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DESCRIPTION OF THE OPTIMIZED EPRF MULTI–LAYER HYDRODYNAMICAL–NUMERICAL MODEL

by

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OCTOBER 1974

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The multi-layer hydrodynamic-numerical (HN) model described here is a redesigned and optimized version of the multi-layer codes developed by the Environmental Prediction Research Facility (EPRF) using the finite difference scheme proposed and tested by Professor W. Hansen, University of Hamburg, Germany.

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20. (continued)

The model described is written in FORTRAN IV for CDC computers. The model is divided into three phases linked by a single intermediate tape. Phase I, which initializes the intermediate tape by writing on it the computed symbolic water height field, the water depth fields at U and V points, and the time 0 water height and velocity fields, is run on EPRF's CDC 3100 computer. Phase II, which computes time and space dependent terms, is run on either the CDC 6500 or the CDC 7600. Phase III is used to analyze, display and compare printed and plotted model results. It also runs on EPRF's CDC 3100 computer and produces plots on a CALCOMP pen plotter.

The optimized code has been designed to be independent of grid size and land-sea configuration so long as the maximum number of elements in the grid used does not exceed the assigned core. The model allows computation of currents in one to three uniform layers of different density water but limits diffusion processes to the surface layer.

The optimized model tests have shown approximately a 50% reduction in CDC 7600 run times, an improvement of the Berkeley ITO: CPU ratio from 1.1 to .5:1, a 10% reduction in small core and a 70% reduction in large core usage.

CONTENTS

INTRODUCTION

This report describes an optimized multi-layer hydrodynamic-numerical (HN) model. The numerical analysis technique used to express the hydrodynamic equations in finite difference form was developed by Professor Walter Hansen, University of Hamburg, Germany and has been tested over the course of two decades. Extensions of the HN model to two and three layers at Environmental Prediction Research Facility (EPRF) have been previously reported (see references 1 through 5) and have been tested by operational use in the New York Bight and in the southern California area.

The optimized multi-layer HN model, unlike earlier models reported, is based on a completely new program design developed to minimize both large computer costs and the number of program changes required to run different areas. This has been accomplished by dividing the functions in earlier models into three separate programs, only one of which requires a large computer, and by using coding techniques that are both more efficient and more generalized than those previously employed.

In the optimized model design, the Phase I program is run on EPRF's CDC 3100 computer. This program provides an edit of the master control card deck used by the Phase II program and initializes the intermediate tape. The program reads the water depth at U and V points, computes the symbolic water height, HTZ, and provides depth unit conversion and edit facilities to change segments or elements in the fields. It also contains logic to convert old and new format depth tables, to punch corrected depth tables and to extract a portion of the grid.

The Phase II program is run on a large computer, either a CDC 6500 or 7600. It contains optimized computation for currents, water heights, and the advection and diffusion of pollutants. Selected current and water heights are stored on the intermediate tape.

The model can be run using one, two, or three layers. It is independent of grid dimension so long as the number of elements in the grid does not exceed allocated storage. Grid indexing is minimized by employing a single subscript within the limits set to the first and last sea cell in each column. In this model, outside boundary rows and columns in the horizontal grid have been eliminated.

Wind fields, tidal input, pollution sources, and boundary flows can be applied to a single point or rectangular sub-area. Although no interpolation between tide stations is provided, the program can accept precomputed data at any grid point. The wind field descriptions may apply either to sequential times or to describe different wind conditions persisting for identical periods in different portions of the grid. Sources of pollutants must have positive concentration and are diffused only in the surface layer but may specify input volumes per time step at any level. Constant flows (e.g., river outflow) specified in terms of current direction and velocity can be added at any or all levels.

Since the program searches the intermediate tape for the Z, U and V fields for the start time specified and writes the same fields back out to the intermediate tape, the intermediate tape provides both an automatic checkpoint capability and the flexibility to change winds or other parameters after any previously computed time step.

The Phase III program reads the current and water height fields from the intermediate tape and provides selective printouts of the results for horizontal fields, for vertical cross-section, and for time series at any specified points. Unlike earlier displays, this program allows graphical comparison for up to three levels or up to three different model runs.

The program computes rest currents and can be modified to compute other auxiliary parameters such as ship drift which are based on the currents and wind but do not influence the HN model results.

Use of the Phase II program has reduced processing costs on the large computer by approximately one-half as compared with an older version of the program. Additional reductions in large computer costs are anticipated because changes in auxiliary computation will not require complete reruns of Phase II.

1. STATEMENT OF THE MODEL

1.0 GENERAL

The use of hydrodynamic-numerical models for the computation of tides and currents was originally proposed by Professor Walter Hansen in 1938. However, until the advent of the electronic computer, the method was not economically feasible or practical. During the last 20 years the basic solutions obtained with single layer models have been well tested. In collaboration with Professor Hansen, Dr. Laevastu (first at FNWC and for the last three years at EPRF) has extended the model to allow multiple open boundaries, multiple layers and various auxiliary computations. Results obtained from the expanded models have been previously reported (see references 1 through 5).

The primary goal of this project was to redesign the existing codes so that they would run faster and use less computer memory and to allow new capabilities to once again be added without excessive increase to the computer overhead costs.

The secondary goal of this project was to provide a single flexible model that could replace more than a dozen single and multi-layer models that have been coded for specific geographic configuration and grid sizes and represented different stages of model development.

1.1 BASIC MULTI-LAYER HYDRODYNAMICAL EQUATIONS

The layer-by-layer vertically integrated hydrodynamic equations were proposed by Professor Walter Hansen (personal communication between Dr. Laevastu and Professor Hansen). They are analogous to the well-proven single layer HN model.

$$\dot{\zeta}_1 - \dot{\zeta}_2 + (H_{u1}\ U1)_x + (H_{v1}\ V1)_y = 0 \tag{1}$$

$$\dot{\zeta}_2 - \dot{\zeta}_3 + (H_{u2}\ U2)_x + (H_{v2}\ V2)_y = 0 \tag{2}$$

$$\dot{\zeta}_3 + (H_{u3}\ U3)_x + (H_{v3}\ V3)_y = 0 \tag{3}$$

$$\dot{U}1 + \frac{r\sqrt{U1^2 + V1^2}}{H_u} U1 - fV1 + g\,\zeta_{1x} = K^{(x)} \tag{4}$$

$$\dot{U}2 + \frac{r\sqrt{U2^2 + V2^2}}{H_{u2}} U2 - fV2 + g\,\frac{\rho_1}{\rho_2}\,\zeta_{1x} + g\,(1 - \frac{\rho_1}{\rho_2})\,\zeta_{2x} = 0 \tag{5}$$

$$\dot{U}3 + \frac{r_b\sqrt{U3^2 + V3^2}}{H_{u3}} U3 - fV3 + g\,\frac{\rho_2}{\rho_3}\,\zeta_{2x} + g\,(1 - \frac{\rho_2}{\rho_3})\,\zeta_{3x} = 0 \tag{6}$$

$$\dot{V}1 + \frac{r\sqrt{U1^2 + V1^2}}{H_{v1}} V1 + fU1 + g\,\zeta_{1y} = K^{(y)} \tag{7}$$

$$\dot{V}2 + \frac{r\sqrt{U2^2 + V2^2}}{H_{v2}} V2 + fU2 + g\,\frac{\rho_1}{\rho_2}\,\zeta_{1y} + g\,(1 - \frac{\rho_1}{\rho_2})\,\zeta_{2y} = 0 \tag{8}$$

$$\dot{V}3 + \frac{r_b\sqrt{U3^2 + V3^2}}{H_{v3}} V3 + fU3 + g\,\frac{\rho_2}{\rho_3}\,\zeta_{2y} + g\,(1 - \frac{\rho_2}{\rho_3})\,\zeta_{3y} = 0 \tag{9}$$

where:

ζ_1 - surface elevation

ζ_2 - deviation of MLD (Mixed Layer Depth) from its mean (initially prescribed) depth

ζ_3 - deviation of second and third layer interface from its mean (initially prescribed) depth

U1, V1 - u,v components in first layer

U2, V2 - u,v components in second layer

U3, V3 - u,v components in third layer

r - friction coefficient (internal friction)

f - Coriolis parameter

r_b - bottom friction coefficient

g - acceleration of gravity

H - depth

ρ_1, ρ_2, ρ_3 - densities of the respective layers

$K^{(x)}, K^{(y)}$ - external forces

There are three inter-dependent continuity equations, one for each layer. These compute the change of sea level, the change of depth, and the thickness of the layers.

The equations of motion for each layer are vertically integrated through the given layer. The lower layers are driven by internal friction and by pressure gradients.

1.2 COMPUTATIONAL GRID

The finite difference technique described in the following section is based on a staggered geographic grid shown in Figure 1-1. The Z grid points (intersection) identify the geographic position where water heights and resultant velocity vectors are

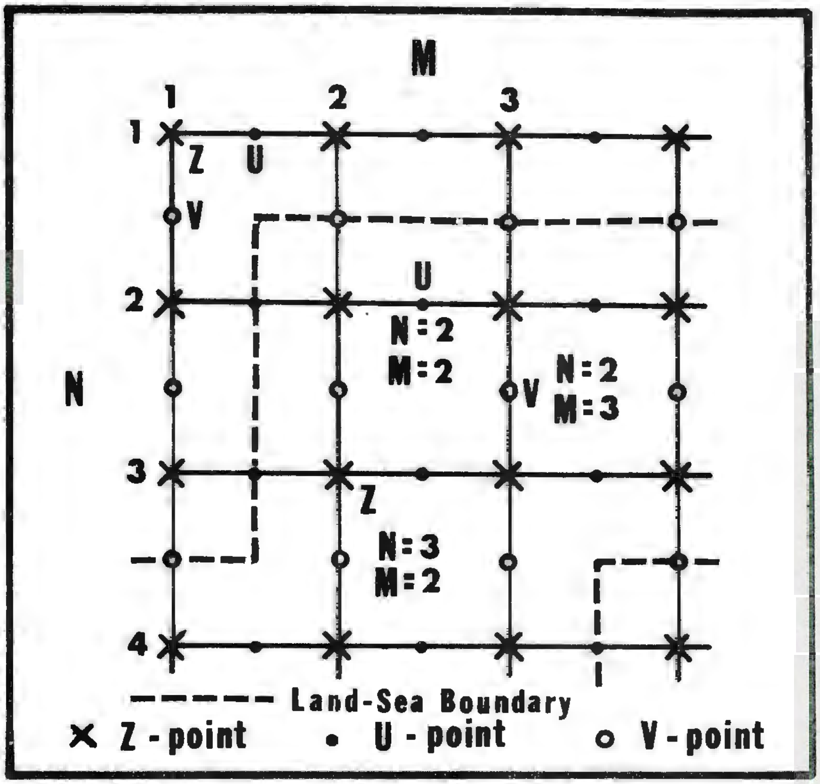


Figure 1-1. Scheme of the grid net.

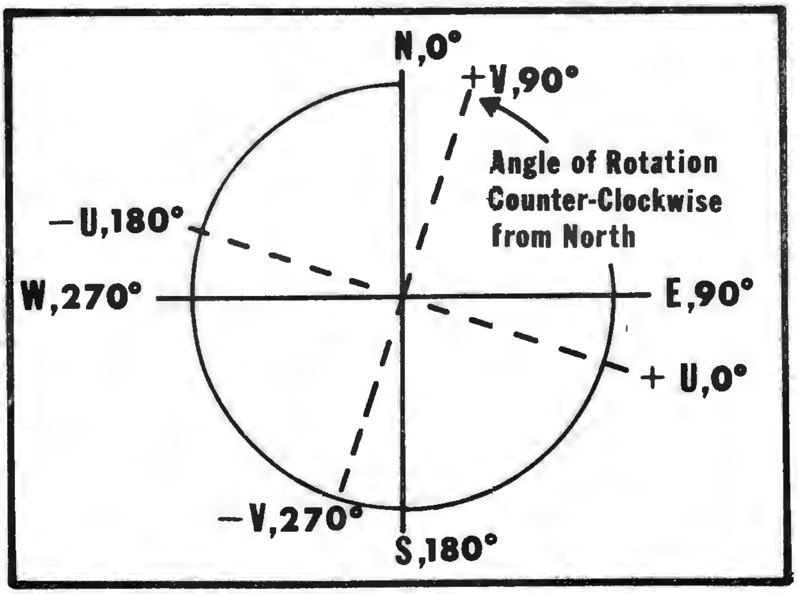


Figure 1-2. Relations between the geographic coordinates and computation coordinates.

calculated. The U grid is offset 1/2 grid length to the right of the Z grid, and the V grid is offset 1/2 grid length below the Z grid. Velocity computed at a U point is positive if the current flows through the U point to the right. Velocity in the V grid is positive if the current flows through the V point upward. To calculate a resultant velocity vector the X component is taken from the U point to the right of the Z grid point and the Y component is taken from the V point below the Z grid point. Because of this convention, velocities calculated for Z cells along the bottom and right sides of the grid are not meaningful.

