP . R . DEPTH . VC	DNO	5
1	THETA=2.0*ATANE((SGRTE(D*H1-H1**2))/(D*0.5-H1))	DNO	10
	IE (THETA) 2.3.3	DNU	11
2	THE TA=6.28316+THE TA	DNO	12
3	A=0.125*(THETA-SINF(THETA))*(D*D)	DNU	13
-	WP=(0.5*D)*THETA	DNG	14
	REAZWP	DNU	15
	B=U*SINF(THETA*0+2)	DNU	10
	DN=H1-(#P-(F*G11*G11)/(8+0+GR*SU*K*K*A))/((3+U*B)/K-2+G/SINF(THET	AUNU	17
	1*0.5))	DINU	10
	IF (AB5F(DN-H1)-0.0001) 7,4.4	DNU	15
4	IF (D-DN) 5,5,6	DNO	20
5	DN=DN+0.5	DNO	21
	G0 T0 4	DNO	22
0	HI=DN	DNU	23
7	60 TO I	DNO	24
•	REI URN	DNG	23
		DNU	< b-

	SUBROUTINE FOR COMPUTING INITIAL CONDITION		
	SUBROUTINE INCOND	1.0	C
	DIMENSION TUI2001. QI(200)	IN	C
	DIMENSION G(400); D(400); V(400); X(330) C(MNON ON H):A:AD:00.41.C1.D1.b1.d2.31.C1.d2	In	ç
	COMMON DIA:X0:XF:GR:ALPHA:HETA:50:F:D:V:G:0X:0I:T:T:D:TF:N:Fh.FC	In In	č
	COMMON M+MM+HHH+L+I+PERD+DDT+VA+10+Tu+QI+NGCD	IN	č
	COMMON HA, HM, VM, HT, VT, NPT, HH, X, QB	IN	¢
	COMMON THETA, WP, R, DEPTH, VC	IN	c
	DT0L=0.00001 15 (0N=0() 1.1.2	IN	c .
1	K=1	Los	
	GO TO 17	IN	c i
2	DIN=(DN+6C)*6.5	10	C 1
	DEPTHEDC	In	C 1
		1.00	
	VH=(VV*VV)/(2+0*GR)	1 fee	
	S1=F*VH/(4.0*R)	Low	či
	EE1=DC+ALPHA*VH	1.04	C 1
	D(2*N+1)=DC	IN	C 2
	V(2*N+1)=VV	1.04	
	NCOUNT*0	In	2 2
	DO 16 L=1.N	IN	6 4
3	DEPTHEDIN	2.000	4
	CALL CIRCLE	Inte	
	DTHET #4.0/(DLA#SINE/DETHY)	1.00	
	DAREA=G.125+DIA+DIA+(1.0-CUSF(THETA))+UTHET	List	2
	DW=0.5*DIA*DTHET	INC	5 3
	DRA=(WP*DAREA-A*DW)/(WP*WP)	INC	с э.
	DENG=1.0-(Q8*Q8/(GR*(A**3)))*DAREA	INC	3.
	USLU==F*GB*GB*(2+0*K*A*DAKEA+(A**2)*DKA)/(8+0*GK*((K*A**2)**2)) VV=Gd/A	100	- 3
	VH=(VV*VV)/(2.0*GR)	1140	- 3
	S2=F*VH/(4.0*R)	INC	
	SF=(51+52)*0+5	Inc	
	ELZ=UIN+ALPHA+VH EVATIO=/ELZ=-Eliz:0+0/4/50_5+11//0+Mui/L.311# (1.0//0-5+11	1 144	
	DCOM=DIN-FRATIO	1140	
	1F (DCOM) 5,4,6	100	4
4	WRITE (6,19)	INC	4
	GO TO 18	INC	4.
6	1E (AdSE/DCOM-DINI=DTO() 15.15.7	LINC	- 44
7	1F (0.82*DIA-DCOM) 8,14,14	INC	14
8	DIN=DCOM+0.5	Inc	4
9	IF (0.82*DIA-DIN) 10.10.11	Inc	44
10		INC	43
	60 TO 9	INC	
11	1F (NCOUNT-20) 12,12,13	INC	52
12	GO TO 3	INC	53
13	WRITE (6,20)	INC	54
14	DIN=DCOM	INC	55
10000	GO TO 3	INC	20
15	DIN=DCOM	INC	20
	S1=52 FF1====2	INC	27
	11=2*(N-1)+1	LINC	00
	D(II)=DIN	INC	01
	V(II)=VV	INC	63
16	CONTINUE	INC	64
	GO TO 18	INC	65
17	WRITE (6,21) K	INC	66
C	RETUR:	INC	60
19	FORMAT ( DOUM EQUALS ZERO *)	INC	07
20	FURMAT (25H D2 MUCH GREATER THAN DIA)	INC	71
55	END	Inc	74
		INC	73

### A.I.3. DEFINITION OF VARIABLES

NAME DEFINITION	STAT	TEMENT	NUMB	E-P				
A AREA OF CIPCULAR SEGMENT	DNO	13	DCR	13	COE	15	801	23
	102	22	508	37	CIR	12		
ALPHA VEL. DISTRIBUTION COFF ENERGY	NST	24						
AP APEA OF CIRCULAR SEGMENT	802	17						
AY ADEA OF CIRCULAR SEGMENT	801	22						
AL COFFEICIENT	COF	19						
A2 COEFCICIENT	COF	21	401	36				
	COL	1.6	DCD	20	COF	10	10.2	22
B FREE-SURFACE WIDTH	LING	10	DUR	14	COL	10	PUL	23
	*02	34	CIR	12				
RETA VEL. DISTRIBUTION COEF MOMENTUM	NST	25						
HP FREE-SURFACE WIDTH	802	10						
H2 COEFFICIENT	1151	31						
CTN COTANGENT OF 1/2 THETA	BUS	52						
CI COEFFICIENT	NST	54						
C2 COEFFICIENT	* <b>IST</b>	35	-			-		
D DIAMETER OF CONDUIT	NST	20	INC	20	INC	62		
DAREA DERIVATIVE OF AREA WITH DEPTH	INC	59						
DAX DERIVATIVE OF AREA WITH DEPTH	801	36						
DC CRITICAL DEPTH	DCR	15	102	29				
DCOM COMPUTED DEPTH	INC	40	INC	44				
DENG DERIVATIVE OF ENGERY WITH DEPTH	INC	32						
DEPTH ASSUMED DEPTH OF FLOW	INC	14	INC	25				
DIN INITIAL DEPTH ASSUMED	INC	13	INC	47	INC	49	INC	56
	INC	58						
ON NORMAL DEPTH	DNO	17	OND	21				
DRA OFRIVATIVE OF HYD. RADIUS WITH DEPI	HINC	31		1910				
DSLO DEPIVATIVE OF SLOPE WITH DEPTH	INC	33						
OT TIME INCROMENT	NST	67						
OTA TINE INCONENT	NST	75	NCT	#1				
OTHET DEDIVATIVE OF THETA WITH DEDTH	THE	28	14.57					
DTOL TOLEDANCE IN ADDROV DEDTH	THC	13						
DE DEDIVITUE OF CUPENCE HIDTH HITH OFPI	HINC	70						
ON INCOMENT IN X-DOCITION	NCT	E.	NCT		Deb	1.8		
DI COFFETCIENT	COF	20	1923.1	-13	UL.N	10		
FEL ENERGY CLODE AT DOFITION 1	TNC	10	THE	× 0.				
EET ENERGY SLOPE AT POSITION 1	INC	20	INC	~0				
ELE COEFFICIENT	NET	35						
ET COEFFICIENT	COF	30	401	78				
E DIDEN WEIGHTEN FOIGTION FLOTON	LUCT	23	Drif	20				
F DARCT-WEISHACH FRICTION FACTOR	451	23						
FB FRICTION FACTOR COEFFICIENT	NST	44						
FC FRICTION FRACTOR EXPONENT	115.1	50						
FD CELERITY OF WAVE	NST	24						
FH (2)	801	34						
FM NUMBER OF POSITION INTERVALS	NST	61						
FNU KINEMATIC VISCOSITY	NST	48						
FORG (2)	POS	59						
FPH (2)	801	37						
FPR1 (2)	802	28						
FRATIO (2)	INC	39						
GR ACCELORATION DUE TO GRAVITY	NST	26						
H DEPTH OF FLOW	COM	12	801	42	602	33		
HA DEPTH OF FLOW	NST	98				-		
HETH1/2 THETA	THE	27						
HM OFPTH OF FLOW	NST	101						
HNAX HAY DEPTH OF FLOW	NST	15	COM	17	801	46	508	43
WN DEDTU OF FLOW-INITIAL	ROT	10	801	60	101	40	1002	4.5
WHILDEDTH OF FLOW-COMPLITED	001	24	not	40				
HD OFFIL OF FLOW COMPUTED	001	38						
HE DEPTH OF FLOW	802	12						
HI DEPTH OF FLOW-MEAN	COE	11						
HA DEPTH OF FLOW	NST	104	802	31				
HI ASSUMED DEPTH	NST	21	DNO	53				
1 (1)	805	41	125797	157				
11 (1)	NST	120	INC	-1				

16 (1)	1954	121						
10 (1)	INST	53	801	16				
IXOX PRINT OUT LIMIT	NST	46	0.004	1.2				
K (1)	NST	82	NST	67	INC	11		
M NO. OF COMPUTATION INTERVALS	NST	60		1.14				
MM NO. OF COMPUTATION POSITIONS	NIST	62						
MMM NO. OF COMPUTATION INTERVALS	NST	63						
N NO. OF LENGTH INTERVALS	NST	43						
NCOUNT (1)	INC	21	INC	50				
NPG (1)	HET	110	1.40	10				
NPO (1)	NET	410						
NT (1)	NCT	53	NCT		1.07	0.6		
NI PRINTOUT INTERVAL	101	30	1421	49	NSI	94		
AL PAINTON INTERAC	100		1000	1.00				
PERU (2)	RSI	41	NST	51				
PN1 (2)	NS1	40						
PN2 (2)	NST	91						
PN3 (2)	MST	45						
Q DISCHARGE	INC	51	INC	64	COM	15	801	- 43
	805	40						
QA DISCHARGE	NST	97		e				
QII DISCHARGE	NST	37						
OM DISCHARGE	NST	100						
QMAX MAX. DISCHARGE	NST	17	COM	23	801	52	802	4
OT DISCHARGE OF LAST POINT ON HYDHO.	401	13	801	18				
R HYDRAULIC RADIUS	DNO	15	COE	17	801	25	CIR	14
RA (2)	NST	66						
SF FRICTION SLOPE	INC	37	COE	22	801	27		
SO CHANNEL BED SLOPE	NST	42						
50 (2)	HOL	29						
SI INITIAL FRICTION SLOPE	INC	18	INC	59				
S2 FINAL FRICTION SLOPE	INC	36						
TTIME	NST	40	NST	95				
TE TOTAL TIME OF INTEGRATION	NST	41	21201					
THETA CENTRAL ANGLE OF CIRC. SEGMENT	DNO	1.0	DNO	12	DCP	10	0CP	13
THETE STATUTE AND TO STATE TO STATE	COF	12	COF	14	ROL	20	BOL	2
	601	20	401	22	102	14	802	1
	802	10	202	-16	202	24	802	-
	C10	17	CIL		0.05	34	0.05	20
THNAY TINE TO HAY, DEDTH	COM	1.0	401	1.7	10.02	6.6		
TO INITIAL TIME		10	0.01	48	PUL	**		
TOWAY TINE TO WAY DISCHAOSE	004	19	12011		1.0.0			
TOO TINE OF INITIAL DISCHARDS	COM	24	901	~3	BUS	50		
TWO TIME OF INITIAL UISCHARGE	ns i	.50	10000	10520	000000	10.24		
TVMAX TIME OF MAX. VELOCITY	COM	51	901	50	805	47		
TI TIME AT END OF TIME INTERVAL	NST	71	NST	96				
V VELOCITY	INC	55	INC	63	COM	13	801	- 44
	19105	39						
VA VELOCITY	NST	99						
VC CRITICAL VELOCITY	004	20						
VH VELOCITY HEAD	INC	17	INC	35				
VM VELOCITY	NST	102						
VMAX MAX. VELOCITY	NST	16	COM	20	101	49	802	44
VP VELOCITY	COM	14	802	13				
VT AVERAGE VELOCITY	COE	10						
VV VELOCITY OF BASE FLOW	INC	16	INC	34				
VX CELERITY OF WAVE	802	24						
WP WETTED PERIMETER	DNO	14	COF	16	HO1	24	610	1.2
X POSITION	NST	125		1.4			- 14	•
XE TOTAL LENGTH OF CHANNEL	NGT	22						
XI INTEGRATION LENGTH	NST	58						
XO INITIAL DISTANCE	NST	21						
(1) DO LOOP COUNTER OF VARIABLE		· · ·						
(2) INTERMEDIATE VARIABLE								

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Format	No. interest of the			SAMPLE INPUT	1				
Format	No. 1 7 7 7 3 5 7 7 7 7	of Discharts Tid		17 50 34 35 34 37 34 39	010040	4 47 49 49 50 51	51 53 54 55 56 5	7 38 37 90 61 62 63 64 65 66 67 68	67 70 71 72 73 74 75 76 77 18 78 80
12	X X X (NUMDer	or Discharge Time	rdirs describing	innow nyarog			T	Distant	The state
	Discharge	Ime	Discharge	Ime	Dis	enorge	1100	Discharge	lime
13	•	•	•	•					
	(Repected A	s Many Cards As	Desired To Descr	ibe Hydrogra	ph)				
	And and an other data in the second sec	5				1022-200			
		.0 4.0	30.0 10.0	50.0	10.	80.0	4.0		
	1	200.0 4.0							
				CAMPLE OUTPUT					
				SAME TEL COLLOR					
			and the second						
DNON	# 7.32608337E=	01 IF = 2.	20+30000000E+05		TIME I	5 4.80206	471E+01 4	SFC.	
Ditteo		S0 = 1.	0000000F-03		PNT	n		۷	Q
<b>UC</b> 48	= 6.204+3705E-	01			1	1.103904	036+00	4.465119888+00	1.0000000E+01
		0 = 2.	924200005+00		4	1.087734	925+00	4.45764206E+00	1.05950130E+01
	#0		Jacobuccest		4	1.084201	336+00	4.64233678E+00	1.04856689E+01
Dx =	2.04717382E+01		200000008-05		5	1.073269	126+00	4.65193921E+00	1.03572673E+01
		RA = 1.	32607036E-01		7	1.060505	702+00	A.63731041E+00	1.02338305E+01
UT =	1.357906476-00		1044-30-45-01			1.04+001	275+00	4.41949992E+00	9.89022024E+00
X0 =	0.		368797396-01		9	1.02632C	00+35+00	4.53402103E+00	9.56939896E+00
1.12		PERU =	1-5000000E+05		10	1.010404	05E+00	4.56295854E+00	9.37098990E+00
XF =	P.21700000E+02				12	9.786449	216-01	A.43743271E+00	8-01090926E+00
To =	0.	<u>F8 = 3</u>	00000000E-05		13	9.443403	89E-01	4.243676#5E+00	7.912074906+00
	93	FC = 0	1		14	4.310301	356-01	4.73140430E+00	7.048+2278E-00
		1877. (18				8.932548	1405-01	3.06953420E+00	6.0820054532F+00
					17	8.438114	665-01	3.75187348E+00	5.93567930E+00
					18	A. 325761	16E-01	3-69/45085E+00	5.73384994E+00
					19	d.n]744(	A0E-01	3.506837702+00	5.17605128E+00
					61	7.70704	605-01	3.319999906+00	4.03906497E+00
	1900 B				2000				
TIME IS	o.	SFC.	0		TIME I	5 6.5184]	961E+01 .	SFC.	
1	7.3268/9745-01	3.035708256+00	4.0000000E+00		PNT	B. 401241	205-01	3.86038347E+00	6- 46356078E+00
e	7.320804444-01	3.03370783E+0U	3.99999451E+00		2	9.483500	56L-01	3.97424237E+00	7.957373+7E+00
З	7.320892335-01	3.03571022E+00	4.0000000E+00			1.024675	5455+00	4.048208496+05	8.59084738E+00
-	7.320892222-01	3.035707452+00	3. 99999830E+00			1.020020	540E+00	4.070605/32+00	R.675291/4E+00
- 6	7.320806786-01	3. 13571790E+00	4.00001485E+00		5	1.047756	03E+00	4.243001506+00	3.24499070E+00
7	7.320901262-01	3. 13074412E+00	4.0000000UE+00		1	1.058801	48E+00	4.37089861E+00	9.03356487E+00
8	7.3208/5102-01	3.0 30740 346 700	4.00002999E+00		B	1.056291	155E+00	4.38112528E+00	9.61578381E+00
10	7.3268+2946-01	3.035720576+00	3.99997636E+00		10	1.05380	B7E+00	4.46889178E+00	9.73770427E+00
1 k	1.320300122-01	3.13570821E+00	4.00000000E+00		11	1.04762	220E+00	4.51104504E+00	9.72446928E+00
-12	7.320724126-01	3.03576739E+00	3.99996960E+00		14	1.041014	90E+00	4.50066783E+00	9.61516311E+00
13	7.32656075E=01	3.015491416+00	3.99995493E+00	3	13	1.02033	49E+00	4.415002222+00	9.44/92/92E+00
15	7.320307755-01	3.035061736+00	4.00000000E+00		15	1.00374	29AL+00	4.46368315E+00	9.033760262+00
16	7.320201616-01	3.030080706+00	3.99996207E+00		.10	9.94987;	2912-01	4.43731805E+00	A.86751218E+00
10	7.32573896E-01	3.130303396+00	4.00000000E+00		17	9.73183	8395-01	4.37/815112+00	8.46310389E+00 8.26212390E+00
19	7.325450946-01	3. 1 105 2147E+0C	4.00000000E+00		14	9.35674	7741-01	4.21147810E+00	7.71741439E+00
20	7.324904792-01	3.1 10795202+00	1.99990231E+00		20	9.23/63	696E-01	4.190266418+00	7.49209216E+00
	7.324515455-01	3.13(059036*00	4.0000000000000	•3	21	8,91196	0016-01	4.025623032+00	A.05323537E+00
TIME IS	1.629554901-01	SFC.			TTAL	15 8.1477	74515+01	SEC.	
PNT	n	v	0		PNT			v	Q
1	9.531136231-01	4.77040548E*CU	7.259109018+00		1	A.38347	027E-01	P.A=786384E+00	4.00000000E+00
2	9.38411556E-01	4.200366664.00	7.66945517E+00		2	8.50621	4291-01	2.91544043E+00	4.80605184E+00 5.38306338E+00
4	H.79+872976-01	1.02050505E*00	6.53375813E+00	P		8.93954	0516-01	3.15971193E*00	5.59529460E+00
5	8.35570546E-01	1.44433572E+00	5. 12048652E+00		5	9.29520	9811-01	3.38140412E+00	6.30495722E+00
- 6-	8.2104/4265-01	3.61/77528E*00	5.48592548E+00	5	6	9.37344	4871-01	1.43537031E+00	6.47311809E+00
	7.740561845-01	3. 329936986+00	4.68060602E+00		7	9.64474	9621-01	3.47077978E+00	7.22073888E+00
	7.502976866-01	3.153004526*00	4.27576009E+00	e		9.89177	8241-01	3.4:7253016+00	7.75750002E+00
10	7.463511845-01	3.132506912+00	4.21491895E+00		10	9.91876	345E-01	3.971895766+00	7.84507918E+00
12	7.349134426-01	3. 196807912+00	4.03425374E+00		11	1.00710	6301+00	4.01000343E+00	R.34347448E+00
13	7.320500426-01	3.030901066+00	4.00003299E+00		13	1.01/2-	611E+UU	4.15687801E+00	A.69406058E+00
14	7.3263+1276-01	3.0 10157692+00	4.00003463E+00		14	1.01544	646L+00	4.17948096E+60	A.70194155E+00
	7. 320101946-01	3.040294625+00	4-00003471E+00	5		1.01483	1643L+00	4.274061042+60	8-89864607F+00
17	7.3200/0535-01	3.0 3044231E+00	4.00002555E+00		17	1.01474	61AL+00	4.34425478E+00	9.9A871256E+00
	7.375207866-01	3.130678028+00	4.00002608E+00	ð.	18	1.00745	+41nc+00	4.34187815E+00	R.91441616E+00
19	1.324002492-01	3.010000/46*00	4.000015426+00		19	1.0016.	130L+00	4.349801882+00	8-855525311 +00
- 61	7.324502471-01	3.137649055100	4.U0000672E+00		20	9.8102	7155-01	4.35051021E+00	A.54370935E+00
TIME IS	3.239109415+61	SFC.			TIME	15 9.777.	2942E+01	SEC.	
1	1.070++2791+04	4.8-040401E+00	1.00000000E+01		PNT	S.eed H	4145-01	2.424278046+00	4.0000000E +00
e	1.071209501+00	4. # /14464E+ 90	1.062560056.01		2	8.4455	064E-01	2.45232768E+00	4.59528985E+00
<u>Э</u>	1.052435715+00	4.743557/6E+00	1.01539752E+01		3	8.4731	0001-01	2.97100492E+00	4.64920714E+00
4	1.0346/4006+00	4.444472302*00	9.0795+044E+00 9.05918380E+00		4	8.4933	7251-01	2.846290346+00	4.80021112E+00
6	Y.571061735-01	4.434930506+00	A. 77455938E+00		5	8.5459	1425-01	2.949392696+00	4.07700639E+00
. 7	4.460104932-01	4.34+13+0+E+0U	7.94304677E+00		1	H.6846	10-21654	3.047544905+00	5-06418158E+00
ь	~.32580022E-01	4.0397020HE+00	7.06395842E+00		8	8.7351	+6455-01	3.145H8143C+00	5.47799164F+00
10	H. 779109271-01	3.958960536+00	6.58225490E+00			A.9344	33AL-01	3.19141736E+00	5.60738107E+00
11	5.380304251-01	3.730288535*00	5.03930245E+00		11	9.1254	23951-01	3.12521879E+00	6-02002541E+00
_12_	7.94998654-01	3.466842036*00	5.02045427E+00	-	- 12	9.1757	1212-01	3.373705398+00	6-15209081E+00
13	7.461331931-31	3.4:725856E+00	4.891525138.00		13	9.4052	122E=01	3.560325412+00	6.72267320E+00
12	7-527-64946-01	3. 2441 98446+00	4.49327580E+00		15	4.5760.	10745-01	3.710446616+00	7-16206602E+00
15	7.577504746-01	3.21001804E+00	4.+1200653E+00		10	9.5936	+1365-01	1.745466655*00	7-24280678E+00
14	7.421603615-01	3.12*039046*00	4.1-1-1-4016E*00 4.15487404E*00		17	9.72+5	03215-01	3.970427156+00	7.669427408+00
19	7.35986667E-01	3.10.1425066+00	4. 05634P96E -00		19	4.6123	9511z-ul	4.010203516+00	7.97125349E+00
d-1	7.3411474AC-01	3-0507++34E+00	4.04408644E.=00		20	9.7959	027AL-01	4.02775925E+00	7.94737305E+00
	1.3243041HE-01	3.103405665+00	4.011105220.00	-	21	7.8308	00105-01	e*1<001254F+00	H.C.I.C. 13573E *00

