A THREE-DIMENSIONAL GROUND-WATER-FLOW MODEL MODIFIED TO REDUCE COMPUTER-MEMORY REQUIREMENTS AND BETTER SIMULATE CONFINING-BED AND AQUIFER PINCHOUTS

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ABSTRACT

The Trescott (1975) computer program for modeling ground-water flow in three dimensions has been modified to (1) treat confining-bed and aquifer pinchouts more realistically and (2) reduce the computer-memory requirements needed for the input data. Simulating aquifer systems having nonrectangular external boundaries with the original program may result in many nodes that are not involved in the numerical solution of the problem, but that require computer memory.

The Trescott program and the modified program are used to develop a cost comparison of the computer programs for large field problems. Steady-state simulations of the northern Atlantic Coastal Plain regional aquifer system and the New Jersey Coastal Plain are used. The comparison shows a 30 percent cost savings for the regional model, which has 11,560 unused nodes of a total of 27,200. The New Jersey model shows an 8 percent savings, where 1,540 of the 14,790 nodes are unused.

Appendices provide data-deck instructions and a listing of the FORTRAN source code.

INTRODUCTION

A computer model (Trescott, 1975) for simulating ground-water flow in three dimensions was developed by the U.S. Geological Survey. Hydrologists of the Survey have applied this program to numerous field problems. The structure of the FORTRAN code, however, is inconsistent with efficient and cost-effective simulation of certain physical and hydrologic situations. In particular, confining-bed and aquifer pinchouts are not easily simulated with the Trescott model. Also, simulating complex external boundaries (shape of the entire aquifer system) results in inefficient use of computer storage. Developing a model that effectively handles these situations is an outgrowth of the study of the northern Atlantic Coastal Plain aquifer system begun in 1979 by the Geological Survey. This project is part of the Regional Aquifer System Analysis (RASA) program that began in 1977. These studies define the geology, hydrology, and geochemistry of the aquifer system and the ground-water-flow regime on a regional scale.

All the regional studies use computer models to simulate flow within an aquifer system, but, unlike many studies that stress the importance of the predictive capabilities of calibrated ground-water-flow models, the RASA studies simulate primarily for analysis (Bennett, 1979). Thus, computer models are used to test hypotheses to increase knowledge of ground-water-flow systems. With this approach, construction of a ground-water-flow model of the Coastal Plain sediments has begun (Meisler, 1980).

The northern Atlantic Coastal Plain includes about 50,000 mi^2, extending from the North Carolina-South Carolina border, through Long Island, N.Y. (fig. 1). The external boundary of the fresh-water system is complex, as shown by the shape of the Fall Line onshore and the 10,000 milligrams-per-liter chloride-concentration line offshore (Meisler, 1981). The concentration line is assumed to approximate the seaward limit of the freshwater-flow system. Ten aquifers and nine intervening confining beds in the ground-water system have been delineated. Because of the large area of the project and the presence of numerous confining-bed and aquifer pinchouts in the system, a modified version of the Trescott model was needed. This report presents (1) conceptual changes in the existing flow model required to reduce computer-memory requirements and better simulate confining-bed and aquifer pinchouts, (2) modifications required in the model input, (3) the modified source code, and (4) a cost comparison of the modified and Trescott (1975) versions of the three-dimensional ground-water-flow model.

MEMORY REDUCTION

To understand the method of memory reduction, knowledge of the nodal numbering or indexing scheme used in the unmodified Trescott model is required. The finite-difference approach requires subdividing of the aquifer system into discrete blocks, which are assumed to have uniform hydraulic properties. A point in the center of the finite-difference block is known as the node and is commonly numbered to conveniently locate the position of the node in the discretized system. A finite-difference approximation of the differential equations of three-dimensional ground-water-flow results in a system of algebraic equations. A generalized equation for this system at node i,j,k is:

$$B_{i,j,k}h_{i-1,j,k} + D_{i,j,k}h_{i,j-1,k} + E_{i,j,k}h_{i,j,k} + F_{i,j,k}h_{i,j+1,k} +$$

$$H_{i,j,k}h_{i+1,j,k} + S_{i,j,k}h_{i,j,k+1} + Z_{i,j,k}h_{i,j,k-1} = \frac{-S'_{i,j,k}}{\Delta t}\hat{h}_{i,j,k} \quad (1)$$

where $B_{i,j,k}$, $D_{i,j,k}$, $E_{i,j,k}$, $F_{i,j,k}$, $H_{i,j,k}$, $S_{i,j,k}$, $Z_{i,j,k}$ are

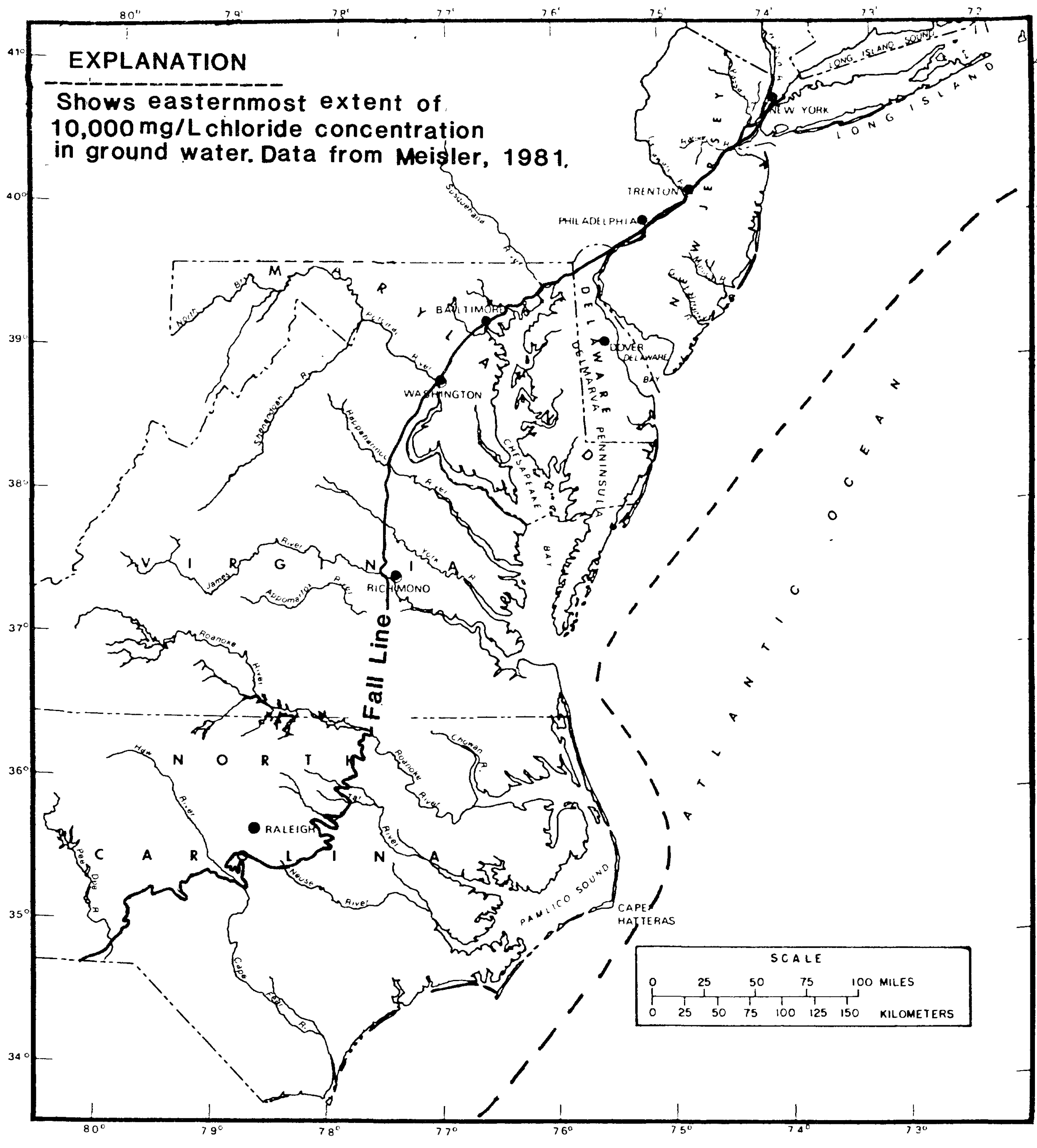


Figure 1.-- Location of northern Atlantic Coastal Plain.

constants, as defined by Trescott (1975). The constants are the harmonic means of the appropriate hydraulic parameters for adjacent blocks. These coefficients provide the correct hydraulic connection between adjacent nodes.

S' is storage coefficient;

Δt is length of time step;

$\hat{h}_{i,j,k}$ is the hydraulic head (known) at time t;

$h_{i,j,k}$ is the hydraulic head (unknown) at time $t + \Delta t$;

i is the node number in the y-direction;

j is the node number in the x-direction;

k is the node number in the z-direction.

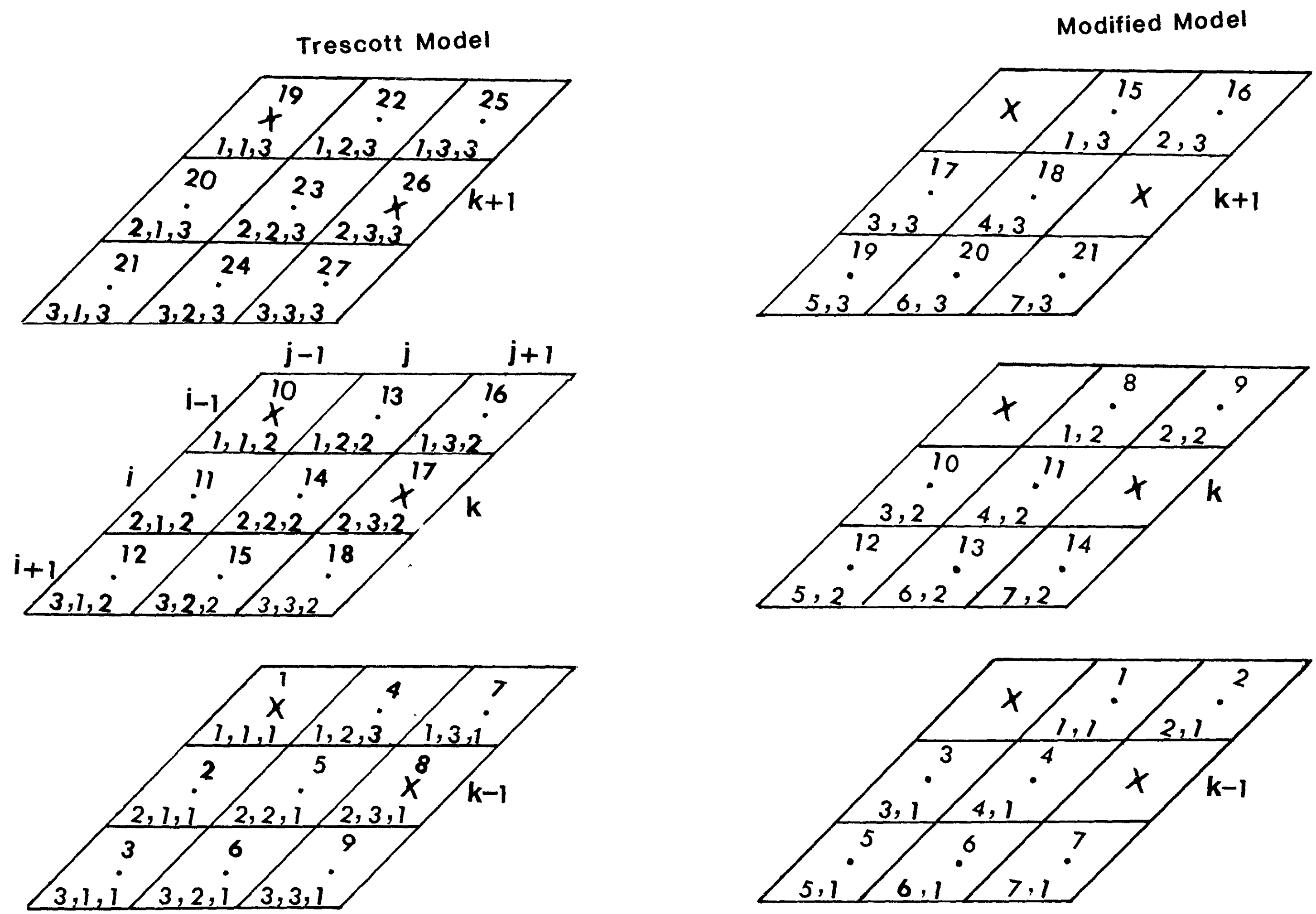
The location of these parameters in a finite-difference mesh is shown on the left of figure 2. In this example, there are a total of 27 finite-difference blocks, 3 blocks in the x-direction, 3 in the y-direction, and 3 in the z-direction. The blocks can be indexed by the i,j,k notation of Equation 1. The indices of each block are shown within the block of figure 2. However, for computation, a more efficient notation is numbering the nodes sequentially (from 1 to 27 in this example), as shown by Trescott, (1975, p. II-5). The i,j,k indices are converted to one index, N, by the following equation:

$$N = i + (j-1)*IO + (k-1)*IO*JO \qquad (2)$$

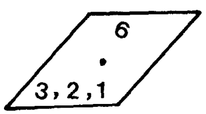
where IO is the total number of blocks in the y-direction and
JO is the total number of blocks in the x-direction.