The land-sea interface line in the staggered grid is defined by a line passing vertically through U points and horizontally through V points. This line passes through the centers of the Z grid cells and will not pass through any Z point. All land and sea features must contain at least one Z grid point.

Open sea boundaries are assumed along the outside rows and columns of the Z grid unless the Z and U or V values in the outside row or column are zero.

Because of limitation in earlier models, it has been the practice to rotate the grid so that the top of the grid is the principal entrance from which the major tide moves into the area.

In this model, the grid rotation is specified as the counter-clockwise angle between North and the +Y axis of the computational grid. See Figure 1-2.

All winds are specified in degrees true from which the winds are blowing. Currents are specified in degrees true in the direction toward which they are flowing.

By convention, the grid intersections are numbered using double subscripts with row first. The row index is N where $1 \le N \le NE$ and the column index is M where $1 \le M \le ME$.

1.3 FINITE DIFFERENCE FORM OF BASIC EQUATIONS

The finite difference forms used for computations are essentially the same as in W. Hansen's single layer model, except for the additional terms dictated by the presence of several layers:

$$\begin{aligned}
\zeta^{t+\tau}_{(n,m,1)} = {} & \bar{\zeta}^{t-\tau}_{(n,m,1)} - \frac{\tau}{\ell} \{H^{t-\tau}_{u(n,m,1)}\, U^{t}_{(n,m,1)} - H^{t-\tau}_{u(n,m-1,1)} \\
& U^{t}_{(n,m-1,1)} + H^{t-\tau}_{v(n-1,m,1)}\, V^{t}_{(n-1,m,1)} - H^{t-\tau}_{v(n.m,1)} \\
& V^{t}_{(n,m,1)}\} - \frac{\tau}{\ell} \{H^{t-\tau}_{u(n,m,2)}\, U^{t}_{(n,m,2)} - H^{t-\tau}_{u(n,m-1,2)} \\
& U^{t}_{(n,m-1,2)} + H^{t-\tau}_{v(n-1,m,2)}\, V^{t}_{(n-1,m,2)} - H^{t-\tau}_{v(n,m,2)} \\
& V^{t}_{(n,m,2)}\} - \frac{\tau}{\ell} \{H^{t-\tau}_{u(n,m,3)}\, U^{t}_{(n,m,3)} - H^{t-\tau}_{u(n,m-1,3)} \\
& U^{t}_{(n,m-1,3)} + H^{t-\tau}_{v(n-1,m,3)}\, V^{t}_{(n-1,m,3)} - H^{t-\tau}_{v(n,m,3)} \\
& V^{t}_{(n,m,3)}\}
\end{aligned} \qquad (10)$$

$$\begin{aligned}
\zeta^{t+\tau}_{(n,m,2)} = {} & \bar{\zeta}^{t-\tau}_{(n,m,2)} - \frac{\tau}{\ell} \{H^{t-\tau}_{u(n.m,2)}\, U^{t}_{(n,m,2)} - H^{t-\tau}_{u(n.m-1,2)} \\
& U^{t}_{(n,m-1,2)} + H^{t-\tau}_{v(n-1,m,2)}\, V^{t}_{(n-1,m,2)} - H^{t-\tau}_{v(n,m,2)} \\
& V^{t}_{(n,m,2)}\} - \frac{\tau}{\ell} \{H^{t-\tau}_{u(n,m,3)}\, U^{t}_{(n,m,3)} - H^{t-\tau}_{u(n,m-1,3)} \\
& U^{t}_{(n,m-1,3)} + H^{t-\tau}_{v(n-1,m,3)}\, V^{t}_{(n-1,m,3)} - H^{t-\tau}_{v(n,m,3)} \\
& V^{t}_{(n,m,3)}\}
\end{aligned} \qquad (11)$$

$$\zeta^{t+\tau}_{(n,m,3)} = \bar{\zeta}^{t-\tau}_{(n,m,3)} - \frac{\tau}{\ell} \{ H^{t-\tau}_{u(n,m,3)} U^{t}_{(n,m,3)} - H^{t-\tau}_{u(n,m-1,3)} U^{t}_{(n,m-1,3)} + H^{t-\tau}_{v(n-1,m,3)} V^{t}_{(n-1,m,3)} - H^{t-\tau}_{v(n,m,3)} V^{t}_{(n,m,3)} \} \tag{12}$$

$$U^{t+2\tau}_{(n,m,1)} = \{1-[2\tau r/H^{t+\tau}_{u(n,m,1)}] \sqrt{\bar{U}^{t\,2}_{(n,m,1)} + V^{*t\,2}_{(n,m,1)}}\} \bar{U}^{t}_{(n,m,1)} + 2\tau f V^{*t}_{(n,m,1)} - \frac{\tau g}{\ell} \{ \zeta^{t+\tau}_{(n,m+1,1)} - \zeta^{t+\tau}_{(n,m,1)}\} + 2\tau X^{t+\tau}_{(n,m)} \tag{13}$$

$$U^{t+2\tau}_{(n,m,2)} = \{1-[2\tau r/H^{t+\tau}_{u(n,m,2)}] \sqrt{\bar{U}^{t\,2}_{(n,m,2)} + V^{*t\,2}_{(n,m,2)}}\} \bar{U}^{t}_{(n,m,2)} + 2\tau f V^{*t}_{(n,m,2)} - \frac{\tau g}{\ell} \{\frac{\rho_1}{\rho_2} [\zeta^{t+\tau}_{(n,m+1,1)} - \zeta^{t+\tau}_{(n,m,1)}]\} - \frac{\tau g}{\ell} \{[1-\frac{\rho_1}{\rho_2}] [\zeta^{t+\tau}_{(n,m+1,2)} - \zeta^{t+\tau}_{(n,m,2)}]\} \tag{14}$$

$$U^{t+2\tau}_{(n,m,3)} = \{1-[2\tau r_b/H^{t+\tau}_{u(n,m,3)}] \sqrt{\bar{U}^{t\,2}_{(n,m,3)} + V^{*t\,2}_{(n,m,3)}}\} \bar{U}^{t}_{(n,m,3)} + 2\tau f V^{*t}_{(n,m,3)} - \frac{\tau g}{\ell} \{\frac{\rho_2}{\rho_3} [\zeta^{t+\tau}_{(n,m+1,2)} - \zeta^{t+\tau}_{(n,m,2)}]\} - \frac{\tau g}{\ell} \{[1-\frac{\rho_2}{\rho_3}] [\zeta^{t+\tau}_{(n,m+1,3)} - \zeta^{t+\tau}_{(n,m,3)}]\} \tag{15}$$

$$V^{t+2\tau}_{(n,m,1)} = \{1-[2\tau r/H^{t+\tau}_{v(n,m,1)}] \sqrt{\bar{V}^{t}_{(n,m,1)}{}^{2} + U^{*t}_{(n,m,1)}{}^{2}}\}\bar{V}^{t}_{(n,m,1)}$$

$$-2\,\tau f U^{*t}_{(n,m,1)} - \frac{\tau g}{\ell}\{\zeta^{t+\tau}_{(n,m,1)} - \zeta^{t+\tau}_{(n+1,m,1)}\}$$

$$+2\tau Y^{t+\tau}_{(n,m)} \qquad (16)$$

$$V^{t+2\tau}_{(n,m,2)} = \{1-[2\tau r/H^{t+\tau}_{v(n,m,2)}] \sqrt{\bar{V}^{t}_{(n,m,2)}{}^{2} + U^{*t}_{(n,m,2)}{}^{2}}\}\bar{V}^{t}_{(n,m,2)}$$

$$-2\tau f\ U^{*t}_{(n,m,2)} - \frac{\tau g}{\ell}\{\frac{\rho_1}{\rho_2}[\zeta^{t+\tau}_{(n,m,1)} - \zeta^{t+\tau}_{(n+1,m,1}]\}$$

$$-\frac{\tau g}{\ell}\{[1-\frac{\rho_1}{\rho_2}][\zeta^{t+\tau}_{(n,m,2)} - \zeta^{t+\tau}_{(n+1,m,2}]\} \qquad (17)$$

$$V^{t+2\tau}_{(n,m,3)} = \{1-[2\tau r_b/H^{t+\tau}_{v(n,m,3)}] \sqrt{\bar{V}^{t}_{(n,m,3)}{}^{2} + U^{*t}_{(n,m,3)}{}^{2}}\}\bar{V}^{t}_{(n,m,3)}$$

$$-2\tau f\ U^{*t}_{(n,m,3)} - \frac{\tau g}{\ell}\{\frac{\rho_2}{\rho_3}[\zeta^{t+\tau}_{(n,m,2)} - \zeta^{t+\tau}_{(n+1,m,2)}]\}$$

$$-\frac{\tau g}{\ell}\{[1-\frac{\rho_2}{\rho_3}][\zeta^{t+\tau}_{(n,m,3)} - \zeta^{t+\tau}_{(n+1,m,3)}]\} \qquad (18)$$

The computation of $\bar{U}$ and U^* is also done as in single-layer model.*

$$\bar{U}^{t}_{(n,m)} = \alpha U^{t}_{(n,m)} + \frac{1-\alpha}{4}\{U^{t}_{(n-1,m)} + U^{t}_{(n+1,m)}$$

$$+ U^{t}_{(n,m+1)} + U^{t}_{(n,m-1)}\} \qquad (19)$$

$$U^{*t}_{(n,m)} = \frac{1}{4}\{U^{t}_{(n,m-1)} + U^{t}_{(n+1,m-1)} + U^{t}_{(n,m)} + U^{t}_{(n+1,m)}\}$$

$$(20)$$

---

*For the deeper layer α is substituted with α_d which has a lower value.

The computation of $\bar{V}$ and V^* are analogous to the corresponding U computations above. The actual depth (and thickness of the layers) is computed with the following equations:

$$H^{t+\tau}_{u(n,m,1)} = h_{u(n,m,1)} + \frac{1}{2}\{\zeta^{t+\tau}_{(n,m,1)} + \zeta^{t+\tau}_{(n,m+1,1)}\}$$
$$-\frac{1}{2}\{\zeta^{t+\tau}_{(n,m,2)} + \zeta^{t+\tau}_{(n,m+1,2)}\} \qquad (21)$$

$$H^{t+\tau}_{v(n,m,1)} = h_{v(n,m,1)} + \frac{1}{2}\{\zeta^{t+\tau}_{(n,m,1)} + \zeta^{t+\tau}_{(n+1,m,1)}\}$$
$$-\frac{1}{2}\{\zeta^{t+\tau}_{(n,m,2)} + \zeta^{t+\tau}_{(n+1,m,2)}\} \qquad (22)$$

$$H^{t+\tau}_{u(n,m,2)} = h_{u(n,m,2)} + \frac{1}{2}\{\zeta^{t+\tau}_{(n,m,2)} + \zeta^{t+\tau}_{(n,m+1,2)}\}$$
$$-\frac{1}{2}\{\zeta^{t+\tau}_{(n,m,3)} + \zeta^{t+\tau}_{(n,m+1,3)}\} \qquad (23)$$

$$H^{t+\tau}_{v(n,m,2)} = h_{v(n,m,2)} + \frac{1}{2}\{\zeta^{t+\tau}_{(n,m,2)} + \zeta^{t+\tau}_{(n+1,m,2)}\}$$
$$-\frac{1}{2}\{\zeta^{t+\tau}_{(n,m,3)} + \zeta^{t+\tau}_{(n+1,m,3)}\} \qquad (24)$$

$$H^{t+\tau}_{u(n,m,3)} = h_{u(n,m,3)} + \frac{1}{2}\{\zeta^{t+\tau}_{(n,m,3)} + \zeta^{t+\tau}_{(n,m+1,3)}\} \qquad (25)$$

$$H^{t+\tau}_{v(n,m,3)} = h_{v(n,m,3)} + \frac{1}{2}\{\zeta^{t+\tau}_{(n,m,3)} + \zeta^{t+\tau}_{(n+1,m,3)}\} \qquad (26)$$