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1 1.116	IS 1.1400884JE+02	CFC.	
PNI	6.35J70653L-01	2.47451201E+00	4.000CG000E+00
2	8.36040085L-01	2.947279266+00	4.5P316175E+00
	8.38+30999L-01	2.43405342E+00	4.61255334E+00
-	A.423725531-01	2.919044632+00	4.040994492+00
6	8.435459915-01	2.926459096+00	4.70777663E+00
7	8.47240761E-01	2.93051088E+00	4.7556755E+00
	A.49051305E-J1	2,953198266+00	4.79+++HYBE+00
10	H.53026195E-01	2,973407666+00	4.84687225E+00
11	8.610206421-01	3. 1/832718E+Au	5-02948193E+00
12	8.640001326-01	3.052521802+00	5.0946 9800E+00
13	A.726909656-01	3.1.022005E+06	5.260307c3E+00
12	5.75/3/114L-01	3.119374726+00	5.34003164F+00
16	8-892595251-01	3.211169185+00	5-56530974E+00
17	9-013075661-01	3. 146673255+00	5.93522957E+00
18	9.040908295-01	3. 3-393788E+00	6.020271918+00
19	9.16743176E-01	3.44235273E+00	6.34102321E+00
20	4.14090/57E-01	3.44144049E*00	6.423/0932E+00
		A A A A A A A A A A A A A A A A A A A	H
1.4E	15 1.303043026+02	SEC.	24
PAL	4.2767US3PE=01	9.01143659E+00	4-0000000E+00
2	A.249745526-01	2.92070893E+00	4.5P0006d1E+00
3	8.3107/431E-01	2. 32+69081E+00	4.00323H34E+00
4	4.32176895E-01	2.43357077E+00	4.62577823E+00
5	8.34+009322-01	2.93001028E+00	4.65074457E+00
7	4.380237851-01	2.4-080.3046+00	4.073013036+00
	8.3919835AL-01	2.4-179620E+00	4.725469501+00
9	8.417736905-01	2.059079726+00	4./5870578E+00
10	8.429741376-01	2.97770749E+00	4.78551976E+00
11	8.450355172-01	3.94058194E*00	A.02685634E*00
13	d.504195276-01	3.117514395+00	4.91320832F+00
14	4.51757392c-01	3.13036832E+00	4.95003849E+00
15	8.558324566-01	3. 14:33633E+00	5.02654657F+00
16	8.572978n1E-01	3.07952415E*00	5+07101749E+00
17	8-6392/2155-01	3.119692266*00	4.17602748E+00
19	8.701136735-01	3.190270106+00	5.35/41647F+00
40 21	8.716630A1E-01	1.21256948E+00	5.42/151/6E+00
20	8.716630411-01 8.786791571-01	1.21256948E+ng 3.22082570E+00	5.42/151/6E+00 5.601/1567F+00
20 21 IME P-VT	8.716633412-01 8.786701575-01 TS 1.45659941E+02 M	1.31346448E+nj 1.22062520E+nj 55C. v	5.42/151/6E+00 5.001/1507F+00
20 21 IME P-VT 1	8.716633911-01 8.786701571-01 TS 1.45659941E+02 M 8.214316491-01	1.31346448E+00 1.22682576E+00 5FC. V 2.442372+60	4.0000000F+00
20 21 IME Port 1 2	8.71663041E-01 8.7857057E-01 TS 1.45559441E+02 7 8.21431640E-01 4.22415565-01 1.25502505	1.3134644KE+nu 3.22062578E+nu **C. y 2.44631247E+nu 2.44671449E+nu 2.4467144125+nu	4+2/15176E+00 5+001/1567F+00 4+00000000E+00 4+5782+278F+00
20 21 IME P-vT 1 2 1	8.71663041E-01 9.78679157E-01 TS 1.40059941E+02 7 8.21431640E-01 8.22411540E-01 8.756864592-01	1.31316948E+00 1.22062577E+00 FFC. V 2.04257247E+00 2.34477349E+00 2.35461851E+00 2.35461851E+00	4.42/151/6E+00 5.601/1567F+00 4.0000000E+00 4.5782+278F+00 4.61673713E+00
20 21 IME Port 1 2 1 4 5	8.71663041E-01 A.78679157E-01 TS 1.40h59941E+02 n 8.21931640E-01 A.2291154AE-01 B.25882652E-01 8.25802558E-01	1.2124644KE+00 3.22662576E+00 2.44237247240 2.442372472400 2.442184100 2.4542184100 2.4543092400 2.4558372400	5.42/151/66.00 5.001/1507f+00 4.00000000000 4.5762+276f+00 4.61673713E+00 4.61673713E+00
20 21 IME Port 1 21 456	8.716430412-01 9.786701572-01 TS 1.405094412+02 9 8.214316442-01 8.224155412-01 8.224155412-01 8.256824522-01 8.279055582-01 8.2843(9932-0)	1.0101644KE+00 1.2066576E+00 2.4463/247E+00 2.4463/247E+00 2.44647849E+00 2.4464308E+00 2.4465837E+00 2.4665837E+00	4.42/151/66-00 5.001/1507F-00 4.00050000F+00 4.575/-276F-00 4.575/1976F-00 4.61673713F-00 4.61673715F-00 4.646/3331F-00
20 21 IME Port 12 45 67	8.71643041±-01 A.78675157±-01 TS 1.4555457±-01 8.21431645±-01 A.22415545±-01 A.22415545±-01 8.75682652±-01 8.75682652±-01 A.27905558±-01 A.31007492±-01 A.31007492±-01	1.01056948E+00 1.22066576+00 P.G. V 2.4465775+60 2.44675496+00 2.45618510 2.45637000 2.45637000 2.45637000 2.47637000 2.47637000 2.47637000 2.47637000 2.47637000 2.47637000 2.47637000 2.47637000 2.47637000 2.47637000 2.47637000 2.47637000 2.47637000 2.47637000 2.47637000 2.47637000 2.47637000 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.476400 2.4764000 2.476400 2.476400 2.476400 2.4764000 2.4764000 2.476000 2.4764000 2.476400000 2.47640000 2.476400000000000000000000000000000000000	11 4. UnCLUDUF+00 4. UNCLUDUF+00 4. UNCLUDUF+00 4. S47752+76f+00 4. S4771976f+00 4. S4771976f+00 4. S4747915F+00 4. S4745915F+00 4. S47452331E+00 4. S47452331E+00 4. S4745231E+00
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20 21 IME For 1 2 2 4 4 5 6 7 8 9 10 11 12 14 5 15 15 15 17 18	<ul> <li>4.716A3041L-01</li> <li>A.78670157L-01</li> <li>TS</li> <li>1.40h50941E+02</li> <li>A</li> <li>78.21431640L-01</li> <li>A.2241154hL-01</li> <li>A.2241154hL-01</li> <li>A.2241154hL-01</li> <li>A.2684652E-01</li> <li>A.760558L-01</li> <li>A.760558L-01</li> <li>A.300742L-01</li> <li>A.310748L-01</li> <li>A.4177840L-01</li> <li>A.4177840L-01</li> <li>A.4177840L-01</li> <li>A.4177840L-01</li> <li>A.4177840L-01</li> <li>A.41764054L-01</li> <li>A.41764054L-01</li> <li>A.41764054L-01</li> <li>A.41764054L-01</li> <li>A.4177840L-01</li> <li>A.420854L-01</li> <li>A.420854L-01</li> <li>A.420854L-01</li> <li>A.420854L-01</li> <li>A.46087283L-01</li> </ul>	1.0104044E+00 1.22662576E+00 2.9462576E+00 2.9462576E+00 2.9462576E+00 2.9462147E+00 2.94641451E+00 2.9465837E+00 2.94765837E+00 2.94765713E+00 2.94765713E+00 2.94765713E+00 3.9459723E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00 3.97221E+00	4.42/151/66-00 5.001/15077-00 4.00000005+00 4.5978/27874-00 4.5977976+00 4.5977976+00 4.616737138+00 6.654575157600 6.654575157600 6.65457318+00 6.72261256+00 6.7226405-00 6.7226405-00 6.709780318+00 6.62359005+00 6.42359005+00 6.423539005+00 6.42742335+00 6.42742335+00 6.42742335+00 6.42742335+00 6.42742335+00 6.42742335+00 6.42742335+00 6.42742335+00 6.42742335+00 6.42742335+00 6.42742335+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.42743455+00 6.4474455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.447455+00 6.44755+00 6.44755+00 6.44755+00 6.44755+00 6.44755+00 6.44755+00 6.44755+00 6.44755+00 6.44755+00 6.44755+00 6.44755+00 6.44755+00 6.44755+00 6.44755+00 6.44755+00 6.44755+00 6.44755+00 6.44755+00 6.44755+00 6.44755+0000000000000000000000000000000000
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40 21 1ME P 1 2 2 4 5 6 7 8 9 10 112 13 4 5 6 7 8 9 10 12 1 10 10 10 10 10 10 10 10 10 10 10 10 10 1	8.716A30A1L-01 8.786701572-01 TS 1.40050941E+02 7 8.214316402-01 8.22415540-01 8.22415540-01 8.22915561-01 8.786864521-01 8.279055561-01 8.279055561-01 8.320121010-01 4.321073452-01 8.35059292-01 8.3505292-01 8.35024010-01 4.479623652-01 8.431075852-01 8.430075552-01 8.442085542-01 8.442085552-01 8.442085552-01 8.442085552-01 8.442085552-01 8.450975552-01 8.450975552-01 8.450975552-01 8.450975552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 8.45097552-01 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TIME	15 1.79c=1039E+02	SFC.	
PIT	A	v	Q
1	H-12700707E-01	2.09133799E+00	4.0000000E+00
2	8.135203935-01	2.4401/4156+00	4.57546804E+00
	B.150365215-01	2.99761045E+00	4.58947u48E+00
4	8-156862810-01	3.00431509E+00	4.60356653E+00
5	6-1745/257E-01	3.004003126+00	4.01874210E+00
6	8-1831+431E-01	3.00885301E+00	4.63292180E+00
7	8.199249512-01	3.11102543E+00	4.64911571E+00
	8.2073/1446-01	3. 11021432E+00	4.66359671E+00
4	H. 22340547E-01	3.019047/35+00	4.080H05J3E+00
10	8.230943492-01	3.12472173E+00	4.09564202E+00
11	8.24673342E-01	3. 12830322E+02	4.71399129E+00
12	8.253243505-01	3.034645926+00	4.72902980E+00
13	8.2664/5555-01	3.03923473E+00	4.74845422E+00
14	H. 273812364-01	3.04523899E+00	4.76370106E+00
15	8-255) v8055-01	3-051-2204E+00	4.78420336E+00
16	8-291940431-01	3-0-9750325+00	4.79959705E+00
17	8-305042486-01	3.000706955+00	A.82121970E+00
18	8-30747 1541-01	3-07250240E+00	4-83670176E+00
19	8-318678645-01	3-043433616+06	4-05956875E+00
20	8.3105/2465-01	3.04162343F+00	4-87509991E+00
21	H-32851591E-01	3-1-402713E+00	4.89947434E+00
TIME	IS 1.955+6588E+02	SEC.	
PNT	H	v	Q
PNT 1	H 3.091042936-01	V 3.1075993E+00	Q 4.0000000E+00
PNT	H 3.091042936-01 4.098352166-01	4. 10759932+00 3. 114744545+00	Q 4.00U00000E+00 4.57+31750E+00
PNT L L	H 3.091092936-01 4.098352166-01 4.111656536-01	V 3.010759932+00 3.114744542+00 3.015793462+00	Q 4.00000000E+00 4.57431780E+00 4.58649591E+00
PNT 1 2 4	H 3.031092935-01 4.040352165-01 4.111655535-01 3.119203545-01	4.010759935+00 3.114744545+00 3.015793465+00 3.019676505+00	Q 4.00U00000E+00 4.57431750E+00 4.58649591E+00 4.59844003E+00
P 1 4 3	H 3.09109293L-01 4.09639216L-01 <u>4.1116553L-01</u> 3.11926364L-01 8.13910194L-01	V 1.01075943£+00 3.1147454±+00 <u>3.01773465+00</u> 3.019675005+00 3.02044905+00	Q 4.0000000000000 4.57+31750E+00 4.598649591E+00 4.59844003E+00 4.51145655E+00
PV1 4 5 6	H 3.091092932-01 4.090322162-01 4.111056322-01 9.119203642-01 8.133101942-01 5.1407462062-01	1. 11739432+00 3. 11744542+00 3. 1177454542+00 3. 11773462+00 3. 019475002+00 3. 01944992+00 3. 01944992+00	Q 4.00000000E+00 4.57431750E+00 4.598449591E+00 4.6114665E+00 4.6114665E+00
P1 1 4 5 0 7	H 3.091092935-01 4.090352165-01 4.11555335-01 9.119203645-01 8.13101945-01 5.140746205-01 5.140746205-01	3.01079935+00 3.014744541+00 3.019793965+00 3.019676505+00 3.01946905+00 3.01946905+00 3.01946905+00	Q 4.000000E+00 4.57431780E+00 4.59844003E+00 4.59844003E+00 4.61146665E+00 4.62367432E+00 4.6376257E+00
P111445075	H 3.09109293c-01 4.090528(c-01 4.1105553c-01 3.135034c-01 3.13510144c-01 5.140746205-01 5.140746205-01 5.1591346c-01 5.1591346c-01	4.1173993E+00 3.114745at+00 3.119743945+60 3.119743945+60 3.119745050E+00 3.11994295E+00 3.119925E+00 3.1159021E+00	Q 4.0000000E+00 4.57431740E+00 4.56649591E+00 4.59844003E+00 4.514665E+00 4.514665E+00 4.6376257E+00 4.657127+8E+00
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#### MAXIMUM VALUES AND TIMES AT FACH LOCATION

DISTANCE	MAA UEPTH	TIME	NAX VEL	TIME	MAX Q	TIME
0.00	1.10	48.80	4.06	92.50	10.00	48.89
cu.47	1.10	48.40	4.01	92.5C	10.71	40.74
40.94	1.49	51.60	4.77	35.31	10-60	48.89
54.10	1.09	51.60	4.13	38.02	10.49	51.50
51.89	1.04	54.37	4.70	+0.74	10.39	54.32
192.30	1.04	57.03	4.67	40.74	10.28	54.32
122.83	1.07	59.75	4.05	40.17	10.17	57.03
143.30	1.07	59.75	4.62	46.17	10.06	57.03
163.77	1+05	02.47	4.00	51.60	9.94	59.75
104.25	1.05	62.47	4.57	51.60	9.83	62.47
204.72	1.05	67.01	4.55	57.03	9.72	65.1A
225.19	1.04	67.90	4.53	57.03	9.62	65.18
245.00	1.04	70.61	4.51	bc.47	9.50	67.90
200.13	1.03	73.33	4.49	02.47	9.39	70.61
286.60	1.03	76.15	4.47	67.90	9.28	73.33
307.08	1.02	76.05	4.45	67.99	9.17	73.33
327.55	4.01	01.48	4.43	13.33	9.06	70.05
348.02	1.01	01.48	4.41	73.33	8.96	78.76
308.49	1-40	44.10	4.39	76.05	8.86	A1.48
366.96	1.00	66.91	4.37	78.75	8.74	84.19
409.43	.99	89.43	4.35	01.48	8.05	A6.91



### A.2.2. FORTRAN IV COMPUTER PROGRAM

MAIN PROGRAM FOR UNSTEADY FLOW BY LAX-WENDROFF SCHEME

	CLEARAN LATER OF INPUT. THE TRUT . TAPES= INPUT . TAPES= ULTPUT )	LHT	1
	DINENSION TO(3300) UI(3300)	LwT	4
	DIMENSION C(400) + H(400) + V(400)	LWT	3
	DIMENSION G(330)	LAT	4
	COMMON DN+H1+A+AP+OP+A1+C1+D1+E1+02+A2+C2+E2+VP+DTA+Q1+HB+DC	LWI	-
	CONHON DIXOXXFIGE ALPHAIBETAISONFINIVIGIDATE TITOTE INTERPORT	LeT	ž
	CUMMUN MARANAMALALARERDADDIAVASIGITATOTATINGCO	LinT	•
	COMMON THE TANK PRANCE PTHEVES JENNEVN	LAT	*
	CUNNUN LMAX14GC1+VMAX14GC)+HMAX14CU)	LeI	10
	CUMMON TURAX(400) + TVMAX(400) + THMAX(400)	L HI	12
	INTEGER RUN	Lat	13
	D0 1 1=1+4C0	LAT	14
	HMAXIII=C	LNT	15
	OMAX(1)=0	Lal	16
1	CONTINUE	LwT	17
C	INPUT WHICH MAY BE ALTERED	LWI	10
	D=2.9262	LaI	20
	50=0.001	LWT	21
		LWT	44
	x0=0-0	LAT	63
	xF=821.7C	Lat	44
	F=0.612	LWI	23
	ALPHA=1.00	LWI	27
	BETA=1.00	LaT	28
	GR=32.175	Lai	49
	H1=0.4*D	LNT	30
	IQ=1 END OF INDUT WHICH MAY BE ALTERED	LwT	31
č	INTIAL TIME, FINAL TIME, INTIAL HEIGHT, NUMBER OF POINTS PER ROW	Lai	24
	TO=0.	LaT	34
	TF=200.	Lel	25
	N=20 N1=N+1	LAI	20
	IXOX=1	LAT	31
	NPO=6	LAI	20
	FB=0.109394	LaT	40
	FC=-0.17944	LeT	41
	ATTENPO	LWT	40
		LWI	43
	CALL DNORM	LAI	44
	DX=DN	Lai	40
	DNOD=DN	Lal	41
	CALL DCRIT	LeT	40
	VI = XF = X0 = 4 - 5 * DC	LWT	49
	FD=SQRTF(GR+A/B)	LaT	20
	FM=N	Lai	51
C	CALCULATION OF DT FROM MAXIMUM VELOCITY AND MAXIMUM HEIGHT	LWT	53
	DX=XL/FM	LwT	54
	RA=1.0/(2.C*VC)	LNT	55
	DT=DT+0.5	LwT	26
	DG 2 J=2.3300	LWI	21
	CALL INFLOW	Let	54
0.927	NGCD=J	LwT	60
2	CONTINUE	LWT	61
	WRITE (6.12) N.DX.DT.XO.XF.TO.TF.SO.D.F	LWT	62
	WRITE (6.13) RA.HI.PERD.FB.FC	LWT	63
C	CALCULATION OF INITIAL CONDITIONS	LwT	64
C	HEIGHTS AT PARTICULAR DISTANCES FROM INLET END	LWT	66
	CALL INCOND	LeT	67
3	15 (NPD-NT) 4+4+6	LwT	60
4	WRITE (6+14) T	LNT	69
	NT=0	LAI	10
	WRITE (6.15)	LeT	12
		LaT	73
	CONTINUE	LHT	74
1.11			