In a finite-difference model, the model grid is always rectangular, whereas the modeled area is generally not. Hence, some nodes in the grid are usually outside the modeled area. Nodes outside the modeled area are designated as no-flow nodes. In the Trescott model, all nodes are numbered, and data are stored at all nodes, including the nodes outside the modeled area. Memory can, therefore, be saved by eliminating the storage of data at these nodes. Because regional models of the scope of the northern Atlantic Coastal Plain need many nodes to represent the aquifer system, wasted computer-memory is not only costly but may affect the choice of the grid spacing used in the model and the computer on which the model will be run. That is, computers have a finite-memory limit, which restricts the size of model that can be run, regardless of cost.

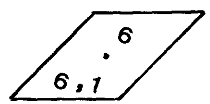
In an aquifer system that contains a large percentage of nodes outside the modeled area, a more efficient method of indexing is numbering only the nodes within the modeled area. These nodes will be referred to as active nodes in the remainder of the report, as opposed to inactive nodes, which are defined in this report as nodes outside the modeled area. The modified model



EXPLANATION



Model block showing block number N=6 and indices i=3, j=2 and k=1. N=i+(j-1) IO+(k-1) IO X JO. In this example IO is 3 and JO is 3. The inactive nodes are denoted with an X.



Model block showing block number N=6 and indices ij=6 and k=1. N = ij+(k-1) IOJO. In this example IOJO is 7, the total number of active nodes in a layer.

Figure 2.--Numbering scheme for finite-difference mesh used by the Trescott (1975) model and the modified model

uses this indexing scheme and takes advantage of the accompanying reduction in computer-memory. The indexing scheme used in the modified model is shown on the right of figure 2. In the example, there are two inactive nodes in each layer, thus, numbering only the active nodes results in a total of 21 finite-difference blocks. In comparison, the standard Trescott indexing scheme results in 27 blocks requiring storage. The i,j indices are not directly used in this indexing scheme; however, a variable ij is used. In any layer, the number of a node is ij, where ij refers only to the active nodes in the layer. The nodal index N is given by the following equation:

$$N = ij + (k-1)*IOJO \qquad (3)$$

where; ij has a range from 1 to IOJO,

k is the number of the layer of interest, and
IOJO is the number of active nodes in any layer.

SIMULATING CONFINING BED AND AQUIFER PINCHOUTS

The Trescott model code uses the transmissivity (T) matrix as a flag for determining if a node is included (T>0) or excluded (T=0) in the computational scheme. The solution process sweeps through all the nodes sequentially, and a check of the value of transmissivity determines the disposition of the node in the model. However, in certain hydrologic situations, the transmissivity matrix alone is not adequate to define the disposition of the node in the model.

Figure 3 shows typical cross sections, with pinchouts of aquifers and confining beds, and the model conceptualizations of the system in a discretized domain. In case one, the confining bed pinches out. In both the Trescott and modified models, the lateral flow in the aquifers is controlled by the transmissivities; the vertical connection between the aquifers is controlled by the appropriate vertical leakance (K_v/b). In areas where the confining bed is absent, the vertical hydraulic properties of the aquifer are used in the model, whereas the vertical properties of the confining bed are used where it is present. Typically, the vertical leakance of the aquifers is much larger than that of the confining beds.

An example of an aquifer pinching out between two adjacent confining beds is shown in case 2. The conceptualization used in the modified model is such that lateral flow in the aquifer is controlled by the transmissivity. Where the aquifer is absent, the transmissivity is specified as zero (no lateral flow), and all flow is in the vertical direction, controlled by the vertical hydraulic properties of the adjacent confining beds. In contrast,

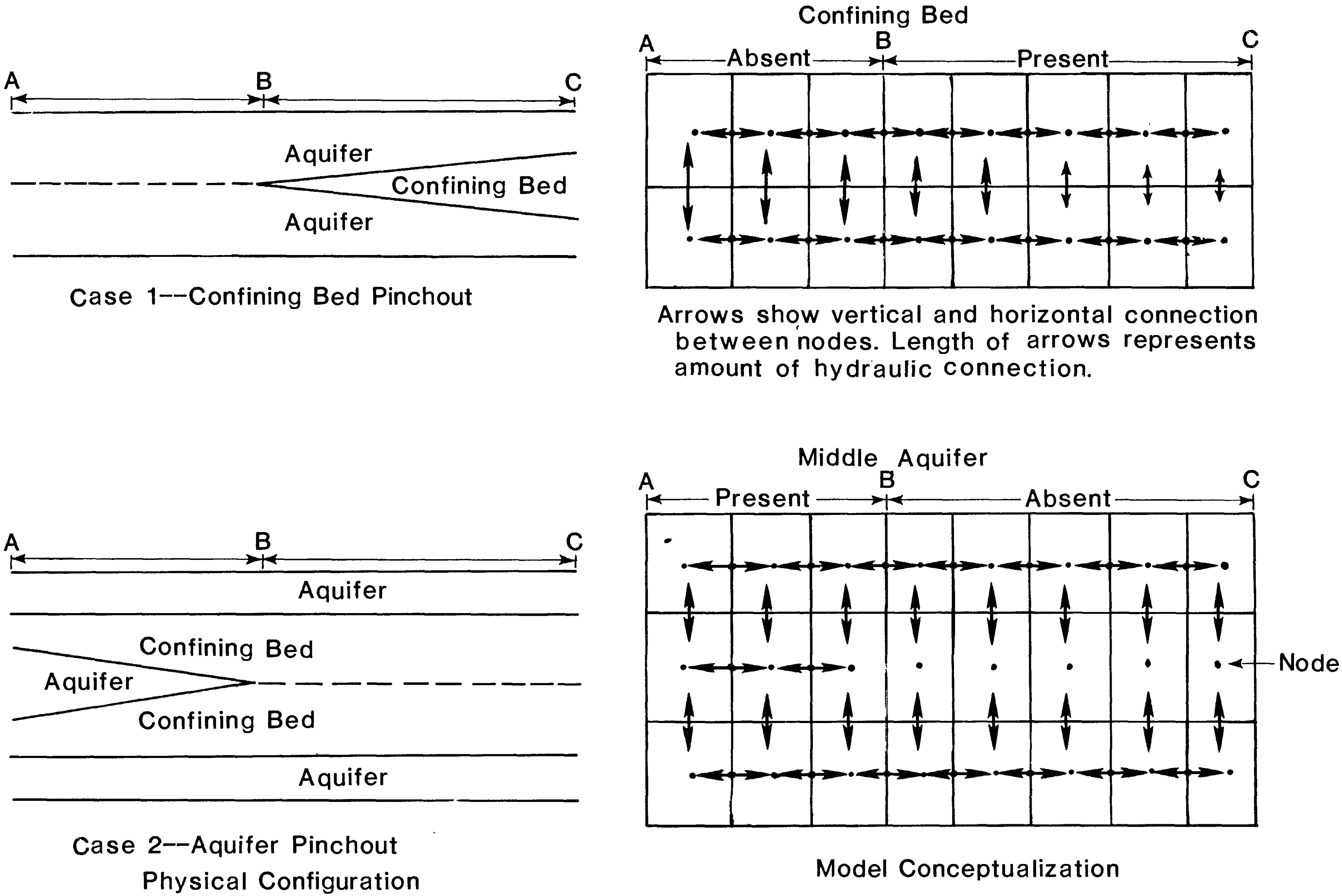


Figure 3.--Generalized cross sections and conceptualizations of aquifer and confining-bed pinchouts.

the logic used in the Trescott model requires that an artificial value of transmissivity greater than zero be specified in the areas where the aquifer is absent. If the transmissivity specified is very small, the lateral flow in this area becomes negligible, and the appropiate hydraulic connections are simulated. Hence, to simulate aquifer pinchouts accurately with the Trescott model artificial values of transmissivity are required to insure that these areas are included in the solution scheme. These artificial values cause unnecessary computational effort (lateral flow), and model results may be sensitive to the value of transmissivity specified.

To model subcrops and pinchouts accurately, the modified model was developed, so that the transmissivity matrix alone is not used to decide whether a node is included in the computational scheme. The modified model checks for vertical hydraulic connections as well as horizontal connections. If both the transmissivity and vertical leakance (K_v/b, variable TK in the model) are zero, the node is skipped in the computational scheme. However, if either the transmissivity or TK are nonzero, the node is retained.

Besides the changes in program logic, the user must calculate and enter appropriate transmissivity and TK values to match the modified conceptualization of the system. However, TK and transmissivity values are read into the model exactly as before.

In areas where an aquifer is absent between adjacent confining beds, the aquifer transmissivity should be set to zero, and appropriate confining-bed leakance values should be entered to control the vertical flow from one confining bed to another. The head computed for the node represents the head at the contact of adjacent confining beds.

In areas where a confining bed pinches out, the vertical flow between adjacent aquifers is controlled by the vertical hydraulic properties of the aquifers. The harmonic mean of the TK values of adjacent aquifers is commonly used as the effective TK between them. The harmonic mean is 2*TK1*TK2/(TK1 + TK2) where TK1 and TK2 are K_v/b of the adjacent aquifers.

INPUT REQUIREMENTS

Model-program modifications required to implement the memory reduction occur in every subroutine. Also, minor modifications to the input requirements of the program were necessary. Input instructions are given in Appendix I, and the modified model program is listed in Appendix II. The model input is essentially identical to the standard flow model, making the model easily compatible with available input data decks with minor additions. Data additions include (1) defining the starting and ending column of active or modeled nodes in each row in the model and (2) the total number of active nodes in a composite layer. For example, if layer 1 in the model has active nodes in columns 5 through 15 and layer 2 has active nodes in columns 8 through 25, the composite layer would have active nodes in columns 5 through 25. The starting and ending position of active or modeled nodes in each row in the model are input as two additional data arrays in the model. The size of each array is IO, the number of rows in the model. Within the modeled part of the finite-difference mesh, nodes representing areas where an aquifer is absent can still be indicated by zero transmissivity.

Even though data at unmodeled nodes are not stored, model data values are input for all nodes in the same format as in the standard flow model. The modified program uses the information that defines unused nodes to skip over unneeded data on input. Use of the same input structure makes conversion simpler than if a new input structure were used. On output, printout positions are maintained for all nodes, but, at unused nodes, values are printed as blanks. This makes it readily apparent which nodes are unused.

The program keeps track of the physical location of the adjacent nodes in relation to the node of interest during computation. This assures that the correct lateral hydraulic connections (coefficients TR and TC) are computed in SUBROUTINE COEF, and the solution algorithm is properly formulated in SUBROUTINE SOLVE.