The following symbols were used in the finite difference formulas above:

x,y	space coordinates
t	time
U,V	components of velocity
u,v	indicators of u and v points (location) in the grid
h	initial depth (when $\zeta=0$)
ζ	surface elevation (for second and third layer it indicates the deviation of the depth of the layer from its prescribed mean value)
H	total depth ($H=h+\zeta$)
H_u,H_v	depths at u and v points respectively (also actual thickness of the layer at u and v points)
X,Y	components of external forces
g	acceleration of gravity
f	Coriolis parameter
r	internal friction coefficient
r_b	bottom stress for lower layer
α	coefficient of horizontal eddy viscosity (also acts as a smoothing coefficient)
n,m	coordinates of the grid point, 1, 2, and 3 indicate the first (surface), second and third layer, respectively
τ	half time step
ℓ	half grid length
ρ_1,ρ_2,ρ_3	densities of first, second, and third layer

1.4 COMPUTATION OF CONSTANTS

The Coriolis parameter and gravity are calculated within the program based on the latitude. Southern latitudes are considered negative. The Coriolis parameter is calculated as follows (Ref. 6):

$$C = 2\omega \text{Sin}\ \phi$$

C = Coriolis parameter

ω = angular velocity of the earth ($7.292116\text{X}10^{-5}$ rad/sec)

ϕ = latitude

Gravity as a function of latitude is given by the following formula (Ref. 7):

$$G = 980.616\ (1.-.0026373\ \text{Cos}\ 2\phi+.0000059\ \text{Cos}^{2} 2\phi)$$

In Phase I the maximum time step based on Courant-Friedrich-Lewy stability criterion is calculated from the maximum actual depth in the HTU and HTV array after inclusion of a false bottom if one is used. The time step calculated is for the full time step in keeping with the manner the time increment is specified on the TIME card.

$$\Delta t = \ell / (2\ GH\ \text{max})^{\frac{1}{2}}$$

Δt = full time step (sec)

ℓ = distance between Z grid points (cm)

H max = maximum water depth at a HTU or HTV point (cm)

Bottom friction is specified on the GRID control card while internal friction is presently set internally to 50 percent of bottom friction.

2. OPERATING INSTRUCTIONS

2.0 GENERAL

This section describes the deck setups and card formats. The variable names used are further identified in paragraph 4.3 and section 5.

The model is divided into three phases as illustrated in Figure 2-1. All programs have the capability to read the entire master control card deck. This deck contains all parameters required by the Phase II program except for the fields located on the intermediate tape. The master control cards that are required for Phases I and III are shown on their deck setups. Unless specified in the deck setup, master control cards may be in any order.

2.1 MASTER CONTROL CARD DECK SPECIFICATIONS

The cards described below are also shown on the master control card layout form shown as Figure 2-2.

NAME Card		Format (20A4)
1-4		NAME
5-80		Comments or titles (any number of cards may be used to identify the output)

GRID Card		Format (A4,2I3,7E10.3)
1-4		GRID
5-7	NE	Number of rows
8-10	ME	Number of columns
11-20	DL	Distance between grid points (cm)
21-30	ROTANG	Counter-clockwise angles between north and the +Y axis of the computational grid (deg)
31-40	C	Wind drag coefficient
41-50	TK	Mid latitude of grid (deg)
51-60	R	Bottom friction coefficient
61-70	AUS	Austausch coefficient

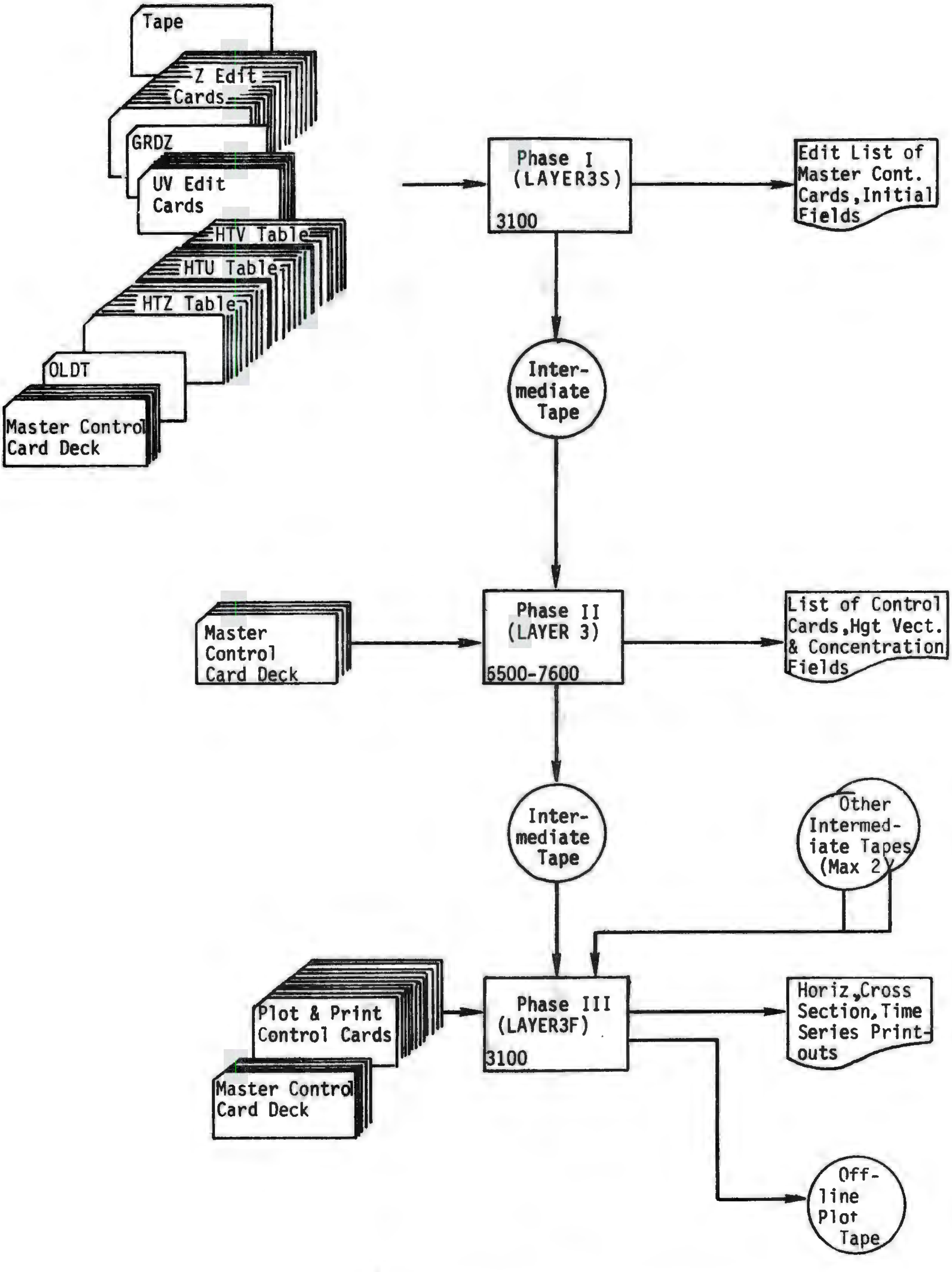
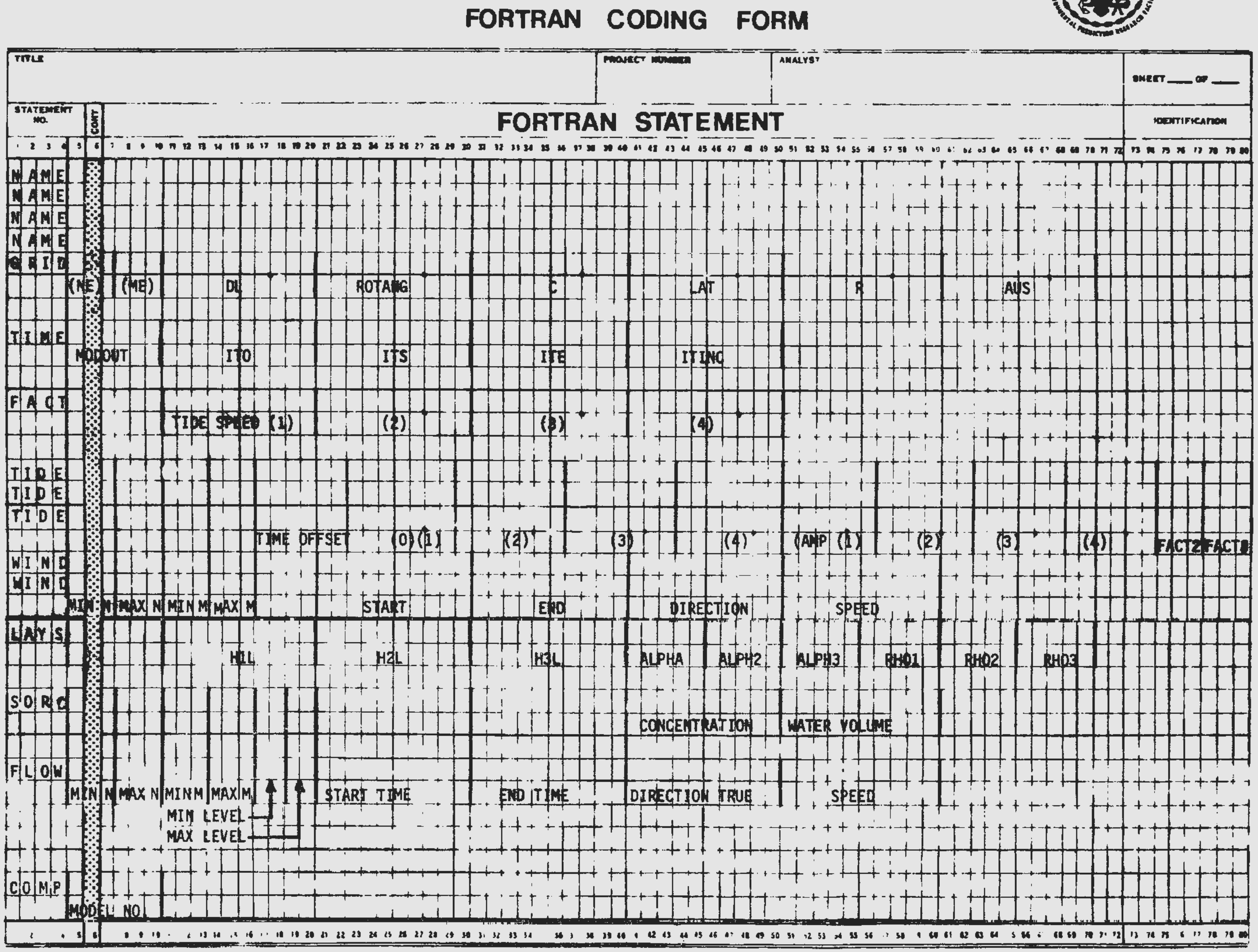


Figure 2-1. Overview of model organization



FORTRAN CODING FORM

TITLE | PROJECT NUMBER | ANALYST | SHEET ___ OF ___

STATEMENT NO. | CONT | FORTRAN STATEMENT | IDENTIFICATION

NAME
NAME
NAME
NAME
GRID
(NE) (ME) DL ROTANG C LAT R AUS
TIME
MODOUT ITO ITS ITE ITINC
FACT
TIDE SPEED (1) (2) (3) (4)
TIDE
TIDE
TIDE
TIME OFFSET (0) (1) (2) (3) (4) (AMP (1) (2) (3) (4) FACT2 FACT3
WIND
WIND
MIN N MAX N MIN M MAX M START END DIRECTION SPEED
LAYS
H1L H2L H3L ALPHA ALPH2 ALPH3 RHO1 RHO2 RHO3
SORC
CONCENTRATION WATER VOLUME
FLOW
MIN N MAX N MIN M MAX M START TIME END TIME DIRECTION TRUE SPEED
MIN LEVEL
MAX LEVEL
COMP
MODEL NO

Figure 2-2. Master control card layout form.