T=T+DTA Lef 7 GA-G(2) Lef 7 HA=H(2) Lif 7 HA=H(2) Lif 7 GA+G(N) Lif 7 GA+G(N) Lif 7 GA+G(N) Lif 7 GA+G(N) Lif 6 HM=H(N) Lef 6 GALC GOED Lif 6 CCALCULATION OF COEFFICIENTS AND SOLUTION OF DIFFERENCE EVUATIONS Lif 6 CCALCULATION OF COEFFICIENTS AND SOLUTION OF DIFFERENCE EVUATIONS Lif 6 CCALCULATION OF COEFFICIENTS AND SOLUTION OF DIFFERENCE EVUATIONS Lif 6 CCALCULATION OF INLET BOUNDARY CONDITIONS Lif 7 CALL COMPTE Lif 7 PAPCANT OF MULTICE DOUNDARY CONDITIONS Lif 7 CALL COMPTE Lif 7 NPCONTINUE L	6	NT=NT+1	LNT	75	
QA+Q(2)       L=1       T         HA=H(2)       L=1       T         VA=V(2)       L=1       T         QH=G(N)       L=1       F         VA=V(2)       L=1       F         QH=G(N)       L=1       F         VA=V(N)       L=1       F         QA+G(N-1)       COUPTE       L=1         CALL COUPTE       L=1       F         CALL COUPTE       L=1       F         CALL COUPTE       L=1       F         CALL BOA2       L=1       F         CALL BOA2       L=1       F         CALL BOA2       L=1       F         CALL BOA2       L=1       F         GATINGE       L=1       F         MARCHINSON       L=1       F         GATINE       L=1 </td <td></td> <td>T=T+DTA</td> <td>LWT</td> <td>76</td> <td></td>		T=T+DTA	LWT	76	
HA=H(2)       LW1 70         QARS(N)       LAT 60         HM=H(N)       LAT 61         VMAV(N)       LAT 61         QARS(N)       LAT 61         VMAV(N)       LAT 61         QARS(N)       LAT 63         VMAV(N)       LAT 63         QARS(N)       LAT 65         VMAV(N+1)       LAT 65         QARS(N)       LAT 66         CCALCULATION OF COEFFICIENTS AND SOLUTION OF DIFFERENCE EQUATIONS       LAT 65         CCALCULATION OF INLET DUUNJARY CONDITIONS       LAT 77         CALL COMPTE       LAT 73         CALL COMPTE       LAT 73         CALL DON2       LAT 73         CALL DON2       LAT 74         CALL DON2       LAT 74         CALL DON2       LAT 75         TF 11       LAT 74         CALL DON2       LAT 75         TATA       LAT 75         TATA       LAT 75         TATA       LAT 75         CALL DON2       LAT 75         TATA       LAT 75         TATA       LAT 75         TATA       LAT 75         TATA       LAT 75         CALL DON2       LAT 75		QA=Q(2)	LHI	11	
VAPV[2] LAT 19 ORFORM LAT 10 UNEXTED 10 UNEXTED 10 UNEXTED 10 UNEXTED 10 UNEXTED 10 UNEXTED 10 UNEXTED 10 CALL COD CALL SOME CALL SOME		HA=H(2)	LWI	10	
QM*C(N)       LAT 50         MM*V(N)       LAT 50         QM*V(N)       LAT 51         QM*V(N)       LAT 52         QM*V(N)       LAT 53         QM*V(N)       LAT 55         QM*V(N)       LAT 55         QM*V(N)       LAT 55         QM*V(N+1)       LAT 55         CALL COULATION OF COEFFICIENTS AND SOLUTION OF DIFFERENCE EQUATIONS       LAT 55         CALL COULATION OF INLET BOUNDARY CONDITIONS       LAT 55         CALL SON1       LAT 55         CALL SON1       LAT 55         CALL SON1       LAT 55         CONTINUE       LAT 55         CONTINUE       LAT 55         CONTINUE       LAT 55         MRITE (6,150)       LAT 56         MRITE (6,150)       LAT 56         MRITE (6,150)       LAT 100         MRITE (6,150)       LAT 100         CONTINUE       LAT 50         MRITE (6,150)       LAT 100         MRITE (6,150)       LAT 100         M		VA=V(2)	LHI	19	
HMM+H(N)       LAT       BA         QN=G(N+1)       LAT       BA         MN+H(N+1)       LAT       BA         QN = G(N+1)       LAT       BA         MN+H(N+1)       LAT       BA         QN = G(N+1)       LAT       BA         CALL COUPTE       LAT       BA         CALL COUPTE       LAT       BA         CALL COUPTE       LAT       BA         CALL COUPTE       LAT       BA         CALL COUNTAUE       LAT       BA         CALL COUNTAUE       LAT       BA         CALL BONA       LAT       LAT         BA       CONTINUE       LAT		QM=G(N)	LAI	60	
VMAV(N) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(N+1) UNAV(NAV(NAV(NAV(NAV(NAV(NAV(NAV(NAV(NAV(		HM=H EN 3	LAI	01	
UNPUTHING HN+HING UNPUTHING UNPUTHING CONTINUE CALL COUPTE CALL COUPTE CALL COUPTE CALL COUPTE CALL COUPTE CALL COUPTE CALL SUMPTE CALL		VM=V(N)	LAT		
UNAPUTATION       LaT         DO 7 1=2:N       LaT         CCALCULATION OF COEFFICIENTS AND SOLUTION OF DIFFERENCE EQUATIONS       LaT         CALL COUD       LaT         CALL COUD       LaT         CALL COUD       LaT         CALL COUD       LaT         CALL COUNTIAN       LaT         CALL COUNTIAN       LaT         CALL COUNTIAN       LaT         CALL SON2       LaT         HOFMA       LaT         CALL SON2       LaT         HOFMAN       LaT         CALL SON2       LaT         CONTIANC       LaT         CONTIANC       LaT         CONTIANC       LaT         CONTIANC       LaT         CONTIANC       LaT         MPGENIZSON       LaT         CONTIANC       LaT         CONTIANC       LaT         CONTIANC       LaT         CONTIANC       LaT         CONTIANC       LaT         CONTIANC       LaT         CON			LAT	54	
CCALCULATION OF COEFFICIENTS AND SOLUTION OF DIFFERENCE EQUATIONS       Lat 74         CCALCULATION OF COEFFICIENTS AND SOLUTION OF DIFFERENCE EQUATIONS       Lat 74         CALL COMPTE       Lat 79         CCALCULATION OF INLET BOUNDARY CONDITIONS       Lat 74         CCALCULATION OF OUTLET BOUNDARY CONDITIONS       Lat 74         CALL BON2       Lat 74         CALL BON2       Lat 74         CALL BON2       Lat 74         CALL BON2       Lat 75         FIF (TF-T) 6:3:5       Lat 75         6       CONTINUE       Lat 75         90 9 111:1:NPG       Lat 100         URT 16:6:10       Lat 100         WRITE (6:17)       Lat 100         WRITE (6:18)       Lat 100         NPG = *E16:6:10       Lat 100         VRITE (6:19) X:THMAX(1):THMAX(1):TWMAX(1):TWMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX(1):TUMAX			LaT	05	
CCALCULATION OF COEFFICIENTS AND SOLUTION OF DIFFERENCE EQUATIONS Left 56 CALL COMPTE 7 - CONTINUE 7 - CONTINUE CCALCULATION OF INLET BOUNDARY CONDITIONS CALL BONZ CCALCULATION OF OUTLET BOUNDARY CONDITIONS CCALCULATION OF OUTLET BOUNDARY CONDITIONS CCALCULATION OF OUTLET BOUNDARY CONDITIONS CCALCULATION			LAT	86	
CALL COMPTE Let I be the set of t	6		LWT	67	
CALL COMPTE       L#T #99         7       CONTINUE       L#T #90         CCALCULATION OF INLET BOUNDARY CONDITIONS       L#T #1         CALL BON2       L#T #90         CCALCULATION OF OUTLET BOUNDARY CONDITIONS       L#T #90         B       CONTINUE       L#T 100         B       CONTINUE       L#T 100         B       CONTINUE       L#T 100         WRITE (6:18)       L#T 100       L#T 100         WRITE (6:19)       X=MMAX(1),TMMAX(1),TVMAX(1),TVMAX(1),TVMAX(1),TVMAX(1),TVMAX(1),TVMAX(1),TVMAX(1),TVMAX(1),TVMAX(1),TVMAX(1),TVMAX(1),TVMAX(1),TVMAX(1),TVMAX(1),TVMAX(1),TVMAX(1),TVMAX(1),TVMAX(1),TVMAX(1),TVMAX(1),TT 100         C		CALL COED	LwT	58	
7       CONTINUE       Laf 90         C=CALCULATION OF INLET BOUNDARY CONDITIONS       Laf 91         CALL BON1       Laf 92         HBERN       Laf 92         C=CALCULATION OF OUTLET BOUNDARY CONDITIONS       Laf 92         C=CALCULATION OF OUTLET BOUNDARY CONDITIONS       Laf 92         C=CALCULATION OF OUTLET BOUNDARY CONDITIONS       Laf 92         CALL BON2       Laf 94         CONTINUE       Laf 96         DO 9 111=1,NPG       Laf 96         DO 9 11=1,NPG       Laf 100         Laf 100       Laf 100         WRITE 16:10)       Laf 100         Laf 100       Laf 100         Continue       Laf 100         Laf 100       Laf 100         Call EXIT       Laf 100         Laf 111       NPGRAT (* IDNUE = *E16.6//* DCOE = *E16.6//       Laf 110         Laf 111       NPGRAT (* ID		CALL COMPTE	LWT	89	
CCALCULATION OF INLET BOUNDARY CONDITIONS CALL BONN CALL BONN CCALCULATION OF OUTLET BOUNDARY CONDITIONS C	7	CONTINUE	LAT	90	
CALL BOAL H0=HN LAT 92 CCALCULATION OF OUTLET BOUNDARY CONDITIONS LAT 92 CALL BOA2 CALL BO	C	CALCULATION OF INLET BOUNDARY CONDITIONS	LeT	71	
H0=HN       LAI #33         C====-CALCULATION OF OUTLET DOUNDARY CONDITIONS       LAI #33         CALL BON2       LAT 95         IF (ITE-T) 5.3+3       LAT 95         B CONTINUE       LAT 97         NPG=MI/SO+1       LAT 96         D0 9 III=1*NPG       LAT 96         IL=50*III-49       LAT 100         MRITE (6:17)       LAT 100         WRITE (6:16)       LAT 100         D0 9 I=11*IL       LAT 100         X=(1-1)*DX       LAT 100         WRITE (6:15)       X+HMAX(1)*THMAX(1)*TWAAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UM		CALL BUN1	LAT	74	
CCALCULATION OF QUILET DOUNDARY CONDITIONS LWT 74 CALL BON2 LWT 75 IF (IF-T) 6.3.5 B CONTINUE LWT 95 B CONTINUE LWT 96 D 9 111-1.NPG LWT 96 IL=11+49 LWT 100 IL=11+49 LWT 100 IL=11+49 LWT 100 WRITE (6.17) LWT 100 WRITE (6.17) LWT 100 WRITE (6.18) LWT 100 IF (.eGc.N) GO TO 10 LWT 107 9 CONTINUE LWT 100 10 CALL EXIT LWT 100 11 FORMAT (*1DNUB = *E16.8//* DCGB = *E16.8// 12 FORMAT (*1DNUB = *E16.8//* DCGB = *E16.8// 14 UN 112 12 FORMAT (*1DNUB = *E16.8//* DCGB = *E16.8// 14 WT 112 15 ORMAT (*1DNUB = *E16.8//* DCGB = *E16.8// 16 CALL EXIT LWT 112 17 SORMAT (*1DNUB = *E16.8// 18 ONFF = *E16.8// 19 CONTINUE LWT 112 10 FORMAT (*1DNUB = *E16.8// 10 CALL EXIT LWT 112 11 FORMAT (*1DNUB = *E16.8// 11 FORMAT (*1DNUB = *E16.8// 12 FORMAT (*1DNUB = *E16.8// 13 FORMAT (*100 4 * XF = *E16.8// 14 WT 123 14 WT = *E16.8// 15 TO = *E16.8// 16 WT 123 16 WT 124 17 SO = *E16.8// 18 FORMAT (*N = *E16.8// 19 FORMAT (*N = *E16.8// 10 CALL EXIT LWT 123 11 * H1 = *E16.8// 12 FORMAT (*N = *E16.8// 13 FORMAT (*N = *E16.8// 14 WT 123 14 WT 14 *E16.8// 15 FORMAT (*N = *E16.8// 16 FORMAT (*N = *E16.8// 17 Y SO = *E16.8// 18 FORMAT (*N = *E16.8// 19 FORMAT (*N = *E16.8// 10 FORMAT (*N = *E16.8// 10 FORMAT (*N = *E16.8// 11 Y 123 13 FORMAT (*N = *E16.8// 14 WT 123 14 WT 14 *E16.8// 15 FORMAT (*N = *E16.8// 16 FORMAT (*N = *E16.8// 17 Y 10 Y		HD=HN	LAI	72	
CALL BON2 IF (TF-T) 5.3.5 B CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTINUE CONTIN	C	CALCULATION OF OUTLET BOUNDARY CONDITIONS	LWI	74	
IF (IF-T) 5.3.3 6 CONTINUE 77 NPG=N1/50+1 D0 9 111=1.NPG 11=50+111-49 11=50+111-49 WRITE (6:17) WRITE (6:17) WRITE (6:18) D0 9 1=11:1L X*(1-1)+DX WRITE (6:19) X*HMAX(1)*TMMAX(1)*TVMAX(1)*TWMAX(1)*TWMAX(1)*TWMAX(1) WRITE (6:19) X*HMAX(1)*TMMAX(1)*TVMAX(1)*TWMAX(1)*TWMAX(1) WRITE (6:10) CONTINUE CONTINUE CONTINUE CONTINUE 10 CALL EXIT CONTINUE 11 FORMAT (*IDAUB = *E16:8//* DCOB = *E16:8// CONTINUE 12 FORMAT (*IDAUB = *E16:8//* 13 FORMAT (*IDAUB = *E16:8// 14 H1 = *E16:8// 15 FORMAT (*R = *E16:8// 16 FG = *E16:8// 17 FG = *E16:8// 18 H1 = *E16:8// 19 FORMAT (*A = *E16:8// 10 FORMAT (*A = *E16:8// 10 FORMAT (*A = *E16:8// 11 FORMAT (*A = *E16:8// 12 FORMAT (*A = *E16:8// 13 FORMAT (*A = *E16:8// 14 FG = *E16:8// 15 FORMAT (*A = *E16:8// 16 FORMAT (*A = *E16:8// 17 FORMAT (*A = *E16:8// 18 FORMAT (*A = *E16:8// 19 FORMAT (*A = *E16:8// 10 FORMAT (*A = *E16:8// 10 FORMAT (*A = *E16:8// 10 FORMAT (*A = *E16:8// 11 FORMAT (*A = *E16:8// 12 FORMAT (*A = *E16:8// 13 FORMAT (*A = *E16:8// 14 FC = *E16:8// 15 FORMAT (*A = *E16:8// 16 FORMAT (*A = *E16:8// 17 FORMAT (*A = *E16:8// 18 FORMAT (*A = *E16:8// 19 FORMAT (*A = *E16:8// 10 FORMAT (*A = *E16:8// 10 FORMAT (*A = *E16:8// 11 TIME*1 12 FORMAT (*A = *E16:8// 13 FORMAT (*A = *E16:8// 14 FORMAT (*A = *E16:8// 15 FORMAT (*A = *E16:8// 15 FORMAT (*A = *E16:8// 15 FORMAT (*A = *E16:8// 16 FORMAT (*A = *E16:8// 17 FORMAT		CALL BON2	LMI	93	
8       CONTINUE       LWT 96         NPGENI/501       LWT 96         00 9 111=1,NPG       LWT 100         11=11+49       LWT 100         WRITE (6:17)       LWT 101         WRITE (6:18)       LWT 101         DO 9 1=11,1L       LWT 102         XWITE (6:19) X+MMAX(1),TMMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1	1.2	IF (1F-T) 6.3.3	LWI	70	
NPGENIJSON       LNT 99         DO 9 III-INPG       LNT 99         II=50*III-49       LNT 100         WRITE (6.17)       LNT 100         WRITE (6.17)       LNT 100         WRITE (6.17)       LNT 100         WRITE (6.18)       LNT 100         DO 9 I=11.IL       LNT 100         X=(1-1)*DX       LNT 100         WRITE (6.19) X+MMAX(I),TMMAX(I),VMAX(I),VMAX(I),VMAX(I),VMAX(I),UMAX(I)       LNT 100         VC       LNT 100         IO CALL EXIT       LNT 100         C       LNT 100         IO CALL EXIT       LNT 100         L * DNPF = *E16.60/* DCOF = *E16.60/       LNT 111         1 * DNPF = *E16.60/* DCOF = *E16.60/       LNT 112         I * OT = *E16.60/* DCOF = *E16.60/       LNT 112         I * OT = *E16.60/*       LNT 112         I * T = *E16.60/* <td>8</td> <td>CONTINUE</td> <td>Lal</td> <td>44</td> <td></td>	8	CONTINUE	Lal	44	
000 9 111-149       LwT 100         11=50*111-49       LwT 101         11=11+49       LwT 101         wRITE (6:17)       LwT 101         wRITE (6:18)       LwT 102         D0 9 1=11-1L       LwT 104         x*(1-1)*0X       LwT 104         wRITE (6:19) X*HMAX(1)*THAX(1)*VMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)       LwT 105         WRITE (6:19) X*HMAX(1)*THAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)       LwT 105         0 CALL EXIT       LwT 107         1 FORMAT (*10NLB = *E16.8//* DCOF = *E16.8//       LwT 110         1 * DNPF = *E16.8//* DCPF = *E16.8/       LwT 112         1 * FORMAT (*10NLB = *E16.8//* DCOF = *E16.8/       LwT 112         1 * ONF = *E16.8//       LwT 112         1 * TO = *E16.8//       LwT 112         1 * ONF = *E16.8//       LwT 112         1 * TO = *E16.8//       LwT 123         1 * TO =			LWT	99	
<pre>11=11+49 11=11+49 WRITE (6:17) WRITE (6:16) D0 9 [=11:1L X*(1=1)*DX WRITE (6:19) X*HMAX(1)*THMAX(1)*UMAX(1)*UMAX(1)*UMAX(1)*UMAX(1) LWT 105 UV 107 WRITE (6:19) X*HMAX(1)*THMAX(1)*UMAX(1)*UMAX(1)*UMAX(1) LWT 105 IF (1.eGeN1) GO TO 10 9 CONTINUE 10 CALL EXIT C CALL EXIT C CALL EXIT 11 FORMAT (*IDNUB = *E16.8//* DCGB = *E16.8// 12 FORMAT (* N = *E15// 14 * DNPF = *E16.8//* DCGB = *E16.8// 12 FORMAT (* N = *E15// 14 * NX = *E16.8// 15 * NO = *E16.8// 16 * TF = *E16.8// 16 * FORMAT (* R = *E16.8// 16 * FORMAT (2X;SHPAT;LOX;LHh;17X:1HC) 17 * FORMAT (* LX;HH;17X:1HV;17X:1HC) 18 * FORMAT (* LX;HH;17X:1HV;17X:1HC) 19 * FORMAT (* DISTANCE MAX DEPTH TIME MAX VEL TIME MAX CL TIME 19 * FORMAT (* LISTANCE MAX DEPTH TIME MAX VEL TIME MAX CL TIME 10 * IMAX (* ISANCE MAX DEPTH TIME MAX VEL TIME MAX CL TIME 17 FORMAT (* DISTANCE MAX DEPTH TIME MAX VEL TIME MAX CL TIME 19 * FORMAT (* LISTANCE MAX DEPTH TIME MAX VEL TIME MAX CL TIME 10 * FORMAT (* DISTANCE MAX DEPTH TIME MAX VEL TIME MAX CL TIME 10 * FORMAT (* DISTANCE MAX DEPTH TIME MAX VEL TIME MAX CL TIME 17 * FORMAT (* DISTANCE MAX DEPTH TIME MAX VEL TIME MAX CL TIME 17 * FORMAT (* DISTANCE MAX DEPTH TIME MAX VEL TIME MAX CL TIME 15 * FORMAT (* DISTANCE MAX DEPTH TIME MAX VEL TIME MAX CL TIME 15 * FORMAT (* DISTANCE MAX DEPTH TIME MAX VEL TIME MAX CL TIME 15 * FORMAT (* DISTANCE MAX DEPTH TIME MAX VEL TIME MAX CL TIME VE TIME 15 * FORMAT (* DISTANCE MAX DEPTH TIME MAX VEL TIME MAX CL TIME VE TIME 15 * FORMAT (* DISTANCE MAX DEPTH TIME MAX VEL TIME MAX CL TIME VE TIME 15 * FORMAT (* DISTANCE MAX DEPTH TIME MAX VEL TIME VE TIM</pre>			LWT	100	
10-11/07       10-11/07         wRITE (6.17)       LwT 102         wRITE (6.18)       LwT 105         DO 9 [=11]IL       LwT 105         xx(1-1)*DX       LwT 106         wRITE (6.19) X+HMAX(1),THHAX(1),VMAX(1),VMAX(1),VMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TWMAX(1),TW		11-30-111-47	LWT	101	
WRITE (6.16)       LeT 103         DO 9 1=11.1L       LeT 104         XRITE (6.19) X: HMAX(1), THMAX(1), VMAX(1), VMAX		weite (6.17)	LNI	104	
DO 9 [=1],IL x=(1-1)*0X WRITE (6,19) x,HMAX(1),THMAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX(1),TWAX		WRITE (6.18)	LAT	263	
Lef 105 WRITE (6:19) X*HMAX(1)*THHAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(1)*VMAX(		DO 9 1=11.1L	LAT	104	
<pre>write (6,19) x+HomAX(1),THHAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),VMAX(1),</pre>		x=(1-1)+DX	LNI	105	
IF (I.EG.NI) GO TO 10       LwT 107         9 CONTINUE       LwT 108         10 CALL EXIT       LwT 107         11 FORMAT (IDNUE) = *E16.8//* DCOB = *E16.8//       LwT 110         11 FORMAT (IDNUE) = *E16.8//* DCOB = *E16.8//       LwT 111         12 FORMAT (* N = *E16.8//* DCPF = *E16.8/)       LwT 112         14 DNPF = *E16.8//       LwT 113         15 ORMAT (* N = *E16.8//       LwT 113         16 ORMAT (* N = *E16.8//       LwT 113         17 FORMAT (* N = *E16.8//       LwT 116         18 ORMAT (* N = *E16.8//       LwT 116         19 F = *E16.8//       LwT 117         10 = *E16.8//       LwT 116         19 F F = *E16.8//       LwT 112         19 FORMAT (* DA = *E16.8//       LwT 112         10 = *E16.8//       LwT 112         11 = *E16.8//       LwT 112         12 = FERD = *E16.8//       LwT 123         13 = FORMAT (* R = *E16.8//       LwT 125         14 = FORMAT (111.7HT1ME 15*E16*0*DH 5EC*)       LwT 125         15 = FORMAT (2X.5HPNT.10X.5HH1.17X.5HV117X.1HG)       LwT 125         14 = FORMAT (111.7HT1ME 15*E16*0*DC*E16*E0*)       LwT 126         15 = FORMAT (111.7HT1MAXIMM VALUES AND TIMES AT EACH LUCATION*//)       LwT 132         16 = FORMAT (111.7HT1MAXIMM VALUES AND TIMES AT EA		WRITE (6,19) X.HMAX(I), THMAX(I), VMAX(I), TVMAX(I), UMAX(I), TUMAX(I)	LWT	100	
9       CONTINUE       LwT 108         10       CALL EXIT       LwT 109         11       FORMAT (*1DNUB = *E16.8//* DCGB = *E16.8//       LwT 110         11       FORMAT (*1DNUB = *E16.8//* DCGB = *E16.8//       LwT 111         12       FORMAT (* N = *E15//       LwT 112         14       DNPF = *E16.8//*       LwT 111         15       FORMAT (* N = *E16.8//       LwT 112         16       N = *E16.8//       LwT 113         17       FORMAT (* N = *E16.8//       LwT 116         18       AU = *E16.8//       LwT 117         19       * T0 = *E16.8//       LwT 117         10       * T0 = *E16.8//       LwT 117         19       * F = *E16.8//       LwT 112         10       * T0 = *E16.8//       LwT 112         10       * T0 = *E16.8//       LwT 112         10       * F0 = *E16.8//       LwT 123         11       * F0 = *E16.8//       LwT 123         12       PERD = *E16.8//       LwT 123         13       FORMAT (* R = *E16.8//       LwT 123         14       # F0 = *E16.8//       LwT 124         15       F0RMAT (111.7/HT1ME 15*E16*0*C*)       LwT 125         14       # F0 = *		IF (1+EG+N1) GO TO 10	LWT	107	
10       CALL EXIT       LAT 109         C=====       LWT 110       LWT 110         11       FORMAT (*1DNUB = *E16.8//* DCGB = *E16.8//       LWT 111         11       1 * DNPF = *E16.8//* DCGB = *E16.8//       LWT 112         12       FORMAT (* = *E15//       LWT 113         14       DNPF = *E16.8//       LWT 113         15       + DN = *E16.8//       LWT 113         16       + DN = *E16.8//       LWT 113         17       + TA = *E16.8//       LWT 115         18       x0 = *E16.8//       LWT 116         19       + TE = *E16.8//       LWT 117         10       + TF = *E16.8//       LWT 117         17       T 50 = *E16.8//       LWT 112         18       + DRAT (* R = *E16.8//       LWT 122         19       F F = *E16.8//       LWT 123         14       + H1 = *E16.8//       LWT 124         14       + H1 = *E16.8//       LWT 123         15       FORMAT (14.8 = *E16.8//       LWT 125         14       + FC = *E16.8//       LWT 126         15       FORMAT (11.7HTIME IS.*E16.*S.*H 5EC.)       LWT 126         16       FORMAT (17.4*X.*HW.*TX.*HW.*TX.*HG)       LWT 126         17	9	CONTINUE	LWT	100	
C	10	CALL EXIT	LAI	109	
11       FORMAT (*1DNLB = *E16.8//* DCGB = *E16.8//       LwT 111         1 * DNPF = *E16.8//* DCPF = *E16.8/)       LwT 112         12       FORMAT (* N = *E16.8//       LwT 112         12       FORMAT (* N = *E16.8//       LwT 112         14       DAT = *E16.8//       LwT 113         1 * DX = *E16.8//       LwT 114         2 * DT = *E16.8//       LwT 115         3 * XU = *E16.8//       LwT 116         4 * XF = *E16.8//       LwT 117         5 * TU = *E16.8//       LwT 119         7 * SO = *E16.8//       LwT 112         10       6 * TF = *E16.8//       LwT 122         11       FORMAT (* RA = *E16.8//       LwT 122         12       FORMAT (* RA = *E16.8//       LwT 123         1 * H1 = *E16.8//       LwT 125       LwT 125         3 * FB = *E16.8//       LwT 125       LwT 126         3 * FB = *E16.8//       LwT 126       LwT 126         1 * FORMAT (1H1.7HTIME IS.*L16.*D*X:L10.*JTX.1HG)       LwT 126         14       FORMAT (1/*1.*AXIMUM VALUES AND TIMES AT EACH LUCATION.*///       LwT 131         16       FORMAT (/*1 MAXIMUM VALUES AND TIMES AT EACH LUCATION.*///       LwT 131         18       FORMAT (* DISTANCE MAX DEPTH TIME MAX VEL TIME MAX VEL TIME LWT 135       LwT 1	C		LWT	110	
1 * DNPF = *E16.87/* DCPF = *E16.87/ 12 FORMAT (* N = *E57/ 14 * DX = *E16.87/ 2 * OT = *E16.87/ 3 * XO = *E16.87/ 4 * XF = *E16.87/ 5 * TO = *E16.87/ 5 * TO = *E16.87/ 6 * TF = *E16.87/ 1 * H1 = *E16.87/ 1 * H1 = *E16.87/ 2 * F = *E16.87/ 1 * H1 = *E16.87/ 2 * F = *E16.87/ 1 * H1 = *E16.87/ 2 * F = *E16.87/ 1 * H1 = *E16.87/ 2 * FEED = *E16.87/ 1 * H1 = *E16.87/ 2 * FEED = *E16.87/ 1 * H1 = *E16.87/ 1 * H1 = *E16.87/ 2 * FEED = *E16.87/ 1 * H1 = *E16.87/ 1 * FG = *E16.87/ 1 *	11	FORMAT (*1DNGB = *E16.8//* DCGB = *E16.8//	LWT	111	
12       FORMAT (1* N = *1577       LWT 115         1 = NX = *E16.877       LWT 115         3 = XD = *E16.877       LWT 115         3 + XD = *E16.877       LWT 115         4 + XF = *E16.877       LWT 115         5 + TD = *E16.877       LWT 115         6 + TF = *E16.877       LWT 115         7 + SD = *E16.877       LWT 117         5 + TD = *E16.877       LWT 117         7 + SD = *E16.877       LWT 121         9 + F = *E16.877       LWT 122         13 FORMAT (* RA = *E16.877       LWT 123         14 + H1 = *E16.877       LWT 123         15 + FB = *E16.877       LWT 123         16 + ORMAT (111.7HT1ME 15*L16*0*DM 5EC*)       LWT 125         17 + FORMAT (111.7HT1ME 15*L16*0*DM 5EC*)       LWT 126         18 + FORMAT (111.7HT1ME 15*L16*0*DM 5EC*)       LWT 127         19 + FORMAT (111.7HT1MAXIMM VALUES AND TIMES AT EACH LUCATION*777       LWT 131         18 + FORMAT (111.7HT1MAXIMM VALUES AND TIMES AT EACH LUCATION*777       LWT 132         19 + FORMAT (111.7HT1MAXIMM VALUES AND DEPTH TIME       MAX VEL TIME       LWT 132         19 + FORMAT (164.2+314X*F6*2*2X*F7*21)       LWT 135       LWT 135         19 + FORMAT (164.2+314X*F6*2*2X*F7*21)       LWT 135       LWT 135	1.1	1 * DNPF = *E16.8//* DCPF = *E16.8/)	LWI	112	
1 * INX = *E16.87/       LWT 115         2 * DT = *E16.87/       LWT 115         3 * XO = *E16.87/       LWT 115         4 * XF = *E16.87/       LWT 116         6 * TF = *E16.87/       LWT 117         7 * SO = *E16.87/       LWT 119         7 * SO = *E16.87/       LWT 119         7 * SO = *E16.87/       LWT 119         7 * SO = *E16.87/       LWT 121         13 FORMAT (* RA = *E16.87/       LWT 122         13 FORMAT (* RA = *E16.87/       LWT 123         1 * H1 = *E16.87/       LWT 123         1 * H1 = *E16.87/       LWT 123         1 * H1 = *E16.87/       LWT 124         2 * PERD = *E16.87/       LWT 125         3 * FB = *E16.87/       LWT 125         3 * FB = *E16.87/       LWT 125         1 * FORMAT (1H1.7HTIME IS.E16.87/SIEC.)       LWT 126         14 FORMAT (1H1.7HTIME IS.E16.87/SIEC.)       LWT 126         15 FORMAT (1H1.7HTIME IS.E16.87/SIEC.)       LWT 127         14 FORMAT (1H1.7HTIME IS.E16.87/SIEC.)       LWT 126         15 FORMAT (1//*I MAXIMUM VALUES AND TIMES AT EACH LUCATION*///)       LWT 131         16 FORMAT (/*1 MAXIMUM VALUES AND TIMES AT EACH LUCATION*///)       LWT 131         18 FORMAT (* DISTANCE MAX DEPTH TIME MAX VEL TIME MAX (L LWT 132       LWT 133	12	FORMAT (* N = *1577	1.47	114	
2 + 01 + 010007       Lm 110         3 + X0 = *E10+87/       Lm 116         4 + XF = *E10+87/       Lm 116         5 + TD = *E10+87/       Lm 117         6 + TF = *E10+87/       Lm 112         7 + SO = *E10+87/       Lm 112         8 + D = *E10+87/       Lm 112         9 + F = *E10+87/       Lm 112         13 FORMAT (* RA = *E10+87/       Lm 122         14 + H1 = *E10+87/       Lm 122         2 + PERD = *E10+87/       Lm 125         3 + F6 = *E10+87/       Lm 125         1 + H1 = *E10+87/       Lm 125         1 + H1 = *E10+87/       Lm 125         1 + H1 = *E10+87/       Lm 125         1 + FC = *E10+87/       Lm 127         1 + FC = *E10+87/       Lm 128         1 + FC = *E10+87/       Lm 132         1 + FC =		$1 = 114 = -E16 \cdot B/7$	LWI	115	
3 * XC = *Ll0*87/       LaT 117         4 * XF = *El0*87/       LaT 117         5 * TO = *El0*87/       LwT 119         6 * TF = *El0*87/       LwT 119         7 * SO = *El0*87/       LwT 119         7 * SO = *El0*87/       LwT 119         7 * SO = *El0*87/       LwT 121         19 * F = *El0*87/       LwT 121         13 FORMAT (* RA = *El0*87/       LwT 123         1 * H1 = *El0*87/       LwT 123         1 * H1 = *El0*87/       LwT 123         1 * H1 = *El0*87/       LwT 124         2 * PERD = *El0*87/       LwT 125         3 * FG = *El0*87/       LwT 125         4 * FC = *El0*87/       LwT 126         4 * FC = *El0*87/       LwT 126         14 FORMAT (111*/HT1ME 15*El0*0*07X:El0*05       LwT 127         15 FORMAT (2X;5MPNT:10X:1MH:17X:1HV:17X:HW:17X:HW:17X:HW:17X:HW:17X:HW:17X:HW:17X:HW:17X:HW:17X:HW:17X:HW:17X:HW:17X:HW:17X:HW:17X:HW:17X:HW:17X:HW:173         16 FORMAT (1/*1 MAXIMUM VALUES AND TIMES AT EACH LUCATION*//)       LwT 129         17 FORMAT (* DISTANCE MAX DEPTH TIME MAX VEL TIME MAX GL LWT 132         18 FORMAT (#0:2:314X:F6:2:2X:F7:21)       LwT 1313         19 FORMAT (#0:2:314X:F6:2:2X:F7:21)       LwT 135-         10 END       LwT 135-		2 • 01 - • 010•077	LaT	116	
5 * TO = *El6.8//       Lwl 110         6 * TF = *El6.8//       Lwl 119         7 * 50 = *El6.8//       Lwl 120         6 * D = *El6.8//       Lwl 120         9 * F = *El6.8//       Lwl 122         13 FORMAT (* RA = *El6.8//       Lwl 123         14 H1 = *El6.8//       Lwl 123         15 * FOR = *El6.8//       Lwl 123         16 * D1 = *El6.8//       Lwl 123         17 * H1 = *El6.8//       Lwl 125         18 * FG = *El6.8//       Lwl 126         19 * FC = *El6.8/       Lwl 126         17 * FORMAT (1/L+1/ATLIME IS.*El6.*0.5)H 5EC.)       Lwl 126         18 * FORMAT (1/L+1/ATLIME IS.*El6.*0.5)H 5IC.*D.*CATELACH LUCATION*//)       Lwl 130         19 * FORMAT ((64.2.3)(4X.F6.2.2X.*F7.2))       Lwl 135         19 * FORMAT (1/L-2.3)(4X.F6.2.2X.*F7.2))       Lwl 135		4 * XF = +E16-6//	LAT	117	
6 * TF = *E16.67/       Let 119         7 * 50 = *E16.87/       Let 120         6 * D = *E16.87/       Let 120         9 * F = *E16.87/       Let 121         9 * F = *E16.87/       Let 122         13 FORMAT (* RA = *E16.87/       Let 122         2 * PERD = *E16.87/       Let 125         3 * FB = *E16.87/       Let 125         14 * FC = *E16.87/       Let 125         15 * F0 # *E16.87/       Let 125         16 F0rMAT (111.7HT1ME IS*E16.0*0.5H 5EC.)       Let 130         17 F0rMAT (111.7HT1ME IS*E16.0*0.5H 5EC.)       Let 130         18 F0rMAT (111.7HT1MAXIMM VALUES AND TIMES AT EACH LUCATION*//)       Let 131         18 F0rMAT (* DISTANCE MAX DEPTH TIME MAX VEL TIME MAX (Let 132       Let 132         19 F0rMAT (Fd.2:314X:F6.2:2X:F7.2))       Let 135         END       Let 135		5 * TO = *F16-8//	Lwi	110	
7 * SO = *E16.87/       Lw1 120         6 * D = *E16.87/       Lw1 121         9 * F = *E16.87/       Lw1 122         13 FORMAT (* RA = *E16.8//       Lw1 122         14 H1 = *E16.87/       Lw1 123         1 * H1 = *E16.87/       Lw1 123         2 * PERD = *E16.87/       Lw1 123         3 * FB = *E16.87/       Lw1 124         4 * FC = *E16.87/       Lw1 125         14 FOHMAT (1141.7411ME IS+E16.05M SEC.)       Lw1 126         15 FORMAT (2X,3HPhT,10X,1HV,17X,1HV,17X,1HG)       Lw1 129         16 FORMAT (1X,14,2X,2E16.05,2X,E10.05,2X,E16.05)       Lw1 129         17 FORMAT (1/*1 MAXIMUM VALUES AND TIMES AT EACH LUCATION*//)       Lw1 131         18 FORMAT (F0.15TANCE MAX DEPTH TIME MAX VEL TIME MAX G Lw1 132       Lw1 133         19 FORMAT (F0.2,3(4X,F6.2,2X,F7.2))       Lw1 135         END       Lw1 135		6 + TF = +E16 + 6/7	LNT	119	
6 * D = *E16.8//       LwT 121         9 * F = *E16.8//       LwT 123         13 FORMAT (* RA = *E16.8//       LwT 123         14 * H1 = *E16.8//       LwT 123         2 * PERD = *E16.8//       LwT 125         3 * FB = *E16.8//       LwT 125         4 * FC = *E16.8//       LwT 126         5 * FB = *E16.8//       LwT 126         6 * FORMAT (1H1*7HTIME IS*E16*0*DH 5EC*)       LwT 126         14 FORMAT (1H1*7HTIME IS*E16*0*0*EC*)       LwT 126         15 FORMAT (1X:14*2X*E16*0*0*X*E16*0)       LwT 127         16 FORMAT (1X:14*2X*E16*0*0*X*E16*0)       LwT 130         17 FORMAT (1X:14*2X*E16*0*0*X*E16*0)       LwT 131         18 FORMAT (* DISTANCE MAX DEPTH TIME MAX VEL TIME MAX (* LwT 132       LwT 133         19 FORMAT (fd:2:3(4X*F6*2:2X*F7*2))       LwT 135         END       LwT 135		7 * SO = *E16.8//	Lel	140	
9 * F = *E16.8// 13 FORMAT (* RA = *E16.8// 1 * H1 = *E16.8// 2 * PERD = *E16.8// 4 * FC = *E16.8// 4 * FC = *E16.8// 5 FORMAT (1H1.7HTIME IS.E16.0.5H SEC.) 14 FORMAT (1H1.7HTIME IS.E16.0.5H SEC.) 15 FORMAT (2X,5HPNT.1CX.1HH.17X.1H4) 16 FORMAT (1X,14.2X,E16.0.5,CX.E16.0] 17 FORMAT (1X,14.2X,E16.0.5,CX.E16.0] 18 FORMAT (1X,14.2X,E16.0.5,CX.E16.0] 19 FORMAT (1X,14.2X,E16.0.5,CX.E16.0] 10 FORMAT (1X,14.2X,E16.0.5,CX.E16.0] 10 FORMAT (1X,14.2X,E16.0.5,CX.E16.0] 11 FORMAT (1X,14.2X,E16.0.5,CX.E16.0] 12 FORMAT (1X,14.2X,E16.0.5,CX.E16.0] 13 FORMAT (14.2.314X,F6.2.2X,F7.2)) END END END END END END END END		6 * D = *E16.6//	LNI	141	
13       FORMAT (* RA = *E16.8//       LwT 123         1 * H1 = *E16.8//       LoT 124         2 * PERD = *E16.8//       LoT 124         3 * FB = *E16.8//       LwT 125         4 * FC = *E16.8//       LwT 125         14       FOHMAT (1H1.7HTIME IS.*E16.*0.5M SEC.)       LwT 126         15       FORMAT (2X.5HPMT.10X.1HV.17X.1HV.17X.1HG)       LwT 129         16       FORMAT (1X.14.2X.2X.E16.*0.2X.E16.*0)       LwT 129         17       FORMAT (1X.14.2X.2X.E16.*0.2X.E16.*0)       LwT 130         18       FORMAT (//*1 MAXIMUM VALUES AND TIMES AT EACH LUCATION*//)       LwT 131         18       FORMAT (F0.2.3(4X.F6.2.2X.F7.2))       LwT 132         19       FORMAT (F0.2.3(4X.F6.2.2X.F7.2))       LwT 135         END       LwT 135       LwT 135		9 * F = *E16.8/)	LWT	122	
1 * H1 = *E16.8//       LaT 124         2 * PERD = *E16.8//       LaT 125         3 * FB = *E16.8//       LaT 125         4 * FC = *E16.8/       LaT 126         14 FORMAT (111.7HT1ME IS*E16.0.5M 5EC.)       LaT 127         15 FORMAT (2X,5HPNT,10X,1Hh,17X,1HG)       LaT 120         16 FORMAT (1X,14,2X,2E16.0.5,2K,1E6.00)       LaT 130         17 FORMAT (1X,14,2X,2E16.0.5,2K,1E6.00)       LaT 131         18 FORMAT (* DISTANCE MAX DEPTH TIME MAX VEL TIME MAX G LaT 132       LaT 132         19 FORMAT (F0.2:31(4X,F6.2:2X,F7.2))       LaT 135         END       LaT 135	13	FORMAT (* RA = *E16.8//	LWI	123	
2 * PERD = *E16.8// 3 * FB = *E16.8// 4 * FC = *E16.8// 14 FORMAT (1H1.7/HTIME IS.*E16.*B, DH SEC.) 15 FORMAT (2X.SHPNT.1(X.SHH).17X.SHV.17X.SHV) 16 FORMAT (1X.SHP.T.1(X.SHH).17X.SHV.17X.SHV) 16 FORMAT (1X.SHP.T.SHV.17X.SHV.17X.SHV) 17 FORMAT (1X.SHP.T.SHV.17X.SHV.17X.SHV) 18 FORMAT (1X.SHP.T.SHT) 19 FORMAT (FD ISTANCE MAX DEPTH TIME MAX VEL TIME NAX G LWT 132 11 TIME*1 19 FORMAT (FD.2.SI(4X.F6.2.2X.F7.2)) END		1 + H1 = +E16.8//	LAT	124	
3 * FB * *L0*87/       Lw1 126         4 * FC * *E10*83/       Lw1 127         14 FOHMAT (1H1*/HTIME IS*E10*85H SEC*)       Lw1 127         15 FORMAT (2X,SHPMT,10X,HH4,17X*HV,17X*HG)       Lw1 129         16 FORMAT (1X:14*ZX*E10*0*ZX*E10*0*ZX*E10*0*ZX*E10*0*//)       Lw1 129         17 FORMAT (//*1 MAXIMUM VALUES AND TIMES AT EACH LUCATION*//)       Lw1 131         18 FORMAT (F0 DISTANCE MAX DEPTH TIME MAX VEL TIME MAX (Lw1 132       Lw1 132         19 FORMAT (F0.2:31(4X*F0.2:2X*F7.2))       Lw1 135         END       Lw1 135		2 • PERD = •E16.8//	LNI	145	
4.************************************		3 * FB = *116.8//	LHI	120	
14         FUNDATION LIANTIAL LOSSINGUES         LWT 120           15         FORMAT (2X, SHPNT, 10X, 114V, 17X, 114V, 17X, 114G)         LWT 129           16         FORMAT (1X, 14, 2X, E16, 5), 2X, E10, 5), 2X, E10, 5), 2X, E10, 5)         LWT 129           17         FORMAT (1X, 14, 2X, E16, 5), 2X, E10, 5), 2X, E10, 5)         LWT 130           17         FORMAT (1/*1 MAXIMUM VALUES AND TIMES AT EACH LUCATION*//)         LWT 131           18         FORMAT (0 IDSTANCE MAX DEPTH TIME MAX VEL TIME NAX G LWT 132         LWT 132           19         FORMAT (F0.2, 3(4X, F6.2, 2X, F7.2))         LWT 134           END         LWT 135	14	4 * PL = *E10+07	LWT	140	
12         FUNDAT 14:07.160.1100.1100.1100.1100.1100.1100.110	14	PORMAT (37.300kT.107.106.177.100.177.1001	IWT	129	
17         FORMAT 1//*1 MAXIMUM VALUES AND TIMES AT EACH LUCATION*//)         LWT 131           18         FORMAT 1* DISTANCE MAX DEPTH TIME MAX VEL TIME MAX G LWT 132         LWT 133           19         FORMAT (F8.2,314X,F6.2,2X,F7.2))         LWT 134           END         LWT 135	15	FORMAT (1X,14,2X,E16,b,2X,E10,b,2X,E16,b)	LAT	120	
18         FORMAT (* DISTANCE MAX DEPTH TIME         MAX VEL TIME         NAX G LWT 132           1         TIME*1         LWT 133         LWT 133           19         FORMAT (F8-2+314X+F6+2+2X+F7+2))         LWT 134           END         LWT 135	17	FORMAT 11/11 WAY MAN VALUES AND TIMES AT FACH LUCATION //)	LWT	1.21	
1 TIME*1 LwT 133 19 FORMAT (F8-2-31(4X+F6-2-2X+F7-2)) LwT 134 END LwT 135	18	EDEMAT IN DISTANCE MAX DEPTH TIME MAX VEL TIME MAX L	LWT	134	
19 FORMAT (F8.2.314X.F6.2.2X.F7.2)) LWT 134 END LWT 135-	10	1 TIME*1	Lul	123	
END LWT 135-	19	FORMAT (F8.2.314X.F6.2.2X.F7.2))	LWT	134	
		END	LWT	135-	