To insure compatibility with the standard Trescott model, the example problem in Trescott (1975, Appendix IV) was simulated with the modified model. In this simulation, the storage for the zero-transmissivity nodes surrounding the active nodes, with the exception of a single dummy node in both rows 1 and 20, was eliminated from the Y-vector (the variable that contains storage for all array data). There were 74 inactive nodes per layer in the modified model simulation out of a total of 400 nodes per layer. The modified model reproduced exactly the results presented in Trescott (1975) for the sample problem.

COMPARISON OF MEMORY REQUIREMENTS AND COST FOR SIMULATION OF THE REGIONAL AQUIFER SYSTEM

The preliminary finite-difference grid used to discretize the northern Atlantic Coastal Plain aquifer system is shown in figure 4. The grid consists of 85 rows, 32 columns, and 10 layers, totalling 27,200 nodes. Because of the complex external geometry, not all of these nodes are actually needed to represent the aquifer system. The modeled or active part of the grid is bounded on the west by the Fall Line (Brown, 1972) and on the east by the seaward limit of the 10,000 mg/L isochlor (Meisler, 1981).

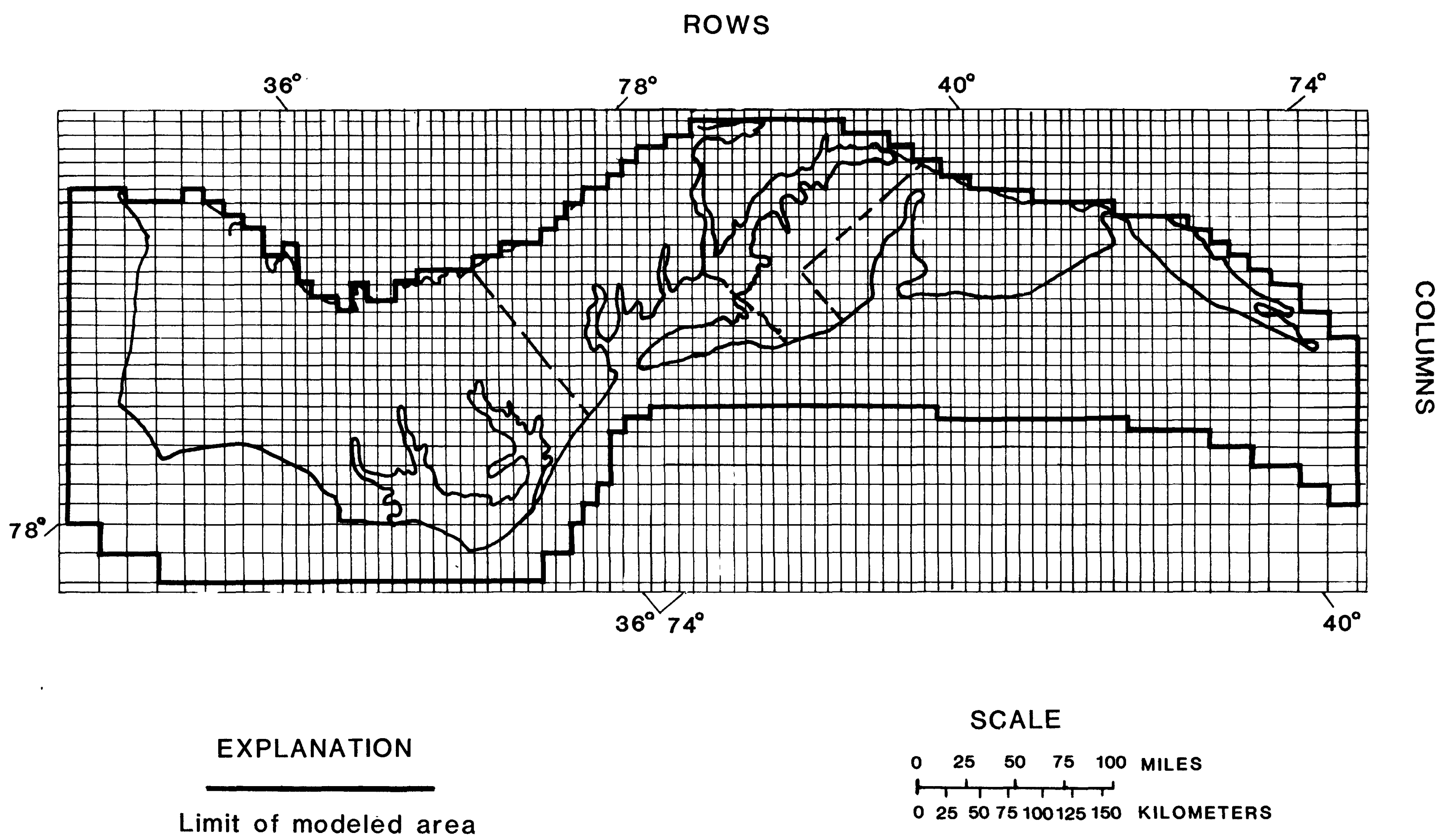


Figure 4.--Finite-difference grid used to discretize the northern Atlantic Coastal Plain aquifer system.

The outline on the grid defines the maximum number of active nodes for a composite of all the layers in the aquifer system. Although some inactive nodes are present within the outline, their number is small. The outline surrounds 15,640 nodes, or 57.5 percent of the 27,200 in the entire grid. The FORTRAN code was modified to store data only for nodes contained within the area defined by the outline (fig. 4).

Simulations of the northern Atlantic Coastal Plain aquifer system model were used to compare costs of the modified model and the Trescott model. Table 1 shows the results. As previously stated, 42.5 percent of the total 27,200 nodes are inactive in this model (simulation 1). The length of the Y-vector required for the simulation is smaller with the modified version. In general, savings were largely on memory costs; savings were also appreciable, however, on cost of execution time. The modified model executes faster because fewer time-consuming disk input and output operations associated with a virtual memory system are required with the smaller memory space. In general, the overall savings increase with an increasing ratio of inactive to total number of nodes. This is demonstrated by simulation 2 (table 1), which is identical to simulation 1 except that only the inactive nodes in the artificial zero transmissivity border (columns 1 and 32, rows 1 and 85) have been removed from storage. With this change, 91.6 percent of the total 27,200 nodes require storage space in the Y-vector.

As a further test of the modified model, the Coastal Plain aquifers of New Jersey were simulated both by the modified and the standard Trescott versions. The modified model duplicated the results of the Trescott model. A cost comparison of these simulations is given in table 1, simulation 3. The total number of nodes in these simulations is 14,790, of which 10 percent are inactive. Because, overall, there are fewer total nodes in this simulation than in the regional model, the memory savings are less. As expected, the overall savings, in comparison to simulation 1, are less.

Table 1.--Cost savings realized by modified model for sample problems.

Simulation	Number of total nodes	Number of nodes requiring storage	Percentage of total	Percentage cost savings realized by use of modified rather than Trescott model for sample problems		
				Overall	CPU	Core
1	27,200	15,640	57.5	30	18	45
2	27,200	24,920	91.6	14	3.5	25.2
3	14,790	13,250	90.0	8	4.4	13

CONCLUSIONS

The modified version of the ground-water-flow model duplicates exactly the results of the standard Trescott model for the sample problem and other test problems. The modified model permits the simulation of confining-bed and aquifer pinchouts without the use of artificial hydraulic parameters and eliminates wasted computer memory. Simulating a large number of nodes, a large percentage of which are inactive, is less expensive if the modified model is used. The savings over the Trescott model are problem dependent, that is, the savings are related to the number of inactive nodes in the simulation. Numerical experiments with the steady-state simulation of the northern Atlantic Coastal Plain regional aquifer study showed overall savings of 30 percent. In general, appreciable savings in simulating regional aquifer systems with complex external boundaries can be realized by the modified model.

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APPENDIX 1

DATA DECK INSTRUCTIONS

The data deck instructions have been made as compatible as possible with the Trescott version of the flow model. This allows existing data decks to be used with the modified model with minimal amount of recoding. The modified model also includes the transient leakage option (ENTRY CLAY) described by Posson, Hearne, Tracy and Frenzel (1980) and a modification to allow a user-specified maximum iteration parameter (WMAX) in ENTRY ITER. Because contouring packages for pen plotters are generally available, the line printer plotting routine (SUBROUTINE PRINTAI) was eliminated. The instructions that follow are adapted from Open-File Report 75-438.

Group I: Title, Simulation Options and Problem Dimensions

This group of cards, which are read by the main program, contains data required to dimension the model. To specify an option on card 4 punch the characters underlined in the definition. For an option not used, that section of card 4 can be left blank.

Note: Default typing of variables applies for all data input.

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
1	1-80	20A4	HEADING	Any title the user wishes to print on one line at the start of output
2	1-52	13A4	HEADING	
3	1-10	I10	IO	Number of rows
	11-20	I10	JO	Number of columns
	21-30	I10	KO	Number of layers
	31-40	I10	ITMAX	Maximum number of iterations per time step
	41-50	I10	NCH	Number of constant head nodes
	51-60	I10	MODE	Number of terms used in transient leakage code
	61-70	I10	IOJO	Number of modeled nodes per layer

DATA DECK INSTRUCTIONS--Continued

NOTE: IOJO is the total number of modeled nodes for a composite layer consisting of a combination of all layers considered together. In other words, the position of JDIML1 may be determined by the external geometry of Layer 1, whereas the position of JDIML2 may be determined by the external geometry of Layer 2. The variable IOJO would be the number of modeled nodes in this composite layer.

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
4	1-4	A4	IDRAW	DRAW to print drawdown
	6-9	A4	IHEAD	HEAD to print hydraulic head
	11-14	A4	IFLOW	MASS to compute a mass balance
	16-18	A3	IDK1	DK1 to read initial head, elapsed time, and mass balance parameters on unit 4 (disk)
	21-23	A3	IDK2	DK2 to write computed head, elapsed time, and mass balance parameters on unit 4 (disk)
	26-29	A4	IWATER	WATE if the upper hydrologic unit is unconfined
	31-34	A4	IQRE	RECH for a constant recharge that may be a function of space
	36-39	A4	IPU1	PUN1 to read initial head, elapsed time, and mass balance parameters from cards
	41-44	A4	IPU2	PUN2 to punch computed head, elapsed time, and mass balance parameters on cards
	46-49	A4	ITK	ITKR to read the value of TK(I,J,K) for simulations in which confining layers are not represented by layers of nodes. TK(I,J,K) = Kv/b.
	51-54	A4	IEQN	EQN3 to solve Equation 3

DATA DECK INSTRUCTIONS--Continued

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
	56-59	A4	ITL	ITLR to read values of Rate (I,J,K-1) M(I,J,K-1),SS(K-1)

Note: For continuation of a simulation, if transient leakage option (ITLR) is specified variables RM, XI, and DELT are written, punched or read on disk or cards dependent on options specified (DK1, DK2, PUN1, PUN2).

Group IA: Modeled nodes array

ARRAY	COLUMNS	FORMAT	VARIABLE	DEFINITION
1	1-80	8I10	JDIML1(IO)	Location of first modeled node in each row in x-direction
2	1-80	8I10	JDIML2(IO)	Location of last modeled node in each row in x-direction

NOTE: The first modeled node may not appear in column 1 and may not appear after column 40.

Group II: Scalar parameters

The parameters required in every problem are underlined. The other parameters are required as noted; when not required, their location on the card can be left blank. The G format is used to read E, F and I format data. Minimize mistakes by always right-justifying data in the field. If F format data do not contain significant figures to the right of the decimal point, the decimal point can be omitted.

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
1	1-10	G10.0	NPER	Number of pumping periods for the simulation
	11-20	G10.0	KTH	Number of time steps between printouts

NOTE: To print only the results for the final time step in a pumping period, make KTH greater than the expected number of time steps. The program always prints the results for the final time step.

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
	21-30	G10.0	ERR	Error criteria for closure (L)

<u>DATA DECK INSTRUCTIONS</u>--Continued

NOTE: When the head change at all nodes on subsequent iterations is less than this value (for example, 0.01 foot), the program has converged to a solution for the time step.