TIME Card

Format (A4,I6,9I10)

1-4		TIME
5-10	MODOUT	Number of seconds between saved results
11-20	ITO	Time of first output in seconds
21-30	ITS	Start time for computations in seconds. If this time is greater than zero, the intermediate tape is assumed to contain U,V and Z arrays for necessary levels at the time specified.
31-40	ITE	End time for computations in seconds
41-50	ITINC	Time step in seconds
51-60	IPO	Time of first printout
61-70	IPMOD	Number of seconds between printouts

FACT Card

Format (A4,6X,7E10.3)

1-4		FACT (when present must precede TIDE cards)
5-10		Blank
11-20	TIDSPD(1)	Speed of the tidal constituents (see Ref. 8) (Match order of component phase angle and amplitude on TIDE card) K1 = 15.0410686 (deg/hr) O1 = 13.9430356 M2 = 28.9841042 S2 = 30.0000000 N2 = 28.4397295
21-30	(2)	
31-40	(3)	
41-50	(4)	

TIDE Card

Format (A4,4I3,I6,4F7.2,4F6.2,2F3.2)

1-4		TIDE $(0 \le J \le 4)$
5-7	ITIDE(1,J)	Minimum row (N) index for tidal input
8-10	ITIDE(2,J)	Maximum row (N) index for tidal input
11-13	ITIDE(3,J)	Minimum column (M) index for tidal input
14-16	ITIDE(4,J)	Maximum column (M) index for tidal input
17-22	ITIDE(5,J)	Time offset between time of computations and time 0 tide phase angle (sec)

23-29	TIDE(1,J)	Tidal constituents 1 phase angle (deg/hr)
30-36	TIDE(2,J)	2
37-43	TIDE(3,J)	3
44-50	TIDE(4,J)	4
51-56	TIDE(5,J)	Tidal constituents 1 amplitude (cm)
57-62	TIDE(6,J)	2
63-68	TIDE(7,J)	3
69-74	TIDE(8,J)	4
75-77	TIDE(9,J)	Weight factor for second layer tide heights
78-70	TIDE(10,J)	Weight factor for third layer tide heights

WIND Card

Format (A4,4I3,4X4I10)

1-4		WIND ($0 \le J \le 4$)
5-7	IWIND(1,J)	Minimum row (N) index for wind field
8-10	IWIND(2,J)	Maximum row (N) index for wind field
11-13	IWIND(3,J)	Minimum column (M) index for wind field
14-16	IWIND(4,J)	Maximum column (M) index for wind field
17-20		Blank
21-30	IWIND(5,J)	Wind start time (sec)
31-40	IWIND(6,J)	Wind end time (sec)
41-50	IWIND(7,J)	Wind direction (degs true from which wind blows)
51-60	IWIND(8,J)	Wind speed (m/sec) Note: This is the only measurement in the input given in meters rather than cm.

LAYS Card

Format (A4,6X,3F10.0,8F5.0)

1-4		LAYS		
5-10		Blank		
11-20	H1L	Maximum depth of layer	1	if zero the layer is ignored in the computations
21-30	H2L		2	
31-40	H3L		3	
41-45	ALPHA	Smoothing parameters for layer	1	
46-50	ALPH2		2	
51-55	ALPH3		3	
56-60	RHO1	Density for layer	1	
61-65	RHO2		2	
66-70	RHO3		3	

SORC Card Format (A4,4I3,2I2,2I10,4E10.3)

1-4		SORC ($0<J\le 10$)
5-7	ISORC(1,J)	Minimum row (N) index for source
8-10	ISORC(2,J)	Maximum row (N) index for source
11-13	ISORC(3,J)	Minimum column (M) for source
14-16	ISORC(4,J)	Maximum column (M) for source
17-18	ISORC(5,J)	Minimum level (LM) index for source
19-20	ISORC(6,J)	Maximum level (LP) index for source
21-30	ISORC(7,J)	Start time for source
31-40	ISORC(8,J)	End time for source
41-50	SORC(1,J)	Concentration introduced per time step
51-60	SORC(2,J)	Volume of water introduced per time step per level (cm^3)

FLOW Card Format (A4,4I3,2I2,2I10,4E10.3)

1-4	FLOW ($0<J\le 4$)
5-40	Same as SORC card
41-50	Direction of flow (degrees true)
51-60	Velocity (cm/time step)

COMP Card Format (A4,I6)

1-4		COMP This card is used to start the computations in the LAYER3 program. It is the last card read in the control card deck by the program LAYER3.
5-10	MODEL	Model number used in record header on intermediate tape.

2.2 PHASE I OPERATING INSTRUCTIONS

The CDC 3ˉ00 Phase I program is called LAYER3S.

2.2.1 Logical Units

1 Intermediate tape (required only if TAPE card is used) 556 output tape

2 Scratch Unit (required only if GRDZ or TAPE cards are used) disk

2.2.2 Deck Set Up

$^{7}_{9}$SEQUENCE,120,RAB,EPRF-OCEAN-CSI

$^{7}_{9}$JOB,LAYER3S,BAUER,5,NP,ND

$^{7}_{9}$FET,LAYER3,BAUER,512,00,0000,0000

$^{7}_{9}$RELEASE,ALL

$^{7}_{9}$ALLOCATE,100,,S

$^{7}_{9}$OPEN,02

$^{7}_{9}$EQUIP,01=MT

Binary decks for

LAYER3S	IOUT
PRTMX	IOERR
XMIT	GEOPOS
GRID	TIDCUR

$^{7}_{9}$RUN

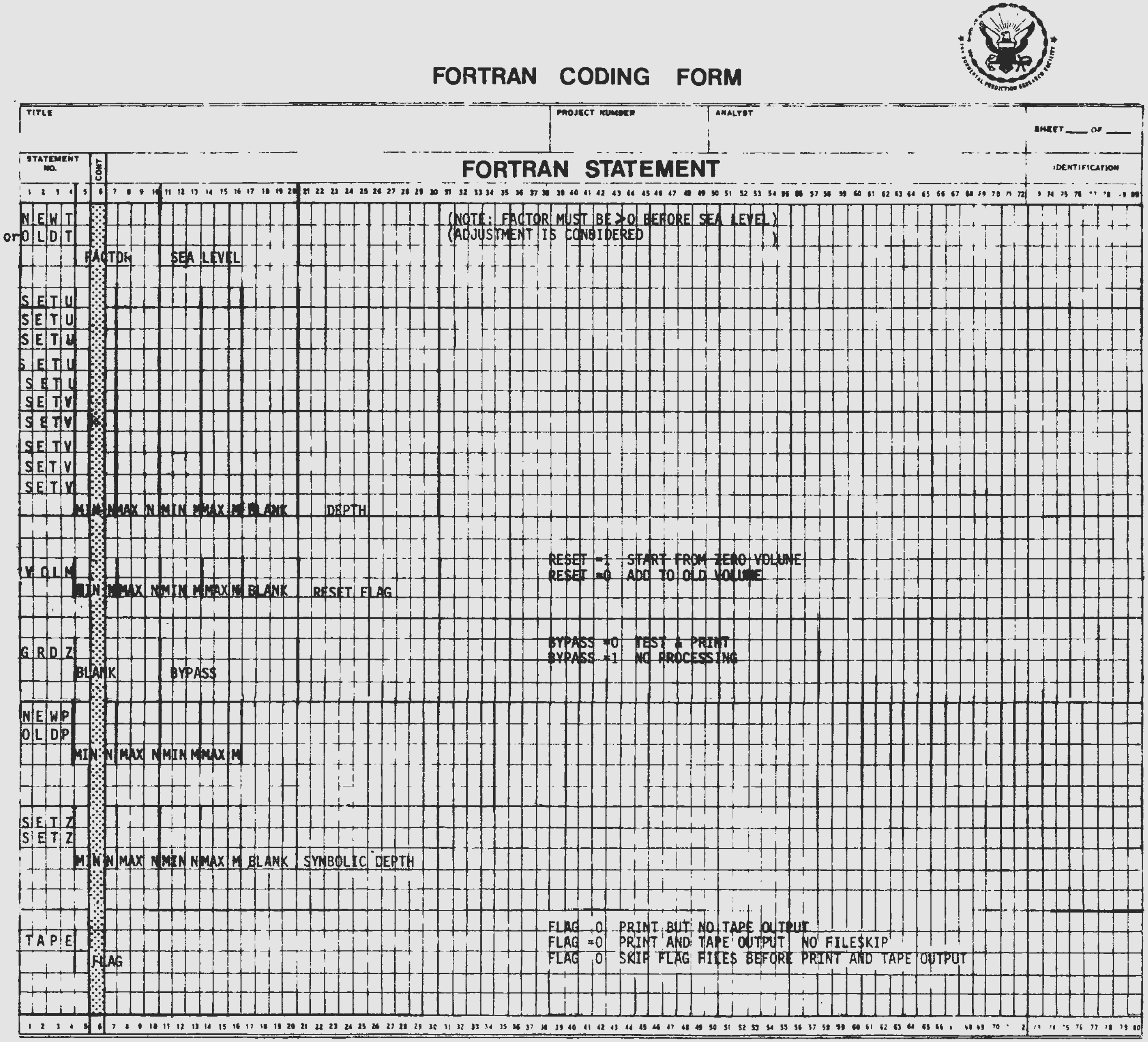
----(MASTER CONTROL CARD DECK)----

NAME	(as many as needed to identify run)
GRID	(required)
TIME	(must precede TIDE card when TIDE card is present)
FACT	(must precede TIDE cards if present)
TIDE	(not more than MAXTIDE)
WIND	(not more than MAXWIND)
LAYS	(required)
SORC	(not more than MAXSORC)
FLOW	(not more than MAXFLOW)
COMP	(required if TAPE card present)

```
----(LAYER3S CONTROL CARDS)----
OLDT       |Read old format HTZ, HTU and HTV tables
Zdeck      |
Udeck      |Option 1
Vdeck      |

NEWT       |Read new format HTU and HTV tables
Udeck      |Option 2
Vdeck      |

SETU        Modify HTU array
SETV        Modify HTV array
VOLM        Compute volume of water in a geographic area
GRDZ        Compute HTZ table using HTU, HTV and depths
              from LAYS card
SETZ        Modify HTZ (set open boundary for old format
              table)
OLDP        Punch old table format HTZ, HTU, HTV fields
NEWP        Punch new table format HTU, HTV fields
TAPE        Write intermediate tape and list HTZ, HTU and
              HTV fields

77
88 (MSOS end-of-job card)

7
9SEQUENCE,120,RAB,EPRF-OCEAN-CSI   (release file)

7
9JOB,LAYER3S,BAUER,5,ND

7
9FET,LAYER3,BAUER,512,00,0000,0000

7
9RELEASE ALL

77
88
```

2.2.3 LAYER3S Control Cards

The cards described below are shown on the PHASE I control card layout form shown as Figure 2-3.



FORTRAN CODING FORM

TITLE | PROJECT NUMBER | ANALYST | SHEET ___ OF ___

STATEMENT NO. | CONT | FORTRAN STATEMENT | IDENTIFICATION

```
   NEWT                               (NOTE: FACTOR MUST BE >0 BEFORE SEA LEVEL)
or OLDT                               (ADJUSTMENT IS CONSIDERED                )
       FACTOR    SEA LEVEL

   SETU
   SETU
   SETU
   SETU
   SETU
   SETV
   SETV
   SETV
   SETV
   SETV
       MIN NMAX NMIN MMAX MBLANK     DEPTH

                                              RESET =1  START FROM ZERO VOLUME
   VOLM                                       RESET =0  ADD TO OLD VOLUME
       MIN NMAX NMIN MMAX NBLANK    RESET FLAG


                                              BYPASS =0  TEST & PRINT
   GRDZ                                       BYPASS =1  NO PROCESSING
       BLANK     BYPASS

   NEWP
   OLDP
       MIN N MAX NMIN MMAX M


   SETZ
   SETZ
       MIN N MAX NMIN NMAX M BLANK  SYMBOLIC DEPTH


                                              FLAG  0  PRINT BUT NO TAPE OUTPUT
   TAPE                                       FLAG =0  PRINT AND TAPE OUTPUT  NO FILESKIP
        FLAG                                  FLAG  0  SKIP FLAG FILES BEFORE PRINT AND TAPE OUTPUT
```

Figure 2-3. Phase I control card layout form.

NEWT Card

Format (A4,F6.3,F10.0)

1-4		NEWT Read in new format HTU and HTV tables that follow card
5-10	FAC	Conversion factor used to change depth units to cm if blank no conversion is made.
11-20	SEALEV	Sea level adjustment to be added to water depths in cm used only if FAC≠0.