#### SUBROUTINE FOR COMPUTING GEOMETRIC PARAMETERS OF CIRCULAR SEGMENT

SUBBOUTINE CIRCLE	CIR	- 1
DIMENSION TH(3300)+ (1(3300)	CIR	2
DIMENSION 6(4001, 0(400), V(400), X(330)	CIR	э
CUMMUN DN.H1.A.AP. DP.A1.C1.01.E1.B2.A2.C2.E2.VP.OTA.UT.HD.OC	CIN	4
COMMON DIA, XO, XF, GR, ALPHA, BETA, SO, F, D, V, G, DX, DT, T, TO, TF, N, FB, FC, B	CIR	2
COMMON M.MM.HMM.L.I.PERD.DDT.VA.IG.TU.QI.NGCD	CIR	0
COMMON HATHMAYMAHTAYTANPTAHHAXAQB	CIR	7
COMMON THETA WP B DEPTH VC J HN VN	CIR	ø
THETA=2.0*ATANE((SORTE(DIA*DEPTH-DEPTH**2))/(DIA/2.0-DEPTH))	CIR	9
IF (THETA) 1.2.2	CIR	10
THE TA=6.28318+THE TA	CIR	11
A=0.125+(THETA-SINF(THETA))*(DIA*DIA)	CIR	12
WPE(DIA/2.0)*THETA	CIR	13
Pat/aD	CIN	14
H=11A+SINF(THETA/2+C)	CIR	12
PETIEN	CIN	10
EN()	CIR	17-
LIND		

#### SUBROUTINE FOR COMPUTING INITIAL CONDITION

	SUBRJUTINE INCOM	INC	1
	DIMENSION 14(3300), 41(3300)	INC	4
	DIMENSION 014001. 014001; V14001; X13301	INC	3
	CONMON DRIHLIAIAPIDPIRIICIULICIICZIAZICZICZICZIVPICIAIUIINDIC	INC	
	COMMON F WHILE HARDER ODDT + VA+ IG+ IG+UI+NUCD	INC	0
	CONMON HATHY . VM . HT . VT . NPT . HH . X . GB	INC	7
	COMMON THETA + AP + R + DEPTH + VC + J + HN + VN	INC	•
	DIOL=0.00001	INC	1
	ELEV=10C.C	INC	10
		INC	10
		INC	13
1	K=1	Inc	14
	GJ TJ 17	INC	45
2	DIN=1.75*DC	INC	16
	DEPTH=DC	INC	14
	CALL CIRCLE	INC	17
	VH=(VV*VV)/(2+C*GR)	INC	20
	51=F*VH/(4.0*R)	INC	41
	EL1=UC+ALPhA*Vn	INC	44
	X(N+1)=XF=XX	INC	43
	D(N+1)=DC	INC	24
		INC	2 D
		INC	47
	DU = 1 + N	INC	20
	XX=XX+DX	INC	69
3	DEPTH=DIN	INC	30
	CALL CIRCLE	INC	31
	HFTH=G.5*THETA	LINC	32
	DINE 1=4.07 (DIA*DIAF (Infin))	INC	34
	DA=0.2*DIA*DIntI	INC	22
	WP=0.5=DIA=THETA	INC	30
	OKA= (AF*UAKEN-A*UW)/ [HP*NP]	LINC	21
	DENG=1.0-(Go*uo/(Gk*(A**3)))*DAREA	INC	20
	DSL0=-F*ub*ub*(2.0*R*A*DAREA+(A**21*DRA)/(6.0*GR*(1R*A**2)**21)	INC	59
		INC	41
	<pre>C2=F*VH/(A_0#)</pre>	INC	42
	SF=(S1+S2)/2.0	INC	43
	EL2=DIN+ALPHA*VH	INC	**
	FRATID=(EL2-EE1+LX*(SU-SF11/(DLNG+(LL2-LE1)*DSLU/(SU-SF))	INC	45
	DCON=DIN-FRATIO	LAC	40
4	RITE (6.19)	INC	40
	GO TO 16	INC	47
5	DCOM=ABSF (DCOH)	INC	20
6	IF TABSFIDCOM-DINI-DTOLI 15:15:7	INC	>1
7	IF (0.82*DIA-DCON) 8.14.14	INC	22
0	DIN-DCOM/2.0	INC	54
10	DIN=DIN(2.0	INC	55
10	NCOUNTENCOUNT+1	INC	20
	GO TO 9	INC	>7
11	1F (NCOUNT-20) 12+12+13	INC	20
12	GO TO 3	DWL	27
13	WRITE (0+20)	INC	00
16.2	GD TO 12	INC	64
14	DIN=DCOM	INC	63
15	DINECOM	INC	64
	51=52	INC	65
	EE1=EE2	INC	66
	II=N-L+1	INC	61
		INC	64
	V(II)=VV	INC	70
	G(11)=GB	INC	71
16	CONTINUE	INC	74
12123	GO TO 18	INC	75
17	RETIDE	INC	75
(	RE I UNIT	INC	76
19	FORMAT (* DCOM EQUALS ZERO *)	INC	77
20	FORMAT (25H 02 MUCH GREATER THAN UIA)	INC	70
21	FORMAT (* STOP *+13)	INC	19
	END	THE	0.0-

	SUBROUTINE FOR COMPUTING INFLOW HYDROGRAPH		
	SUBROUTINE INFLOW	INF	1
	DIMENSION TO(3300). GI(33CC)	INF	4
	DIMENSION G(400), H(400), V(400)	INF	3
	COMMON DNIHIAAAPIOPIALICIIULIELIOZIAZICEIEEIVPIOTAIUTINDIUC	INF	2
	COMMON DIXOIXFIGHIALPHAIDETAIDUFIMIVIGIUXIDTITITUIFINIFOIFCID	1NF	
	CURMUN KANKANNANAL + I + PERO+DUT+VA+14+TU+41+NUCU	Int	
	COMMON THE TANAP RAJEPTHAVE A JAMAAVA	INF	•
	Q0=10.0	INF	10
	TP=100.0	INF	11
	TG=150+0	INF	12
		INF	14
	TQ(J)=(AJ-1.0)+DT	INF	15
	Q1(J)=QE+QO*(EXPF(-(TQ(J)-TP)/(TG-TP)))*(TG(J)/TP)**50	INF	16
	FND	INF	17
	SUBROUTINE FOR COMPUTING DEPTH & VELOCITY AT END OF TIME INTERVAL		
	SUBROUTINE COMPTE	CUM	1
	DIMENSION G(330)	Cum	4
	DIMENSION (400), H(400), V(400)	CUM	4
	CUMMUN DN+H1+A+AP+0P+A1+C1+D1+E1+D2+A2+C2+E2+VP+UTA+uT+NO+UC	CUM	Ś
	COMMON D.XO.XF.GR.ALPHA.BETA.SO.F.H.V.G.DX.DI.T.TO.IF.N.FB.FC.d	CUM	0
	COMMON M.NM.MMM.L.I.PERD.DDI.VA.IL.TU.UI.NGCO	COM	
	COMMON HAIHMIVMIHIVVIINPIINHIVOIVII	COM	7
	COMMON QMAX(400) + VMAX(400) + HMAX(400)	COM	10
	COMMON TQMAX(400) TVMAX(400) THMAX(400)	COM	11
	Z1=DT/DX	COM	12
	22=A/8 23=A1 PHA/NETA	Cum	14
	24=GR/bETA	Cum	12
	H(1)=H(1)-0.5*21*(22*(V(1+1)-V(1-1))+V(1)*(H(1+1)-H(1-1))+.5*(21	*CUM	15
	121)*((23+1+0)*V(1)*22*(V(1+1)-2+0*V(1)+V(1-1))+(22*24*V(1)**27*(0	CUM	10
	V(1)=V(1)-0.5*21*(23*V(1)*(V(1+1)-V(1-1))+24*(n(1+1)-H(1-1))+2.0*	DCOM	19
	1X*Z4*E2)+0.5*21*21*((23*Z3*V(I)**Z+24*Z2)*(V(1+1)-2.0*V(I)+V(1-1)	1COM	26
	2+(Z3+1+C)*Z4*V(I)*(H(I+1)-2+0*H(I)+H(I-1)))	COM	22
	IE (H(1) + I + HMAX(1)) GQ TQ 1	CUM	23
	HMAX(1)=H(1)	COM	24
	THMAX(1)=1	CUM	43
1	IF (V(I)+LT+VMAX(I)) GU IU Z	CUm	27
	IVMAX(I)=I	CUM	40
z	IF (Q(1).LT.WMAX(1)) GO TO 3	Curl	67
	GMAX(1)=Q(1)	CUM	30
2	PETIEN	CUM	34
	END	COM	33-
	SUBDOUTING FOR COMPUTING COEFFICIENTS IN DIFFERENCE FOUNTIONS		
		Cur	÷.
	SUBROUTINE COED	CUE	2
	DIMENSION (4001, H(400), V(400)	CUE	з
	DIMENSION G(330)	COE	4
	COMMON DN+H1+A+AP+BP+A1+C1+D1+E1+B2+A2+C2+E2+VP+UTA+UT+HB+DC	COF	6
	COMMON DIXOLAFIGRIALPHAIDE TAISOFFINITION DIVISION DITTING	CUL	7
	COMMON HA +HM + VM +HT + VT +NFT +HH + G + QII	COE	•
	COMMON THETA .WP .R .UEPTH .VC . J .HN .VN	COE	10
	THETA=2.0*ATANF((SGRIF(0*H(1)-H(1)**2))/(0/2.0-H(1)))	CUE	11
1	IF (INEIA) 19292 THETA=6.20310+THETA	CUE	14
ż	A=0.125*(THETA-SINF(THETA))*(D*D)	CUE	13
	WP=(D/2.C)*THETA	CUE	14
	R=A/WP p=p=sine(THETA/2.0)	COE	16
	A1=A/(V(1)#B)	COE	17
	C1=1.0	COE	18
	D1=1.0/V(I)	CUE	20
	B2=6ETA/6R	CUE	41
	A2=V(1)*ALPHA/GR	CUE	44
	C2=1.0.	CUL	43
	5F=+123+F+82*V(1)*V(1)/K	CUL	42
	RETURN	COL	26
	END	CUL	27-

SUBROUTINE	FOR	COMPUTING	UPSTREAM	BOUNDARY	CONDITION

	SUBRUUTINE BUNI	DV1	*
	DIMENSION THISSUOL HISSOOL	BUI	4
	DIMENSION WI4001, HI4001, VI4001	001	2
	DIMENSION G(330)	301	2
	COMMON DN+H1+A+AP+OP+A1+C1+D1+E1+B2+A2+C2+E2+VP+DTATOTHOTOC	801	
	COMMON DIXO AF FOR ALPHAIBETASSOF INVIGIDATION CO	301	7
	COMMON MINMINAL TITET TO TOT THE SOLI	BOL	0
	COMMON THE TANPAR DEPTH VC J HN VN	BUL	7
	COMMON GMAX(400), VMAX(400), HMAX(400)	801	10
	CUNMUN TUMAX(400) TVMAX(400) THMAX(400)	BOI	11
1	1F [10.0L.NUCU] 2.3	801	14
2	01=01160(0)	BUL	14
	GU TU 6	041	10
2	In the state of th	001	10
7	50 IG 1	001	17
6	QT=CI(IQ)+(QI(IQ+1)-QI(IQ))*(T-TG(IQ))/(TG(IQ+1)-Tu(IQ))	B01	10
6	HL=H(1)	801	14
5773	THE TA=2.0*ATANF((SGRTF(D*H(2)-H(2)**2))/(0/2.0+H(2)))	801	20
	IF (THETA) 7.8.8	801	21
7	THETA=6.2d310+THETA	801	13
ö	A=0.125*(THETA-SINF(THETA))*(D*D)	BUL	24
	WP=(D/2.0)*THETA	DUL	63
	K=A/mP	bul	20
		401	27
	57 = 123 T 802 V (2) = V (2) F	BOI	20
0	THE TAR 2. 0*ATANE (ISORTE ()*HI -HI **2))/(D/2.0-HL))	801	69
	508 548 75 (D+HL-HL++2)	801	30
	1F (THETA) 16-11-11	801	31
10	THE TA=6.28316+THE TA	601	36
11	AX=D+125*(THETA-SINF(THETA))*(0*0)	BOI	33
	FH=HL-A2*(V(3)+VA-V(1)-GT/AX)-B2*DX/DT*(V(3)+QT/AX-VA-V(1))-C2*(H)	1001	34
	1+H(3)-H(1))-4.0*6X*E2	601	36
	DAX=(D+D/6.0+11.0-COSFTHETAT)/2.0/DOTTD-2.0/DOTTD-2.0	8-1	21
		bul.	20
	TE CANSE HANDAHI 1-0.0000011 13.12.12	BUL	37
12	H HAND	801	40
	60 10 9	801	41
13	H(1)=HNU	801	44
2.5	Q(1)=GT	901	43
	V(1)=QT/AX	BUI	65
	IF (H(1).LT.HMAX(1)) GO TO 14	Bul	46
	HMAX (1)=H(1)	BUI	47
14	IHMAX(1)=1	BUI	40
14		DU1	44
	TVMAx(1) = T	001	20
15	IF (u(1).LT.UMAX(1)) GO TO 16	DUI	>1
	QMAX(1)=Q(1)	ROI	52
	TGMAX (1) = T	801	23
16	RETURN	BOI	34
	END	001	
	SUBROUTINE FOR COMPUTING CRITICAL DEPTH		
	A DELETE DEDIT	DCR	1
	SUBROUTINE DURIT	UCK	2
	DIMENSION G(330) MIACOLE MIACOLE	DCK	5
	DIMENSION TO(3160), BI(300)	DCK	4
	COMMON ON HI A AP dP AI CIDIELED AZ CONCONCAL AL AD	DCR	2
	COMMON D.XO.XF.GR.ALPHA.BETA.SO.F.H.V.G.UA.UT.T.TU.TF.N.FD.FC.B	DCK	0
	COMMON M.MM.MM.L. I. PERD. DUT . VA. IG. TU. UI . NOCO	DCR	7
	COMMON HASHNIVMINTIVTINPTIHHIGIGII	DCR	b
	COMMON THETA+WP+R+DEPTH+VC+J+HN+VN	DCR	20
1	THETA=2.0*ATANE((SQRTF(D*DX-DX**2))/(D/2.0-DX))	DCR	10
2	IF (THETA) 2.3.3	DCH	12
2		DCH	13
9	REGESTINE (THETA/2.0)	DCH	1 4
	DC=DX-(8*(A**3)-ALPHA*((8*u11)**2)/uk)/(3+0*((0*A)**2)-(2+0*(A**3	IUCK	15
	1*COSF (THETA/2.01)/(SINF(THETA/2.01))	DCH	10
	IF (A85F(UC-UX)-0.0001) 5:4:4	DCR	17
4	DX=DC	DCH	10
	GO TO 1	DCR	13
5	VC=QI1/A	DCR	21
	RETURN	DCA	22-
	END	nen	

	SUBROUTINE BONZ	DU4		
	DIMENSION TU(3300) . UI(3300)	802	4	
	DIMENSION 0(400) + H(400) + V(400)	802	4	
	DIMENSION G(330)	802	5	
	COMMON DAYNI AAAP OF AA PHA NETA SOF HY YOUX DI I TOTF NS B FC B	BOZ	0	
	COMMUN N.MM.MMH.L. I.PERU.DUT.VA.IG.L.G.I.G.	80∠	7	
	COMMON HASHMSVMSHISVISNPISHHSGSVII	BUK	۰	
	COMMON THETA P .K . UEPTH . VC . J . HN . VN	804	3	
	COMMON GMAX(400) + VMAX(400) + HMAX(400)	802	10	
	COMMON TEMAX(400) TVMAX(400) THMAX(400)	802	14	
	VP = (VN + V(N))/2 + 0	DUZ	13	
	THE TA=2.C*ATANE((SURTE(D*HP-hP*HP))/(D/2.0-HP))	BOZ	14	
	IF (THETA) 1.1.2	602	15	
1	THETA=6.20310+THETA	802	16	
2	AP=0.125*(THETA-SINF(THETA))*(0*D)	802	10	
	BP=D#SINF(THETA/2+0)	802	17	
2	IF I THE TAL 4.5.5	DUC	×0	
4	THETA=0.20310+THETA	OUL	41	
5	A=0+125*(THETA-SINF(THETA))*(D*0)	BUZ	44	
	D=U*SINF(THETA/2.0)	BUZ	43	
	VX=SURTF(A*GR/b)	802	24	
	CTN=COSF(THETA/2.0)/SINF(THETA/2.0)	MAGU2	26	
	FORGE (MIN) +HD-HM-HN)/DI+VP/DX*(HATHD-HM-HIN)/TAP/(BP-DX)-ITRIVA-	BUZ	27	
	EPRT = AP/(AP+DX+2.0+VX)+(GR-A+GR+2.0+CTN/(0+B))+VP/DX+1.0/DT	BO2	28	
	DC=HB-FORG/FPR1	802	29	
	1F (AbSF(DC-HB)-C.0001) 7.6.6	B02	30	
6	HB=DC	802	21	
	GO TO 3	DUE	22	
1	H(N+1)=0C	BOZ	34	
	IF (THETA) 01915	DUL	33	
8	THETA=6.20310+THETA	BUZ	30	
9	A=U.125*(THETA-SINF (THETA))*(D*D)	BUZ	27	
	B=D*SINF(THETA/2.C)	BOZ	30	
	V(N+1)=SQRTF(A*GR/o)	802	39	
	O(N+1) = A = V(N+1)	802	41	
	I=N+1	BU2	42	
		302	43	
	THMAX(I)=T	304	44	
10	IF (V(1).LT.VMAX(1)) GO TO 11	BUZ	45	
	VMAX(1)=V(1)	802	40	
1275	TVMAX(I)=T	802	20	
11	IF (u(f).L1.uMAX(I)) GO TO 12	BUZ	49	
		802	20	
12	RETURN	BUZ	>1	14.1
	END	802	52-	
	SUBROUTINE FOR COMPUTING NORMAL DEPTH			
	SUBBOUTINE DAORM	DINO	1	
	SUBROUTHE DIGHT, 01(3300)	DNO	2	
	DIMENSION G(400) + H(400) + V(400)	DNO	3	
	DIMENSION G(330)	DNO	4	
	COMMON DN+H1+A+AP+dP+A1+C1+D1+E1+B2+A2+C2+E2+VP+UTA+UT+HB+DC	DNU	2	
	COMMON D,X0,XF,GR,ALPHA,BETA,50,F,H,V,Q,UX,DT,T,TO,TF,N,FB,FC,B	DRU	7	
	COMMON MANAMAL I PERDIDDI VA I GAGINACO	anu		
	COMMON THETA APPRESEPTION CALINA VN	DINU		
1	THE TA=2.0*ATANE ((SGRIF(D*H1-H1**2))/(D/2.0-H1))	DNO	10	
- C.	IF (THETA) 2+3+3	DNU	11	
2	THETA=6.28316+THETA	DNO	12	
3	A=0.125+1THETA-SINF(THETA))*(D*D)	DNO	14	
	WP=(D/2.0)*THETA	DNU	15	
	REA/WP BEDISSINF(THETA/2.0)	DNO	16	
	DN=H1-(WP-(F+GII+GII)/(6+0*GR*S0*R*K*A1)/((3+0*b)/K-2+0/SINF(THE	TADNO	17	
	1/2.0))	DAU	10	
	IF (Ab5F(DN-h1)-0.C001) 5.4.4	DNU	19	
4	H1=DN	DNU	20	
	GO TO 1	DNU	44	
2	END	DNU	43-	
	LTN.	0550		

SUBROUTINE FOR COMPUTING DOWNSTREAM BOUNDARY CONDITION

### A.2.3. DEFINITION OF VARIABLES

DEFINITION		FUENT	ALC: NO	FRICK				
NAME DEFINITION	ONO	LMENT	DCA	17	COF	13	801	23
A AREA OF CIRCULAR SCOMENT	802	22	BO2	37	CIP	12	001	-4
AN INTERMEDIATE AREA	801	33	DUE	31	otu			
AA INTERMEDIATE ANEA	INF	14						
ALDHA VELOCITY DIST FACTOR-ENERGY	LWT	26						
AD INTEDUEDIATE ADEA	802	17						
AT INICACCITATE ANEX	COF	17						
41 (2)	COF	22	BOI	26				
B EDEE SUDEACE WIDTH	DNO	16	DCR	14	COE	16	802	23
A FREE JORFREE FLORIN	802	38	CIR	15				
BETA VELOCITY DIST FACTOR-HOMENTUM	LWT	27	12020					
BP INTERMEDIATE FREE SURFACE WIDTH	802	18						
A2 (2)	COE	21						
CTN COTANGENT OF ANGLE	802	25						
(1 (2)	COE	18						
(2) (2)	COE	23						
D DIAMETER OF PIPE	LWT	19	INC	24	INC	69		
DAREA DERIVATIVE OF AREA WITH DEPTH	INC	34						
DAX DERIVATIVE OF AX	801	36						
DC CRITICAL DEPTH	DCR	15	802	29				
DCOM COMPUTED DEPTH	INC	46	INC	50				
DCOB CRITICAL DEPTH	LWT	48						
DENG (2)	INC	38						
DEPTH DEPTH OF FLOW	INC	17	INC	30				
DIN INITIAL VALUE OF DEPTH	INC	16	INC	53	INC	55	INC	62
	INC	64						
DN NORMAL DEPTH	DNO	17						
DNOB NORHAL DEPTH	LWT	46						
OGA DERIVATIVE OF HYD RADIUS WITH DEPTH	INC	37						
DSLO DERIVATIVE OF EN SLOPE WITH DEPTH	INC	39		-				
OT INCREMENT OF TIME	LWT	55	LWT	56				
DTA INCREMENT OF TIME	IWT	67						
OTHET DERIVATIVE OF THETA WITH DEPTH	INC	33						
OTOL MAX ERROR IN DEPTH CALCULATIONS	INC	9						
OW DERIVATIVE OF WP WITH DEPTH	INC	35			0.00			
DX INCREMENT OF DISTANCE	COF	45	CAL	22	ULK	10		
	TNC	19	THE					
EET ENERGY AT UNKNOWN DEPTH	TNC	22	INC	00				
ELEVENENT AT UNKNUWN DEPTH	INC	10	THE	12				
	COF	20	INC	16				
F1 (C)	COF	25	801	28				
E DADEY HETEDACH EDICTION EACTOR	LWT	25	001	20				
EN EACTOR IN DEV. NO. DADCY FUNCTION	LWT	19						
EC EACTOR IN DEV. NODARCY FUNCTION	1.47	4.0						
ED CELEDITY OF WAVE	I WT	50						
FH (2)	801	34						
FM NUMBER OF DISTANCE INTERVALS	TWT	51						
FORG (2)	508	26						
FPH (2)	BO1	37						
FPR1 (2)	802	28						
FRAT10 (2)	INC	45						
GR ACCELERATION OF GRAVITY	LWT	28						
H DEPTH OF FLOW	COM	16	801	42	802	33		
HA DEPTH OF FIOW	LWT	78						
HB DEPTH OF FLOW	LWT	93	BOZ	31				
HETH ONE-HALF THETA	INC	35						
HL INTERMEDIATE DEPTH	801	19	801	40				
HM INTERMEDIATE DEPTH	LWT	81	100.70-	and a	0.010	2012		102222
HMAX MAXIMUM DEPTH	LWT	14	COM	24	801	46	802	43
HN INTERMEDIATE DEPTH	LWT	84						
HNU COMPUTED DEPTH	801	38						
HP INITIAL DEPTH	805	12	202					
H) INITIAL DEPTH	LWT	59	DNO	20				

1 (1)	902	41							
1X0X (1)	LWI	100	INC	67					
	LUT	100	TLAP.	01					
	TWE	30	BOL	16					
K (1)	INC	14							
NCOUNT ITERATION CONTROL COUNTER	INC	27	INC	56					
N NUMBER OF DISTANCE INTERVALS	1. WT	15	0100						
NT TIME INTERVAL PRT OUT CTROL COUNTER	LWT	41	LWT	70	LWT	75			
NPG PRINT OUT CONTROL	LWT	99	0.0412000						
NPO TIME INTERVAL PRINTOUT LIMIT	LWT	38							
NOCONO. OF INFLOW DISCHARGE VALUES	LWT	59							
NI NO. OF X-POSITIONS	LWT	36							
Q COMPUTED DISCHARGE	INC	25	INC	71	COM	22	801	43	
	SUB	40							
QA INTERMEDIATE DISCHARGE	I WT	77							
QB BASE FLOW	I.WT	51							
QI INTERPOLATED DISCHARGE	INF	16							
OII INTERMEDIATE DISCHARGE	IWT	43							
QM INTERMEDIATE DISCHARGE	IWT	80	-	-			0.0.2		
QMAX MAX. DISCHARGE	I WT	16	COM	30	801	54	802	44	
ON INTERMEDIATE DISCHARGE	IWT	83							
OO EXCESS OF PEAK & OVER OR	INF	10	Det	10					
OT INFLOW DISCHARGE	108	13	801	11	0.01	25	C . D	14	
R HYDRAULIC RADIUS	DNU	15	LUE	15	901	. 25	CIN	14	
RA RATIO OF DT TO DX	LWI	54	COF	34	801	27			
SP AVENAGE PRICION SLUPE	INC	20	LUE	24	801	21			
SO CHANNEL HED SLUPE	201	20							
	INC	21	TNC	65					
SI FRICTION STOPE	TNC	42	1140	0.3					
T THE IN SECONDS	IWT	22	LWT	76					
TUMAY TIME OF MAX. VELOCITY	COM	28	801	50	802	47			
TE TIME LINIT FOR SOLUTION	IWT	34							
TO TIME TO C. OF G. OFINELOW HYDROGRAPH	INF	12							
THETA CENTRAL ANGLE OF CIRCULAR SEGMENT	DNO	10	DNO	12	DCR	10	DCR	12	
	COE	10	COE	12	801	20	801	22	
	801	29	801	32	B05	14	802	16	
	SOB	19	802	21	802	34	802	36	
	CIR	9	CIR	11					
THMAX TIME OF MAX. DEPTH	COM	25	801	47	802	44			
TO (2)	LWT	33							
TP TIME TO PEAK INFLOW HYD. DISCHARGE	INF	11							
(2) OT	INF	15	1000	02200		1212			
TOMAX TIME OF MAX. DISCHARGE	COM	31	801	53	805	50			
UU (?)	INF	13		-				1.0	
V VELOCITY	INC	26	INC	70	COM	19	801	44	
	508	39							
VV VELOCITY	INC	19	INC	40					
VX CELERITY OF WAVE	802	24							
VA INTERMEDIATE VELOCITY	LWI	19							
VC CRITICAL VELOCITY	OCR	20	1.00						
VH VELOCITY HEAD	INC	20	INC	41					
VM INTERMEDIATE VELOCITY	LWI	15	CON	27	801	40 -	802	46	
VMAX MAXIMUM VELOCITY	LWT	12	COM	21	901	47	BUE	40	
VN INTERMEDIATE VELOCITY	PO2	13							
VP AVERAGE VELOCITY	THC	15	ONO	14	COF	14	801	24	
WP WEITED PERIMETER	CTO	13	DIAD	14	COL		301		
- Partition a out cumul	1.17	105	THE	27	THE	6.8			
X POSITION ALONG CHANNEL	TNC	11	INC	20	THE	00			
YE TOTAL LENGTH OF CHANNEL	INT	24	Arres .						
VI HODE ING I FNGTH OF CHANNEL	I WT	49							
TO INITIAL DOSITION ALONG CHANNEL	I WT	23							
71 (2)	COM	12							
73 (3)	COM	13							
73 121	COM	14							
76 (2)	COM	15							
• The second se second second sec									

### A.2.4. SAMPLE OUTPUT

(No input required)

			TF		2.0000000E+02
DNOR		1.228582175.00	50		1.00000000000-03
DCQ8 :	=	1.007854585.00	502		
DAVOE		1 244202170+00	D	٠	5*4595000E+UN
UNPF		1.550305114.00	F		1-200000005-12
DCPF :	=	1.0078546dE+00			
1000		24	RA	-	1-02613185E-01
		20	=1		1.228590676.00
DX =		4.005823272-01			
			PE	¥D	4.13844083-145
DT =		2.076296705+00	FR		1-0939+0005-01
×0 =		0.			
			FC		-1.7+440000E-01
XF =		8.21700000E+02			

TO = 0.