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
	31-40	G10.0	<u>LENGTH</u>	Number of iteration parameters
2	1-20	G20.10	SUM	
	21-40	G20.10	SUMP	
	41-60	G20.10	PUMPT	Parameters in which elapsed time and cumulative volumes for mass balance are stored. For the start of a simulation insert three blank cards. <u>For continuation</u> of a previous run using cards as input, replace the three blank cards with the first three cards of punched output from the previous run. Using data from disk for input, leave the three blank cards in the data deck.
	61-80	G20.10	CFLUXT	
3	1-20	G20.10	QRET	
	21-40	G20.10	CHST	
	41-60	G20.10	CHDT	
	61-80	G20.10	FLUXT	
4	1-20	G20.10	STORT	
4	21-40	G20.10	ETFLXT	
	41-60	G20.10	FLXNT	

<u>Group III: Array Data</u>

Each of the following data sets (except data set 1) consists of a parameter card and, if the data set contains variable data, a set of data cards for each layer in the model. Each parameter card contains at least five variables. The final card in Group III is not a part of an array data set but rather a single card defining the maximum iteration parameter.

DATA DECK INSTRUCTIONS--Continued

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
Every Parameter Card	1-10	G10.0	FAC	If IVAR = 0, FAC is the value assigned to every element of the matrix for this layer. If IVAR = 1, FAC is the multiplication factor for the following set of data cards for this layer.
	11-20	G10.0	IVAR	= 0 if no data cards are to be read for this layer. = 1 if data cards for this layer follow.
	21-30	G10.0	IPRN	=0 if input data for this layer are to be printed. = 1 if input data for the layer are <u>not</u> to be printed.
Transmissivity Parameters Cards also have these Variables	31-40	G10.0	FACT(K,1)	multiplication factor for transmissivity in x-direction
	41-50	G10.0	FACT(K,2)	multiplication factor for transmissivity in the y-direction
	51-60	G10.0	FACT(K,3)	multiplication factor for hydraulic conductivity in the z-direction. (Not used when confining bed nodes are eliminated and TK values are read)

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
Every Parameter Card	61-70	G10.0	IRECS	= 0 if the matrix is being read from cards or if each element is being set equal to FAC. = 1 if the matrix is to be read from disk (unit 2)
	71-80	G10.0	IRECD	= 0 if the matrix is not to be stored on disk. = 1 if the matrix being read from cards or set equal to FAC is to be stored on disk (unit 2) for later retrieval.

When data cards are included, start each row on a new card. To prepare a set of data cards for an array that is a function of space, the general procedure is to overlay the finite-difference grid on a contoured map of the parameter and record the average value of the parameter for each finite-difference block on coding forms according to the appropriate format. In general, record only significant digits and no decimal points (except for data set 2); use the multiplication factor to convert the data to their appropriate values. For example, if DELX ranges from 1,000 to 15,000 feet, coded values should range from 1-15; the multiplication factor (FAC) would be 1,000.

DATA SET	COLUMNS	FORMAT	VARIABLE	DEFINITION
1	1-80	8F10.4	PHI(IJ,K)	Head values for continuation of a previous run (L)

NOTE: For a new simulation this data set is omitted. Do not include a parameter card with this data set.

DATA SET	COLUMNS	FORMAT	VARIABLE	DEFINITION
2	1-80	8F10.4	STRT(IJ,K)	Starting head matrix (L)
3	1-80	20F4.0	S (IJ,K)	Storage coefficient (dimensionless)

NOTE: This matrix is also used to locate constant head boundaries by coding a negative number at constant head nodes.

DATA SET	COLUMNS	FORMAT	VARIABLE	DEFINITION
4	1-80	20F4.0	T(IJ,K)	Transmissivity (L^2/t)

NOTE: 1) See the previous page for the additional requirements on the parameter cards for this data set.

2) If the upper modeled layer is unconfined and PERM and BOTTOM are to be read for this layer, insert a parameter card for this layer with only the values for FACT on it.

3) Zero values may be used to represent aquifer pinchouts. Finite values of TK will allow flow directly from confining bed to confining bed in these areas.

5	1-80	8F10.4	TK(IJ,K)	= K_v/b leakance (/T).

NOTE: This data set is read for both steady leakage(ITKR) and transient leakage(ITLR) options. If the Transient Leakge Option is specified, zero values must be specified for TK. The number of layers of TK values is KO-1.

6	1-80	20F4.0	PERM(IJ)	Hydraulic conductivity (L/T) (see note 1 for data set 4)
7	1-80	20F4.0	BOTTOM(IJ)	Elevation of bottom of water-table unit (L)

NOTE: Data set 6 and 7 are required only for simulating unconfined conditions in the upper hydrologic unit.

8	1-80	20F 4.0	QRE(IJ)	Recharge rate (L/T)

NOTE: Omit if not used

9	1-80	20F 4.0	RATE(IJ,K)	Vertical hydraulic conductivity of confining bed (K') (L/T)
10	1-80	20F 4.0	ZCB(IJ,K)	Thickness of confining bed (L)

DATA DECK INSTRUCTIONS--Continued

DATA SET	COLUMNS	FORMAT	VARIABLE	DEFINITION
11	1-80	8G10.0	SS(K)	Specific storage of confining bed (/L)

NOTE: Data sets 9, 10, and 11 are required for simulating transient leakage from confining beds. If steady leakage is required for a particular confining bed in the simulation, specific storage for the particular confining bed can be specified as zero, or rate can be specified as zero and a finite value of TK for the confining bed can be used.

DATA SET	COLUMNS	FORMAT	VARIABLE	DEFINITION
12	1-80	8G10.0	DELX(J)	Grid spacing in x direction (L)
13	1-80	8G10.0	DELY(I)	Grid spacing in y direction (L)
14	1-80	8G10.0	DELZ(K)	Grid spacing in z direction (L)
	1-10	F10.7	WMAX	Maximum iteration parameter (optimum value can be determined by trial and error for each problem, 0.99863 is a good first guess)

Group IV: Parameters that change with the pumping period

The program has two options for the simulation period:

1. To simulate a given number of time steps, set TMAX to a value larger than the expected simulation period. The program will use NUMT, CDLT, and DELT as coded.

2. To simulate a given pumping period, set NUMT larger than the number required for the simulation period (for example, 100). The program will compute the exact DELT (which will be ≤ DELT coded) and NUMT to arrive exactly at TMAX on the last time step.

DATA DECK INSTRUCTIONS--Continued

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
1	1-10	G10.0	KP	Number of the pumping period
	11-20	G10.0	KPM1	Number of the previous pumping period

NOTE: KPM1 is currently not used

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
	21-30	G10.0	NWEL	Number of wells for this pumping period
	31-40	G10.0	TMAX	Number of days in this pumping period
	41-50	G10.0	NUMT	Number of time steps
	51-60	G10.0	CDLT	Multiplying factor for DELT

NOTE: 1.5 is commonly used

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
	61-70	G10.0	DELT	Initial time step in hours

---

if NWEL = 0 the following set of cards is omitted

DATA SET 1 (NWEL cards)

CARD	COLUMNS	FORMAT	VARIABLE	DEFINITION
	1-10	G10.0	K	Layer in which well is located
	11-20	G10.0	I	Row location of well
	21-30	G10.0	J	Column location of well
	31-40	G10.0	WELL(IJ,K)	Pumping rate (L^3/t), negative for a pumping well.

For each additional pumping period, another set of group IV cards is required (that is, NPER sets of group IV cards are required).