OLDT Card

Format (A4,F6.3,F10.0)

1-4		OLDT Read in old format HTZ, HTU, HTV tables that follow card
5-10	FAC	Conversion factor used to change depth units to cm if required. If blank no conversion is performed
11-20	SEALEV	Sea level adjustment to be added to water depths in cm

SETU Card

Format (A4,4I3,4X,I10)

1-4		SETU Set the value ICC in HTU within the limits
5-7		Minimum row (N) dimension
8-10		Maximum row (N) dimension, if 0 set to min value
11-13		Minimum column (M) dimension
14-16		Maximum column (M) dimension, if 0 set to min value
17-20		Blank
21-30	ICC	Value to be placed in array. (Same units as HTU field)

SETV Card

Same as SETU. Modify HTV array

VOLM Card

Format (A4,4I3,4X,I10)

1-4	VOLM
5-20	Same as SETU card
21-30	Reset flag 1 = volume to zero before computing volume 0 = add computed volume to previous volume

GRDZ Card	Format (A4,6XI10)
1-4	GRDZ Set HTZ and -1 values in HTU and HTV field; test boundary configuration
5-10	Blank
11-20	Flag to bypass boundary error testing and combined symbolic HTZ, HTU, and HTV printout 0 = test and print 1 = bypass test and printout

SETZ Card	Same as SETU except no conversion factor is used. Modify HTZ array

OLDP Card	Format (A4,4I3)
1-4	OLDP Punch old format HTZ, HTU, and HTV cards
5-16	Same as SETU card, except if left blank limits set to 1, ME or NE as appropriate.

NEWP Card	Format (A4,4I3)
1-4	NEWP Punch new format HTU and HTV table
5-16	Same as OLDP card

TAPE Card	Format (A,I6)
1-4	TAPE 1) Set HTZ, HTU and HTV values less than 0 to 0 2) Print HTZ, HTU and HTV 3) Write HTZ, HTU and HTV fields on tape 4) Set Z, U, V fields to 2 for all cells over water, -0 for all cells over land. Write on tape for layer 1 5) Repeat 4 for layer 2 and then 3 if H2L and H3L non zero 6) Write double EOF on tape 7) End program

5-10	ICC	Skip parameter <0 = Print HTZ, HTU and HTV but do not write tape 0 = Print and write tape >0 = Number of files to skip on intermediate tape before placing the HTZ, HTU, and HTV and the Z, U and V fields on the tape. This allows the stacking of the initial states of various models on the same tape.

2.3 PHASE II OPERATING INSTRUCTIONS

The Phase II program runs on the CDC 7600, is called LAYER3 and resides on a program library tape.

2.3.1 Logical Units

1	Intermediate file 556 read/write tape
LGO	Load-and-Go unit
INPUT	System control cards, update decks and master control card deck
OUTPUT	Control card list and horizontal printout
COMPILE	Corrected source code
OLDPL	Program library tape

2.3.2 Deck Set Up

```
HNGEN1,Pu,Tvvvv,CMxxxxx,yyyyyy,zzzzz
REQUEST,OLDPL,R,aaaaa.zzzzz
UPDATE,Q.
RETURN,OLDPL.
RFL,60000.
FTN,LR,OPT=2,I=COMPILE.
RETURN,COMPILE.
REQUEST,TAPE1,D5,bbbbb.zzzzz
LINK,X.
FIN.
REQUEST,TAPE1,D5,bbbbb.zzzzz
7
8
9
```

```
*IDENT correction cards
*COMPILE,HNG,BARSTAR,UTIL
7
8
9
----MASTER CONTROL CARD DECK----
NAME      (any number)
GRID      (required)
TIME      (required)
FACT      (required if TIDE card present must precede
          TIDE cards)
TIDE      (not more than MAXTIDE)
WIND      (not more than MAXWIND)
LAYS      (required)
SORC      (not more than MAXSORC)
FLOW      (not more than MAXFLOW must not precede
          GRID card)
COMP      (required last card read by program)
6
7
8
9
```

u	Priority
vvvv	Computing unit limit
xxxx	Update memory requirement (34000)
yyyy	Account number
zzzzz	User name
aaaaa	Program library tape file number
bbbbb	Intermediate tape file number

2.4 PHASE III OPERATING INSTRUCTIONS

The CDC 3100 Phase III program is called LAYER3F. To run the program all decks must be compiled and punched in object form so that the MSOS overlay system can load the decks.

2.4.1 Logical Units

Units	Use
1	Intermediate tape corresponding to first COMP card
2	Intermediate tape corresponding to second COMP card
3	Intermediate tape corresponding to third COMP card
4	Scratch unit to store data for cross-sections
5	Scratch unit to store data for cross-sections

6	Scratch unit to store land boundary description
7	Scratch unit for rest currents
8	Scratch unit for rest currents
10	Plot tape unit
20	Overlay unit

2.4.2 Deck Setup

```
⁷₉SEQUENCE,120,BAUER-OCEAN-EPRF

⁷₉JOB,LAYER3F,BAUER,5,ND,NP

⁷₉RAT

⁷₉RAT,852/7

⁷₉FET,LAYER3S,BAUER,512,00,0000,0000

⁷₉RELEASE,ALL

⁷₉ALLOCATE,100,,S

⁷₉OPEN,20

⁷₉FET,LAYER34,BAUER,512,00,0000,0000

⁷₉RELEASE,ALL

⁷₉ALLOCATE,100,,S

⁷₉OPEN,04

⁷₉FET,LAYER35,BAUER,512,00,0000,0000

⁷₉RELEASE,ALL

⁷₉ALLOCATE,100,,S

⁷₉OPEN,05
```

```
7
9FET,LAYER36,BAUER,512,00,0000,0000

7
9RELEASE,ALL

7
9ALLOCATE,40,,S

7
9OPEN,06

7
9FET,LAYER37,BAUER,512,00,0000,0000

7
9RELEASE,ALL

7
9ALLOCATE,10,,S

7
9OPEN,07

7
9FET,LAYER38,BAUER,512,00,0000,0000

7
9RELEASE,ALL

7
9ALLOCATE,10,,S

7
9OPEN,08

7
9EQUIP,01=MT

7
9EQUIP,02=MT                  Used only if 2nd and 3rd inter-
                              mediate tapes are required
7
9EQUIP,03=MT

7
9EQUIP,10=MT

+
0 20                          (Main card)
7
9
```

```
       Binary decks for  LAYER3F
                         ARROW
                         INOUT
                         ATAN2
                         MZERO
                         PLOTEND
                         IOERR
                         XMIT

+
0
3 20,01                     (Overlay 1)

       Binary decks for  CNTRLCRD

+
0
3 20,02                     (Overlay 2)

       Binary decks for  HORZSEC
                         HORZPLT
                         PRTMAX
                         LANDBRY

+
0
2 20,01                     (Segment 2.1)
7
9

       Binary decks for  ZUVFLD
                         MAKLAND

+
0
2 20,01                     (Segment 2.2)

       Binary deck for  REST

+
0
3 20,03                     (Overlay 3)

       Binary decks for  VERPROC
                         VERAXIS
                         DASHCRV

7
  RUN
9
```

```
     ---(LAYER3 CONTROL CARDS)---
NAME        (required)
GRID        (required)
TIME        (required)
FACT
TIDE
WIND
SORC
FLOW
COMP        (required)
COMP        (2 addition COMP cards permitted)

     ---(LAYER3F CONTROL CARDS)---
HORZ       |Not more than 20 allowed.  All cards of a
VECT       |type together and grouped in order showr.
CROS       |
SPEC       |
REST       |
PLOM        (required if HORZ,VECT, or CROS card present
            and plots are desired)
PLOS        (required if CROS or SPEC card present and
            plots are desired)
GO          (required)

     ---OTHER SETS OF LAYER3 AND LAYER3F CONTROL CARDS---
```

$^{77}_{88}$ (MOS EOF CARD)

$^{7}_{9}$SEQUENCE,120,BAUER-OCEAN-EPRF-CSI (Job to release disk space)

$^{7}_{9}$JOB,LAYER3F,BAUER,2,ND,NP

$^{7}_{9}$FET,LAYER3S,BAUER,512,00,0000,0000

$^{7}_{9}$RELEASE,ALL

$^{7}_{9}$FET,LAYER34,BAUER,512,00,0000,0000

$^{7}_{9}$RELEASE,ALL

$^{7}_{9}$FET,LAYER35,BAUER,512,00,0000,0000

$^{7}_{9}$RELEASE,ALL

$^{7}_{9}$FET,LAYER36,BAUER,512,00,0000,0000

$^{7}_{9}$RELEASE,ALL

$^{7}_{9}$FET,LAYER37,BAUER,512,00,0000,0000

$^{7}_{9}$RELEASE,ALL

$^{7}_{9}$FET,LAYER38,BAUER,512,00,C000,0000

$^{7}_{9}$RELEASE,ALL

$^{77}_{88}$

2.4.3 LAYER3F Control Cards

HORZ Card		Format (A4,4I3,4I1,4I10,5A4) Print or plot water height fields. Must follow COMP cards and precede VECT cards. Must be accompanied by PROM card.
1-4		HORZ
5-7	ITIM (2,N)	Min. row (N) dimension[1]
8-10	(3,N)	Max. row (N) dimension[1]
11-13	(4,N)	Min column (M) dimension[1]
14-16	(5,N)	Max row (M) dimension[1]

[1] If blank, duplicate values on previous card. For the first card the previous values are 1,NE,1,ME. NE and ME are defined on GRID card.

17	(6,N)	Min level number[2]

[2] If blank, duplicate value on previous card. For the first card, the previous value = 1.

18	(7,N)	Max level number[3]

[3] If blank, set to min level number.

19	(8,N)	Print control 0 = print 1 = bypass
20	(9,N)	Plot control 0 = plot 1 = bypass

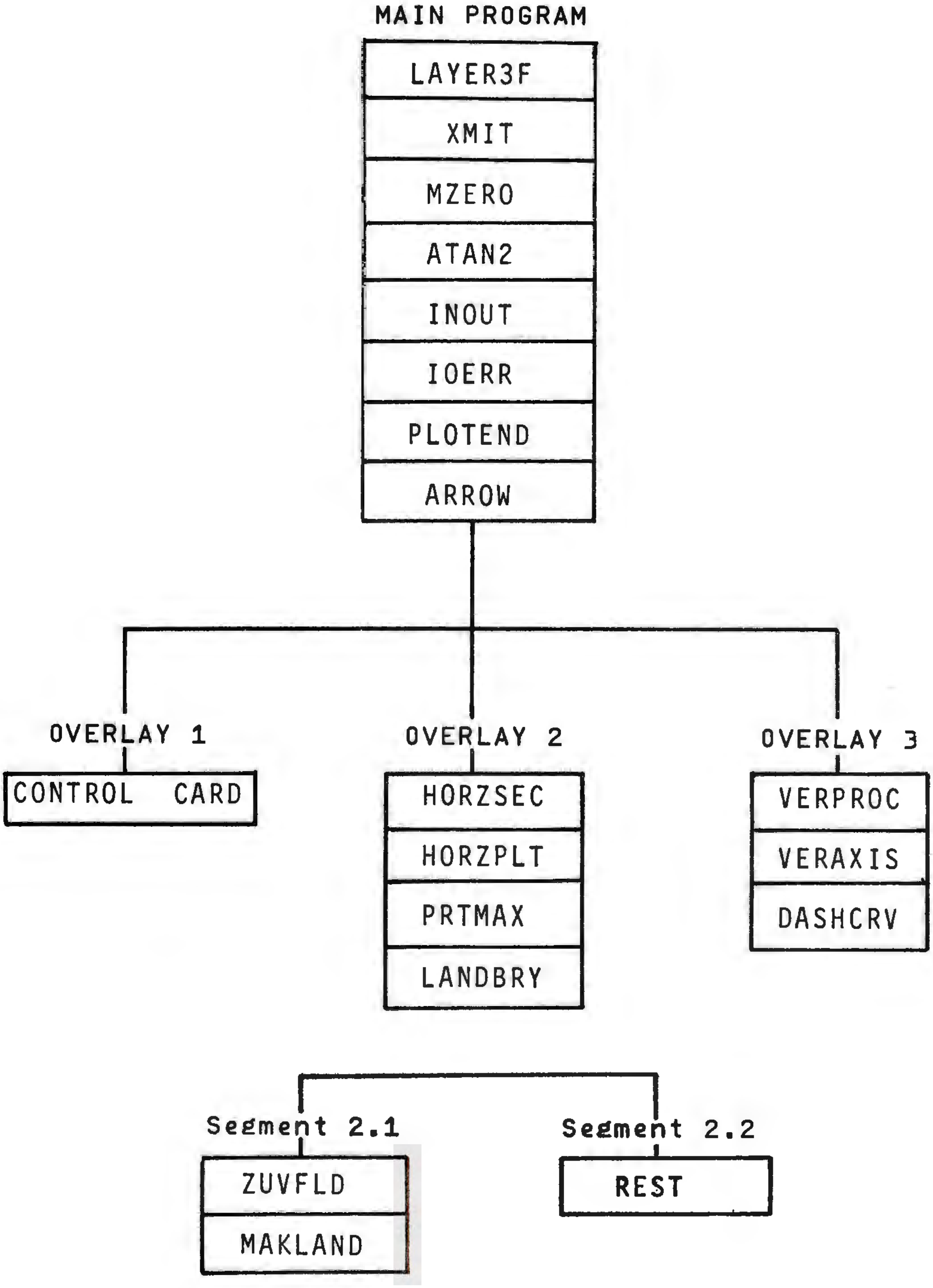


Figure 2-4. LAYER3F organization

21-30	(10,N)	Start time of first sequence[4]
31-40	(11,N)	End time off first sequence[4]
41-50	(12,N)	Time increment between printouts and/or plots[4]
51-60	(13,N)	Time sequence increment[4]
61-80		Label[4]