÷

TIME	15	0.	-	SEC	•		v							a l			
1		1.42	751153E+00	3	١.	7366	93	28£	+00		1.	CO	00	U0	0.0	E٠	01
5		1.22	725478E+00	3	١.	1377	54	4E	+00		1.	00	00	00	00	E+	01
3		1.22	693597E+00	- 3	•	7390	09	SE	+00		1.	00	00	00	00	E+	01
		1.62	604705F-00		•	7406	054	19E	+00		!•	00	00	00	00	E*	01
6		1.22	5633906-00		•	7-50	411	100	+00		1.	00	00	00	00	E.*	01
7		1.42	407883E.UO		1	7401	56	SOE	.00		::	00	00	ŭä	00	Ε.	
8		1.42	3739556.00	1	1	7519	64	SE	.00		1.	00	00	00	0.0	÷.	01
9		1.22	256764E+00	1	١.	7567	350	SPE	+00		i .	0 ũ	00	U O	00	Ē.	01
10		1.42	110173E+00	2	3.	7627	14	BOE	+00		1.	00	00	00	00	E+	01
11		1.21	925208E+00		3.	7702	424	+8E	•00		1.	00	00	U Q	00	٤+	91
14		1.21	694368E+00		•	7797	70.	LOE	+00		1.	00	00	00	00	E٠	01
1.5		1.41	4005092.00		•	0075	041	JOE	+00		1.	00	00	00	00	E+	-1
15		1.20	543223E.00		÷	8277	80		+00		11	00	00	00	00	5.	01
10		1.19	913617E.00	- 3	1	8545	121	TE	.00		1.	00	00	00	00	Ē.	01
17		1.19	075871L+00		١.	8906	67	17E	+00		1.	00	00	00	00	Ē.	01
18		1.17	9291451.00	3	3.	9412	1.01	35 O	+00		i.	00	00	00	00	Ē+	01
19		1.16	278538L+00	4	۰.	0100	43	546	.00		1.	00	00	00	00	E٠	01
20		1.13	005534E+00		••	1402	45	15E	+00		1.	00	00	00	00	E٠	01
. 51		1.00	7054682.00	4	٠.	A727	644	27E	+00		1.	00	0 0	00	00	E+	01
PNT	15	1.2	5777802=+01	SEC	•		v							Q			
Ŧ		1.64	3+3175E+00	4		0074	514	4E	+00		1.	04	0.0	90	52	۶.	01
S		1.24	2334092+00	3	١.	A109	197	23E	•00		1.	62	96	57	57	È+	01
3		1.23	503933E+00	3	١.	7813	57	39E	+00		1.	01	63	20	11	E+	01
2		1.43	077535E+00	3	•	7628	53:	51E	+00		1.	00	95	91	23	E٠	01
2		1.22	8151936+00	3	•	7537	SI	OL	+00		1.	00	+0	34	55	E٠	01
7		1.22	512882F-00	-	•	7504	31.	57E	• 00		1.	00	18	80	÷2	5.	01
8		1.42	3724901.00		•	7510	74	SF	-00		1.	00	03	54	53	51	01
9		1.42	202615E+00	3	1	7572	1 38	BBE	+ 50		1.	00	01	24	04	Ē.,	01
10		1.22	109743E+00	3	3.	7629	90	78E	+00		1.	00	00	55	05	E .	01
11		1.21	922238E+00	3	١.	7703	140	17E	.00	9	9.	99	96	57	95	Ē.	00
12		1.21	687818E.U0	3	۰.	7777	928	25E	.00	1	۰.	99	33	66	99	E٠	00
13		1.21	3915522+00	-	•	7919	22	11E	• 00	1	9.	94	31	<1	26	٤٠	00
15		1.20	526893E.00	1	•	80/5	321	JBE	•00		9.	99	병명	29	79	E*	00
16		1.19	891042E+U0			0546	204	AF	.00	-		77	87	20	30		00
17		1.19	0+2701E+00	3		8910	893	IE	+00		ġ.	99	74	21	28	2.	00
18		1.17	868937E+UU	3		9427	332	6E	.00	3	ó.	99	84	69	78	÷.	00
14		1.16	U75100E+U0	4	0	0269	643	57E	+00	2	1 .	00	00	84	90	Ë.	01
50		1.15	1840165+00	4		5115	145	9E	+00	1	1.	00	33	45	80	Ē+	01
21		1.01	1752116+00	4		8833	97:	99E	• 0 0		1.	00	74	76	13	£٠	01
PNT	IS	2:5	155560+F.01	550	•		v							u			
ĩ		1.26	3577032+00	4		6117	140	17E	+00	3	1.	28	27	21	30	E٠	01
2		1.30	8+30922+00	4		0204	345	7É	•00	1	1.	15	<b>\$</b> 3	70	10	٤•	01
з		1.67	991237E+00	4		0115	821	6E	• 00		1.	12	27	29	+7	£*	01
:		1.46	604725E+00	3	•	9359	34	390	+00	1	1.	08	12	23	D2	E*	01
2		1.05	3504232+00	1.0	•	8408	931	15	•00	3	1.	00	30	14	35	E*	01
7		1.43	567535F+00		•	0045	371	76	+00		1	03	50	62	60	2.	01
		1.23	1030025-00			7896	57	35	.00	1	1.	01	53	06	66	F .	01
9		1.22	640571E+00	3		7194	47	OE	.00		1.	00	90	27	71	ē.	01
10		1.42	358088E+U0	3		7759		S9E	+00		1.	00	51	44	19	Ē+	01
11		1.22	000741E.00	3	١.	7778	05	1E	.00		1.	00	28	23	83	٤.	01
12		1.21	7611352+00	3		7840	ORS	9E	• 0 0		1.	00	14	76	14	E •	01
13		1.41	4258132.00	3		7942	91	TE	.00		1.	00	07	13	09		01
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5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.00 5.034405E.0	4 1.9+723471E+01 1.9+03842E+01 1.93600776E+01 1.92735612E+01 1.91547718E+01 1.915477185293E+01 1.9615293E+01 1.853723755E+01 1.853723755E+01 1.85372236E+01 1.80+71+17E+01 1.70015342E+01 1.7005379E+01 1.7045374E+01 1.72053579E+01 1.64123404E+01 1.6412073E+01 1.6412073E+01 1.6412073E+01 1.6412073E+01 1.6412073E+01 1.6412073E+01 1.6412073E+01 1.64177552E+01 1.6412073E+01 1.64177552E+01 1.64177552E+01 1.64177552E+01 1.64177552E+01 1.64177552E+01 1.64177552E+01 1.64177552E+01 1.64177552E+01 1.64177552E+01 1.64177552E+01 1.64177552E+01 1.64177552E+01 1.6417752E+01 1.6417752E+01 1.6417752E+01 1.6417752E+01 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PNT 2 3 4 5 6 7 7 9 10 11 12 13 12 13 14 15 16 17 18 19 20 21 21 21 MaxImum	۷ųL		V 4.14901736:.nn 4.255167946:n0 4.237631356:n0 4.297314128:nn 4.300535976:n0 4.33804796:n0 4.338474306:00 4.33946485:n0 4.31946485:n0 4.431946485:n0 4.431946485:n0 4.434774285:n0 4.544774285:n0 4.544774385:n0 4.544774385:n0 4.544774385:n0 4.544774385:n0 4.544774385:n0 4.544774385:n0 4.5447431755:n0 4.544743765:n0 5.73327656:n0 5.733227676:n0 5.733227676:n0	$\begin{array}{c} 9\\ 1.60+20+32E+01\\ 1.60+20+32E+01\\ 1.66+396775E+01\\ 1.66+396775E+01\\ 1.66+396775E+01\\ 1.60+2696E+01\\ 1.6950246E+01\\ 1.69051159E+01\\ 1.69051159E+01\\ 1.70124672E+01\\ 1.70124672E+01\\ 1.70540565E+01\\ 1.70540565E+01\\ 1.71256+94E+01\\ 1.71256+94E+01\\ 1.712376e+20\\ 1.712376e+01\\ 1.70+7766E+01\\ 1.70+7766E+01\\ 1.70+7766E+01\\ 1.70+7766E+01\\ 1.70+7766E+01\\ 1.70+7766E+01\\ 1.70+7766E+01\\ 1.70+7766E+01\\ 1.70+7766E+01\\ 1.70+90+972E+01\\ 1.70+90+972E+0\\ 1.70+90+982E+0\\ 1.70+90+982E+0\\ 1.70+90+982E+0\\ 1.70+90+982E+0\\ 1.70+90+982E+0$
1         1           2         1           2         1           3         1           5         1           6         1           7         1           9         1           10         1           12         1           14         1           16         1           17         1           18         1           19         1           12         1           14         1           17         1           18         1           19         1           20         1           21         1	7234202.00 09798025.00 09798025.00 09798025.00 07498025.00 07493075.00 06733145.00 0643412.00 0643412.00 0643412.00 0643412.00 0643412.00 0643412.00 0643412.00 0643412.00 0643412.00 0643412.00 0643412.00 0665012.00 0665012.00 0695612.00 0695612.00 0695612.00 0695612.00 069562.00 060562.00	4,54273121E.00 4,72404527E.00 4,7353402E.00 4,7353402E.00 4,74451035E.00 4,74537795E.00 4,74564795E.00 4,74564779E.00 4,74564779E.00 4,74544703E.00 4,74714538E.00 4,74714538E.00 4,6109057E.00 4,85011654E.00 4,85011654E.00 4,85011654E.00 5,079548164.00 5,079548164.00	1.80475072.01 1.912237862.01 1.90120377.01 1.80530877.01 1.805324245.01 1.805324245.01 1.80534245.01 1.8053425.01 1.8054592287.01 1.824592387.01 1.805457115.01 1.704110375.01 1.7033635.01 1.74965715.01 1.74965715.01 1.603240755.01		DISTANCE 0.00 40.06 81.72 124.57 164.43 274.29 245.15 320.87 367.72 4.70.58 449.44 490.30 531.16 572.02 612.47 653.73 476.51 735.45 735.45 817.16	ма	X DEFTH TIME 1.73 134.14 1.70 129.97 1.70 136.24 1.64 142.55 1.65 148.84 1.66 148.84 1.65 155.13 1.65 155.13 1.63 161.41 1.63 161.41 1.63 161.41 1.63 161.41 1.63 161.41 1.63 161.41 1.63 161.41 1.63 173.49 1.56 173.49 1.51 160.24 1.51 160.24 1.51 178.16 1.83 176.04	45.X         yFL         114F           5,00         96.53         5.05         83.85           5,05         83.85         6.95         94.83           4,95         92.24         4.93         94.33           4,95         92.84         101.62         4.89           4,95         101.052         4.86         106.91           4,86         105.92         4.86         105.92           4,86         105.92         4.86         113.90           4,85         113.90         4.87         119.40           4,85         127.47         5.96         127.47           4,96         127.47         4.96         124.76           4,96         127.47         5.74         176.96	144 0         TIME           20.00         100.62           14.74         100.62           14.75         106.91           14.37         111.10           14.37         111.10           14.37         111.10           14.37         121.59           14.73         125.78           14.50         179.49           14.30         179.49           14.44         14.16           14.30         179.49           14.30         179.49           14.44         17.76           15.513         17.63           17.64         153.03           17.39         167.70           17.29         167.70           17.15         177.60

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PROGRAM UNSTDY	UNS	5
1 (INPUT+OUTPUT+TAPE5=IMPUT+TAPE6=00TPUT)	UNS	4
CATTENUATION ANALYSIS - CIRCULAR CROSS SECTION	UNS	6
CHI INITIAL CONDITIONS	UNS	3.0
CDETERMINATION OF HYDROGRAPH AT THE SPECIFIC POINT WITH TWO CON	TROLUNS	10
C ( AT UPSTREAH AND DOWNSTREAM ) BY THE METHOD OF CHARACTERISTIC	S UNS	10
CFPICIION COEFFICIENT F VARIES WITH RETROLUS NUMBER	UNS	16
DIMENSION DISULT: BALLSUIT: DEALEDUTE GISTOFT GUSTER	UNS	18
DIMENSION OFFICIAL TOTAL COULT, TOMAX (2001, TYMAX (200)	UNS	20
DIMENSION VISADI, VOTISADI, VMA(200), XISOD	UNS	22
COMMON A. AR. AC. AD. AF. ALPHA. H. RC. HD. HFTA. CD. CO. D. DC. DDT	UNS	24
COMMON DEPTH.OD.DIA.DIN.ON.ONAK.UN.DOUT.DI.DIGL.DY.ED	UNS	26
COMMON F.FB.FC.FD.FNU.GR.1. (TO. 110C. 1XO. 1XOC.J.MC.N.NUCD	UNS	28
COMMON NT.NI.Q.OB.GDT.QI.QIN.OMAX.QP.OO.R.REY.SO.F.TOMAX	UNS	30
COMMON IF. THE TA. TIO. TO. TO. TOMAX. IVMAX. V. VOT. VMAX. VV. WP	UNS	35
COMMON X+XE+XF+XX	UNS	34
CPHYSICAL CONSTANTS OF THE SYSTEM	UNS	36
014=2.9262	UNS	38
xF=821.70	UNS	40
S0=0.001	UNS	40
CONFFICIENTS FOR COMPUTING F FROM THE REYNOLDS NUMBER	UNS	44
F NH=0.0000141	LINS	40
FB=0.109394	UNS	50
F C==0.17944	UNS	52
CPHYSICAL PARAMETERS	UNS	54
0P = 32 + 173	UNS	56
ALTRA-1.00	UNS	58
CONSTRAM CONTROL CONSTANTS	UNS	60
CD=0.0	UNS	62
ED=1.35	UNS	64
CCOMPUTATIONAL PARAMETERS	UNS	66
N=20	UNS	68
S=0x1	UNS	70
TF=200.	UNS	74
110=20.	IME	76
DTOL = 0.00001	LING	78
CINFLOW HYDROGRAPH	UNS	80
READ (5:206) NOCD	UNS	82
RFAD (5.210) (10(1).01(1).1-1.00(0)	UNS	84
QR=Q1(1)	UNS	86
	UNS	88
	UNS	90
004=08/08	UNS	92
N1=N+1	UNS	94
DO 10 I=1.N1	UNS	96
DMAX(1)=0.0	UNS	98
VMAX(1)=0.0	UNS	100
10 QMAX(I)=0.0	UNS	102
WRITE (6,220)	UNS	104
WRITE (6+270)	LINS	108
WPITE (6+230) 04	UNS	110
WRITE (6.250) 00	UNS	112
NOTTE 16-3201 004	UNS	114
HO11E (6.240) VOL	UNS	116
WD1TF (6.270)	UNS	118
WRITE (6.280)	UNS	120
WRITE (6.290) 50	UNS	155
WPITE (6.300) ALPHA	UNS	124
WRITE (6.310) 9FTA	UNS	126

	WRITE (6+270)	UNS	12
	WRITE (6.330) N.IX0.IF.110	UNS	13
C	COMPUTATION OF NORMAL DEPIN NAME CALIFICAL DEPIN	UNS	13
	00=08	UNIS	1.3
	CALL DCRIT	UNS	12
	CALL DNORM	LINE	1.6
2.0	1F (0N-DC1 20+20+30	LINES	14
20	BRITE (01140)	UNS	14
30	IE 100 46.50.40	UNS	14
40	HC 1	UNS	14
40	x x = 0 - 0	UNS	15
	DOUT=(08/CD)**(1.0/FD)	UNS	15
	Gn T0 60	UNS	15
50	NC=2	UNS	15
	Xx=4.5+DC	UNS	15
	DOUT=DC	UNS	16
60	XF=XF-XX	UNS	16
	A <sub>M</sub> =N	UNS	10
	Dx=XE/AN	1145	10
1	WRITE (6.350) ON DE	LINE	17
C	COMPUTATION OF DT ( TIPE INCOEDENT)	LINC	14
	00=0P	LINS	17
	DEPTH-DC	UNS	17
	CALL CIDCLE	UNS	17
	VC+OP/A	UNS	18
	VC-9F7#	UNIS	11
		UNS	16
	DTMAX=(DX#2,D#RFTA)/(VC+TALPHA+HFTA)+SOUTF(((ALPHA-HFTA)+#2)#VC+V	CUNS	16
	1+(4-0@BFTA@GR#DM)))	UNS	18
	DT=DTMAX*.5	UNS	15
	CO=-DT/DX	UNS	15
	NT=TF/DT	UNS	19
	110=110/01	UNS	15
	WRITE (6.360) DX.DT	UNS	19
C	COMPUTATION OF VELOCITY AND DEPTH FOR ALL DISTANCES & AT TIME 0.0	UNS	20
	DIN=(DOUT+ON1/2.0	LINE	20
	DEPTHENOUT	LINS	20
	CALL INCOMP	LINS	20
		UNS	21
	UDITE (6.370) T	UNS	21
	NOTIF (6.380)	IINS	21
	WEITE (6.390)	UNS	15
	Do 70 1=1+N1+IX0	UNS	21
	WRITE (6,400) X(1), P(1), V(1), Q(1)	UNS	22
70	CONTINUE	UNS	55
	110C=1	UNS	55
	Do 170 J=2+NT	UNS	SS
	T=T+DT	UNS	55
C	COMPUTATION OF VELOCITY AND DEPTH FOR THE PALET AT TIME T	UNS	.53
	CALL BOUNDI	UNS	S
	IF (ITOC-ITO) 90.80.90	UNS	53
80	WRITE (6+370) T	UNS	2
	WRITE (6,380)	UNS	23
	WRITE (6.190)	UNS	24
0.0		UNS	24
40	120L=1	UNS	24
C	DU 120 1-210	UNS	24
6		UNS	25
	IF (110C.FO.IIO.AND.IX0C.FO.IX0) 100-110	UNS	25
100	1x0C=1	UNS	25
	WRITE (6+400) X(1) +DD1(1) +VDT(1) +(D)1(1)	UNS	25
	60 10 120	UNS	25
110	1x0C=1x0C+1	UNS	26
120	CONTINUE	UNS	26
C	COMPUTATION OF VELOCITY AND DEPTH FOR THE DUTLET AT TIME I	UNS	26
	I=N1	UNS	56
	CALL BOUND?	UNS	26
	IF (ITOC-ITO) 140+130+140	UNS	27
130	ITOC=1	UNS	21
	WRITE (6+400) x(1)+001(1)+001(1)+001(1)	UNS	27
1001	60 10 150	UNS	21
140	110C=110C+1	UNS	20
150	DO 160 LEINNI	UNC	20
	0(1)=001(1)	0115	60

### A.3.2. FORTRAN IV COMPUTER PROGRAM

MAIN PROGRAM FOR UNSTEADY FLOW BY METHOD OF CHARACTERISTICS

	SUBROUTINE FOR COMPUTING INITIAL CONDITION	
	SUBROUTINE INCOND	INC
	DIMENSION D(500), DDT(500), DMAX(200), Q(500), QDT(500)	INC
	DIMENSION 01(200) . QMAX(200)	INC
	DIMENSION TOMAX(200) + TO(200) + TOMAX(200) + TVMAX(200)	INC
	DIMENSION V(500), VDI(500), VMAX(200), X(500)	INC
	COMMON A+AR+AC+AD+AE+ALPHA+H+BC+BD+BETA+CD+CO+D+DC+DDT	INC
	COMMON DEPTH+DD+DIA+DIN+DM+DMAX+DN+DOUT+DT+DT+DT+L+DX+ED	INC
	COMMON F+FB+FC+FD+FNU+GR+I+IT0+IT0C+IXO+IXOC+J+MC+N+NQCD	INC
	COMMON NT+N1+Q+OB+ODT+DI+QIN+DMAX+QP+OQ+K+PEY+S0+T+TDMAX	INC
	COMMON TF+THETA+TIO+TP+TO+TOMAX+TVMAX+V+VDT+VMAX+VV+WP	INC
	COMMON X,XF,XF,XX	INC
0823	CALL CIRCLF	INC
С	CONDITION AT INITIAL POSITION	INC
	VV=QB/A	INC
-	VH=VV+VV/(2.0+GR)	INC
C	COMPUTE REYNOLDS NUMBER	INC
920	RFY=VV+R/FNU	INC
C	COMPUTE FRICTION FACTOR	INC
	F=FB®REY®®FC	INC
	5)=FeVH/(4.0eR)	INC
	EE)=OEPTH+ALPHA*VH	INC
	X(N+1) = XF - XX	INC
	D(N+1) = DO(1)T	INC
	V (N+1)=VV	INC
	Q(N+1)=QB	INC
	NCOUNT=0	INC