APPENDIX 2
LISTING OF SOURCE CODE

```
C  MODIFIED FLOW MODEL TO REDUCE CORE STORAGE, INCLUDES TRANSIENT LEAKAGE
C  JUNE 1982
C     ------------------------------------------------------------------
C     FINITE-DIFFERENCE MODEL FOR SIMULATION OF GROUND-WATER FLOW IN
C     THREE DIMENSIONS, SEPTEMBER, 1975 BY P.C. TRESCOTT, U. S. G. S.
C     WITH CONTRIBUTIONS TO MAIN, DATAI AND SOLVE BY S.P. LARSON
C     CHANGES TO REDUCE Y-VECTOR LENGTH BY P.P. LEAHY
C     ------------------------------------------------------------------
C
C     SPECIFICATIONS:
      REAL *8YSTR
C
      DIMENSION Y(20000), L(34), HEADNG(33), NAME(54), DUM(3)
     1, LL(2), JD(100)
C
      EQUIVALENCE (YSTR,Y(1))
C
      COMMON /INTEGR/ IO,JO,KO,I1,J1,K1,NPER,KTH,ITMAX,LENGTH,KP,NWEL,
     1NUMT,IFINAL,IT,KT,IHEAD,IDRAW,IFLO,IERR,I2,J2,K2,IMAX,ITMX1,NCH,
     2IDK1,IDK2,IWATER,IQRE,IPJP,IQJQ,IKJK,K5,IPU1,IPU2,ITK,IEQN,MODE
     .,ITL,IOJO,K6,K7,ILJL
      COMMON /SPARAM/ TMAX,CDLT,DELT,ERR,TEST,SUM,SUMP,QR,DELTM1
      COMMON /SARRAY/ ICHK(13)
C
      DATA NAME/2*4H    ,4H   S,4HTART,4HING ,4HHEAD,4H    ,4H STO,4HRAG
     1E,4H COE,4HFFIC,4HIENT,2*4H    ,4H  TR,4HANSM,4HISSI,4HVITY,5*4H
     2  ,4H  TK,4H  HY,4HDRAU,4HLIC ,4HCOND,4HUCTI,4HVITY,2*4H    ,4HBOT
     3T,4HOM E,4HLEVA,4HTION,2*4H    ,4H   R,4HECHA,4HRGE ,4HRATE,4H   A
     4,4HQUIT,4HARD ,4HCOND,4HUCTI,4HVITY,4H    ,4H  AQ,4HUITA,4HRD T,4H
     5HICK,4HNESS/
C
      DEFINE FILE 2(8,1520,U,KKK)
      ILENGY=20000
      JLENG=100
C     ..................................................................
C
C     ---READ TITLE, PROGRAM SIZE AND OPTIONS---
      READ (5,200) HEADNG
      WRITE (6,190) HEADNG
      READ (5,160) IO,JO,KO,ITMAX,NCH,MODE,IOJO
      WRITE (6,180) IO,JO,KO,ITMAX,NCH,MODE,IOJO
      READ (5,210) IDRAW,IHEAD,IFLO,IDK1,IDK2,IWATER,IQRE,IPU1,IPU2,ITK
     1,IEQN,ITL
      WRITE (6,220) IDRAW,IHEAD,IFLO,IDK1,IDK2,IWATER,IQRE,IPU1,IPU2,ITK
     1,IEQN,ITL
      IERR=0
C
C     ---COMPUTE DIMENSIONS FOR ARRAYS---
      J1=JO-1
      I1=IO-1
      K1=KO-1
```

```
      I2=I0-2
      J2=J0-2
      K2=K0-2
      IMAX=MAX0(I0,J0)
      NCD=MAX0(1,NCH)
      ITMX1=ITMAX+1
      ISIZ=I0J0*K0
      IK1=I0J0
      IK2=MAX0(IK1*K1,1)
      ISUM=2*ISIZ+1
      L(1)=1
      DO 30 I=2,14
      IF (I.NE.8) GO TO 20
      L(8)=ISUM
      ISUM=ISUM+IK2
      IF (IK2.EQ.1) GO TO 10
      IKJK=IK1
      K5=K1
      GO TO 30
   10 IKJK=1
      K5=1
      GO TO 30
   20 L(I)=ISUM
      ISUM=ISUM+ISIZ
   30 CONTINUE
      L(15)=ISUM
      ISUM=ISUM+J0
      L(16)=ISUM
      ISUM=ISUM+I0
      L(17)=ISUM
      ISUM=ISUM+K0
      L(18)=ISUM
      ISUM=ISUM+IMAX
      L(19)=ISUM
      ISUM=ISUM+K0*3
      L(20)=ISUM
      ISUM=ISUM+ITMX1
      L(21)=ISUM
      ISUM=ISUM+3*NCD
      L(22)=ISUM
      ISUM=ISUM+NCD
      L(23)=ISUM
      IF (IWATER.NE.ICHK(6)) GO TO 40
      ISUM=ISUM+IK1
      L(24)=ISUM
      ISUM=ISUM+IK1
      IPJP=IK1
      GO TO 50
   40 ISUM=ISUM+1
      L(24)=ISUM
      ISUM=ISUM+1
```

```
      IPJP=1
   50 L(25)=ISUM
      IF (IQRE.NE.ICHK(7)) GO TO 60
      ISUM=ISUM+IK1
      IQJQ=IK1
      GO TO 70
   60 ISUM=ISUM+1
      IQJQ=1
   70 L(26) = ISUM
      IF ( ITL.NE.ICHK(12) )   GO TO 75
      ILJL=IK1
      K6=K0
      K7=K1
      ISUM = ISUM + IK2
      L(27) = ISUM
      ISUM = ISUM + IK2
      L(28) = ISUM
      ISUM = ISUM + K1
      L(29) = ISUM
      ISUM = ISUM + ISIZ
      L(30) = ISUM
      ISUM = ISUM + ISIZ
      L(31) = ISUM
      ISUM = ISUM + ISIZ
      L(32) = ISUM
      ISUM = ISUM + 2*MODE*IK2
      GO TO 77
   75 ILJL=1
      MODE=1
      K6=1
      K7=1
      ISUM=ISUM+1
      L(27)=ISUM
      ISUM=ISUM+1
      L(28)=ISUM
      ISUM=ISUM+1
      L(29)=ISUM
      ISUM=ISUM+1
      L(30)=ISUM
      ISUM=ISUM+1
      L(31)=ISUM
      ISUM=ISUM+1
      L(32)=ISUM
      ISUM=ISUM+2
   77 JSUM = IO
      LL(1)=1
      LL(2)=JSUM+1
      JSUM = JSUM + IO
      WRITE (6,170) ISUM,ILENGY
      WRITE (6,175) JSUM,JLENG
      IF (ISUM.GT.ILENGY)   GO TO 155
```

```
C
C     ---PASS INITIAL ADDRESSES OF ARRAYS TO SUBROUTINES---
      CALL DATAI(Y(L(1)),Y(L(2)),Y(L(3)),Y(L(4)),Y(L(5)),Y(L(6)),Y(L(7))
     1,Y(L(8)),Y(L(9)),Y(L(15)),Y(L(16)),Y(L(17)),Y(L(19)),Y(L(23)),Y(L(
     224)),Y(L(25)),Y(L(14)),Y(L(32)),JD(LL(1)),JD(LL(2)) )
      CALL STEP(Y(L(1)),Y(L(2)),Y(L(3)),Y(L(4)),Y(L(5)),Y(L(6)),Y(L(7)),
     1Y(L(8)),Y(L(9)),Y(L(15)),Y(L(16)),Y(L(17)),Y(L(19)),Y(L(18)),Y(L(2
     20)),Y(L(14)),Y(L(32)),JD(LL(1)),JD(LL(2)) )
      CALL SOLVE(Y(L(1)),Y(L(2)),Y(L(3)),Y(L(4)),Y(L(5)),Y(L(6)),Y(L(7))
     1,Y(L(8)),Y(L(9)),Y(L(15)),Y(L(16)),Y(L(17)),Y(L(19)),Y(L(10)),Y(L(
     211)),Y(L(12)),Y(L(13)),Y(L(14)),Y(L(20)),Y(L(25))
     3,Y(L(26)),Y(L(27)),Y(L(28)),Y(L(29)),Y(L(30)),Y(L(31)),Y(L(32)),
     4JD(LL(1)),JD(LL(2)) )
      CALL COEF(Y(L(1)),Y(L(2)),Y(L(3)),Y(L(4)),Y(L(5)),Y(L(6)),Y(L(7)),
     1Y(L(8)),Y(L(9)),Y(L(15)),Y(L(16)),Y(L(17)),Y(L(19)),Y(L(23)),Y(L(2
     24)),Y(L(25)),Y(L(14))
     3,Y(L(26)),Y(L(27)),Y(L(28)),Y(L(29)),Y(L(30)),Y(L(31)),Y(L(32)),
     4JD(LL(1)),JD(LL(2)) )
      CALL CHECKI(Y(L(1)),Y(L(2)),Y(L(3)),Y(L(4)),Y(L(5)),Y(L(6)),Y(L(7)
     1),Y(L(8)),Y(L(9)),Y(L(15)),Y(L(16)),Y(L(17)),Y(L(19)),Y(L(21)),Y(L
     2(22)),Y(L(25)),Y(L(14))
     3,Y(L(26)),Y(L(27)),Y(L(28)),Y(L(29)),Y(L(30)),Y(L(31)),Y(L(32)),
     4JD(LL(1)),JD(LL(2)) )
C
C     ---START COMPUTATIONS---
C     ************************
C     ---READ AND WRITE DATA FOR GROUPS II AND III---
      CALL DATAIN
      IRN=1
      NIJ=IOJO
      DO 80 K=1,KO
      LOC=L(2)+(K-1)*NIJ
   80 CALL ARRAY(Y(LOC),2,1,NAME(1),IRN,DUM,K)
      DO 90 K=1,KO
      LOC=L(5)+(K-1)*NIJ
   90 CALL ARRAY(Y(LOC),1,2,NAME(7),IRN,DUM,K)
      DO 100 K=1,KO
      LOC=L(4)+(K-1)*NIJ
      L1=L(19)+K-1
      L2=L(19)+KO+K-1
      L3=L(19)+2*KO+K-1
      CALL ARRAY(Y(LOC),1,2,NAME(13),IRN,DUM,K)
      Y(L1)=DUM(1)
      Y(L2)=DUM(2)
      Y(L3)=DUM(3)
  100 WRITE (6,230) K,Y(L1),Y(L2),Y(L3)
      IF (ITK.NE.ICHK(10)) GO TO 120
      DO 110 K=1,K1
      LOC=L(8)+(K-1)*NIJ
  110 CALL ARRAY(Y(LOC),2,3,NAME(19),IRN,DUM,K)
  120 IF (IWATER.NE.ICHK(6)) GO TO 130
      K=KO
      CALL ARRAY(Y(L(23)),1,4,NAME(25),IRN,DUM,K)
      CALL ARRAY(Y(L(24)),1,1,NAME(31),IRN,DUM,K)
```

```
  130 IF (IQRE.EQ.ICHK(7)) CALL ARRAY(Y(L(25)),1,4,NAME(37),IRN,DUM,K)
      IF (ITL.NE.ICHK(12) )   GO TO 135
      DO 131 K=1,K1
      LOC = L(26) + (K-1)*NIJ
  131 CALL ARRAY (Y(LOC),1,3,NAME(43),IRN,DUM,K)
      DO 132 K=1,K1
      LOC = L(27) + (K-1)*NIJ
  132 CALL ARRAY (Y(LOC),1,1,NAME(49),IRN,DUM,K)
      READ (5,240) FAC,IVAR,IPRN
      LOC = L(28)
      IF (IVAR.EQ.1) READ (5,240)(Y(LOC+K-1),K=1,K1)
      DO 133 K=1,K1
      IF (IVAR.NE.1) GO TO 134
      Y(LOC+K-1) = Y(LOC+K-1)*FAC
      GO TO 133
  134 Y(LOC+K-1) = FAC
  133 CONTINUE
      IF (IVAR.EQ.1.AND.IPRN.NE.1) WRITE (6,250) (Y(LOC+K-1),K=1,K1)
      IF (IVAR.EQ.0) WRITE (6,260) FAC
  135 CONTINUE
      CALL MDAT
C
C     ---COMPUTE TRANSMISSIVITY FOR UNCONFINED LAYER---
      IF (IWATER.EQ.ICHK(6)) CALL TRANS(1)
C
C     ---COMPUTE T COEFFICIENTS---
      CALL TCOF
C
C     ---COMPUTE ITERATION PARAMETERS---
      CALL ITER
C
C     ---READ TIME PARAMETERS AND PUMPING DATA FOR A NEW PUMPING PERIOD-
  140 CALL NEWPER
C
      KT=0
      IFINAL=0
C
C     ---START NEW TIME STEP COMPUTATIONS---
  150 CALL NEWSTP
C
C     ---START NEW ITERATION IF MAXIMUM NO. ITERATIONS NOT EXCEEDED---
      CALL NEWITA
C
C     ---PRINT OUTPUT AT DESIGNATED TIME STEPS---
      CALL OUTPUT
C
C     ---LAST TIME STEP IN PUMPING PERIOD μ---
      IF (IFINAL.NE.1) GO TO 150
C
C     ---CHECK FOR NEW PUMPING PERIOD---
      IF (KP.LT.NPER) GO TO 140
```

```
C
  155 STOP                                                              00001870
C
C     ---FORMATS---
C
C
C
  160 FORMAT (8I10)                                                     00001880
  170 FORMAT ('0',54X,'WORDS OF VECTOR Y USED =',I7,8X,' OF Y = ',I7)   00001890
  175 FORMAT ('0',54X,'WORDS OF VECTOR JD USED =',I6,8X,' OF JD = ',I6) 00001900
  180 FORMAT ('0',62X,'NUMBER OF ROWS =',I5/60X,'NUMBER OF COLUMNS =',I500001910
     1/61X,'NUMBER OF LAYERS =',I5//39X,'MAXIMUM PERMITTED NUMBER OF ITE
     2RATIONS =',I5//48X,'NUMBER OF CONSTANT HEAD NODES =',I5//44X,