[4] If blank, duplicate value on previous card. For the the first default values are:
Start time = ITO;
End time = ITE;
Time Increment = MODOUT;
Time sequence increment = 0

VECT Card	Format same as HORZ card Must follow all HORZ cards and precede CROS cards. Print or plot horizontal velocity vector fields. Must be accompanied by PLOM card
CROS Card	Format same as HORZ card Must follow all VECT cards and precede SPEC cards. Print or plot cross-sections. Must be accompanied by PLOS card
SPEC Card	Format same as HORZ card Must follow all CROS cards and precede REST, PLOM or PLOS card. Print or plot time series data for special points. Must be accompanied by PLOS card
REST Card	Format same as HORZ card except as follows: only one REST card may be present and columns 51-60 must be blank.
PLOM Card	Format (4XI1,3F5.0,2I5,2I1,12A4)
1-4	PLOM
5	Composite plot (plot more than one model or layer on a plot) 0 = yes 1 = no

6-10	GPPI	Grid points/inch. If equal to zero, no horizontal plots are produced.
11-15	WHS	Water height scale cm/in
16-20	VVS	Vector scale cm/sec/in
21-25	NTHPT	Thinning parameter Plot every Nth point
26-30	LAND	Number of blank cells to leave blank next to land
31	LEDGE	Land boundary flag 0 = plot land boundary 1 = bypass
32		Blank
33-80		First line of figure title. Second line of horizontal listing title
PLOS Card		Format (4X,I1,3F5.0,2I5,2I1,12A4)
1-4		PLOS
5	IVC	Composite flag 0 = plot composite 1 = plot each level or model on a separate plot
6-10	TMS	Time scale for X axis in sec/in
11-15	TDS	Tide scale for Y axis in cm/in
16-20	VES	Velocity scale for water speed vectors in cm/sec/in
21-30		Blank
31	ITY	Type of special point plot desired 1 = Plot only tide heights 2 = Plot only water vectors, starting points on the tide curve 3 = Plot both of the above 4 = Plot current ellipse 5 = Plot vector sum diagram
32	ITD	Offset vertical plot axes 0 = yes 1 = aligned axes
33-80		Label same as on PLOM card
GO Card		Format (A4,3I)
1-4		GO
5	ISPACE	Print control character 0 = double space horizontal field listings Blank = single space horizontal field listings

6	ISHORT	Fast plot option 0 = produce plots with minimum headings and scales 1 = produce fully labeled plots
7	INTFLD	Printout symbolic and actual water depth fields 0 = print fields 1 = bypass

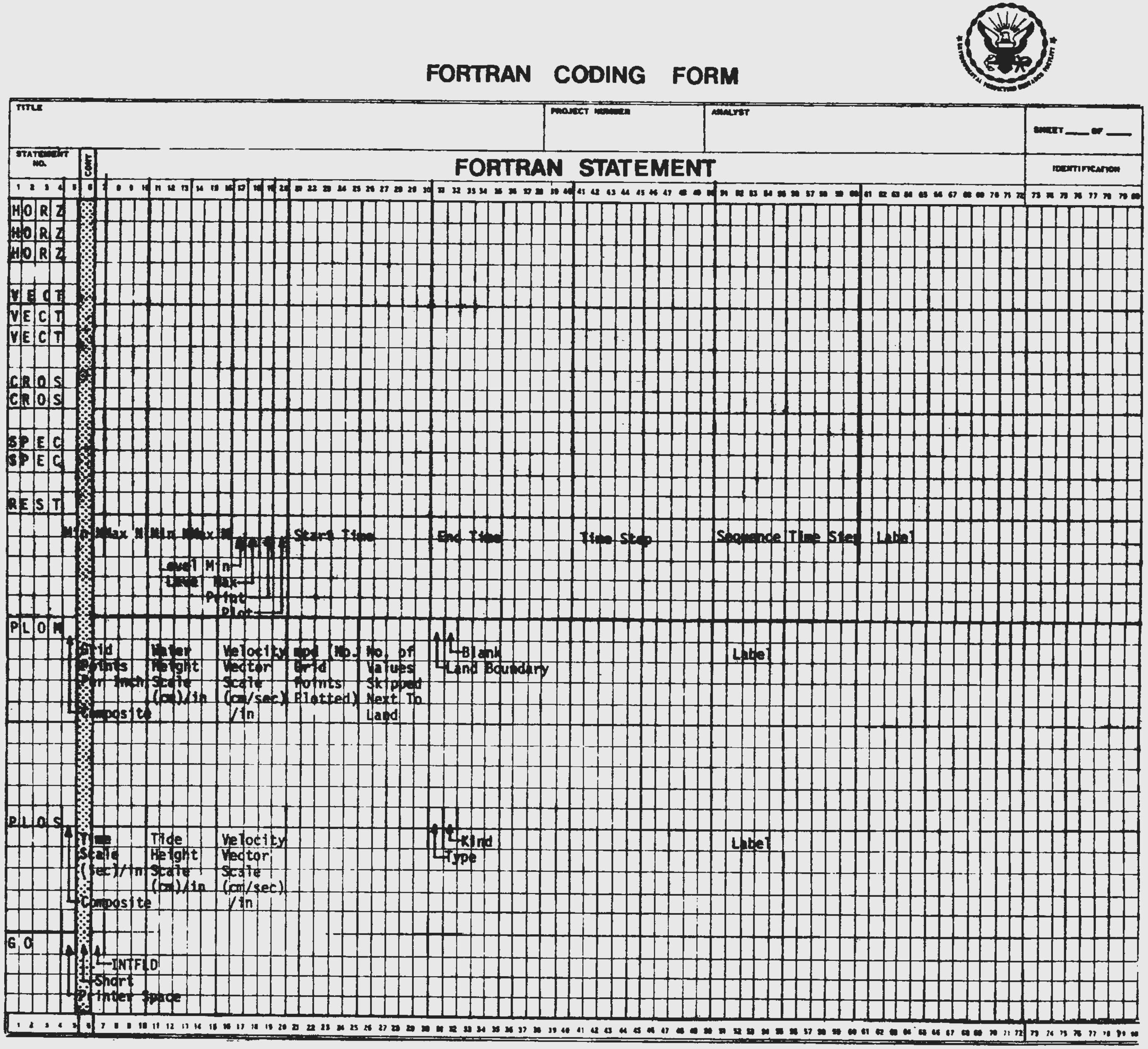


Figure 2-5. Phase III control card layout

3. FORMAT DESCRIPTIONS

3.1 FILE FORMAT

The intermediate file is the means of transferring array of data between processing phases. The design of the file provides the flexibility to expand the file to include other types of data arrays without losing present capabilities to start and restart the model from data stored in the file and to use standard system routines to copy, sort or merge the files.

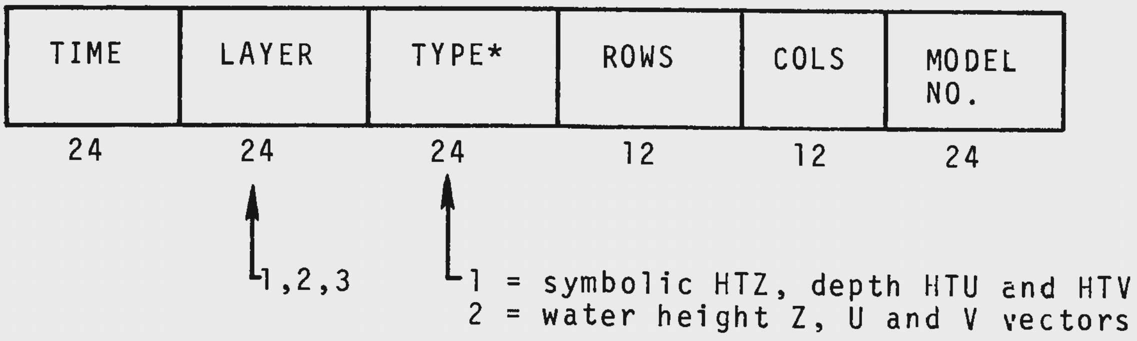
3.2 CDC FORMAT

The CDC format is based on 7-track tape frames of 6 bits each. The tapes are recorded as a single file in binary mode at 556 BPI. The records are of variable length from 144 bits to 30000 bits with a fixed length header of 120 bits. The header bits, as shown in Figure 3-1, are divided into 24- and 12-bit fields. All values in the header are positive binary integers. The header is followed by from 1 to 1245, 24-bit fields. These data fields contained scaled integers in tenths which may be positive or negative. Negative numbers are expressed in CDC 1's complement (in octal (B):0001B=.1, 0000B=0, 7777B=-0, 7776B=-.1).

A logical record will require more than one physical record if the grid contains more than 1245 values. Any number of physical records can make up a logical record but no logical records share a physical record. Records with type numbers less than 8 are assumed to be grouped logical records with 3 logical records per group. In grouped records, since all logical records have identical headings, the Z logical record must be first followed by the U and then the V logical record.

Logical records are ordered on the tape in ascending sequence based on the entire header. The first logical record group on the tape should contain the symbolic water height, HTZ field, and the water depths at U and V points, HTU and HTV.

HEADER FORMAT



* types 1-7 reserved for grouped records

4. PROGRAM DESIGN

4.1 PROGRAMMING CONVENTION

The following paragraphs define the convention followed in writing the revised code.

4.1.1 Control Cards

All control cards except the depth tables have four character names. The deck of control cards read by the Phase II program and identified as the master control cards deck is processed by all three programs. Phase I processing of the master control cards provides an edit of the cards prior to submission for a Phase II run. Phase III processing provides a readable printout of the constants for use in reports.

4.1.2 Intermediate File

All horizontal fields are packed when written on tape to allow the frequency of output required for auxiliary computations and a reasonable file size. Only one logical unit and set of buffers is used for both input and output.

4.1.3 Program Size

Phase II program size is kept to a minimum by removing auxiliary calculation, minimizing printouts, using system routines whenever possible, and equivalencing variables.

4.1.4 Initialization

All variables are initialized within the program so that the setting of core to zero is not necessary.

4.1.5 Use of Functions

Maximum use is made of system functions such as MIN0, MAX0, AMIN1, and AMAX1 in place of IF statements.

4.1.6 Indexing

All horizontal array processing is done with single subscripts so that COMMON does not have to be changed to run areas of different sizes. Before an index is used in a horizontal array, it is tested to insure that it lies inside the array. If, as a result of this testing, the value lies outside the boundary, the index is modified to point to an appropriate value. The convention of modifying indexes rather than computing partial results is designed to minimize references to the arrays so that, in the event the array must be stored in large core at a later date, the loss in the efficiency of the program will be minimized.

DO loops are nested so that the grid is processed left to right and within each column from top to bottom. Location (1,1) is the upper left corner of the matrix. Whenever possible the limit arrays are used to reduce the processing required for each column. The examples in Figure 4-1 are representative.

4.1.7 Coding Convention

Formats are given 4-digit statement labels; other statements are given 1- to 3-digit statement numbers.

Statement numbers, except for formats, are in ascending sequence.

Format follows the read or write statement when first used.

Code is sequenced to minimize transfers to statements that occur before the transfer.

If an IF test results in a single statement being executed, the one branch form is used with the statement following the test.