160       V(1)=VDT(T)       UNS 286         170       CONTINUE       UNS 288         NPR=N1/50+1       UNS 292         It=50*111-49       UNS 296         WRITE       UNS 296         WRITE       UNS 296         WRITE       UNS 296         WRITE       (6+40)         UNS 100       UNS 296         WRITE       (6+40)         WRITE       (6+40)         WRITE       (6+40)         WRITE       (6+30)         WRITE       (0+30)         WRITE       (0+30)         WRITE       (0+30)         WRITE       (0+30)         WRITE       (0		D(I)=00T(I)	IINS	284
170       CONTINUE       UNS 260         NPG=N1/50+1       UNS 290         D0 180 ITI=1*NPG       UNS 294         It=50*ITI=4*9       UNS 294         It=1**49       UNS 294         WRITE (6*40)       UNS 296         WRITE (6*40)       UNS 296         WRITE (6*40)       UNS 300         D0 180 I=11*1       UNS 306         WRITE (6*430) X(I)*DMAX(I)*IDMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(I)*UMAX(	160	V(1)=V0T(1)	LIME	284
NPG=N1/50+1       UNS 240         D0 180 ITI=1*NPG       UNS 294         II=50*III-49       UNS 294         II=1**0       UNS 294         WRITE (6*410)       UNS 296         WRITE (6*420)       UNS 300         D0 180 I=II:IL       UNS 300         WRITE (6*430) X(I)*DMAX(I)*TDMAX(I)*TVMAX(I)*TVMAX(I)*OMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOMAX(I)*TOM	170	CONTINUE	LING	288
D0 180 TIT=1+NPG UNS 292 IT=50*III-49 UNS 294 WPITE (6+410) UNS 296 WPITE (6+420) UNS 296 WPITE (6+430) X(1)+DMAX(1)+TDMAX(1)+VMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+TDMAX(1)+		NPG=N1/50+1	LINS	290
IT=50#III-49       UNS 294         IL=II+49       UNS 296         WRITE (6.420)       UNS 300         DO 180 I=II.1L       UNS 300         WRITE (6.420)       UNS 300         WRITE (6.430) x(I).DMAx(I).TDMAx(I).TOMAx(I).TOMAx(I).TOMAx(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).TOMAX(I).		DO 180 III=I-NPG	UNS	292
IL = II + 49 WP ITE (6+40) WP ITE (6+40) UNS 298 WP ITE (6+40) UNS 300 DO 180 I= II + 1L WR ITE (6+40) X(I) + DMAX(I) + UMAX(I) + UMAX(I) + UMAX(I) + TOMAX(I)		I1=50+111-49	UNS	294
WPITE (6.410)       UNS 204         WRITE (6.420)       UNS 300         DO 180 T=T1:LL       UNS 300         WRITE (6.420)       UNS 300         WRITE (6.430) X(1),DMAX(1),TDMAX(1),FVMAX(1),FVMAX(1),GMAX(I),TDMAXUNS 304       UNS 300         I(1)       UNS 300         10 CALL EXIT       UNS 310         Continue       UNS 316         200 FORMAT (13)       UNS 316         210 FORMAT (14):A:#EFLOW HYDRUGPAPH PARAMETERS*/)       UNS 318         220 FORMAT (2X.*0A0= *F10.5.*0CFS*)       UNS 322         240 FORMAT (2X.*0A0= *F10.5.*0CFS*)       UNS 322         240 FORMAT (2X.*0A0= *F10.5.*0CFS*)       UNS 322         250 FORMAT (2X.*0A0= *F10.5.*0CFS*)       UNS 322         260 FORMAT (2X.*0A0= *F10.5.*0CFS*)       UNS 322         270 FORMAT (2X.*0A0= *F10.5.*0CFS*)       UNS 323         280 FORMAT (2X.*0P= *F10.5.*0CFS*)       UNS 332         280 FORMAT (2X.*0P= *F10.5.*0CFS*)       UNS 333         380 FORMAT (2X.*0P= *F10.5.*0CFS*)       UNS 332         380 FORMAT (2X.*0P= *F10.5.*0CFS*)       UNS 334         380 FORMAT (4X.*0P= *F10.5.*0CFS*)       UNS 334         380 FORMAT (* N =*15/* IX.*0(FF)*.1(F =*F6.0/* IIO =*F10.5)       UNS 342         380 FORMAT (* N =*15/* IX.*0(FF)*.1(F =*F6.0/* IIO =*F10.5)       UNS 344 <td></td> <td>11 = 11 + 69</td> <td>LINS</td> <td>296</td>		11 = 11 + 69	LINS	296
WRITE (6+420)       UNS 300         DO 180 T=TI+1L       UNS 302         WRITE (6+420)       UNS 302         WRITE (6+430) X(I)+DMAX(I)+IDMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(I)+UMAX(		WRITE (6.410)	LINC	208
D0 180 T=T1+1L UNS 302 WRITE (6+330) X(1)+DMAX(1)+TDMAX(1)+VMAX(1)+UMAX(1)+UMAX(1)+TDMAXUNS 304 1(1) IF (1.EQ.N1) G0 TO 190 UNS 308 190 CALL EXIT UNS 312 200 FORMAT (13) 210 FORMAT (14)+2X+@INFLOW HYOROGPAPH PARAMEIERS®+/) UNS 312 210 FORMAT (14)+2X+@INFLOW HYOROGPAPH PARAMEIERS®+/) UNS 312 230 FORMAT (2X+@NAVE VOLUMF ANDVE HASE FLOW= @F8.2+@CU FT@) UNS 322 240 FORMAT (2X+@NAVE VOLUMF ANDVE HASE FLOW= @F8.2+@CU FT@) UNS 322 250 FORMAT (2X+@NAVE VOLUMF ANDVE HASE FLOW= @F8.2+@CU FT@) UNS 326 270 FORMAT (2X+@NAVE VOLUMF ANDVE HASE FLOW= @F8.2+@CU FT@) UNS 326 270 FORMAT (2X+@NAVE VOLUMF ANDVE HASE FLOW= @F8.2+@CU FT@) UNS 326 270 FORMAT (2X+@NAVE VOLUMF ANDVE HASE FLOW= @F8.2+@CU FT@) UNS 330 280 FORMAT (2X+@NAVE ASU UNF ANDVE HASE FLOW= @F8.2+@CU FT@) UNS 332 280 FORMAT (2X+@NAVE YOLUMF ANDVE HASE FLOW= @F8.2+@CU FT@) UNS 332 280 FORMAT (2X+@NAVE YOLUMF ANDVE HASE FLOW= @F8.2+@CU FT@) UNS 332 280 FORMAT (2X+@NAVE YOLUMF ANDVE HASE FLOW= @F8.2+@CU FT@) UNS 332 280 FORMAT (2X+@NAVE YOLUMF ANDVE HASE FLOW= @F8.2+@CU FT@) UNS 334 300 FORMAT (4 SD =#F10.5) UNS 334 300 FORMAT (4 SD =#F10.5) UNS 334 300 FORMAT (4 SD =#F10.5) UNS 334 300 FORMAT (4 PLAM=#F10.5) UNS 334 300 FORMAT (4 PLAM=#F10.5) UNS 334 300 FORMAT (4 PLAM=#F10.5) UNS 344 300 FORMAT (2X+@NORMAL DEPTH= #F6.4+@FT@+4X+@CITICAL DEPTH= #F6.4+#FUNS 346 1 TX+*) UNS 355 300 FORMAT (2X+@DX= @F8.5*@FT@+4X+@DT= @F4.5*\$EC@+/) UNS 355 300 FORMAT (2X+@DX= @F8.5*@FT@+4X+@DT= @F4.5*\$EC@+/) UNS 356 300 FORMAT (2X+@DX= @FA.5*@FT@+4X+@DT= @F4.5*\$EC@+/) UNS 356 300 FORMAT (2X+@DX= @FA.5*@FT@+4X+@FT@= NAVEL TIME MAX Q UNS 366 1 TIME#3 400 FORMAT (2X+@CDX= MAX UPDTH TIME MAX VEL TIME MAX Q UNS 366 1 TIME#3		WRITE (6.420)	LINS	300
WRITE (6+430) x(1),DMAx(1),IDMAx(1),TVMAx(1),TVMAx(1),TOMAX(I),TOMAX(I),TOMAX(I),TOMAX(I),IDMAX(I),TOMAX(I),IDMAX(I),TOMAX(I),IDMAX(I),TOMAX(I),IDMAX(I),TOMAX(I),IDMAX(I),TOMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I),IDMAX(I)		DO 160 I=II-II	UNS	302
1(1)       UNS 306         1F (I.FQ.N1) GO TO 190       UNS 308         1AO CONTINUE       UNS 312         200       FORMAT (RF10.4)       UNS 316         200       FORMAT (RF10.4)       UNS 318         200       FORMAT (RF10.4)       UNS 318         200       FORMAT (2X.*008= *F10.5.*0°F5*)       UNS 320         230       FORMAT (2X.*008= *F10.5.*0°F5*)       UNS 322         240       FORMAT (2X.*008= *F10.5.*0°F5*)       UNS 326         250       FORMAT (2X.*008= *F10.5.*0°F5*)       UNS 326         260       FORMAT (2X.*008= *F10.5.*0°F5*)       UNS 326         250       FORMAT (2X.*008= *F10.5.*0°F5*)       UNS 326         260       FORMAT (2X.*008= *F10.5.*0°F5*)       UNS 332         270       FORMAT (2X.*075510       UNS 332         270       FORMAT (2X.*05510       UNS 332         270       FORMAT (2X.*05510       UNS 334         300       FORMAT (* ALPHA=*F10.5)       UNS 334         310       FORMAT (* DAD=*F10.5)       UNS 343         320       FORMAT (* DAD=*F10.5)       UNS 344         330       FORMAT (* CANONITIONS AT ** 4.*071= *F6.4.*C2171CAL DEPTH= *F6.4.*FUNS 346         340       FORMAT (2X.*015TANCE*.4.*05F1*.44X.*071= *F6.		WRITE (6.430) X(1), DMAX(1), TOMAX(1), VMAX(1), TVMAX(1), OMAX(1), TOMA	TUNS	304
IF (I.FQ.N1) GO TO 190       UNS 300         IAO       CONTINUE       UNS 310         IAO       CONTINUE       UNS 310         UNS 300       GALL EXIT       UNS 314         Containe       UNS 314       UNS 316         200       FORMAT (13)       UNS 316         201       FORMAT (14)       UNS 316         202       FORMAT (2X.*00E *F10.5x*0CFS*)       UNS 326         213       FORMAT (2X.*00E *F10.5x*0CFS*)       UNS 326         2140       FORMAT (2X.*00E *F10.5x*0CFS*)       UNS 326         2150       FORMAT (2X.*00E *F10.5x*0CFS*)       UNS 326         2160       FORMAT (2X.*00E *F10.5x*0CFS*)       UNS 326         2160       FORMAT (2X.*00E *F10.5x*0CFS*)       UNS 332         2160       FORMAT (2X.*00E *F10.5x*0CFS*)       UNS 332         210       FORMAT (2X.*00E *F10.5x*0CFS*)       UNS 333         210       FORMAT (2X.*00E *F10.5x*0CFS*)       UNS 334         311       FORMAT (2X.*00E *F10.5x*0CFC*)       UNS 334         312			UNC	304
180       CONTINUE       UNS 10         190       CALL EXIT       UNS 312         200       FORMAT (13)       UNS 312         201       FORMAT (13)       UNS 318         202       FORMAT (14)-2X.*1NFLOW HYDROGRAPH PARAMETERS*/)       UNS 318         203       FORMAT (14)-2X.*1NFLOW HYDROGRAPH PARAMETERS*/)       UNS 320         204       FORMAT (2X.*00E= *F10.5.*0CFS*)       UNS 322         205       FORMAT (2X.*00E= *F10.5.*0CFS*)       UNS 322         206       FORMAT (2X.*00E= *F10.5.*0CFS*)       UNS 322         207       FORMAT (2X.*0DE *F10.5.*0CFS*)       UNS 322         208       FORMAT (2X.*0TFE *F10.5.*0FC*)       UNS 322         209       FORMAT (2X.*0TE *F10.5.*0FC*)       UNS 332         200       FORMAT (4)       S0 = *F10.5.*0FC*)       UNS 332         200       FORMAT (* 0.07.0F1.5)       UNS 334       336         300       FORMAT (* 0.87.*0F1.10.5)       UNS 343         301       FORMAT (* FLOW 15 SUPFPCRITICAL*)       UNS 344         302       FORMAT (* FLOW 15 SUPFPCRITICAL*)       UNS 344         301       FORMAT (* 2X.*0DE *F1*.4X.*0DE *F1*.4X.*0CHITCAL DEPTH= *F6.4.*FUS 5.*SEC*./)       UNS 356         301       FORMAT (* 2X.*0DE *F1*.4X.*0DE *F1*.4X.*0CHI		IF (I_F0.N) 60 TO 190	LINC	300
190       CALL EXIT       UNS 312         C=	180	CONTINUE	LINC	310
200       FORMAT (13)       UNS 314         200       FORMAT (11)       UNS 316         201       FORMAT (11)       UNS 318         220       FORMAT (11)       UNS 318         220       FORMAT (11)       UNS 318         220       FORMAT (21, *008= #10.5,*0CFS*)       UNS 322         240       FORMAT (21,*008= #F10.5,*0CFS*)       UNS 322         250       FORMAT (21,*008= #F10.5,*0CFS*)       UNS 322         260       FORMAT (21,*008= #F10.5,*0CFS*)       UNS 322         260       FORMAT (21,*008= #F10.5,*05EC*)       UNS 323         270       FORMAT (21,*078= #F10.5,*05EC*)       UNS 332         280       FORMAT (4 SD ==0F10.5)       UNS 3330         290       FORMAT (4 SD ==0F10.5)       UNS 334         310       FORMAT (4 SD ==0F10.5)       UNS 334         320       FORMAT (4 SD ==0F10.5)       UNS 343         320       FORMAT (4 SD ==0F10.5)       UNS 344         351       FORMAT (4 SNORHAL DEPTH= #F6.4,*0T1* #F1*.43.*0C11CAL DEPTH= #F6.4,*FUNS 346         321       FORMAT (22,*00E* #F1*.43.*0T1* #F1*.43.*0CN15*//       UNS 346         320       FORMAT (22,*00E* #F1*.43.*0T1* #F1*.43.*0CN15*//       UNS 356         320       FORMAT (22,*01E*.140.EE*.43.*0EF	190	CALL FXIT	LINS	312
200       FORMAT (13)       UNS 316         210       FORMAT (14)+2X.*[INFLOW_HYDROGPAPH_PARAMETERS*+/)       UNS 318         210       FORMAT (14)+2X.*[INFLOW_HYDROGPAPH_PARAMETERS*+/)       UNS 322         210       FORMAT (2X.*0DE= *F10.5.*0CFS*)       UNS 322         210       FORMAT (2X.*0NAVE VOLUME ARAVE HASE FLOW= *F8.2.*CU FT*)       UNS 322         210       FORMAT (2X.*0PE= *F10.5.*0CFS*)       UNS 326         210       FORMAT (2X.*0PE= *F10.5.*0CFS*)       UNS 328         210       FORMAT (2X.*0PE *F10.5.*0CFS*)       UNS 332         210       FORMAT (2X.*0PE *F10.5.*0CFS*)       UNS 332         210       FORMAT (2X.*0PE *F10.5.*0CFS*)       UNS 332         210       FORMAT (2X.*0PE *F10.5.*0CFC*)       UNS 333         210       FORMAT (4 S.0 =*F10.5.*0       UNS 333         210       FORMAT (* S.0 =*F10.5.*0       UNS 338         210       FORMAT (* 0B/0P=*F10.5.*0       UNS 334         310       FORMAT (* 0B/0P=*F10.5.*0       UNS 334         320       FORMAT (* CLOW IS SUPPPORTITCAL*)       UNS 344         320       FORMAT (* CLOW IS SUPPORTITCAL*)       UNS 356         320       FORMAT (* 2X.*0DX= *FA.5.*FT*.4X.*0C1T1CAL DEPTH= *F6.4.*FUNS.*SCC*/)       UNS 356         320	C		LINS	314
210       FORMAT (14F10.4)       UNS 318         220       FORMAT (14) + 2X.* 01F104 HYDROGPAPH PARAMETERS*./)       UNS 312         220       FORMAT (2X.*008= *F10.5.*0CFS*)       UNS 322         240       FORMAT (2X.*00P= *F10.5.*0CFS*)       UNS 322         250       FORMAT (2X.*0P= *F10.5.*55C*)       UNS 328         270       FORMAT (2X.*0FF= *F10.5.*55C*)       UNS 332         270       FORMAT (* 2X.*SYSTEM PARAMETERS*./)       UNS 332         270       FORMAT (* 2X.*0SYSTEM PARAMETERS*./)       UNS 332         270       FORMAT (* 2X.*0SYSTEM PARAMETERS*./)       UNS 333         370       FORMAT (* 0B./0P=*10.5)       UNS 334         370       FORMAT (* FLOW 1S SUPFOCITICAL*)       UNS 346         371       FORMAT (2X.*0NORMAL DEPTH= *FA.4.*6TF*.4X.*CCITICAL DEPTH= *F6.4.*FTNS 346         370       FORMAT (2X.*0NORMAL DEPTH* *FA.4.*0TF*.4X.*CCITICAL DEPTH= *F6.4.*FTNS 346         370       FORMAT (2X.*0NORMAL DEPTH* *FA.4.*0TF*.4X.*CCITICAL DEPTH= *F6.4.*FTNS 346         370       FORMAT (2X.*0TSTANCE*.9A.*0EPFH*.4X.*0TF*.1X.*CCFS)*./)       UNS 356 <td>200</td> <td>FORMAT (13)</td> <td>LINC</td> <td>216</td>	200	FORMAT (13)	LINC	216
220       FORMAT (1H):2X:*INFLOW HYDRUGGPAPH PARAMETERS*;/)       UNS 322         230       FORMAT (2X:*0RE *FI0.5*0°F5*)       UNS 322         240       FORMAT (2X:*0RE *FI0.5*0°F5*)       UNS 322         250       FORMAT (2X:*0RE *FI0.5*0°F5*)       UNS 322         250       FORMAT (2X:*0RE *FI0.5*0°F5*)       UNS 326         250       FORMAT (2X:*0RE *FI0.5*0°F5*)       UNS 326         250       FORMAT (2X:*0TE *FI0.5*0°F5*)       UNS 328         250       FORMAT (2X:*0TE *FI0.5*0°F5*)       UNS 332         270       FORMAT (2X:*0TE *FI0.5)       UNS 332         280       FORMAT (4: SO =*F10.5)       UNS 338         290       FORMAT (* SD =*F10.5)       UNS 338         301       FORMAT (* 0B/02*FI1.5)       UNS 334         302       FORMAT (* 0B/02*FI1.5)       UNS 344         303       FORMAT (* FLOW IS SUPFPCRITICAL*)       UNS 344         304       FORMAT (* 2X:*0NORMAL DEPTH= *F6.4*0*F1*:4X:*0CHITCAL DEPTH= *F6.4**FUNS 346         314       TX:*0DISTANCE*:9X:*DEPTH*:4X:*0CHITCAL DEPTH= *F6.4**FUNS 345         304       FORMAT (2X:*0DISTANCE*:9X:*0EPTH*:4X:*0F1***CHITCAL DEPTH= *F6.4**FUNS 355         305       FORMAT (2X:*0DISTANCE*:9X:*0EPTH*:4X:*0CHIT**       UNS 356         304       FORMAT (2X:*0DISTANCE*:9X:*0	210	FORMAT (AFI0.4)	LINC	210
230       FORMAT       (2X,*0B=*F10.5.*0CFS*)       UNS 322         240       FORMAT       (2X,*0A2K       VOLUME AND/F HASE FLOW= *F8.2**CU FT*)       UNS 322         240       FORMAT       (2X,*0CF=*f10.5,*0CFS*)       UNS 322         260       FORMAT       (2X,*0CF=*f10.5,*0CFS*)       UNS 326         260       FORMAT       (2X,*0TF=*f10.5,*0SEC*)       UNS 332         270       FORMAT       (2X,*0SYSTEM PAHAMELEHS*/)       UNS 332         280       FORMAT       (2X,*0SYSTEM PAHAMELEHS*/)       UNS 334         280       FORMAT       (* ADHA=*f10.5)       UNS 336         310       FORMAT       (* BETA =*f10.5)       UNS 344         320       FORMAT       (* BETA =*f10.5)       UNS 342         320       FORMAT       (* BETA =*f10.5)       UNS 343         320       FORMAT       (* BETA =*f10.5)       UNS 343         320       FORMAT       (* BETA =*f10.5)       UNS 344         330       FORMAT       (* SUPFPCRITICAL*)       UNS 344         340       FORMAT       (* SUPFPCRITICAL*)       UNS 352         370       FORMAT       (2X.*0DS=*fA.5.*FI*.4X.*0TE**FA.4*CTITCAL DEPTH=*F6.4*FF0.NS 346         17*.*)       UNS 356       UNS 356<	220	FORMAT (1H) 22. SINFLOW HYDRUGPAPH PARAMETERSS. ()	UNS	320
240       FORMAT (2X.*MAVE VOLUME AND/F MASE FLOW= *F8.2**CU FT*)       UNS 324         250       FORMAT (2X.*MAVE VOLUME AND/F MASE FLOW= *F8.2**CU FT*)       UNS 326         250       FORMAT (2X.*ML*TP= *F10.5**S*)       UNS 326         250       FORMAT (2X.*ML*TP= *F10.5**S*C*)       UNS 328         270       FORMAT (2X.*ML*TP= *F10.5**S*C*)       UNS 332         270       FORMAT (2X.*SYSTEM PAMAMELENS*/)       UNS 332         280       FORMAT (* SD ==*F10.5)       UNS 334         300       FORMAT (* ALPHA=*F10.5)       UNS 338         320       FORMAT (* BETA =*F10.5)       UNS 334         320       FORMAT (* OB/00=*F10.5)       UNS 343         320       FORMAT (* N=*15/* IXD =*15/* IF =*F6.0/* IID =*F10.5)       UNS 343         320       FORMAT (* FLOW IS SUPFPCRITICAL*)       UNS 344         340       FORMAT (* ALPANEL DEPTH= *F6.4.**T*4.**CRITICAL DEPTH= *F6.4.**FUNS 346       INS 346         351       FORMAT (2X.**ORMAI DEPTH= *F6.4.**T*4.**CRITICAL DEPTH= *F6.4.**FUNS 346       INS 352         360       FORMAT (2X.**DISTANCE*4.***DEPTH*4.***VELOCITY*       UNS 354         374       FORMAT (2X.**DISTANCE*4.***DEPTH*4.***VELOCITY*       UNS 356         375       FORMAT (2X.**DISTANCE*4.***********************************	230	FORMAT (2X.+008= +F10.5.+0(FS+)	LINS	322
250       FORMAT       (2X,*0GP= *F10.5,*0CFS*)       UNS 326         260       FORMAT       (2X,*0TP= *F10.5,*0SC*)       UNS 328         270       FORMAT       (2X,*SYSTEM PARAMETERS*/)       UNS 332         280       FORMAT       (2X,*SYSTEM PARAMETERS*/)       UNS 332         290       FORMAT       (2X,*SYSTEM PARAMETERS*/)       UNS 334         290       FORMAT       (* ALPHA=*F10.5)       UNS 336         310       FORMAT       (* BETA =*F10.5)       UNS 346         310       FORMAT       (* BETA =*F10.5)       UNS 346         310       FORMAT       (* DA/OP=*F10.5)       UNS 346         310       FORMAT       (* DA/OP=*F10.5)       UNS 346         310       FORMAT       (* N =*15/* IX0 =*15/* IF =*F6.0/* II0 =*F10.5)       UNS 346         311       FORMAT       (* N =*15/* IX0 =*15/* IF =*F6.0/* II0 =*F10.5)       UNS 346         311       FORMAT       (* N =*15/* IX0 =*15/* IX0 =*15/* UX102       UNS 346         312       FORMAT       (2X.*NORMAL DEPTH= *F6.4.*FT*.4X.*CRITICAL DEPTH= *F6.4.*FUNS 346       11*/         313       FORMAT       (2X.*NORMAL DEPTH= *F6.4.*FT*.4X.*CRITICAL DEPTH= *F6.4.*FUNS 346       10.005 352         314       FORMAT       (2X.*NORMAL DEPTH= *F	240	FORMAT (2X. WAVE VOLUME ABOVE HASE FLOW= #F8.2. *CU FT*)	LINS	324
260       FORMAT (2X,*TP= *F10.5;*SFC*)       UNS 328         270       FORMAT (2X.*SYSTEM PARAMETERS*/)       UNS 330         270       FORMAT (4)       UNS 332         270       FORMAT (4)       UNS 332         270       FORMAT (5)       UNS 332         270       FORMAT (* SD =*F10.5)       UNS 336         310       FORMAT (* ALPHA=*F10.5)       UNS 336         320       FORMAT (* ALPHA=*F10.5)       UNS 343         320       FORMAT (* OB/GP=*F10.5)       UNS 346         340       FORMAT (* FLOW 15 SUPFPC(TTICAL*)       UNS 346         340       FORMAT (* FLOW 15 SUPFPC(TTICAL*)       UNS 346         340       FORMAT (* ANORHAL DEPTH= *F6.4.**CT*1*.4X.**CTITCAL DEPTH= *F6.4.**FINS 346         341       FORMAT (2X.**NORHAL DEPTH= *F6.4.**DI= *FH.5.*SEC*./)       UNS 350         370       FORMAT (2X.**OISTANCE**F*.4.**DI= *FH.5.*SEC*./)       UNS 356         370       FORMAT (2X.**OISTANCE**F*.**OFF1*.4X.**ULOCITY*.       UNS 356         370       FORMAT (2X.**OISTANCE**F*.**OFF1*.4X.**ULOCITY*.       UNS 356         370       FORMAT (2X.**OISTANCE**F*.**OFF1*.1X.**(CFS)*./)       UNS 356         370       FORMAT (2X.**OISTANCE**A.**DEPTH*.**OFF2*.**OFF1*.1X.**(CFS)*./)       UNS 356         370       FO	250	FORMAT (2X, *QP= *F)0.5.*(FS*)	UNS	326
270       FORMAT (/)       UNS 330         280       FORMAT (2X**SYSTEM PARAMETERS*/)       UNS 332         280       FORMAT (* SO =*F10.5)       UNS 334         300       FORMAT (* ALPHA=*F10.5)       UNS 336         310       FORMAT (* ALPHA=*F10.5)       UNS 336         310       FORMAT (* DA/QP=*F10.5)       UNS 342         331       FORMAT (* N =*15/* IX = *15/* IF =*F6.0/* 1I0 =*F10.5)       UNS 342         333       FORMAT (* FLOW IS SUPFPCRITICAL*)       UNS 344         340       FORMAT (* LOW IS SUPFPCRITICAL*)       UNS 348         350       FORMAT (2X.*NORMAL DEPTH= *F6.4.*FT*.4X.*CRITICAL DEPTH= *F6.4.*FUNS 346         360       FORMAT (2X.*DISTANCE*,9X.*OFFT*.4X.*DIT= *FF.5.*SEC*./)       UNS 352         370       FORMAT (2X.*DISTANCE*,9X.*OFPT*.4X.*DIT= *FA.5.*SEC*./)       UNS 352         380       FORMAT (2X.*DISTANCE*,9X.*OFPT*.4X.*DIT= *FA.5.*SEC*./)       UNS 354         370       FORMAT (2X.*DISTANCE*,9X.*OFPT*.4X.*DIT= *FA.5.*SEC*./)       UNS 354         370       FORMAT (2X.*DISTANCE*,9X.*OFPT*.4X.*DIT= *FA.5.*SEC*./)       UNS 356         380       FORMAT (2X.*DISTANCE*,9X.*OFPT*.4X.*DIT*.       UNS 356         390       FORMAT (4X.*OTT*.1X.*0(FT)*.1X.*0(FFS)*.1X.*0(CFS)*./)       UNS 368         41       TIME*.	260	FORMAT (2X.*TP= #F10.5.#SEC*)	LINS	328
280         FORMAT         (2X**SYSTEM PAHAMETERS**/)         UNS 332           290         FORMAT         (* SD ==*F10.5)         UNS 334           290         FORMAT         (* SD ==*F10.5)         UNS 334           310         FORMAT         (* BETA ==*F10.5)         UNS 338           310         FORMAT         (* BETA ==*F10.5)         UNS 338           310         FORMAT         (* BETA ==*F10.5)         UNS 340           320         FORMAT         (* BETA ==*F10.5)         UNS 340           330         FORMAT         (* DS/OP=*F10.5)         UNS 342           340         FORMAT         (* N ==*15/* IX* ==*15/* IF =*F6.0/* IIO ==*F10.5)         UNS 342           340         FORMAT         (* N=*NORMAL DEPTH= =*F*.4.**FT*.4.**CRITICAL DEPTH= *F6.4.**FINS 346         IX***           341         TX***NORMAL DEPTH= =*F*.5.**FT*.4.**CRITICAL DEPTH= *F6.4.**FINS 346         INS 356           341         TX***OCONDITIONS AT =+9.3**SFCONUS*//)         UNS 352           340         FORMAT (141.*\$X.**CONDITIONS AT =+9.3**SFCONUS*//)         UNS 352           341         TX***DISCHARGE*)         UNS 354           342         FORMAT (44.**(FII**.11X**(FT)*.11X**(FPS)*.11X**(CFS)*./)         UNS 356           340         FORMAT (44.**(FII**.11X**(FT)*.	270	FORMAT (/)	UNS	330
290       FORMAT (* SO ==*F10.5)       UNS 334         300       FORMAT (* ALPHA=*F10.5)       UNS 336         301       FORMAT (* ALPHA=*F10.5)       UNS 338         302       FORMAT (* OB/QP=*F10.5)       UNS 338         320       FORMAT (* OB/QP=*F10.5)       UNS 338         320       FORMAT (* OB/QP=*F10.5)       UNS 344         330       FORMAT (* FLOW IS SUPFOCITICAL*)       UNS 344         350       FORMAT (* FLOW IS SUPFOCITICAL*)       UNS 344         350       FORMAT (* ANORMAL DEPTH= *F6.4.**FT*.4X.**CRITICAL DEPTH= *F6.4.**FUNS 346       UNS 344         360       FORMAT (2X.*DIX=*GA.**GFT*.4X.**CRITICAL DEPTH= *F6.4.**FUNS 346       UNS 350         360       FORMAT (2X.*DIX=*GA.**GFT*.4X.**CLOTIY*.       UNS 354         360       FORMAT (2X.*DIX=*GA.**GE*F*.4X.**CLOTIY*.       UNS 355         370       FORMAT (2X.*DIX=*GA.**GE*F*.4X.**CLOTIY*.       UNS 356         371       FORMAT (2X.*DIX=*GA.**GE*F*.4X.**CLOTIY*.       UNS 356         372       FORMAT (2X.*DIX=*GA.**GE*F*.4X.**CLOCIY*.       UNS 356         374       FORMAT (44.**(FT)*.11X.**(FT)*.1UX.**(FPS)*.11X.**(CFS)*./)       UNS 356         374       FORMAT (CD.4.**GX)       UNS 366       UNS 366         410       FORMAT (CD.5AXCE* MAX UEPTH TIME* MAX VEL TI	280	FORMAT (2X. SYSTEM PARAMETERS	LINS	332
300         FORMAT (* ALPHA=*FI0.5)         UNS 336           310         FORMAT (* ALPHA=*FI0.5)         UNS 336           310         FORMAT (* BETA =*FI0.5)         UNS 338           310         FORMAT (* DE7A=*FI0.5)         UNS 336           320         FORMAT (* DE7A=*FI0.5)         UNS 342           330         FORMAT (* N =*I5/* IX0 =*I5/* IF =*F6.0/* II0 =*F10.5)         UNS 342           330         FORMAT (* LOW IS SUPFPCRITICAL*)         UNS 343           350         FORMAT (2X.*DNORMAL DEPTH= #FA.4.*FT*.4X.*CRITICAL DEPTH= *F6.4.*FUNS 346           11**/         STO         FORMAT (2X.*DNORMAL DEPTH= #FA.5.*SEC*./)         UNS 354           360         FORMAT (2X.*DISTANCE*.9X.*DEPTH*.4X.*DIT= #FA.5.*SEC*./)         UNS 352           370         FORMAT (2X.*DISTANCE*.9X.*DEPTH*.4X.*DIT= #FA.5.*SEC*./)         UNS 352           380         FORMAT (2X.*DISTANCE*.9X.*DEPTH*.4X.*DIT= #FA.5.*SEC*./)         UNS 354           370         FORMAT (2X.*DISTANCE*.9X.*DEPTH*.4X.*DIT= #FA.5.*SEC*./)         UNS 354           371         FORMAT (2X.*DISTANCE*.9X.*DEPTH*.4X.*DIT= #FA.5.*SEC*./)         UNS 354           372         FORMAT (24.*CITI*.11X.*DIT= *FA.5.*SEC*./)         UNS 354           374         FORMAT (24.*CITI*.11X.*DIT= *FA.5.*SEC*./)         UNS 356           370 <td< td=""><td>290</td><td>FORMAT (* 50 = #F10-5)</td><td>LINS</td><td>334</td></td<>	290	FORMAT (* 50 = #F10-5)	LINS	334
310       FORMAT (* BETA =*FI0.5)       UNS 338         320       FORMAT (* 0B/GP=*FI0.5)       UNS 340         320       FORMAT (* 0B/GP=*FI0.5)       UNS 343         340       FORMAT (* FLOW IS SUPFORITICAL*)       UNS 344         340       FORMAT (* FLOW IS SUPFORITICAL*)       UNS 344         340       FORMAT (* FLOW IS SUPFORITICAL*)       UNS 346         340       FORMAT (* NORMAL DEPTH= *FA.4**FT***4X**CRITICAL DEPTH= *F6.4**FUNS 346         350       FORMAT (2X**NORMAL DEPTH= *FA.4***CRITICAL DEPTH= *F6.4**FUNS 346         370       FORMAT (2X**OLSTANCE**FX*****FE***************************	300	FORMAT (* ALPHA=+F10.5)	UNS	336
320         FORMAT (* 0B/QP=*FIB.5)         UNS 340           330         FORMAT (* N =*I5/* IXO =*I5/* IF =*F6.0/* IIO =*F10.5)         UNS 342           330         FORMAT (* FLOW IS SUPFPCRITICAL*)         UNS 343           340         FORMAT (* LOW IS SUPFPCRITICAL*)         UNS 343           350         FORMAT (* LOW IS SUPFPCRITICAL*)         UNS 344           350         FORMAT (2X.*NORHAL DEPTH= *F6.4.**FT*.4X.*CRITICAL DEPTH= *F6.4.**FUNS 346           360         FORMAT (2X.*DISTANCE**FT*.4X.**DIT= *FH.5.**SEC*./)         UNS 348           361         FORMAT (2X.*DISTANCE**9X.**DEPT**********************************	310	FORMAT (* BETA =*F10.5)	UNS	138
330         FORMAT (* N =*I5/* Ix0 =*I5/* Ir =*F6.0/* II0 =*F10.5)         UNS 342           340         FORMAT (* LOW IS SUPFOCTITCAL*)         UNS 343           340         FORMAT (* FLOW IS SUPFOCTITCAL*)         UNS 344           340         FORMAT (2X.*NORMAL DEPTH= *F6.4*FT*.4X.*CRITICAL DEPTH= *F6.4*FUNS 346         UNS 348           340         FORMAT (2X.*NORMAL DEPTH= *FA.4**FT*.4X.*CRITICAL DEPTH= *F6.4*FUNS 346         UNS 348           341         TX*.*CONDITIONS AT *F9.3*FCONUS*//)         UNS 352           360         FORMAT (2X.*OISTANCE*.*X.*PLF(+4x.**VFLOCITY*.         UNS 352           370         FORMAT (2X.*OISTANCE*.*X.*PLF(+1)*.**(FS)*.*)         UNS 352           380         FORMAT (4X.*(FII*.11X.**(FT)*.1UX.**(FFS)*.1IX.**(CFS)*./)         UNS 356           370         FORMAT (4X.*(FII*.11X.**(FT)*.1UX.**(FFS)*.1IX.**(CFS)*./)         UNS 356           370         FORMAT (4X.*(FII*.1IX.**(FT)*.1UX.**(FFS)*.1IX.**(CFS)*./)         UNS 356           370         FORMAT (4X.*(FII*.1IX.**(FT)*.1UX.**(FFS)*.1IX.**(CFS)*./)         UNS 356           370         FORMAT (4X.*FA.**)         UNS 366         UNS 366           370         FORMAT (4X.*FA.**)         UNS 366         UNS 368           370         FORMAT (4X.*FA.**)         UNS 366         UNS 366           370         FORMAT (* DI	320	FORMAT (# 08/0P=#F10.5)	UNIS	340
340     FORMAT (* FLOW IS SUPPORITICAL*)     UNS 344       350     FORMAT (2X**NORMAL DEPTH= *F*.4**FT***4X**CRITICAL DEPTH= *F6.4**FUNS 346     IT**/)       360     FORMAT (2X**NORMAL DEPTH= *F*.4**FT***4X**CRITICAL DEPTH= *F6.4**FUNS 346       370     FORMAT (2X**ODX= *F8.5**FT***4X**CRITICAL DEPTH= *F6.4**FUNS 350       370     FORMAT (2X**ODX= *F8.5**FT***4X**CRITICAL DEPTH= *F6.4**FUNS 350       370     FORMAT (2X**ODX= *F8.5**FT***4X**CRITICAL DEPTH= *F6.4**FUNS 350       370     FORMAT (2X**ODX= *F8.5**FT****       370     FORMAT (2X**ODX= *F8.5**FT****       380     FORMAT (2X**ODX=**F8.****       380     FORMAT (2X**ODX=**F8.*****       380     FORMAT (2X**ODX=*******       380     FORMAT (2X**ODX=*********************************	330	FORMAT (* N =*15/* IXO =*15/* IF =*F6.0/* IIO =*F10.5)	UNS	342
350         FORMAT         (2X,*NORHAL         DEPTH=         *FA.4.**FT*.4X,*C21T1CAL         DEPTH=         *F6.4.**FUNS         346           360         FORMAT         (2X,*DX=         *FA.5.*FT*.4X,*DT=         *FH.5.*SEC*./)         UNS         348           360         FORMAT         (2X,*DX=         *FA.5.*FT*.4X,*DT=         *FH.5.*SEC*./)         UNS         348           370         FORMAT         (1H1.5X.*CONDITIONS AT *F9.3*SECONUS*//)         UNS         352           380         FORMAT         (2X,*DISTANCE*,9X.*DEPTH*.8X.*VFLOCITY*.         UNS         354           1         7X.*DISCHARGE*)         UNS         355         UNS         354           390         FORMAT         (4X,*(FT)*.11X,*(FT)*.1UX.*(FPS)*.11X.*(CFS)*./)         UNS         358           410         FORMAT         (47.6.2.*3)         UNS         356           420         FORMAT (*/10.4.*SX)         UNS         362         424         FORMAT (* DISTANCE         MAX         UPTH         TIME*         MAX 0         UNS         364           1         TIME*         430         FORMAT         (FA.2.*3(4X.*F6.2.*2X.*F /.2))         UNS         368           UND         END         UNS         368         UNS	340	FORMAT (* FLOW IS SUPERCRITICAL*)	UNS	344
1T*,/)       UNS 348         360       FORMAT (2X,*DX= *FA.5.*FT*.4X,*D)T= *FH.5.*SEC*,*/)       UNS 350         370       FORMAT (1H1.5X.*CONDITIONS AT *F3.3*SECONUS*//)       UNS 350         370       FORMAT (2X,*DISTANCE*.5X.*DEPTH*.5X.*VELOCITY*.       UNS 354         17X.*DISCHARGE*)       UNS 355         390       FORMAT (4X.*(TI)*.11X.*(FT)*.1UX.*(FPS)*.11X.*(CFS)*./)       UNS 356         390       FORMAT (4X.*(TI)*.11X.*(FT)*.1UX.*(FPS)*.11X.*(CFS)*./)       UNS 358         410       FORMAT (4/10.4.5X.*)       UNS 360         410       FORMAT (*/10.4.5X.*)       UPTH         420       FORMAT (* DISTANCE MAX UEPTH       TIME*         1       TIME*       MAX VEL       UNS 360         430       FORMAT (FR.2.3(4X.*F6.2.2X.*F/.2))       UNS 360         END       UNS 360       UNS 360	350	FORMAT (2X, *NORMAL DEPTH= *F6.4.*FT*.4X.*CRITICAL DEPTH= *F6.4.*	FUNS	346
360         FORMAT (2X,*0X= 0FR.5.*FF0.4X,*0)T= 0FH.5.*SEC0.*/)         UNS 350           370         FORMAT (1X,*0X.*CONDITIONS AT 0+0.30SFCONUS#/)         UNS 352           370         FORMAT (2X,*0)STANCE.*QX.*0)FF0*(4X,*0)FL0CITY*.         UNS 352           370         FORMAT (2X,*0)STANCE.*QX.*0)FF0*(4X,*0)FL0CITY*.         UNS 356           370         FORMAT (2X,*0)STANCE.*QX.*0)FF1*(4X,*0)FL0CITY*.         UNS 356           370         FORMAT (4X,*0)STANCE.*QX.*0)FF1*(4X,*0)FL0CITY*.         UNS 356           370         FORMAT (4X,*0)STANCE.*QX.*0)FF1*(FF)*(1X,*0)FF2(CF5)*/)         UNS 356           370         FORMAT (4X,*0)STANCE.MAX UEDTH TIMES AT EACH L0CATION*//)         UNS 362           420         FORMAT (//0) MAXINIM VALUES AND TIMES AT EACH L0CATION*//)         UNS 362           420         FORMAT (% DISTANCE.MAX UEDTH TIME* MAX VEL TIME* MAX Q UNS 364         UNS 366           430         FORMAT (FR.2+3(4X,F6.2+2X,F /-2))         UNS 368           END         UNS 368         UNS 368		11*•//	UNS	348
370         FORMAT (141+5X*@CONDITIONS AT #+9.3®SECONDS*//)         UNS 352           380         FORMAT (2X*@EDISTANCE*.9X*@EPIH*.5X*@VFLOCITY*         UNS 354           1         7X*@EDISTANCE*.9X*@EPIH*.5X*@VFLOCITY*         UNS 354           370         FORMAT (4X*@[TI*.1]X*@[(F])*.1UX*@[FPS]*.1IX*"(CFS]*./)         UNS 358           370         FORMAT (4X.*[10.4.5X])         UNS 358           410         FORMAT (4(F10.4.5X))         UNS 360           410         FORMAT (4/10.4.5X)         UNS 366           420         FORMAT (* DISTANCE MAX UEPTH TIME MAX VEL TIME MAX Q UNS 364         1           1         TIME*!         UNS 368           430         FORMAT (FR.2.3(4X*F6.2.2X*F /.2))         UNS 368           END         UNS 368	360	FORMAT (2X, +DX= +FA,5, +FT++4X, +DT= +FH,5, +SFC++/)	UNS	350
380         FORMAT (2x, @DISTANCE®, 9x, @DEPIH*, 8x, @vFLOCITY*,         UNS 354           1         1x, @DISCHARGE®)         UNS 356           90         FORMAT (4x, @(FI)*,11x, @(FI)*,10x, @(FPS)*,11x, @(CFS)*,/)         UNS 356           400         FORMAT (4x, @(FI)*,11x, @(FI)*,10x, @(FPS)*,11x, @(CFS)*,/)         UNS 360           410         FORMAT (4, [F10,4,5x))         UNS 362           420         FORMAT (//*I MAXIMIM VALUES AND TIMES AT EACH LOCATION*//)         UNS 362           420         FORMAT (0 DISTANCE MAX UEPTH TIME* MAX VEL TIME MAX Q UNS 364         UNS 366           430         FORMAT (FR,2,3(4x,F6,2,2x,F/,2))         UNS 368           END         UNS 364         UNS 364	370	FORMAT (1H) .5X .* CONDITIONS AT *+ 9.3* SECONDS*//)	UNS	352
1         7X**DISCHARGE*)         UNS 356           390         FORMAT (4X**(FT)*+11X**(FT)*+1UX**(FPS)*+11X**(CFS)*+/)         UNS 356           390         FORMAT (44(10.4+5X))         UNS 358           410         FORMAT (44(10.4+5X))         UNS 362           410         FORMAT (4/F10.4+5X)         UNS 362           420         FORMAT (4/F10.4+5X)         UNS 362           420         FORMAT (*DISTANCE MAX UEPTH TIME MAX VEL TIME MAX Q UNS 364         UNS 364           1         IIME*)         UNS 368           430         FORMAT (FA.2+3(4X+F6.2+2X+F/-2))         UNS 368           END         UNS 368         UNS 368	380	FORMAT (2X, *DISTANCE*,9X, *DEP(H*,HX,*VELOCITY*,	UNS	354
390         FORMAT (4X,*(FT)*,1)X,*(FT)*,1)X,*(FPS)*,1)X,*(CFS)*,/)         UNS 350           400         FORMAT (4(F1)*,1)X,*(FT)*,1)X,*(FPS)*,1)X,*(CFS)*,/)         UNS 350           410         FORMAT (4(F1)*,4)X,*(FT)*,1)X,*(FPS)*,1)X,*(CFS)*,/)         UNS 360           410         FORMAT (4/F1)*,4)X,*(FT)*,1)X,*(FPS)*,1)X,*(CFS)*,/)         UNS 360           420         FORMAT (*/F1)*,4)X,*(FF)*,1)X,*(FPS)*,1)X,*(CFS)*,/)         UNS 360           420         FORMAT (*/F1)*,4)X,*(FF)*,2)X,*(F)*,2)         UNS 360           430         FORMAT (FR,2+3(4X,+F6,2*,2X,+F,2))         UNS 360           END         UNS 360         UNS 360		1 7X, *DISCHARGE*)	UNS	356
400         FORMAT (4(FL0.4.5X))         UNS 361           410         FORMAT (//*I MAXIMUM VALUES AND TIMES AT EACH LOCATION*//)         UNS 362           420         FORMAT (* DISTANCE MAX UEDTH TIME' MAX VEL TIME MAX Q UNS 364         UNS 366           1         TIME*)         UNS 366           430         FORMAT (FA.2.3(4X.F6.2.2X.F/.2))         UNS 368           END         UNS 368	390	FORMAT (4X.*(FT)*,11X.*(FT)*,10X.*(FPS)*,11X.*(CFS)*,/)	UNS	358
410         FORMAT (*/*)         MAXIMUM VALUES AND TIMES AT EACH LOCATION*//)         UNS 362           420         FORMAT (* DISTANCE MAX UEPTH TIME' MAX VEL TIME MAX Q UNS 364         1         TIME*)         400 S 364           430         FORMAT (FR.2*3(4X*F6.2*2X*F/*2))         UNS 368         UNS 368         UNS 368           430         FORMAT (FR.2*3(4X*F6.2*2X*F/*2))         UNS 368         UNS 368         UNS 368	400	FORMAT (4(F10.4.5X))	UNS	360
420 FORMAT (* DISTANCE MAX UEPTH TIME MAX VEL TIME MAX Q UNS 366 1 TIME*) 430 FORMAT (FR.2+3(4X+F6.2+2X+F/.2)) END UNS 370 UNS 370	410	FORMAT (//*1 MAXIMUM VALUES AND TIMES AT EACH LOCATION#//)	UNS	362
) TIME*) UNS 366 430 FORMAT (FA.2+3(4X+F6+2+2X+F/+2)) UNS 368 END UNS 370	420	FORMAT (* DISTANCE MAX DEPTH TIME MAX VEL TIME MAX O	UNS	364
430 FORMAT (FR.2.3(4X.F6.2.2X.F/.2)) UNS 368 END UNS 370		1 TIME*)	UNS	366
END UNS 370	430	FORMAT (F8,2,3(4X,F6,2,2X,F/,2))	UNS	368
		END	UNS	370