     .'NUMBER OF TRANSIENT LEAKAGE MODES =',I5//44X,'NUMBER OF ACTIVE NO
     .DES PER LAYER =',I5)
  190 FORMAT ('1',33A4)                                                 00001920
  200 FORMAT (20A4)                                                     00001930
  210 FORMAT (16(A4,1X))                                                00001940
  220 FORMAT ('-SIMULATION OPTIONS:  ',12(A4,4X))                       00001950
  230 FORMAT (1H0,44X,'DIRECTIONAL TRANSMISSIVITY MULTIPLICATION FACTORS00001960
     1 FOR LAYER',I3,/,76X,'X =',1P1G15.7/76X,'Y =',1P1G15.7/76X,'Z =',
     .1P1G15.7)
  240 FORMAT (8G10.0)                                                   00001970
  250 FORMAT (1H ,46X,'SPECIFIC STORAGE'/47X,40('-')//('0',1P18G15.7))  00001980
  260 FORMAT ('0',55X,'ALL SPECIFIC STORAGES = ',1P1G15.7)              00001990
  270 FORMAT (1H1,46X,'POSITION OF FIRST ACTIVE NODE IN X DIRECTION'/   00002000
     .47X,44('-')//('0',12I10))
  280 FORMAT (1H1,46X,'POSITION OF LAST ACTIVE NODE IN X DIRECTION'/    00002010
     .47X,43('-')//('0',12I10))
      END                                                               00002020
      SUBROUTINE DATAI(PHI,STRT,OLD,T,S,TR,TC,TK,WELL,DELX,DELY,DELZ,FAC00002030
     1T,PERM,BOTTOM,QRE,XI,RM,JDIML1,JDIML2)
C     -----------------------------------------------------------------
C     READ AND WRITE DATA
C     -----------------------------------------------------------------
C
C     SPECIFICATIONS:
      REAL *8PHI                                                        00002040
        REAL*4 IOFT1(12),INFT1(12)                                      00002050
C
      DIMENSION PHI(IOJO,KO), STRT(IOJO,KO), OLD(IOJO,KO), T(IOJO,KO    00002060
     1), S(IOJO,KO), TR(IOJO,KO), TC(IOJO,KO), TK(IKJK,K5), WELL(IOJO,KO
     2), DELX(JO), DELY(IO), DELZ(KO), FACT(KO,3), PERM(IPJP), BOTTOM(
     3IPJP), QRE(IQJQ), TF(3), A(IOJO), IN(6), XI(IOJO,KO), RM(2,MODE,
     4ILJL,K7), JDIML1(IO), JDIML2(IO)
C
      COMMON /INTEGR/ IO,JO,KO,I1,J1,K1,NPER,KTH,ITMAX,LENGTH,KP,NWEL,  00002070
     1NUMT,IFINAL,IT,KT,IHEAD,IDRAW,IFLO,IERR,I2,J2,K2,IMAX,ITMX1,NCH,
     2IDK1,IDK2,IWATER,IQRE,IPJP,IQJQ,IKJK,K5,IPU1,IPU2,ITK,IEQN,MODE
     .,ITL,IOJO,K6,K7,ILJL
      COMMON /SPARAM/ TMAX,CDLT,DELT,ERR,TEST,SUM,SUMP,QR,DELTM1        00002080
```

```
      COMMON /SARRAY/ ICHK(13)
      COMMON /CK/ ETFLXT,STORT,QRET,CHST,CHDT,FLUXT,PUMPT,CFLUXT,FLXNT
      COMMON /PR/ DIGIT(129),VF4(12),VF5(12),
     1VF6(12),VF7(12),VF8(12),VF9(12),VF10(12)
      RETURN
C     ..................................................................
C     ********************
      ENTRY DATAIN
C     ********************
C
C
C     ---READ AND WRITE LIMIT OF ACTIVE NODES IN X DIRECTION
C
      READ (5,330) (JDIML1(I),I=1,IO)
      READ (5,330) (JDIML2(I),I=1,IO)
      WRITE (6,460) (JDIML1(I),I=1,IO)
      WRITE (6,470) (JDIML2(I),I=1,IO)
C
C     ---READ AND WRITE SCALAR PARAMETERS---
      READ (5,330) NPER,KTH,ERR,LENGTH
      WRITE (6,340) NPER,KTH,ERR
C
C     ---READ CUMULATIVE MASS BALANCE PARAMETERS---
      READ (5,450) SUM,SUMP,PUMPT,CFLUXT,QRET,CHST,CHDT,FLUXT,STORT,ETFL
     1XT,FLXNT,DELT
      IF (IDK1.EQ.ICHK(4)) GO TO 20
      IF (IPU1.NE.ICHK(8)) GO TO 50
C
C     ---READ INITIAL HEAD VALUES FROM CARDS---
      DO 15 K=1,KO
      J4=1
      DO 10 I=1,IO
      JJ=JO-JDIML2(I)
      VF4(4)=DIGIT(129)
      ND=(JDIML1(I)-1)*10
      ND1=ND/80 + 123
      ND=ND-80*(ND1-123)
      J5=JDIML2(I)-JDIML1(I)+J4
      IF(ND1.EQ.123) ND1=128
      VF4(2)=DIGIT(ND1)
      IF(ND.NE.0) GO TO 12
      VF4(3)=DIGIT(128)
      VF4(4)=DIGIT(128)
      GO TO 11
   12 VF4(3)=DIGIT(ND)
   11 NE=(80-ND)/10
      VF4(5)=DIGIT(NE)
      READ (5,VF4) (PHI(IJ,K),IJ=J4,J5),(DELX(J),J=1,JJ)
   10 J4=J5+1
   15  CONTINUE
      IF(ITL.NE.ICHK(12)) GO TO 16
      DO 17 K=1,KO
```

```
      READ(5,330) (XI(IJ,K),IJ=1,IOJO)
   17 CONTINUE
      READ(5,480) ((((RM(N,M,IJ,K),N=1,2),M=1,MODE),IJ=1,ILJL),K=1,K7)
   16 CONTINUE
      GO TO 30
C
C     ---READ INITIAL HEAD AND MASS BALANCE PARAMETERS FROM DISK---
   20 READ (4) PHI,SUM,SUMP,PUMPT,CFLUXT,QRET,CHST,CHDT,FLUXT,STORT,ETFL
     1XT,FLXNT,DELT,XI,RM
      REWIND 4
   30 WRITE (6,430) SUM
      DO 45 K=1,KO
      J4=1
      WRITE (6,440) K
      DO 40 I=1,IO
      ND=(JDIML1(I)-1)*6
      ND1=ND/120 + 123
      VF5(2)=DIGIT(ND1)
      ND=ND-120*(ND1-123)
      NE=(120-ND)/6
      J5=JDIML2(I)-JDIML1(I)+J4
      IF(ND1.NE.123) ND=3+ND
      ND=ND+2
      VF5(3)=DIGIT(ND)
      VF5(5)=DIGIT(NE)
      WRITE (6,VF5) I,(PHI(IJ,K),IJ=J4,J5)
   40 J4=J5+1
   45  CONTINUE
C
   50 DO 60 K=1,KO
      DO 60 IJ=1,IOJO
      WELL(IJ,K)=0.
      TR(IJ,K)=0.
      TC(IJ,K)=0.
      IF (K.NE.KO) TK(IJ,K)=0.
   60 CONTINUE
      RETURN
C     **********************
      ENTRY ARRAY(A,INFT,IOFT,IN,IRN,TF,K)
C     **********************
      READ (5,330) FAC,IVAR,IPRN,TF,IRECS,IRECD
      IC=4*IRECS+2*IVAR+IPRN+1
      GO TO (70,70,90,90,120,120), IC
   70 DO 80 IJ=1,IOJO
   80 A(IJ)=FAC
      WRITE (6,280) IN,FAC,K
      GO TO 140
   90 IF (IC.EQ.3) WRITE (6,290) IN,K
      J4=1
      DO 111 I=1,IO
      JJ=JO-JDIML2(I)
```

```
      IF (INFT.EQ.1) GO TO 91
      VF4(4)=DIGIT(129)
      ND=(JDIML1(I)-1)*10
      ND1=ND/80 + 123
      ND=ND-80*(ND1-123)
      J5=JDIML2(I)-JDIML1(I)+J4
      IF(ND1.EQ.123) ND1=128
      VF4(2)=DIGIT(ND1)
      IF(ND.NE.0) GO TO 71
      VF4(3)=DIGIT(128)
      VF4(4)=DIGIT(128)
      GO TO 72
   71 VF4(3)=DIGIT(ND)
   72 NE=(80-ND)/10
      VF4(5)=DIGIT(NE)
        DO 89 KVF=1,12
   89 INFT1(KVF)=VF4(KVF)
      GO TO 92
   91 ND=(JDIML1(I)-1)*4
      VF6(4)=DIGIT(129)
      ND1=ND/80 + 123
      ND=ND-80*(ND1-123)
      J5=JDIML2(I)-JDIML1(I)+J4
      IF(ND1.EQ.123) ND1=128
      VF6(2)=DIGIT(ND1)
      IF(ND.NE.0) GO TO 73
      VF6(3)=DIGIT(128)
      VF6(4)=DIGIT(128)
      GO TO 74
   73 VF6(3)=DIGIT(ND)
   74 NE=(80-ND)/4
       IF(J0.LE.20) NE=NE+JJ
      VF6(5)=DIGIT(NE)
        DO 88 KVF=1,12
   88 INFT1(KVF)=VF6(KVF)
   92 READ (5,INFT1) (A(IJ),IJ=J4,J5),(DELX(J),J=1,JJ)
      DO 100 IJ=J4,J5
  100 A(IJ)=A(IJ)*FAC
      GO TO (101,102,103,104) ,IOFT
  101 ND=(JDIML1(I)-1)*6
      ND1=ND/120 + 123
      VF5(2)=DIGIT(ND1)
      ND=ND-120*(ND1-123)
      NE=(120-ND)/6
      IF(ND1.NE.123) ND=3+ND
      ND=ND+2
      VF5(3)=DIGIT(ND)
      VF5(5)=DIGIT(NE)
        DO 87 KVF=1,12
   87 IOFT1(KVF)=VF5(KVF)
      GO TO 110
```

```
102 ND=(JDIML1(I)-1)*9
    ND1=ND/126 + 123
    VF7(2)=DIGIT(ND1)
    ND=ND - 126*(ND1 - 123)
    NE=(126-ND)/9
    IF(ND1.NE.123) ND=6+ND
    VF7(3)=DIGIT(ND)
    VF7(5)=DIGIT(NE)
      DO 86 KVF=1,12
 86 IOFT1(KVF)=VF7(KVF)
    GO TO 110
103 ND=(JDIML1(I)-1)*12
    ND1=ND/120 + 123
    VF8(2)=DIGIT(ND1)
    ND=ND - 120*(ND1 - 123)
    NE=(120 - ND)/12
    IF(ND1.NE.123) ND=6+ND
    VF8(3)=DIGIT(ND)
    VF8(5)=DIGIT(NE)
      DO 85 KVF=1,12
 85 IOFT1(KVF)=VF8(KVF)
    GO TO 110
104 ND=(JDIML1(I)-1)*11
    ND1=ND/110 + 123
    VF9(2)=DIGIT(ND1)
    ND=ND-110*(ND1-123)
    NE=(110-ND)/11
    IF(ND1.NE.123) ND=6+ND
    VF9(3)=DIGIT(ND)
    VF9(5)=DIGIT(NE)
      DO 105 KVF=1,12
105 IOFT1(KVF)=VF9(KVF)
110 IF (IC.EQ.3) WRITE (6,IOFT1) I,(A(IJ),IJ=J4,J5)
111 J4=J5+1
    GO TO 140
120 READ (2'IRN) A
    IF (IC.EQ.6) GO TO 140
    WRITE (6,290) IN,K
    J4=1
    DO 131 I=1,IO
    GO TO (121,122,123,124) ,IOFT
121 ND=(JDIML1(I)-1)*6
    ND1=ND/120 + 123
    VF5(2)=DIGIT(ND1)
    ND=ND-120*(ND1-123)
    NE=(120-ND)/6
    IF(ND1.NE.123) ND=3+ND
    ND=ND+2
    VF5(3)=DIGIT(ND)
    VF5(5)=DIGIT(NE)
      DO 119 KVF=1,12
```

```
  119 IOFT1(KVF)=VF5(KVF)
      GO TO 130
  122 ND=(JDIML1(I)-1)*9
      ND1=ND/126 + 123
      VF7(2)=DIGIT(ND1)
      ND=ND-126*(ND1-123)
      NE=(126-ND)/9
      IF(ND1.NE.123) ND=6+ND
      VF7(3)=DIGIT(ND)
      VF7(5)=DIGIT(NE)
        DO 118 KVF=1,12
  118 IOFT1(KVF)=VF7(KVF)
      GO TO 130
  123 ND=(JDIML1(I)-1)*12
      ND1=ND/120 + 123
      VF8(2)=DIGIT(ND1)
      ND=ND-120*(ND1-123)
      NE=(120-ND)/12
      IF(ND1.NE.123) ND=6+ND
      VF8(3)=DIGIT(ND)
      VF8(5)=DIGIT(NE)
        DO 117 KVF=1,12
  117 IOFT1(KVF)=VF8(KVF)
      GO TO 130
  124 ND=(JDIML1(I)-1)*11
      ND1=ND/110 + 123
      VF9(2)=DIGIT(ND1)