Logical IF statements are used unless there are three meaningful branches. IF conditions linked by .OR. and .AND. are preferred to a sequence of simple IF statements except for

```
      OLD Code       (outside rows and column of HTZ set to zero)

      NEH=NE-1
      MEH=ME-1
      DO 585 N=2,NEH
      DO 585 M=2,MEH
      IF (HTU(N,M)) 585,585,543
543   IF(1-N)544,547,544
544   IF(HTU(N-1,M)545,547,545
545   VUP=U(N-1,M)
      GO TO 548
547   VUP=U(N,M)
548   IF(NE-N)549,552,549
549   IF(HTU(N+1,M)550,552,550
550   VLO=U(N+1,M)
      GO TO 553
552   VLO=U(N,M)
553   IF(1-M)554,557,554
554   IF(HTU(N,M-1))555,557,555
555   VLE=U(N,M-1)
      GO TO 558
557   VLE=U(N,M)
558   IF(ME-M)559,562,559
559   VRI=U(N,U+1)
      GO TO 563
562   VRI=U(N,M)
563   A(N,M)=ALPHA*U(N,M)+BETA*(VUP+VLO+VLE+VRI)
585   CONTINUE

------------------------------------------------------------------

      NEW Code       (no outside rows and columns of zeros)

      DO 30 M=1,ME                outside loop processes columns
                                    starting at the left
      IM=NNM(M)                   pick up row limits
      IP=NNP(M)
      IF(IP.LT.IM) GO TO 30       skip inside loop if entire
                                    columns is zeros
      IPP=NE*M                    compute maximum column index
      IMM=IPP-NE+1                compute minimum column index
      DO 25 I=IM,IP               process down the column
      IF(H(I).GT.TEST) GO TO 20   test to see if point is on
                                    land H=HTZ, HTU or HTV
      A(I)=-0.                    island or land edge detected
      GO TO 25
      NM=MAX0(I-1,IMM)            if NM.LT.IMM indexing row 0
      NP=MIN0(I+1,IPP)            if NP.GT.IPP indexing row NE+1
      MM=I-NE$IF(MM.LE.0)MM=I     if MM.LE.0 indexing column M=0
      MP=I+NE$IF(MP.GT.NO)MP=I    if MP.GT.NO indexing column
                                    M=ME+1
      A(I)=U(I)*ALPHA+(U(NM)+U(NP)+U(MM)+U(MP))*BETA
25    CONTINUE
30    CONTINUE
```

Figure 4-1. Example of revised coding structure.

tests where the index and the array value with the index must be tested. In this case, separate IF statements are used because the 7600 compiler will test both conditions before branching even if the first test fails. This compiler problem can result in an indefinite argument fault.

Computed GO TO statements are used only where there are more than three options or when it is convenient to use a positive non-zero index to control the transfer.

4.1.8 Land Edges

Land edges are excluded from as many calculations as possible by using limit arrays which define the first and last cell in each column in HTZ, HTU or HTV that are sea cells. Note, that the use of these limit arrays prevents the land areas from even being set to -0 in many of the calculations such as BAR and UVSTAR.

4.1.9 Upwelling and Tidal Flats

Calculations are not performed for cells where the layer is missing in the initial land-sea water depth table. This feature prevents tidal flat or upwelling of lower layer in most areas.

4.2 COMMON STRUCTURE

To minimize the number of formal parameters passec in subroutine calling sequences the arrays transferred to and from the intermediate file have been sequenced in COMMCN with the Z array first followed by the U array and V array. In addition, the ZM_n, ZST_n, HGU_n and HGV_n arrays for each level; the XK and YK arrays; and the S, US and VS arrays are sequenced so that a reference to ZM_n, XK and S can zero out the entire group.

Blank COMMON is used for the 7 main computational arrays to allow the program to overlay the loader and use the entire 170000B of available small core on the CDC 7600.

In COMMON/CONTROL/ the last 500 words of the block are available for storage of local variables (this 500 words begin after the location assigned to variable ROT). All values in this work area are presumed to be destroyed whenever any subroutine is called.

4.3 DESCRIPTION OF VARIABLES

A		output array from BAR and BARUV vector direction in PRTMAX input/output array in INPOUT
AA		Friction term used at bottom of layer
	=A3	for layers that reach the bottom
	=A6	for layers that do not reach the bottom
ALPHA ALPH2 ALPH3		See LAYS card
AUS		See GRID card
A1		Full time step = ITINC
A2		F*A1
A3		R*A1 (bottom friction)
A4		A1/DL
A5		G*A1/DL
A5RH01		(1.-RH01/RH02)*A5
A5RH02		(1.-RH02/RH03)*A5
A5RH1		(RH01/RH02)*A5
A5RH2		(RH02/RH03)*A5
A6		A3/2. (between layer friction)
B		input array for BAR vector direction in PRTMAX

B1	A1*AUS/(DL*DL/2.)
B2	A1/(2.*DL)
C	See GRID card
C3	C*A1*10000.
DL	See GRID card
F	See GRID card
D	second formal parameter in PRTMAX routine. If =4HNONE only S array is printed. If ≠4HNONE D is the X component of the vector, S is the Y component
D1	DL^2
F	Coriolis parameter
FLOW	See FLOW card
G	gravity
HGU HGU2 HGU3	layer thickness at U points layer 1, 2, 3
HGV HGV2 HGV3	layer thickness at V points layer 1, 2, 3
HH1 HH2 HH3	initial layer thickness
HTU	total water depth at U points
HTV	total water depth at V points
HTZ	symbolic water height table for Z points -0= outer point (over land) 1= inner point (surface layer only) 2= inner point (surface layer and layer 2 only) 3= inner point (all layers)

H1L H2L H3L	maximum depth of layer (cm) layer 1, 2, 3
I	index often used for incrementing down a column
IC	area used to DECODE control cards
IC1	area used to READ control cards
ID	dummy parameter used to save on the number of FORMATS required
ID1 ID2	header for record requested or to be written on intermediate tape
IERR	tape read/write error flag
IFLOW	see FLOW card
IFNO	number of FLOW cards read
IM	minimum row single subscripts index found in sea area in HTU, HTV or HTZ
IMM	index = (1,M)
IP	maximum row single subscript index found in sea area in HTU, HTV or HTZ
IPMOD	see TIME card
IPO	see TIME card
IPP	index = (NE,M)
IREC	intermediate file physical record position
ISNO	number of SORC cards read
ISORC	see SORC card
IT	index in main time loop, = time in seconds
ITIDE	see TIDE card

ITINC	see TIME card
ITNO	number of TIDE cards read
ITO ITS	see TIME card
ITW	time next wind field is turned on or off
IW	a 500 word work area in COMMON block CONTROL used in equivalencing work variables. All variable values stored in this area can be destroyed by other subroutines
IWIND	see WIND card
IWNO	number of WIND cards read or the index to the next wind data to be used
IWW	word being packed or unpacked
I1 I2 I3 I4	indexes used to when the computation involves diagonal corners
IS	formal parameter for PRTMAX to control line spacing 1H = single space, 1HO = double space
ITY	see intermediate FILE format
J	index often used to index parameters originally read from the multiple cards of the same type
K	array number index 1=Z, 2=U, 3=V
KK	offset for first word in array

LAND	location of a zero land value
LAYER	layer number and input/output control for INPOUT -LAYER = read A +LAYER = write A
LM	minimum level number
LEN	maximum number of words in physical record
LP	maximum level number
LU	logical unit for horizontal field printouts
M	column index
MAXDIM	size of arrays used to store horizontal data
MAXFLOW	number of FLOW cards allowed - number of columns in IFLOW and FLOW
MAXNAME	number of control cards types
MAXSORC	number of SORC cards allowed - number of columns in ISORC or SORC
ME	see GRID card
MF	index to first column in a data row being printed
MINFLOW	time of first flow, if no FLOW cards are present = 9999999999
MINSORC	time of first source, if no SORC cards are present = 9999999999
ML	index for last column in a data row being printed
MM	index for (N,M-1)
MODEL	see COMP card

MODOUT	see TIME card
MP	index for (N,M+1)
M12	right justified 12 bit mask
M24	right justified 24 bit mask
NAME	array of names used as label on control cards
NAME1	horizontal printout page heading
NCPW	number of characters per word for the computer being used
NE	see GRID card
NM	index for (N-1,M)
NNM NNP	arrays specifying the first row (NNM) and last row (NNP) values that need to be calculated in each column of the horizontal arrays, must be dimensioned at least as large as ME.
NO	ME*NE
NOP	(M-1)/15+1 number of pages required to print horizontal arrays
NP	index for (N+1,M)
NW	word count for packed words in physical record
R	see GRID card
RHO1 RHO2 RHO3	see LAYS card
ROT	810.-ROTANG used to convert between geographic and geometric angles
ROTANG	see GRID card

S	horizontal diffusion field first formal parameter for PRTMAX if D=4HNONE = Y component of vector if D=4HNONE = array to be printed
SLOPEX	see FACT card
SLOPX	slope factor used for tide for the first tide card SLOPX = SLOPEX for all others SLOPX = 0.
SORC	see SORC card
SSH	diffusion term in X direction
SSL	combined column index and slope term
SSV	diffusion term in Y direction
STAR	formal parameter in routine UVSTAR used for U* or V* terms
TEST	depth of top of layer for HTU and HTV TEST = 0 for layer 1 H1L for layer 2 H2L for layer 3 for HTZ TEST = 0 for layer 1 1 for layer 2 2 for layer 3
TIDSPD	see FACT card
TK	see GRID card. Also time used to compute tide
U U2L U3L	X - component of velocity (cm/sec) layer 1, 2, 3 (-0= land value)
US	diffusion array
UV	formal parameter in UVSTAR used for U or V array input
V V2L V3L	Y - component of velocity (cm/sec) layer 1, 2, 3 (-0= land value)

VS	diffusion array
XK	U components of wind current
XW	value to be stored in XK
YK	V components of wind current
YW	value to be stored in YK
Z Z2L Z3L	water level deviations (cm) layers 1, 2, 3 (-0= land value)
ZM ZM2 ZM3	work arrays (used for $\bar{Z}$, $\bar{U}$, U and V) layer 1, 2, 3
ZST ZST2 ZST3	work arrays (used for V* or U*) layer 1, 2, 3
ZT	array used to compute tides at each level ZT(1) ≡ ZZ ZT(2) ≡ ZZ2 ZT(3) ≡ ZZ3
ZZ ZZ2 ZZ3	terms used to store intermediate results for each level

5. PROGRAM NARRATIVE

5.1 PHASE I PROGRAM LAYER3S

This program is coded for the CDC 3100 FORTRAN compiler. The program consists of a main program LAYER3S and the routines XMIT, GRID, IOUT, IOERR, TIDCUR, GEOPOS and PRTMX. The main program is composed of a number of logic blocks that process master and Phase I control cards. Although these logic blocks are activated independently, the effect that they have on the results varies depending on the order in which they are called.

5.1.1 Master Control Card Logic

Program LAYER3S reads the master control card deck. After each card is read in "A" format the card image is printed on the output sheet. The 4-character label on the card is matched to a table of card types and the program branches to the appropriate DECODE statement. The decoded values are listed below the card image so that the fields can be checked for proper scaling and punching.

In order to process Phase I control and data cards, the program requires the GRID card containing the number of rows and columns, the LAYS card containing the maximum layer depths, and, if an intermediate tape is desired, the COMP card containing the model number and the TIME card containing the start time.

In addition, the program requires the grid length and mid-latitude to correctly compute the Courant-Fredrich-Lewy stability criterion and the maximum depth of the water in the area.

The program assumes that if TIDE cards are encountered in the master control card deck that printer plots of the tidal cycles are desired. This plotting requires that the TIME and

FACT cards precede any TIDE card in the master control card deck. The printer plot uses the frequency for save result value as the time interval between lines on the plot and uses the model start and stop time to determine the segment of the curve plotted.

5.1.2 Reading Land-Sea Tables

The program allows the use of either old or new style land-sea tables. Old style cards are punched and read using a single string of numbers for each array and are punched in every card field except for possibly the last card. New style cards are punched so that each row starts at the beginning of a card. Old style card decks contain an HTZ deck while the new style decks contain only HTU and HTV decks. If the conversion factor field is non-zero the HTU and HTZ fields are converted to cm as they are read and can be adjusted for changes in sea level reference height.

5.1.3 Edits

The HTZ, HTU and HTV fields can all be edited by the program using the SETZ, SETU and SETV control cards. The depths specified on the SETU and SETV card are converted and adjusted as specified on the OLDT or NEWT cards. The HTU and HTV fields are normally edited prior to the GRDZ card while the SETZ cards normally follow the GRDZ card and precede the TAPE card. SETU and SETV cards are used to correct the digitized bottom depth. SETZ cards must be used to insert -2 and -3 values in old style HTZ tables. If the HTZ fields are computed by routine GRID, the fields returned have -1 values set on land boundaries, -0 values over land and the number of layers or depth values over water. GRID destroys values less than -1 in the HTZ field so open boundaries must be reset using SETZ cards after the GRID card. To compute an old style HTZ field with 1's for water, set the maximum layer thickness for the surface layer to the maximum depth for all layers and set other layer thicknesses to zero.