С	INTEGRATION OF STEADY FLOW Do 150 L=1.N	INC	5
	Xx=XX+DX	INC	5
10	DFPTH=DIN	INC	6
	CALL CIRCLE	INC	6
	VV=QB/A	INC	6
	RFY=VV+R/FNU	INC	6
	F=FR*REY**FC	INC	6
	HFTH=0.5*THETA	INC	7
	DTHET=4.0/(DIA*SINF(HFTH))	INC	7
	DAREA=0.125*DIA*01A*(1.0-CDSE(THETA))*DIMET	INC	7
	DW=0.50DIA*DIHET	INC	7
	WP=0.5*DIA*THETA	INC	7
	DRA=(WP*DAREA-A*DW)/(WP*WP)	INC	8
	DFNG=1.0-(QR*QB/(GR*(A**3)))*DARFA	INC	6
	DSL0=-F*0R*0B*(2.0*R*A*DARFA+(A**2)*00A)/(H.*GH*((R*A**2)**2))	INC	8
	VV=QB/A	INC	8
	VH=VV=VV/(2+0=GP)	INC	8
	RFY=VV≈R/FNU	INC	9
	F=FB*REY**FC	INC	5
	52=F*VH/(4.0*R)	INC	5
	SF=(51+52)/2.0	INC	5
	EF2=DIN+ALPHA+VH	INC	9
	FPATIO=(EF2-EF1+DX*(S0-SF))/(0ENG+(FE2-EE1)*0SLU/(S0-SF))	1NC	10
C	NEWTON-RAPHSON ITERATION	INC	10
	DCOM=DIN-FRATIO	INC	10
	IF (DCOH) 30+20+40	INC	16
20	WRITE (6,200)	INC	10
	G0 T0 190	INC	11
30	DCOM=ABSE (DCOM)	INC	11
40	IF (ABSE(DCOM-DIN)-DTOL) 130.130.50	INC	11
50	IF (0.82*DIA-DCOM) 60.120.120	INC	11
60	DIN=DCOM#0.5	INC	11
70	1F (0.82*01A-DIN) 80.80.90	INC	12
80	DIN=DIN*0.5	INC	12
	NCOUNT=NCOUNT+1	INC	12
	GO TO 70	INC	12
90	IF (NCGUNT-20) 100,100,110	INC	12
100	GO TO 10	INC	13
110	WRITE (6.210)	INC	13
	GN TO 190	INC	13
120	DIN=DCOM	INC	13
	G0 T0 10	INC	13
130	IF (ABSF(DCOM-DN).LF.DTOL) 160,140	INC	14
С	END OF NEWTON-RAPHSON	INC	14
140	DIN=DCOM	INC	14
	\$1=\$2	INC	14
	EF1=EF2	INC	14
С	REDEFINITION OF SUBSCRIPTS	1NC	15
	I I =N-I +1	INC	15
	x(T1)=xF-xx	INC	15
	D(II)=DIN	INC	19
	V(II)=VV	INC	15
	0(11)=08	INC	16
150	CONTINUE	INC	16
	50 TO 180	INC	16
160	DEPTHEDN	INC	16
100	CALL CTOCLE	TNC	16
	VV-DZA	INC	17
C	CONSTANT CONDITIONS	INC	17
	Do 170 Jel N	INC	17
		INC	17
	X(II)=xF-XX	TNC	17
	D(II) = DN	INC	16
	V(TT)=VV	INC	16
	0(11)=08	INC	1.6
	XX=XX+DX	INC	1.6
170	CONTINUE	INC	1.6
180	RETURN	INC	19
190	CALL FXIT	INC	19
C		INC	19
	FADRAT IS DEAN FAILUR 2500 AL	INC	10
200		E 1946	17
200	FORMAT (* THEONE DOES NOT CONVERGENT	TNIC	10
200	FORMAT (* INCOND DOES NOT CONVERGE®)	INC	19

N.,

	SUBROUTINE COMP	COM	2
C	COMPUTATION OF VELOCITY AND DEPTH AT THE TIME TOT BY KNOWING THE	COM	4
C	VELOCITY AND THE DEPTH AT THE TIME T	COM	6
7.27	UIMENSION D(500), DDT(500), DMAX(280), D(500), GDT(500)	COM	в
	DIMENSION 01(200) . 0MAX(200)	COM	10
	DIMENSION TOMAX(200) . TO(200) . TOMAX(200) . TVMAX(200)	COM	15
	DIMENSION-V(500), VDI(500), VMAX(200), X(500)	COM	14
	COMMON A.AB.AC.AD.AF.ALPHA.H.HC.HD.HETA.CU.CO.D.D.C.HDT	COM	16
	COMMON DEPTH+DD+DIA+DIN+DM+UMAX+DN+DOUT+0T+DIOL+DX+ED	COM	18
	COMMON F.FB.FC.FD.FNU.GR.I.110.ITOC.IX0.IX0C.J.MC.N.NQCU	COM	20
	COMMON NT+N1+Q+QR+QDT+01+G1N+QMAX+OP+QQ+P+REY+S0+T+TDMAX	COM	55
	COMMON TF, THEIA. TIO. TO. TOMAX, TVMAX, V, VDT, VMAX, VV, WP	COM	24
	COMMON X+XE+XF+XX	COM	26
	D0=0(1)	COM	28
	Vv=V(I)	COM	30
	CALL COEFF	COM	32
	DE61H=D(I)	COM	34
	CALL CIRCLE	COM	36
C	POSITIVE CHARACTERISTIC	COM	38
	CP=(2.0*BETA)/(V(1)*(ALPHA+HETA)+SQRTF(((ALPHA-BETA)**2)*V(1)*V(1	COM	40
	1+(4.0*A*BFTA*GR/8)))	COM	42
C	NFGATIVE CHARACTERISTIC	COM	44
	CM=(2.0+BFTA)/(V(1)+(ALPHA+HETA)-SURTF(((ALPHA-HETA)+2)+V(1)+V(1	COM	46
	1+(4.0*A*AFTA*GR/R)))	COM	40
	UP=CO/CP	CON	50
	UN=CO/CM	COM	52
C	2ND ORDER INTERPOLATION	COM	34
	DR = D(1-1)*0.5*0P*(0P-1.)*D(1)*(1.0-0P*02)*D(1*1)*0.5*0P*(0P*1.)	CON	20
	VP = V(1 - 1) + 0.5 + 0P + (0P - 1.) + V(1) + (1 0P + 3.2) + V(1 + 1) + 0.5 + 0P + 1.1	COM	50
	$D_{S=D}(I-1) = 0.5 = 0 + 0.0 = 1.0 + 0.0 + 1.0 + 0.0 = 0.0 = 0.0 + 0.0 + 1.0 = 0.0 = 0.0 + 0.0 + 1.0 = 0.0 = 0.0 + 0.0 + 0.0 + 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0 = 0.0$	COM	62
	VS#V(1-1)*0.5*0N*00N-1.)*V(1)*(10N*2)*V(1*1)*0.5*0N*00N*1.1	COM	64
	F CP=AC@CP=HC	COM	66
	r cheate with the	COM	68
	GCM=AH	COM	70
		COM	72
		COM	74
	50	COM	76
	TOW-FORSDC (CMSVC-SCHOLL/CM	COM	78
6	VELOCITY AND DEPTH AT END OF TIME INTERVAL	COM	80
C.	VD=(FCD=TCM=FCM=TCD)/(FCD=GCM=FCM=GCD)	COM	82
	DP=(TCP=6CM-TCN=6CP)/(FCP=6CM-FCH=6CP)	COM	84
	IF (DP-0.62*DIA) 20.10.10	COM	86
10	WRITE (6.90) X(1).1	COM	88
10	Go 10 80	COM	90
20	DEPTHEOP	COM	92
	CALL CIRCLE	COM	94
	QDT(1)=A*VP	COM	96
	DOT (1)=DP	COM	98
	VOT (I)=VP	COM	100
C	MAX DEPTH. VELOCITY. AND DISCHARGE. AND THEIR ASSOCIATED TIMES	COM	102
052	IF (DDT(1)-DMAX(1)) 40.40.30	COM	104
30	DMAX(I)=DTT(I)	COM	106
	TOMAX(1)=T	COM	108
40	1F (VDT(I)-VMAX(I)) 60.60.50	COM	110
50	VMAX(])=VDT(])	COM	115
	T = T = T	COM	114
60	IF (QDT(1)-QMAX(1)) 80.80.70	COM	116
70	QMAX(1)=QD1(1)	COM	118
	TOMAX(T) = T	COM	120
80	RETURN	COM	155
C		COM	124
90	FORMAT (* FLOW IS FULL AT $x = *+F/.2+*$ T = *+F*.2) END	COM	126

SUBROUTINE FOR COMPUTING NORMAL DEPTH SURROUTINE DNORM DNO 2 SURROUTINE DNORM DIMENSION D15001, DD1[5001, DMAX[200], Q(500), QD1(500) DIMENSION 01(200), OMAX(200) DIMENSION TOMAX(200), TQMAX(200), TVMAX(200) DIMENSION V1500), VOT(5001, VMAX(200), TVMAX(200) DIMENSION V1500), VOT(5001, VMAX(200), TVMAX(200) DIMENSION V1500), VOT(5001, VMAX(200), TVMAX(200)) COMMON A.48,AC,AD,AE,AIPHA.H.HC.80,HEIA.CD.CO.D.HC.ADDI DNO 4 DNO 6 8 10 12 COMMON DEPTH.DD.DIA.DIN.DM.UMAX.DN.DOUI.DI.DTOL.UX.FD COMMON F.FB.FC.FD.FNU.GR.1. ITO. 110C. IX0. JXUC. J.MC.N.NUCO 16 18 20 22 24 26 28 30 COMMON NT+N1+Q+08+00T+01+01N+0MAX+0P+00+R+PEY+50+T+10MAX COMMON IF. THE LA. TIO. TP. TQ. LUMAX . IVMAX . V. VIII . VMAX . VV. WP COMMON X. XE. XF. XX DFPTH=0.62\*DIA 10 CALL CIRCLE VV=00/A REYNOLDS NUMBER DNO С REY=VV+R/FNU FRICTION FACTOR DNO 32 346 380 380 424 468 502 52 DNO С F=FB+REY++FC DNO NEWTON-RAPHSON DNO С NEWTON-RAPHSON DN=DEPTH-(WP-(F\*(GG\*\*2))/(H,\*GF\*5G\*(R\*\*2)\*A))/((3,0\*H)/P-2,0/SINE(DNG) 11HETA/2,0)) 1F(ABSE(DN-DEPTH)-DIG() 30+20+20 DPTH=DN GG T0 10 GG T0 10 DFTUN DDD DNO DNO DNO 1THETA/2.011 20 30 RETURN

END

DNO

	SUBROUTINE COEFF	COE	z
C	-COMPUTATION OF ALL COEFFICIENTS OF THE IND PARTIAL DIFFERENTIAL	COF	4
C	-EQUATIONS	COE	6
	DIMENSION D(500), DDT(500), DMAX(200), Q(500), QDT(500)	COE	8
	DIMENSION GI(200), GMAX(200)	COE	10
	DIMENSION TOMAX(200) . TO(200) . (QMAX(200) . TVMAX(200)	COF	12
	DIMENSION V(500), VOT(500), VMAX(200), X(500)	COE	14
	COMMON A+AR+AC+AD+AF+AI PHA+H+HC+HU+HETA+CU+CO+U+UC+DDT	COE	16
	COMMON DEPTH-DO.DIA.DIN.DM.UMAX.ON.DOUTT.DT.DTOL.DX.ED	COE	18
	COMMON F.FR.FC.FD.FNU.GR.I.ITO.ITOC.IX0.IX0C.J.MC.N.NQCO	COE	20
	COMMON NT+N1+Q+QB+ODT+OI+UIN+QMAX+QP+OU+R+REY+S0+T+TDMAX	COE	55
	COMMON TF+THETA+TIO+TP+TO+TOMAX+TVMAX+V+VDT+VMAX+VV+WP	COE	24
	COMMON X.XE.XF.XX	COE	26
	DEPTHEOD	COE	28
	CALL CIRCLE	COE	30
	A)=A/(VV*R)	COE	32
	D)=1.6/VV	COE	34
	A7=ALPHA*VV/GR	COE	36
	B2=BETA/GP	COE	38
C	REYNOLDS NUMBER	COE	40
	RFY=VV+R/FNU	COE	42
C	FRICTION FACTOR	COE	44
	F=FH=REY=+FC	COE	46
С	ENERGY SLOPE	COE	48
	SF=.125*F*VV*VV/(R*GR)	COE	50
	E2=SF-S0	COE	52
	AR=A1=82	COE	54
	AC=41-42	COE	56
	A0=-A2*01	COF	58
	AF=A1=F2	COE	60
	BC=-B2	COF	62
	80=-82*01	COE	64
	RETURN	COE	66

SUBROUTINE FOR COMPUTING DEPTH & VELOCITY AT END OF TIME INTERVAL

SUBROUTINE FOR COMPUTING COEFFICIENTS IN ORDINARY DIFFERENTIAL EQUATIONS

	SUBROUT INF BOUND 1	801	2
	COMPUTATION OF VELOCITY AND DEPTH FOR X=0.0 AT THE TIME T	801	4
	DIMENSION D(500), DDI(500), DMAX(200), 4(500), 4DI(500) DIMENSION DI(200), DMAX(200)	801	8
	DIMENSION TOMAX(200) . TO(200) . TOMAX(200) . TVMAX(200)	801	10
	DIMENSION V(500), VDT(500), VMAX(200), X(500)	801	15
	COMMON A+AB+AC+AD+AE+AI PHA+H+BC+HD+BE (A+CD+CU+D+DC+DD)	B01	14
	COMMON OFPTH+DD+DIA+DIN+DM+DM+X+DN+DOUT+DT+DTOL+DX+ED	801	16
	COMMON NT-NI-D-DB-ODT-01-01N-0MAX-0P-00-R-WFY-S0-1-T0MAX	801	20
	COMMON TF. THETA. TIO. TP. (Q. TUMAL. TVMAX. V. VDT. VMAX. VV. WP	801	22
	COMMON X.XE.XF.XX	801	24
	CALL INFLO1	B01	26
	DEPTH=D(1)	801	28
	NEGATIVE CHARACIERISTIC	801	30
	CH=(2.0*HETA)/(V(1)*(ALPHA+HETA)-SQRIF(((ALPHA-HETA)**2)*V(1)*V(1)	801	34
	1+(4+0=A*RFTA=GR/H)))	B01	36
1	IF (CH) 10.20.30	801	38
0	UN=CO/CM 2ND ODDED INTERPOLATION FOR DEVING AND VELOCITY	HOI	40
	DS=D(1)*0.5*UN*(UN-).)+U(2)*(1UN**2)+U(3)*0.5*UN*(UN+).)	801	44
	V5=V(1)*0.5*UN*(UN-1.)+V(2)*(1UN**2)+V(3)*0.5*UN*(UN+1.)	801	46
	GO TO 40	B01	48
20	X<=X(1)	B01	50
	US=D(1) VC=V(1)	801	52
	GO TO 40	BOI	56
80	QQ=QIN	BOL	58
	CALL DCRIT	801	60
		801	62
0	0n=0(1)	801	66
	VV=V(1)	801	68
	CALL COEFF	B01	70
	FCM=AC+CM-BC	B01	72
	SCM=AB	BOI	74
	ASMALL=DS-(SCH+CM+DT-GCH+VS)/FCM	801	78
	BSMALL=-QIN*GCM/FCM	801	80
	OP1=D(1)	801	82
90	RD=2.0*0P1/01A=1.0	801	84
		801	88
	FOP1=DP1-ASMALL-(RSMALL/A)	801	90
	FDP1P=1.0+(BSMALL/A**?)*((D1A*(1.0-COSF(THETA))/2.0)*(1.0/SQRTF(1.	.B01	92
88	IO-RD**2)))	801	94
•	DP2=DP1=FDP1/FDP1P	BOI	98
	IF (ABSF(DP2-DP1)-DTOL) 70,70,60	BOI	100
50	0P1=0P2	801	102
		B01	104
0	DD=DD1	801	100
30	IF (DP-0.82*DIA) 100.90.90	BOI	110
0	WRITE (6.170) X(1).T	801	112
	Gn TO 160	801	114
00		801	116
	VP=QIN/A	801	120
	DDT(1)=DP	BOI	122
	VnT(1)=VP	801	124
	QDT(1)=QIN	801	126
	TE (DOT(1)-DMAX(1)) 120-120-110	BOI	128
10	DMAX(1)=DDT(1)	801	132
	TDMAX(1)=T	801	134
20	IF (VDT(1)-VMAX(1)) 140,140,130	801	136
30	YMAX(1)=V())(1) TVWAX(1)=T	801	138
40	IF (QDT(1)-QMAX(1)) 160+160+150	801	140
150	QMAX(1)=ODT(1)	BOI	144
	TOMAX(1)=T	801	146
60	REIURN	801	148
70	FORMAT (9 FLOW IS FULL AT X = 4.57.2.6 T = 4.54.2)	BOI	150
	END	801	154

SUBROUTINE FOR COMPUTING DOWNSTREAM BOUNDARY CONDITION. SUBBOUTINE BOUND2 802 2 DIMENSION D(500) + DDT(500) + DMAX(200) + Q(500) + QDT(500) 802 4 DIMENSION DI (200) . DMAX (200) 508 6 DIMENSION TOMAX (200) . TO (200) . TOMAX (200) . TVMAX (200) 8 802 DIMENSION V(500) . VDT(500) . VMAX(200) . X(500) 802 10 COMMON A.AR.AC.AD.AF.AL PHA.H.HC.HD.HETA.CU.CO.D.DC.DDT BOS COMMON DEPTH+DD+DIA+DIN+DM+DMAX+DN+DOUT+DT+DT0L+DX+ED 805 14 H02 H02 H02 H02 H02 H02 H02 COMMON F.FB.FC.FO.FNU.GR.I.ITO.ITOC.IXO.IXOC.J.MC.N.NQCD COMMON NT .N1 .Q. QR. ODT .QI. QIN. OMAX .QP. OQ. R. REY. SO. T. TOMAX 18 20 22 24 26 28 30 24 26 28 30 32 40 40 40 40 40 COMMON TF.THETA.TIO.TP.TO.TOMAX.TVMAX.V.VDT.VMAX.VV.WP COMMON X.XE.XF.XX DEPTH=D(N1) CALL CTRCLE 802 C POSITIVE CHARACTERISTIC 802 CP=(2.0\*BETA)/(V(N1)\*(ALPHA+BETA)+SURTFIC(ALPHA-BETA)\*\*2)\*V(N1)\*V(BO2 1N1)+(4.0\*A\*BETA\*GR/B))) 802 UP=CO/CP 802 С 2ND ORDER INTERPOLATION FOR DEPTH AND VELOCITY 802 DR=D(N-1)\*0.5\*UP\*(UP-1.)+D(1)\*(1.-UP\*\*2)+D(N1)\*0.5\*UP\*(UP+1.) 802 VR=V(N-1)\*0.5\*UP\*(UP-1.)+V(W)\*(1.-UP\*\*2)+V(N1)\*0.5\*UP\*(UP+1.) 508 DD=D(N1) 802 VV=V(N1) 802 CALL COEFF HOZ FCP=AC+CP-BC 802 48 50 GCP=AB 802 SCP=AE+CP 802 52 54 56 60 62 64 66 68 CSMALL=DR+(SCP+CP+DT-GCP+VH)/FCP 802 DSMALL =-GCP/FCP 802 802 802 802 DP1=0(N1) 10 RD=DP1+2.0/DIA-1.0 OFPTH=DP1 CALL CIRCLE 802 GO TO (20.30). MC 802 20 FD=CD+DP1++ED SOH F01=CD+ED+0P1++(E0-1.0) 802 70 U=FD/A 802 72 FDP1=DP1-CSMALL-DSMALL #1) 802 74 THFTA2=THFTA/2.0 DADD=(DIA/2.0)\*(1.0-COSF(TH+TA))\*(1.0/SORTF(1.0-RO\*\*2)) 802 802 78 DUDD=((A\*FD1)-(FD\*DADD))/(A\*A) 802 80 82 GO TO 40 802 30 U=SQRTF (GR#A/B) 84 86 88 90 802 FDP1=DP1-CSMALL-DSMALL #U 802 THETA2=THETA/2.0 802 DUDD=(2./DIA)\*(1.0/SORTF(1.0-RD\*02))\*(1.0/H)\*((UIA\*\*2\*(1.0-COSF(THHOZ 92 94 96 1ETA)))/(8.0\*B)-(A\*(01A/2.0)\*COSF(THF1A2)/H\*\*2)) 802 40 FDP1P=1.0-DSMALL +DUDD 802 С NEWTON-RAPHSON ITERATION 802 OP2=OP1-FOP1/FOP1P 802 98 IF (ABSF(DP2-DP1)-DT0L) 60.60.50 BO2 100 50 0P1=0P2 B02 102 GO TO 10 B02 104 END OF NEWTON-RAPHSON C 802 106 60 DEDTH=DD2 B02 108 IF (DEPTH-0.82\*DIA) 80.70.70 802 110 70 WRITE (6.180) X(1).T 802 112 GO TO 170 B02 114 CALL CIRCLE 80 802 116 DDT (N1)=DFPTH 802 118 GO TO (90.100), MC BOS 150 90 QOT (N1)=CO\*DEPTH\*\*ED 802 122 VOT (N1) =QOT (N1) /A B02 124 GO TO 110 802 126 100 VOT (N] )=SORTF (GR\*A/B) 802 128 QDT (N1)=VDT (N1) #A B02 130 MAX DEPTH, VELOCITY, AND DISCHARGE, AND THEIR ASSOCIATED TIMES C 802 132 110 IF (DDT(N1)-DMAX(N1)) 130+130+120 802 134 120 DMAX(N1)=DOT(N1) B02 136 TOMAX (NI) = I B02 138 IF (VDT(N1)-VMAX(N))) 150,150,140 130 B02 140 B02 142 VMAX(N1)=VDT(N1) 140 TVMAX (N1)=T 802 144 150 IF (QDT(N))-QMAX(N1)) 170+170+160 802 146 QMAX(N1)=ODT(N1) 160 802 148 TOMAX (N1)=T B02 150 170 RFTURN B02 152 C---802 154 FORMAT (\* FLOW IS FULL AT X = \*. F7.2.\* 1 = \*. F6.2) 180 B02 156

802 158

END

SUBROUTINE FOR COMPUTING UPSTREAM BOUNDARY CONDITION.