      ND=ND-110*(ND1-123)
      NE=(110-ND)/11
      IF(ND1.NE.123) ND=6+ND
      VF9(3)=DIGIT(ND)
      VF9(5)=DIGIT(NE)
        DO 125 KVF=1,12
  125 IOFT1(KVF)=VF9(KVF)
  130 WRITE (6,IOFT1) I,(A(IJ),IJ=J4,J5)
  131 J4=J5+1
  140 IF (IRECD.EQ.1) WRITE (2'IRN) A
      IRN=IRN+1
      RETURN
C     *********************
      ENTRY MDAT
C     *********************
      DO 155 K=1,K0
      J4=1
      DO 152 I=1,I0
      J5=JDIML2(I)-JDIML1(I)+J4
      DO 150 IJ=J4,J5
      IF (I.EQ.1.OR.I.EQ.I0) T(IJ,K)=0.
      IF (IDK1.NE.ICHK(4).AND.IPU1.NE.ICHK(8)) PHI(IJ,K)=STRT(IJ,K)
      IF (K.NE.K0.OR.IWATER.NE.ICHK(6)) GO TO 150
      IF (I.EQ.1.OR.I.EQ.I0) PERM(IJ)=0.
```

```
  150  CONTINUE
  152 J4=J5+1
  155   CONTINUE
C       ............................. DELX ..............................
        DO 153 J=1,J0
  153 DELX(J)=0.
        READ (5,330) FAC,IVAR,IPRN
        IF (IVAR.EQ.1) READ (5,330) (DELX(J),J=1,J0)
        DO 170 J=1,J0
        IF (IVAR.NE.1) GO TO 160
        DELX(J)=DELX(J)*FAC
        GO TO 170
  160 DELX(J)=FAC
  170 CONTINUE
        IF (IVAR.EQ.1.AND.IPRN.NE.1) WRITE (6,370) (DELX(J),J=1,J0)
        IF (IVAR.EQ.0) WRITE (6,300) FAC
C       ............................. DELY ..............................
        READ (5,330) FAC,IVAR,IPRN
        IF (IVAR.EQ.1) READ (5,330) (DELY(I),I=1,I0)
        DO 190 I=1,I0
        IF (IVAR.NE.1) GO TO 180
        DELY(I)=DELY(I)*FAC
        GO TO 190
  180 DELY(I)=FAC
  190 CONTINUE
        IF (IVAR.EQ.1.AND.IPRN.NE.1) WRITE (6,380) (DELY(I),I=1,I0)
        IF (IVAR.EQ.0) WRITE (6,310) FAC
C       ............................. DELZ ..............................
        READ (5,330) FAC,IVAR,IPRN
        IF (IVAR.EQ.1) READ (5,330) (DELZ(K),K=1,K0)
        DO 210 K=1,K0
        IF (IVAR.NE.1) GO TO 200
        DELZ(K)=DELZ(K)*FAC
        GO TO 210
  200 DELZ(K)=FAC
  210 CONTINUE
        IF (IVAR.EQ.1.AND.IPRN.NE.1) WRITE (6,390) (DELZ(K),K=1,K0)
        IF (IVAR.EQ.0) WRITE (6,320) FAC
C
C       ---INITIALIZE VARIABLES---
        B=0.
        D=0.
        F=0.
        H=0.
        SU=0.
        Z=0.
        RETURN
C       ..................................................................
C       ---READ TIME PARAMETERS AND PUMPING DATA FOR A NEW PUMPING PERIOD-
```

```
C     *********************
      ENTRY NEWPER
C     *********************
C
      DELTM1 = DELT
      READ (5,330) KP,KPM1,NWEL,TMAX,NUMT,CDLT,DELT
      IF (KP.GT.1)   GO TO 225
      IF(ITL.EQ.ICHK(12).AND.(IDK1.EQ.ICHK(4).OR.IPU1.EQ.ICHK(8))) GO TO
     1 225
      DELTM1 = 1.0
      DO 215 K=1,KO
      DO 215 IJ=1,IOJO
  215 XI(IJ,K) = 0.0
C
C     ---COMPUTE ACTUAL DELT AND NUMT---
  225 DT=DELT/24.
      TM=0.0
      DO 220 I=1,NUMT
      DT=CDLT*DT
      TM=TM+DT
      IF (TM.GE.TMAX) GO TO 230
  220 CONTINUE
      GO TO 240
  230 DELT=TMAX/TM*DELT
      NUMT=I
  240 WRITE (6,400) KP,TMAX,NUMT,DELT,CDLT
      DELT=DELT*3600.
      TMAX=TMAX*86400.
      SUMP=0.0
C
C     ---READ AND WRITE WELL PUMPING RATES---
      WRITE (6,410) NWEL
      IF (NWEL.EQ.0) GO TO 260
      DO 245 K=1,KO
      DO 245 IJ=1,IOJO
  245 WELL(IJ,K)=0.0
      DO 250 II=1,NWEL
      READ (5,330) K,I,J,TWELL
      IJ=0
      J4=1
        IV=I-1
      DO 246 III=1,IV
      J5=JDIML2(III)-JDIML1(III)+J4
  246 J4=J5+1
      IJ=J4+J-JDIML1(I)
      WRITE (6,420) K,I,J,TWELL
  250 WELL(IJ,K)=TWELL/(DELX(J)*DELY(I))
  260 RETURN
C
C     ---FORMATS---
C
```

```
C
C
  280 FORMAT (1H0,52X,6A4,' =',1P1G15.7,' FOR LAYER',I3)                00005240
  290 FORMAT (1H1,45X,6A4,' MATRIX, LAYER',I3/46X,41('-'))              00005250
  300 FORMAT ('0',72X,'DELX =',1P1G15.7)                                00005260
  310 FORMAT ('0',72X,'DELY =',1P1G15.7)                                00005270
  320 FORMAT ('0',72X,'DELZ =',1P1G15.7)                                00005280
  330 FORMAT (8G10.0)                                                   00005290
  340 FORMAT ('0',51X,'NUMBER OF PUMPING PERIODS =',I5/49X,'TIME STEPS B00005300
     1ETWEEN PRINTOUTS =',I5//51X,'ERROR CRITERIA FOR CLOSURE =',1P1G15.
     .7/)
  370 FORMAT (1H1,46X,40HGRID SPACING IN PROTOTYPE IN X DIRECTION/47X,4000005310
     1('-')//('0',12F10.0))
  380 FORMAT (1H-,46X,40HGRID SPACING IN PROTOTYPE IN Y DIRECTION/47X,4000005320
     1('-')//('0',12F10.0))
  390 FORMAT (1H-,46X,40HGRID SPACING IN PROTOTYPE IN Z DIRECTION/47X,4000005330
     1('-')//('0',12F10.0))
  400 FORMAT ('-',50X,'PUMPING PERIOD NO.',I4,':',F10.2,' DAYS'/51X,38('00005340
     1-')//53X,'NUMBER OF TIME STEPS=',I6//59X,'DELT IN HOURS =',F10.3//
     253X,'MULTIPLIER FOR DELT =',F10.3)
  410 FORMAT ('-',63X,I4,' WELLS'/65X,9('-')//50X,'K',9X,'I',9X,'J    PU00005350
     1MPING RATE'/)
  420 FORMAT (41X,3I10,2F13.2)                                          00005360
  430 FORMAT ('-',40X,' CONTINUATION - HEAD AFTER ',G20.7,' SEC PUMPING 00005370
     1'/42X,58('-'))
  440 FORMAT ('1',55X,'INITIAL  HEAD MATRIX, LAYER',I3/56X,30('-'))     00005[illegible]
  450 FORMAT (4G20.10)                                                  00005390
  460 FORMAT(1H1,46X,'POSITION OF FIRST ACTIVE NODE IN THE X DIRECTION'/00005400
     147X,44('-')//('0',12I10))
  470 FORMAT(1H0,46X,'POSITION OF LAST ACTIVE NODE IN THE X DIRECTION'/ 00005410
     147X,43('-')//('0',12I10))
  480 FORMAT(6E13.6)                                                    00005420
      END                                                               00005430
      SUBROUTINE STEP(PHI,STRT,OLD,T,S,TR,TC,TK,WELL,DELX,DELY,DELZ,FACT00005440
     1,DDN,TEST3,XI,RM,JDIML1,JDIML2)
C     ------------------------------------------------------------------
C     INITIALIZE DATA FOR A NEW TIME STEP AND PRINT RESULTS
C     ------------------------------------------------------------------
C
C     SPECIFICATIONS:
      REAL *8PHI                                                        00005450
C
      DIMENSION PHI(IOJO,KO), STRT(IOJO,KO), OLD(IOJO,KO), T(IOJO,KO    00005460
     1), S(IOJO,KO), TR(IOJO,KO), TC(IOJO,KO), TK(IKJK,K5), WELL(IOJO
     2,KO), DELX(JO), DELY(IO), DELZ(KO), FACT(KO,3), DDN(IMAX), TEST3
     3(ITMX1), ITTO(50)
     4,XI(IOJO,KO),RM(2,MODE,ILJL,K7),JDIML1(IO),JDIML2(IO)
C
      COMMON /INTEGR/ IO,JO,KO,I1,J1,K1,NPER,KTH,ITMAX,LENGTH,KP,NWEL,  00005470
     1NUMT,IFINAL,IT,KT,IHEAD,IDRAW,IFLO,IERR,I2,J2,K2,IMAX,ITMX1,NCH,
     2IDK1,IDK2,IWATER,IQRE,IPJP,IQJQ,IKJK,K5,IPU1,IPU2,ITK,IEQN,MODE
```

```
     .,ITL,IOJO,K6,K7,ILJL
      COMMON /SPARAM/ TMAX,CDLT,DELT,ERR,TEST,SUM,SUMP,QR,DELTM1
      COMMON /SARRAY/ ICHK(13)
      COMMON /CK/ ETFLXT,STORT,QRET,CHST,CHDT,FLUXT,PUMPT,CFLUXT,FLXNT
      COMMON /PR/ DIGIT(129),VF4(12),VF5(12),
     1VF6(12),VF7(12),VF8(12),VF9(12),VF10(12)
      RETURN
C     ..................................................................
C     ********************
      ENTRY NEWSTP
C     ********************
      KT=KT+1
      IT=0
      IF (KT.GT.1)   DELTM1 = DELT
      DELT=CDLT*DELT
      SUM=SUM+DELT
      SUMP=SUMP+DELT
      DAYSP=SUMP/86400.
      YRSP=DAYSP/365.
      HRS=SUM/3600.
      SMIN=HRS*60.
      DAYS=HRS/24.
      YRS=DAYS/365.
C     ..................COMPUTE TRANSIENT LEAKAGE COEFFICIENTS.........
      IF (ITL.NE.ICHK(12)) GO TO 11
      CALL CLAY
   11 DO 10 K=1,KO
      DO 10 IJ=1,IOJO
      XI(IJ,K) = 0.0
   10 OLD(IJ,K)=PHI(IJ,K)
      RETURN
C
C     ---PRINT OUTPUT AT DESIGNATED TIME STEPS---
C     *********************
      ENTRY OUTPUT
C     *********************
      IF (KT.EQ.NUMT) IFINAL=1
      ITTO(KT)=IT
      IF (IT.LE.ITMAX) GO TO 20
      IT=IT-1
      ITTO(KT)=IT
      IERR=2
C
C     ---IF MAXIMUM ITERATIONS EXCEEDED,WRITE RESULTS ON DISK OR CARDS--
      IF (IDK2.EQ.ICHK(5)) WRITE (4) PHI,SUM,SUMP,PUMPT,CFLUXT,QRET,CHST
     1,CHDT,FLUXT,STORT,ETFLXT,FLXNT,DELT,XI,RM
      IF (IPU2.EQ.ICHK(9)) WRITE (7,230) SUM,SUMP,PUMPT,CFLUXT,QRET,CHST
     1,CHDT,FLUXT,STORT,ETFLXT,FLXNT,DELT
C
   20 IF (IFLO.EQ.ICHK(3)) CALL CHECK
      IF (IERR.EQ.2) GO TO 30
```

```
      IF (MOD(KT,KTH).NE.0.AND.IFINAL.NE.1) RETURN
   30 WRITE (6,210) KT,DELT,SUM,SMIN,HRS,DAYS,YRS,DAYSP,YRSP
      IF (IFLO.EQ.ICHK(3)) CALL CWRITE
      IT=IT+1
      WRITE (6,180) (TEST3(J),J=1,IT)