5.1.4 Punching New Decks

The OLDP card allows the punching of old style HTZ, HTU and HTV cards for the entire array.

The NEWP cards allow extraction of a section of the grid by identifying the minimum and maximum row and column limits in terms of the old grid. This option can be used to delete the outside row and column required by old versions of the hydrodynamical models. The program does not alter the in core arrays during this process so if the extracted field is the one desired on the intermediate tape, the field must be punched and then read back using a corrected GRID card.

5.1.5 Computing The HTZ Field

The HTZ field is computed from the HTU and HTV fields and the set of maximum water depths for each layer by subroutine GRID. GRID values in the HTU and HTV fields are first set to 0 if less than the minimum water depth for the layer and -1 values are placed in the first land cells adjacent to water areas. Using these HTU and HTV fields, test are performed on adjacent HTU and HTV cells to determine whether HTZ is on land, on the boundary, or in a sea area. If level one is being processed, 0, -1 and +1 values are placed in HTZ for their respective conditions. After processing layer one only, those HTZ that are in the sea areas at lower layers are modified by inserting the layer number. Although separate HTU and HTV fields are generated for each layer, the routine returns only the HTU and HTV field for the surface layer and the HTZ field with the number of layers in the sea areas. Partial results are stored on disk file 2.

The processing of HTU and HTV fields requires three separate steps. First, all land and sea values less than the minimum layer thicknesses are set to -0. Second, the -0 values next to sea values in the row for HTU and column for HTV are reset to -1. These steps do not define channels one cell wide, so as a third step in the loop to compute the combined HTU and HTV, fields are tested for the presence of channels. If one pair of HTU or HTV points adjacent to an HTZ point is land and the other pair is sea, a channel exists and additional -1 values are placed in the HTU or HTV field before the HTZ value is set. HTZ is preset to -0 so only the sea values and -1 land edges have to be added to it. A -1 value is set into the HTZ field if the level being processed is the surface and one of the four adjacent HTU and HTV values is -1. HTZ is set to the level number if all adjacent HTU and HTV values are positive non-zero numbers.

5.1.6 Printing Combined HTZ, HTU, HTV Field and Error Testing

When the print flag on the GRDZ card is zero, subroutine GEOPOS is called from GRID. In GEOPOS the combined HTU and HTV field is tested for boundary setting errors where the combined HTZ, HTU, HTV field is printed. The testing is done on each set of four HTU and HTV values located on the midpoints of the HTZ grid squares.

The only allowed conditions, after handling the conditions on the lower and right hand edge of the grid, are that there be o,z, or 4 -1's in the set of four values. The program only lists the erroneous land boundary lines connecting either HTU or HTV points that lie between pairs of HTZ points both on land or on water. Correction must be made in a separate run. The testing is done on each level specified on the LAYS card prior to printing the combined field.

When the combined field is printed, all HTU and HTV values greater than "1" are set to "1" so that the combined HTU, HTZ lines can be printed in quasi-geographic relationship with the HTV lines.

5.1.7 Grid Print of HTZ, HTU and HTV Field

The HTZ, HTU and HTV fields that exist in core at the time a TAPE card is read are printed using routine PRTMX. All negative values on the land-sea boundary are set to 0 prior to the time the arrays are written on tape. If the flag on the TAPE card is negative, writing of the intermediate tape is bypassed.

5.1.8 Writing an Intermediate Tape

An intermediate tape is created when the TAPE card is processed by calling routine IOUT once for HTZ, HTU and HTV and once for each layer with the initial Z, U and V fields. Before the HTZ, HTU and HTV fields are placed on the intermediate tape they are printed using routine PRTMX. All values are written on disk file 2, are scaled, and have values less than 0 set to -0. After writing the HTZ, HTU, and HTV arrays on the intermediate tape, the disk file is read back for each level and Z, U and V fields containing -0 for land and .2 for water are created and written on the tape. Upon completion of the output of Z, U, and V fields a double EOF is written on logical unit 1 and backspaced once. Subroutine IOUT call subroutine IOERR when an EOF or parity error is encountered.

5.1.9 Utility Routine XMIT

XMIT is a CDC 3100 COMPASS assembly language routine that has a variable number of calling parameters and is used to zero out and transfer integer arrays in core. The first parameter is the address transferred from. The second is the address transferred to. The third parameter is the number of words transferred. The fourth is the number of words the transferred from address is incremented by between transfers. If the routine is called with 3 parameters, it is assumed to be 1. The fifth parameter is the number of words the transferred to address is incremented by between transfers. If only 3 or 4 parameters are used to call the routine, the fifth parameter is assumed to be 1.

5.2 PHASE II PROGRAM LAYER3

The program LAYER3 is coded in CDC 6000 series FORTRAN IV. The main program calls XMIT, INPOUT, SETHUV, BAR, UVSTAR, and PRTMAX. INPOUT calls routine IOERR when EOF or parity errors occur.

5.2.1 Master Control Card Processing

All control cards read by the program are read and listed by a single read and write statement in "A" format. Only after the control cards are listed and the label is matched against a card type table is the card image decoded by the appropriate set of variables and format. Except for a check on the number of cards of each type, no error tests are provided. Card count and label errors cause immediate program termination. In a few cases the order of the control card deck is important and these cases are specified in the operating instructions. No cards are read from the input file after the COMP card is processed.

5.2.2 Reading the Intermediate File

After reading the master control card deck, LAYER3 reads the HTZ, HTU and HTV fields from the intermediate file and then reads down the intermediate file searching for a Z, U, and V field for the start time given. If the model numbers of layers or grid size are incorrect, no match can be made and the program will terminate when the EOF is read on the intermediate file. If the fields are located, the intermediate file is left positioned after the bottom layer V field for the start time to accept output from the program.

5.2.3 Limit Arrays

The limit arrays are computed by testing the HTZ, HTU, and HTV fields for sea values. The NNM for the column is set to the first index value in the column initially and is then set ahead one row each time land is found until at least one water cell is found in the HTZ, HTU or HTV. If the entire column is zero in all three arrays, NNM will equal the number of rows plus one at the end of this process. The NNP value for the column is set to index for the last row in the column initially but is set to the index in the column each time a water cell is located. If the column is all land or the last cell is water, NNP equals the last row index. Because of this zero column possibility the indexes for processing rows within columns must be tested to skip processing when the NNM is greater than NNP.

5.2.4 Initialization

All work arrays are set to -0 in the program and all indexes are set either by DATA statements or by implicit statements. To minimize computations a number of variables are combined into program constants. The "A" series of constants all have time components, the "B" series are diffusion related, the "C" series are wind related, and the "D" series are related to inflow.

5.2.5 Computing Total Layer Thickness

Subroutine SETHUV computes the total layer thickness, HGU_n, given the maximum initial layer depth, the water depths, and the deviations at the layer interfaces. This routine is called to set the initial field and once each time through the time loop.

5.2.6 Time Loop Processing

The time loop includes two sets of processes. The first, including the calculation of the water height deviations, and the inputs of tide and water columns, occurs at full time step intervals starting at a half interval time. The second set, including the calculation of new U and V velocities and diffusion processes, occurs at full time intervals starting at 0 time. However, to simplify calculation, the first water height deviation calculation assumes a whole time step has passed and tides are calculated with a time one-half time step ahead.

5.2.7 Calculation of New Z

To calculate a new Z, $\bar{Z}$ is calculated by calling routine BAR storing the Z term in ZM. The net flow is calculated based on the average of the nearest layer thickness, HGU, and the velocities U and V. The new deviation is stored in Z.

5.2.8 Tide Input

Tide height is calculated for the time plus offset. Lower layer tides are computed as a multiple of the surface tide.

5.2.9 Source Flows

The program allows the input of a volume of water with the SORC card. The volume is converted to a thickness by dividing by the grid length squared.

5.2.10 Wind Input

Winds are applied after some initial period. The program provides for uniform winds over a region or the entire grid. The layer and thickness of the layer on which the winds act is dependent upon the time step and is a part of the U and V calculation.

5.2.11 Calculation of New Layer Thickness

Routine SETHUV is used to calculate new layer thickness and ends the half step calculation.

5.2.12 Calculation of New U

To calculate a new U, $\bar{U}$ is computed from U by routine BAR and stored in ZM. V* is calculated from V in routine UVSTAR and stored in ZST. Finally, a new U component is computed using a combination of the statement function for GRZ and inline code. The result is stored in ZM since U is still needed for the new V calculation. The wind component is added to layer 1 or 2 depending on which is touching the surface. The inter-layer friction or bottom friction is used depending on whether the layer intersects the bottom.

5.2.13 Computation of New V

U* is calculated from U by routine UVSTAR and stored in ZST. This allows U to be stored in its own array from ZM. ZM is then used for the computation of $\bar{V}$. The results of the new V calculation are stored in V using logic that parallels the new U calculation.

5.2.14 FLOW Addition

If FLOW cards are present, the constant flows are added to computed flows in the areas specified.

5.2.15 Output to Intermediate File

Starting after time ITO and with frequency MODOUT, the water deviation and velocity fields are written on the intermediate tape by routine INPOUT. The program relies on the system to write the end of file on the output file at the close of the program when the file is copied or returned.

5.2.16 Diffusion Calculations

Diffusion takes place as a two stage process. The first is to add material to the S matrix and the second is to calculate the diffusion using the US and VS advection calculation.

5.2.17 Printed Output

Water height, velocity vectors, and diffusion fields are printed using routine PRTMAX controlled by IPO and IPMOD parameters on the TIME card.

5.3 PHASE III PROGRAM LAYER3F

This program is coded for the CDC 3100 FORTRAN compiler. The program consists of a main program, LAYER3F, and three overlays, Programs CNTRLCRD, HORZSEC, and VERPROC. In addition, overlay 2 has two segments, Programs ZUVFLD and REST. Each of the programs refers to a number of other subroutines and functions listed in the operating instructions.

5.3.1 Master Control Card Logic

Program LAYER3F reads and lists the master control card deck in Program CNTRLCRD using extensive line labeling. In order to function, the program requires at least one NAME card, the number of rows and columns from the GRID card, all fields on the TIME except the print controls, and the model number or numbers from the COMP card or cards.

5.3.2 Phase III Control Card Processing

Program CNTRLCRD zeros out indexes stored in COMMON when it is called by the main program LAYER3F. Phase III control cards with begin and end times are stored together in a control array that is used to sequence the processing of the cata as it is read from the intermediate tape(s). Since some of the processes destroy the original data, the order of the Phase III control cards is important. The plot parameter cards are usually required but many of the parameters may be blank unless plots are specified. The GO card is the final card processed by the CNTRLCRD overlay. After DECODING the GO card, control returns to the main program. However, the CNTRLCRD overlay is recalled after completion of all specified tasks and the program will attempt to process additional cards after reinitializing all indexes.

5.3.3 Reading the Intermediate Files and Processing Horizontal Fields

Program HORZSEC can process up to three intermediate files or three different layers at one time. The choice is controlled by the number of layers specified on the Phase III control cards and the number of COMP cards present. If the GO card specifies printing of the HTZ, HTU, and HTV fields, or if land boundaries are requested on horizontal plots, the program reads the HTZ, HTU, and HTV fields by calling segment 2.1, Program ZUVFLD, from overlay two. Within Program ZUVFLD, each intermediate tape is processed in turn. The field is first printed, if requested, and then passed to routine MAKLAND which places land boundary coordinates on disk file six.

After this initial processing HORZSEC reads the intermediate tapes, selecting the fields required by the Phase III control cards. This process takes place in a pair of DO loops. The first of the pair is a triple nested loop with the file number determined in the outside loop, layer number in the middle, and control card type in the inner loop. All loops are dependent upon time desired which is preset initially by CNTRLCRD and is advanced in the second of the pair of DO loops in HORZSEC.

Once a field has been read from an intermediate file the field may be printed or plotted, data for a water deviation cross-section may be preprocessed and stored on logical unit four. Data for time series analyses may be preprocessed and stored on logical unit five, and the rest currents can be computed using logical units seven and eight.

Upon completion of the tape processing, if rest currents are computed, they are printed and plotted in segment 2.2, Program REST, before control returns to the main program.

5.3.4 Processing Vertical Sections and Time Series

All data required to print and plot cross-sections and time-series are stored on files generated by HORZSEC. Overlay three, Program VERPROC, first reads and processes the cross-section file until an end-of-file is detected and then processes the time-series file. The time-series file is searched for data matching each Phase III control card and must be read once for each card. After all data have been processed, control returns to the main program.

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