SUBROUTINE FOR COMPUTING GEOMETRIC PARAMETERS OF CIRCULAR SEGMENT

#### SUBROUTINE FOR COMPUTING INFLOW HYDROGRAPH

2

	SUBROUTINE CIRCLE	CIR	- 34
	DIMENSION D(500), DD1(500), DMAX(200), Q(500), Q0T(500)	CIR	- 3
	DIMENSION OI (200) + DMAX (200)	CIR	- 9
	DIMENSION TOMAX(200), TQ(200), TOMAX(200), TVMAX(200)	CIR	3
	DIMENSION V(500) . VOT(500) . VMAX(200) . X(500)	CIR	1
	COMMON A.AB.AC.AD.AE.AI PHA.H.HC.HD.BETA.CD.CO.D.DC.DDT	CIR	1;
	COMMON DEPTH-DD.DIA.DIN.DM.OMAX.ON.DOUT.DI.DTOL.UX.ED	CIR	14
	COMMON F.FR.FC.FD.FNU.GR.I.ITU.IIDC.IXU.IXUC.I.MC.N.NOCD	CIR	10
	COMMON NT.NI.O.OB.ODT.OI.OTV.OMAX.OP.OO.H.PEY.SO.T.TDMAX	CIR	11
	COMMON TF THETA . TIO. TO . TOMAX . I VMAX . V . VDT . VMAX . V . WP	CIR	2
	COMMON X.XE.XF.XX	CIR	2
C	TEST TO INSURE DEPTH LESS THAN U.H2 DIA.	CIR	24
	IF (DEPTH) 10.20.20	CIR	20
10	WRITE (6+100)	CIR	51
	CALL EXIT	CIR	31
20	IF (DEPTH-0.82*DIA) 40.40.30	CIR	3
30	WRITE (6.110)	CIR	34
	CALL EXIT	CIR	36
40	1F (DTA/2.0-DEPTH) 60.50.70	CIR	38
50	THE TA= 3.14159	CIR	46
	60 TO 90	CIR	47
C	SUBTENDED ANGLE	CIR	44
60	THETA=6.28318-2.09ATANF((SORTF(DIA#DEPTH=DEPTH=DEPTH))/(DEPTH=DI	A/CIR	48
	12.0))	CIR	48
	60 10 90	CIR	5
70	THETA=2,0*ATANE((SORTE(DIA=DEPTH=DEPTH=DEPTH))/(DTA/2.0-DEPTH))	CIR	5
	IF (THETA) 80,90,90	CIR	54
80	THETA=6.28318+THETA	CIR	5
C	ADFA	CIR	5
90	A=0.1250(THETA-SINF(THETA))*(0)[A++2)	CIR	6
C	WETTED PERIMETER	CIR	6
	WP=(014/2.0)*THFTA	CIR	64
C	HYDRAULIC PADIUS	CIR	6
	R=A/WP	CIR	6
C	SUPFACE WIDTH	CIR	7
	B=DIA#SINF(THETA/2.0)	CIR	7
C	HYDRAULIC DEPTH	CIR	74
	UM=A/R	CIR	71
	RETURN	CIN	71
C		CIR	81
100	FORMAT (* DEPTH 15 NEGATIVE*)	CIR	84
110	FORMAT (* FLOW IS FILL*)	CIR	84
	END	CIR	86

#### SUBROUTINE FOR COMPUTING CRITICAL DEPTH

	SUPROUTINE OCHIT	OCR	2
	DIMENSION D(500), DDT(500), DMAX(200), D(500), QDT(500)	DCR	4
	DIMENSION 01(200) . OMAX(200)	DCR	6
	DIMENSION IDMAX(200), TO(200), IDMAX(200), TVMAX(200)	DCR	8
	DIMENSION V(580) . V01(500) . VMAA(200) . X(500)	DCR	10
	COMMON A.AR.AC.AD.AF.AI PHA.H.HC.HD.BF LA.CD.CO.D.BC.DDT	DCR	12
	COMMON DEPTH-DD-DTA-DTA-0*+0*4X+0*+0001+01+010L+0X+ED	DCR	14
	COMMON F.FR.FC.FD.FNU.SR.I.110.110C.LKG.IX0C.J.MC.N.NOCD	DCR	16
	COMMON NT.N1.9.08.001.01.01N.04AX.0P.00.8.PEY.50.1.TOMAX	DCR	18
	COMMON TF.THETA.TTO.TO.TO.IDMAX.TVMAX.V.VUT.VMAX.VV.WP	DCR	20
	COMMON X+XE+XE+XX	DCR	22
	DEPTH=0.62*01A	DCR	24
10	CALL CIRCIF	DCR	26
c	NEWTON-RAPHSON	DCR	85
	DC=DEPTH=(R*(A**3)=ALPHA*((H*G))**2)/(R)/(1,0*((8*A)**2)=(2.0*(A*	**DCR	30
	13) PCOSE (THETA/2.0))/(STHE (THETA/2.0)))	DCR	32
	IF (ABSE(DC-DEPTH)-0101) 30-20-20	DCR	34
05	DEPTHENC	DCR	36
	60 TO 10	DCR	38
30	RETURN	DCR	40
	END	DCR	42

	SUBBOUTINE INFLOI	INF	- 2
C	COMPUTATION OF THE INFLOW HYDRODYAPH	1NF	4
	DECHARTES AT TRREGULAR TIME INTERVALS	INF	6
· ·	DIMENSION D(500), DDI(500), DMAX(200), 0(500), 007(500)	INF	8
	DIMENSION 01(200), 0MAX(200)	INF	10
	DIMENSION TOWAY (200), TO(200), TOMAX (200), TVMAX (200)	INF	12
	DIMENSION V(500), VDI (500), VMAX(200), X(500)	INF	14
	COMMON A. AB. AC. AD. AF. AL PHA. H. HC. HD. HF TA. CD. CO. D. DC. DUT	INF	16
	COMMON DEPTH-DD-DIA-DIN-DM-DMAX-DN-DDUI-UI-DIOL DX-ED	INF	18
	COMMON F. FR.FC.FD.FNU.GR.1.1TO.1TOC.1X0.1X0C.J.MC.N.NOCO	INF	20
	COMMON NT.NI.D.OH.ODT.OI.OIN.OMA3.DP.OD.R.REY.SO.T.TUMAX	INF	22
	COMMON TE, THE LA, T LO, TP, TO, TOMAX, TVHAX, V, VDI, VHAK, VV, WP	INF	24
	COMMON Y YESTERY	INF	26
		1NF	28
	Totals 1.010DT	1NF	30
		INF	32
r.	INTERPOLATION FOR REGULAR TIME INTERVALS	INF	34
5	IF (T_6F_T0(N0CD)) 10.20	INF	36
10		INF	38
10	GO TO EO	INF	40
20	16 (1 65 10/10) AND 1 (1 T0(1))(1) 40.30	INF	42
20		INF	44
30	10=10+1	INF	46
		INF	48
40	give a to the	INF	50
		INF	52
50	RETURN	INF	54
	END	1.44	

NAME	DEFINITION	S	TATEME	NT N	UMHEN	(5)			
A	AREA OF CIRCULAR SEGMENT	CIN	60						
AB	(2)	COF	54						
AC	(2)	COE	56						
AD	(2)	COE	58						
AF	(2)	COF	60						
4.)	(1)	INF	28						
AI PHA	VEL DISTRIBUTION FACIOR-ENERGY	INS	56						
AN	NUMBER OF DISTANCE INTERVALS	13145	164						
ASMAL	( (2)	801	78						
A1	(2)	COF	32						
42	(2)	COF	.16						
8	EREE SURFACE WIDTH	CTR	72						
BC	(2)	COF	62						
80	(2)	COF	64						
BETA	VEL DISTRIBUTION FACTOR-MOMENTUM	1185	58						
RSMAL	1 (2)	601	80						
82	(3)	COF	38						
CD	OUTLET DISCHARGE COFFEICIENT	UNS	62						
CN	NEGATIVE CHARACTERISTIC DIRECTION	601	34	COM	46				
00	WINDS OT /DY	UNS	192		20				
LU	BIND DITTO	0.00	170	40.2	70				
CP	POSITIVE CHARACTERISTIC DIRECTION	202	40	nue	312				
LSMAL		BILC		14.0	154	THE	100	LINC	286
0	DEPTH OF FLOW AT TIME T	INC	40	TWC	150	T.AC	100	UNA	204
DADD	DEPIVATIVE OF AREA WITH DEPTH	102	10						
DAREA	DEPIVATIVE OF AREA WITH DEPIH	IN	C 14						
DC	CRITICAL DEPTH	nC4	30						
DCOM	COMPUTED DEPTH	INC	184	INC	115	1000	10002		
DD	DFPTH	101	66	905	42	COM	28		
DDT	DEPTH OF FLOW AT TIME TONT	H01	155	805	118	COM	98		
DENG	(2)	INC	82						
DEPTH	DEPTH OF FLOW	HOL	28	801	86	801	116	COE	28
		508	24	805	62	802	108	COM	34
		1INS	176	UNS	142	UNS	204	COM	92
		INC	60	INC	166	DNO	24	DNO	46
		DCH.	24	DCH	36				
DIA	DIAMETER OF PIPE	UNS	38						
DIN	INITIAL VALUE OF DEPTH	INC	118	INC	122	INC	136	INC	144
		UNS	202						
DM	HYDRAU IC DEPTH	CIN	16						
OMAX	NAXIMUM DEPTH	UNS	98	801	132	802	136	COM	106
ON	NOPHAL DEPTH	DNO	40						
DOUT	DEPTH OT OUTLET	UNS	152	UNS	160				
0P	DEPTH	HOL	62	BOL	108	COM	84		
081	INITIAL VALUE OF DEPTH	en1	82	HOL	102	508	58	802	102
002	COMPLITED VALUE OF DEPTH	801	98	HOZ	9B	artist.			
000	INTEROAL ATER VALUE OF DERTH	102	24	COM	56				
DOA	INTERPOLATED VALUE OF DEPTH	INC	140	COR	10				
OF	INTERROLATED VALUE OF DEUTH	140	0.0	401		COM	60		
DELO	DEDIVATIVE OF ENERGY CLOOP WITH UN	THE		DOL	76	COM	00		
DOLU	DERIVATIVE OF ENERGY SLOPE WITH OF	Der 3	0.4						
DIMALL	THEDEMENT OF TIME	HUC	100						
DTUET	DEDINATIVE OF THETA WITH DENTH	1110	73						
DINEI	THE OF HASTNESS DESTU	Tue!C	10						
DIMAX	TIME OF MAXIMUM DEPTH	UNS	100						
DTOL	MAXIMUM ERROR IN DEPTH CALCULATION	UNS	10		-				
0000	121	802	P1.(2	802	40				
OW		1746	10						
DX	INCHEMENT OF DISTANCE	1145	100						
01	(2)	COF	.34						
EU	DUTLET DISCHARGE EXPONENT	UNS	04						
EEI	ENERGY AT KNOWN OFFICE	1.40	44	tie.	148				
ete	ENERGY AT UNKNOWN GEPTH	1.00	44						
22		1.00	25	6.00		2.2		and the	1.0
,	ATACLASS LOSACA RESISTANCE COSA	1940	20	1.46	20	1.4%	42	Cified of	345
1.	And a second sec	1.04							
	FACTOR ON REFLACE F DEPENDENCES	6,005	**						
1.5	* \$417.57# D& #E1.987. * D&PC* * 08.10100	1.96.1	2-5						
124	- P.I.	442.0	2.5	10,125	4.6				
100	2. <b>3</b> 4	<b>#</b> 67	4/8	200					
87.B	BRANKTARIAN BED, 27 Instrantia	wast.	9.05						
or set	14834	神社	1925	49.00	394	Seine .	ANK .		
10.354.74	Service and the service of the servi	86.5	-	ADE.	-				
STREET.	107	1000	1986						

ENU	KINENATIC VISCOSITY	11125	46						
FRAT	10(2)	1140	100						
GCM	(2)	Har I	14	COM	4 70				
GCP	(2)	HOZ	2 50	COM	4 68	£			
GR	ACCELERATION OF GRAVITY	Linis	5 54						
HFTH	(2)	1140	: 70						
I	(1)	1,14,5	266						
11	(1)	A Deg S	244	1140	152	IN	C 176		
IL.	LINE PRINTING INDEX	11145	145						
10	(1)	INF	51	INF	44				
ITO	TIME INTERVAL BETWEEN OUTPUTS	UNS	146						
ITOC	TIME. OUTPUT INTERVAL COUNTER	11115	224	1,215	512	UN	5 2/A		
IXO	DISTANCE INTERVAL HETWEEN OUTPUT	5 11:15	14						
TXOC	DISTANCE. OUTPUT INTERVAL COULIF	11 1145	144	14-25	: 254	UN	5 200		
J	(1)	1140	158	11015	226	í interestado			
I.	(1)	1146	48						
MC	BACKWATER PROFILE CODE	11115	148	UNS	146				
N	NUMBER OF X-INTERVALS	11145	68						
NCOUN	NTITERATION COUNTER	INC	52	ENC	124				
NPG	OUTPUT PAGE CONTROL	11115	240						
NOCD	NUMBER OF INPUT HYDROGRAPH POINT	\$ 1,645	80						
NT	NUMBER OF TIME INTERVALS	1045	194						
N1	NUMBER OF X-INTEGRATION LOCATION	15 11015	94						
0	DISCHARGE AT TIME T	IN	545	INC	50	INC	5 160	1NC	184
QB	BASE DISCHARGE	UNS	H4						
DOT	DISCHARGE AT TIME TODT	401	126	802	122	HO	2 130	COM	96
10	INPUT HYDROGRAPH DISCHARGE	11145	42						
QIN	INITIAL DISCHARGE	IINS	204	1 NIF	18	INF	48		
QMAX	MAXIMUM DISCHARGE AT TIME T	11MS	102	HOL	144	HO	2 148	COM	118
QP	PEAK HYDROGRAPH DISCHARGE	UNS	86						
00	DISCHARGE	0.45	1 14	UNS	172	HOL	58		
ORA	PEAK TO BASE DISCHARGE HAILU	11115	42		01033075	5 0000			
R	HYDRAULIC RADIUS	CIN	64						
80	DEPTH TO PADIUS PATIO	ROL	84	802	60				
REY	REYNOLDS NUMBER	INC	44	INC	66	INC	90	DNO	32
DEY	AT THEEDS HONDER	COF	42					0.10	
SCH	(2)	hard 1	76	COM	14				
SCP	(2)	HOZ	52	COM	12				
CE	EDICTION SLOPE (AVEDAGE)	THE	NA	COF	50				
60	INVERT CLOPE	LILLE	4.2	Curr					
50	FOICTION CLOPE AT KNOWN DEDTU	INC	40	THE	146				
51	EDICTION SLOPE AT UNKNOWN DEDTH	LMC	90	T.a.	140				
36	TINE	Leac	210	110.0	250	10.00	20		
TCH	1 THE	COM	10	(INS)	1.10	1.945	30		
TCD	(2)	Crud	10						
TOHAY	THE TO HAVE MAN DEDTH	Lun	10	0.02	1.80	10000	100		
TUMAA	TIME 10 MAAIMON DEPTH	101	1.34	HUS	1 10	LOM	108		
THETA	CENT AND CURTENOLD BY EVER CONTACT	DINS	10	C	12.92				-
THETA	CENT AND SUDIENDED BY FREE SURFAL	FLIN	40	CIN	90	CIK	52	CIN	20
THETA	CUNE-HALF THE TA	HUZ	10	HOZ	98				
110	TIME INTERVAL RETWEEN OUTPUTS	UNS	14						
TP	TIME TO PEAK INPUT DISCHAPIGE	UNS	18						
10	INFLOW HYDROGRAPH TIME	UNS	HS						
TOMAX	TIME TO MAXIMUM DISCHARGE	H01	146	805	150	COM	150		
TVMAX	TIME TO MAXIMUM VELOCITY	+01	140	805	144	COM	114		
U	VFLOCITY	RUS	12	1115	84				
UN	(2)	en1	48	CUM	52				
UP	(2)	ROS	34	COM	50				
v	VELOCITY AT TIME T	IINS	246	INC	48	INC	158	INC	182
VC	CRITICAL VELOCITY	IINS	180						
VDT	VELOCITY AT TIME TOT	H01	124	805 1	24	802 1	158	COM	100
VH	VFLOCITY HEAD	THC	.30	INC	88				
VHAX	MAXIMUM VFLOCITY	1615	100	801	1 18	504	142	COM	112
VOL	VOLUME OF HYDROGPARH WAVE	1145	40						
VP	VELOCITY	HOL	124	COM	-2				
VR	INTERPOLATED VALUE OF VELOCITY	n.12	-	COL	58				
VS	INTERPOLATED VALUE OF VELOCITY	-1 i	- 1-	15.+4	4.4	C/H	50		
WW	VFLOCITY	ma 8	÷.n	n 2		6.74	30	DNO.	28
		5.40*	/=	1.00		240	7.6	INC	174
		+ 427		1.6.1	2.				
¥۴	WETTED DESIMETEN		-	1.44.5					
₩P 1	BURITED BERINETEN BURITED BERINETEN	8.95		INC.		144	124		
#P 1 42	WETTED RESIMETED ROSITION ALONG CHANNEL WORKING LENGTH OF CHANNEL	1.45		145		144			
#P 1 41 8#	WEITED PERIMETEU POSITION ALONG CHANNE, WHRETAL (FASTH OF CHANNE, UNITIAL (FASTH OF CHANNE,	141	**	inc.		144			
#P 1 41 84 84 81	AFTER DESIMETO POSIETA AL AND CHANNEL MERETHE FEASTH OF CHANNEL SATELAL LEMBER OF CHANNEL STREETHE ADSIDEM	191	1 2 2 2 3	L'NC		144			

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The sold can developed the second developer to be a second second

127122112					CONDITIO	S AT 94.6	23SECONDS	
A.3.4.	SAMPLE	INPUT AND	OUTPUT		DISTANCE	DESLH	VELDCITY	UISCHARGE
					(F1)	(FT)	(==5)	(CFS)
*	SAMPLE	INPUT			.0000	. 8295	2.5505	
					81.8870	. 8+22	2.6344	+.2239
	Same format	t as in A.1.4.			163.7739	. 4002	7.0444	5.3496
5 4.0	30.0	10.0 50.0	10.	80.0 4.0	327.5478	. ++23	3.8510	7.7364
200.0 4.0					409.4348	. ++32	4.0117	8.0094
					491.3217	1.0019	4.2641	9.0845
					655.0950	7989	3.8844	0.4545
	SAMPLE	OUTPUT			730.9829	.7390	1.1521	4.2044
					610.8645	. 5374	3.795.	4.104B
INFLOR HIDR	USUADH PARAMET	Pas			DISTANCE	15 AT 113.5	ARECONDS	DIFFERENCE
THE LOW THUS		2.43			(FT)	(FI)	(625)	(CES)
Q8= 4.00	OOOCFS						,	
QP= 10-00	000CFS				.0000	. 5186	2.5944	+.0000
08/UP= .40	000				163.7739	. 3313	2.0334	4.1003
WAVE VOLUME	ABOVE BASE FLO	W= 180.00CU F	r	*	245.6609	. 3615	2.8325	+.0823
					327.5478	.9054	3.1650	5.6051
SYSTEM PARAM	ETERS,				491.3217	. 7484	7.0367	5.6769
<u>SO = +00</u>	100				573.2047	. 2096	3.9720	7.7310
ALPHAS 1.00	000				655.0956	. 7642	6.21A.3	8.1489
N # 20	000				730.9826	.5394	3.8319	6.1088
1x0 = 5					CONDITION	S AT 132.4	ZSECONS	•. 4•/3
TF = 200		10.			DISTANCE	DESLU	VELOCITY	DISCHARGE
NORMAL DEPTH	000	CRITTCAL OFRTHE	6200ET		(FT)	(FT)	(==5)	(CFS)
		N	A CONTRACTOR OF		.0000	. 0100	2.6368	4.0000
DX= 40.9+34	SFT DI# 1	.455744EC			81.8870	.8177	2.0036	4.0942
					163.7739	. 4259	2.7020	4. <106
. CONDITIO	INS AT 0.0	INSECONDS			327.5478	.0290	2.0875	4.4272
DISTANCE	DEPTH	VEI DETTY	DISCHARGE		409.43+8	.8704	2.9676	4.9761
· (FT)	(FT)	(125)	(CFS)		491.3217	. 9055	1105.5	5.7765
.0000	7650			4	573.2087		7.5523	6.5445
81.8870	7658	2.8522	4.0000		736.9826	.+372	4.1744	7. /537
163.7739	.7058	2+8529	4.0000	-	818.8695	. 5042	4.4732	7.4271
245.0609	.7656	2.0535	4.0000		CONDITION	5 AT 151.35	TRECONTS	
409.4348	.7054	2.6549	4.0000		(FT)	(FT)	(FPS)	(CFS)
491.3217	.7037	2.8639	4.0000					
573.2087	.7612	2.8768	4.0000		.0000	. 9030	2.6690	4.0000
736.9826	./559	2.9052	4.0000		163.7739	. 3168	2.0875	4.0770
818.0095	.6290	3.7683	4.0000		245.6609	. 9265	2.7503	4.2911
CONDITION	5 AT 18.925	SECONDS		14	327.5478	. 3297	2.7525	4.3182
DISTANCE	DEPTH	VELOCITY	DISCHARGE		491.3217	. 5342	2.768.	4.3757
	(FT)	(==>5)	(CFS)		573.2007	. 3720	3.0865	5.1840
.0000	.9539	4.0905	7.7849		655.0956	. 9950	7.3874	5.9100
81,8870	,8362	3.3542	5.3194		730.9825	. 5062	4.5284	6.2366
245.6609	.7734	2.9100	4.1378		CONDITION	5 AT 170.32	ISECONDS	0.5087
327.5478	.7654	2.8550	4.0001		DISTANCE	DEPIN	VELDCITY	DISCHARGE
409.+348	.7048	2.8579	4.0000		(FT)	(FT)	(505)	(CFS)
573.2087	. 7036	2.8640	4.0000		.0000	. 7973	2.6953	4.0000
655.0956	.7559	2.9071	4.0024	-	81.8870	. 3036	2.7086	4.0632
736.9826	.7427	3.0034	4.0338		163.7739	. 5101	2./201	+.1+07
818.0045	.0369	3.7940	4.0992		327.5+78	.5161	2.7427	4.2043
DISTANCE	00PT4	VEL OCTEV	DISCHARGE		409.4348	.8301	2.8077	4.4074
(FT)	(FT)	(FPS)	(CFS)		491.3217	. 3310	2-8107	4.4187
	1				655.0956	.0360	2.8713	4.5524
81.8870	1.0700	4.4918	10.0000		730.4824	. 3439	3.3117	5.3636
163.7739	. 4140	3.8807	7.0221		818.8695	.7584	4.1663	5.7630
245.6609	.8053	3-1387	+.7230		CONDITION	189.7 AT 189.7	465ECONDS	
327.5478	.1704	2.8920	4.0892		(FT)	(FT)	(EPS)	UISCHANGE (CES)
491.3217	.7636	2.8643	4.0004		14 A 2 A 4		10 2WAW	
573.2087	.7012	2.8782	4.0020	- C	.0000	.7925	2.718A	*.0000
736.9826	.7390	2.9125	4.0117		163.7739	. 5337	2.7414	4.1137
818.8695	.5359	3.7906	4.0854		245.6609	. 9105	2.7507	4.1444
CONDITION	NS AT 56.77	ASECONDS			327.5474	.0155	2.7742	4.2485
DISTANCE	UEPTH (ET)	VELOCITY	DISCHARGE		491.3217	.0280	2.0041	4.4530
			(Crar		573.2087	.8272	2.6701	4.4839
.0000	1.0404	4.0341	8.6452		655.0956	.0229	2.9294	4.5433
81.8870	1.0060	4.3090	9.5438		818.8675	.7053	4-094-	4.6919
245.6609	1.0048	4.3710	5.8619		MAXIMUM VALUES A	ND FIMES AT B	ACH _UCATION	
327.5478	. 3731	3.5932	5.V508		DISTANCE MAX DEP	TH TIME	HAX VEL TIME	MAN Q TIME
409.4348	.7883	3.0276	4.4214		40.94	49.50	4.54 30.57	10.00 30.57
573.2087	.7068	2.881	4.0573		81.89 1.07	23.32	4.47 40.74	9.86 40.76
655.0956	.7556	5.9160	+.0125		122.83 1.06	59.69	+. 45 40.58	9.59 48.04
736.9826	.7353	1.0541	+.0500		163.77 1.05	54.35	4.43 50.95	9.48 52.41
010.0045	.5347	3.7870	4.0714		245.06 1.03	05.51	4.40 5.32	9.39 58.23
DISTANCE	DE214	VEL OCT TY	DISCHARGE		286.00 1.03	09.88	4.39 65-51	9.22 55.60
(FT)	(FT)	(====)	(CFS)		327.55 1.02	74.24	4.37 71.33	9.13 72.79
				-	1.02	00.07	4.35 77.15	9.02 79.61
.0000	.3836	2.8386	4.8603		450.38 1.01	90.26	4.30 81.52	8.81 82.98
163.7739	1,0199	3.9327	8.2021		491.32 1.00	94.62	4.28 93.17	8.69 94.62
245.6609	1.0257	4.1375	8.0958		573.21 1.00	100.45	4.20 98.99	8.57 98.99
327.5478	1.0230	4.312+	9.0317		614.15 .08	110.60	4.24 103.36	8.46 104.81
409.4348	. 7042	4.1384	7.9931	-	655.10 .97	110.46	4.22 115.00	5.21 110.64
573.2087	7753	2.9823	4.2551		696.04 .95	122.24	4.22 119.37	1.99 120.83
655.0956	.7568	2.9366	+.05U0		730.98 .95	128.10	4.34 125.19	8.13 126.65
736.9826	.7325	3.0785	4.0551		818.87 .87	133.93	4.48 132.47	7.37 133.93
010.0095	.0340	3.7045	+. UHZ1			17 - 17 2 15 F		133:43

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Key Words: Finite-Difference Schemes, Unsteady Flow Equations, Method of Characteristics, Numerical Solutions of Differential Equations.	Key Words: Finite-Difference Schemes, Unsteady Flow Equations, Method of Characteristics, Numerical Solutions of Differential Equations.
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