      I3=1
      I5=0
  352 I5=I5+40
      I4=MIN0(KT,I5)
      WRITE (6,240) (I,I=I3,I4)
      WRITE (6,260)
      WRITE (6,250) (ITTO(I),I=I3,I4)
      WRITE (6,260)
      IF(KT.LE.I5) GO TO 353
      I3=I3+40
      GO TO 352
C
  353 IF (IDRAW.NE.ICHK(1)) GO TO 100
C
C     ---PRINT DRAWDOWN---
      DO 90 K=1,K0
      J4=1
      WRITE (6,200) K
      DO 90 I=1,I0
      J=0
      J5=JDIML2(I)-JDIML1(I)+J4
      ND=(JDIML1(I)-1)*7
      ND1=ND/126 + 123
      VF10(2)=DIGIT(ND1)
      ND=ND-126*(ND1-123)
      NE=(126-ND)/7
      IF(ND1.NE.123) ND=5+ND
      VF10(3)=DIGIT(ND)
      VF10(5)=DIGIT(NE)
      DO 80 IJ=J4,J5
      J=J+1
   80 DDN(J)=STRT(IJ,K)-PHI(IJ,K)
      J4=J5+1
   90 WRITE (6,VF10) I,(DDN(II),II=1,J)
  100 IF (IHEAD.NE.ICHK(2)) GO TO 120
C
C     ---PRINT HEAD MATRIX---
      DO 115 K=1,K0
      J4=1
      WRITE (6,190) K
      DO 110 I=1,I0
      J5=JDIML2(I)-JDIML1(I)+J4
      ND=(JDIML1(I)-1)*7
      ND1=ND/126 + 123
      VF10(2)=DIGIT(ND1)
      ND=ND-126*(ND1-123)
```

```
      NE=(126-ND)/7
      IF(ND1.NE.123) ND=5+ND
      VF10(3)=DIGIT(ND)
      VF10(5)=DIGIT(NE)
      WRITE (6,VF10) I,(PHI(IJ,K),IJ=J4,J5)
  110 J4=J5+1
  115 CONTINUE
C
C     ---WRITE ON DISK---
  120 IF (IERR.EQ.2) GO TO 130
      IF (KP.LT.NPER.OR.IFINAL.NE.1) RETURN
      IF (IDK2.EQ.ICHK(5)) WRITE (4) PHI,SUM,SUMP,PUMPT,CFLUXT,QRET,CHST
     1,CHDT,FLUXT,STORT,ETFLXT,FLXNT,DELT,XI,RM
C
C     ---PUNCHED OUTPUT---
  130 IF (IPU2.NE.ICHK(9)) GO TO 160
      IF (IERR.EQ.2) GO TO 140
      WRITE (7,230) SUM,SUMP,PUMPT,CFLUXT,QRET,CHST,CHDT,FLUXT,STORT,ETF
     1LXT,FLXNT,DELT
  140 DO 135 J=1,J0
  135 DELX(J)=0.0
      DO 155 K=1,K0
      J4=1
      DO 150 I=1,I0
      JJ=J0-JDIML2(I)
      VF4(4)=DIGIT(129)
      J5=JDIML2(I)-JDIML1(I)+J4
      ND=(JDIML1(I)-1)*10
      ND1=ND/80 + 123
      ND=ND-80*(ND1-123)
      IF(ND1.EQ.123) ND1=128
      VF4(2)=DIGIT(ND1)
      IF(ND.NE.0) GO TO 141
      VF4(4)=DIGIT(128)
      VF4(3)=DIGIT(128)
      GO TO 142
  141 VF4(3)=DIGIT(ND)
  142 NE=(80-ND)/10
      VF4(5)=DIGIT(NE)
      WRITE (7,VF4)  (PHI(IJ,K),IJ=J4,J5),(DELX(J),J=1,JJ)
  150 J4=J5+1
  155 CONTINUE
      IF(ITL.NE.ICHK(12)) GO TO 160
      DO 156 K=1,K0
      WRITE(7,270) (XI(IJ,K),IJ=1,I0J0)
  156 CONTINUE
      WRITE(7,280) ((((RM(N,M,IJ,K),N=1,2),M=1,MODE),IJ=1,ILJL),K=1,K7)
  160 IF (IERR.EQ.2) STOP
      RETURN
C
C     ---FORMATS---
```

```
C
C
C
  180 FORMAT ('OMAXIMUM HEAD CHANGE FOR EACH ITERATION:'/' ',39('-')/('000006730
     1',10F12.4))
  190 FORMAT ('1',55X,'HEAD MATRIX, LAYER',I3/56X,21('-'))              00006740
  200 FORMAT ('1',55X,'   DRAWDOWN, LAYER',I3/59X,18('-'))              00006750
  210 FORMAT (1H1,44X,57('-')/45X,'±',14X,'TIME STEP NUMBER =',I9,14X,'±00006760
     1'/45X,57('-')//50X,29HSIZE OF TIME STEP IN SECONDS=,F14.2//55X,'TO
     2TAL SIMULATION TIME IN SECONDS=',F14.2/80X,8HMINUTES=,F14.2/82X,6H
     3HOURS=,F14.2/83X,5HDAYS=,F14.2/82X,'YEARS=',F14.2///45X,'DURATION
     4OF CURRENT PUMPING PERIOD IN DAYS=',F14.2/82X,'YEARS=',F14.2//)
  230 FORMAT (1P4G20.10)                                                00006770
  240 FORMAT ('OTIME STEP :',40I3)                                      00006780
  250 FORMAT ('OITERATIONS:',40I3)                                      00006790
  260 FORMAT (' ',10('-'))                                              00006800
  270 FORMAT(8F10.6)                                                    00006810
  280 FORMAT(6E13.6)                                                    00006820
      END                                                               00006830
      SUBROUTINE SOLVE(PHI,STRT,OLD,T,S,TR,TC,TK,WELL,DELX,DELY,DELZ,FAC00006840
     1T,EL,FL,GL,V,XI,TEST3,QRE,RATE,ZCB,SS,TL,TLK,SL,RM,JDIML1,JDIML2)
C     ------------------------------------------------------------------
C     SOLUTION BY THE STRONGLY IMPLICIT PROCEDURE
C     ------------------------------------------------------------------
C
C     SPECIFICATIONS:
      REAL *8PHI,RHO,B,D,F,H,Z,SU,RHOP,W,WMIN,RHO1,RHO2,RHO3,XPART,YPART0000
     1,ZPART,DMIN1,WMAX,XT,YT,ZT,DABS,DMAX1,DEN,TXM,TYM,TZM
      REAL *8E,AL,BL,CL,A,C,G,WU,TU,U,DL,RES,SUPH,GLXI,ZPHI             00006
C
      DIMENSION PHI(1), STRT(1), OLD(1), T(1), S(1), TR(1), TC(1), TK(1)00006870
     1, WELL(1), DELX(1), DELY(1), DELZ(1), FACT(K0,3), RHOP(20), TEST3(
     21), EL(1), FL(1), GL(1), V(1), XI(1), QRE(1), RATE(1), ZCB(1),
     3SS(1), TL(1), TLK(1), SL(1), RM(1), JDIML1(1), JDIML2(1)
C
      COMMON /INTEGR/ I0,J0,K0,I1,J1,K1,NPER,KTH,ITMAX,LENGTH,KP,NWEL,  00006880
     1NUMT,IFINAL,IT,KT,IHEAD,IDRAW,IFLO,IERR,I2,J2,K2,IMAX,ITMX1,NCH,
     2IDK1,IDK2,IWATER,IQRE,IPJP,IQJQ,IKJK,K5,IPU1,IPU2,ITK,IEQN,MODE
     .,ITL,I0J0,K6,K7,ILJL
      COMMON /SPARAM/ TMAX,CDLT,DELT,ERR,TEST,SUM,SUMP,QR,DELTM1        00006890
      COMMON /SARRAY/ ICHK(13)                                          00006900
      RETURN                                                            00006910
C     ..................................................................
C     *********************
      ENTRY ITER                                                        00006920
C     *********************
C     ---COMPUTE AND PRINT ITERATION PARAMETERS---
      WRITE (6,240)                                                     00006930
      P2=LENGTH-1                                                       00006940
      NT=I0J0*K0                                                        00006950
      NIJ=I0J0                                                          00006960
```

```
      READ 888,WMAX
  888 FORMAT(F10.0)
      PRINT 889,WMAX
  889 FORMAT(5X,6HWMAX =,F10.7)
      PJ=-1.
      DO 50 I=1,LENGTH
      PJ=PJ+1.
   50 RHOP(I)=1.D0-(1.D0-WMAX)**(PJ/P2)
      WRITE (6,230) LENGTH,(RHOP(J),J=1,LENGTH)
      RETURN
C     ..................................................................
C
C     ---INITIALIZE DATA FOR A NEW ITERATION---
   60 IT=IT+1
      IF (IT.LE.ITMAX) GO TO 70
      WRITE (6,220)
      CALL OUTPUT
   70 IF (MOD(IT,LENGTH)) 80,80,90
C     *********************
      ENTRY NEWITA
C     *********************
   80 NTH=0
   90 NTH=NTH+1
      W=RHOP(NTH)
      TEST3(IT+1)=0.
      TEST=0.0
      BIG=0.
      DO 100 I=1,NT
      EL(I)=0.
      FL(I)=0.
      GL(I)=0.
  100 V(I)=0.
C
C     ---COMPUTE TRANSMISSIVITY AND T COEFFICIENTS FOR UPPER
C     HYDROLOGIC UNIT WHEN IT IS UNCONFINED---
      IF (IWATER.NE.ICHK(6)) GO TO 110
      CALL TRANS(0)
C
C     ---CHOOSE SIP NORMAL OR REVERSE ALGORITHM---
  110 IF (MOD(IT,2)) 120,120,170
  120  J9=1
      DO 155 K=1,K0
        J4=JDIML2(1)-JDIML1(1)+2
        KN=(K-1)*NIJ
      DO 152 I=2,I1
        J5=JDIML2(I)-JDIML1(I)+J4
        J6=J4+KN
        J7=J5+KN
        J8=J7+JDIML2(I+1)-JDIML1(I+1)+1
      DO 150 IJ=J4,J5
      N=IJ+KN
```

```
C
C     ---SKIP COMPUTATIONS IF NODE CONSTANT HEAD---
C
      IF(S(N).LT.0.) GO TO 150
C
      NIB=N-JDIML2(I-1)+JDIML1(I)-1
      NIA=N+JDIML2(I)-JDIML1(I+1)+1
      NJA=N+1
      NJB=N-1
        IF(N.EQ.J6) NJB=1
        IF(N.EQ.J7) NJA=1
        IF(NIB.GE.J6)NIB=1
        IF(NIB.LT.J9) NIB=1
        IF(NIA.GT.J8)NIA=1
        IF(NIA.LE.J7) NIA=1
        IF(I.EQ.2) NIB=1
        IF(I.EQ.I1) NIA=1
      NKA=N+NIJ
      NKB=N-NIJ
C
C
      IF (ITL.NE.ICHK(12)) GO TO 121
      L=N
      LKB=NKB
      GO TO 122
 121   L=1
      LKB=1
      TLK(LKB)=0.
      TLK(L)=0.
      TL(L)=0.
      SL(L)=0.
C
C     ---SKIP COMPUTATIONS IF NODE OUTSIDE FLOW SYSTEM---
C
 122   IF(K.EQ.1) GO TO 111
       IF(K.EQ.K0) GO TO 113
       IF(T(N).EQ.0..AND.TK(N).EQ.0..AND.TK(NKB).EQ.0..AND.TLK(L).EQ.0.
     1 .AND.TLK(LKB).EQ.0.) GO TO 150
      GO TO 112
 111  IF(T(N).EQ.0..AND.TK(N).EQ.0..AND.TLK(L).EQ.0.) GO TO 150
      GO TO 112
 113  IF(T(N).EQ.0..AND.TK(NKB).EQ.0..AND.TLK(LKB).EQ.0.) GO TO 150
C     ---COMPUTE COEFFICIENTS---
 112  J=N-J4-KN+JDIML1(I)
      D=TR(NJB)/DELX(J)
      F=TR(N)/DELX(J)
      B=TC(NIB)/DELY(I)
      H=TC(N)/DELY(I)
      SU=0.D0
      Z=0.D0
      IF(K.EQ.1) GO TO 124
```

```
      Z=TK(NKB) + TLK(LKB)
      IF(IEQN.EQ.ICHK(11)) Z=Z/DELZ(K)
  124 IF(K.EQ.KO) GO TO 125
      SU=TK(N) + TLK(L)
      IF(IEQN.EQ.ICHK(11))SU=SU/DELZ(K)
  125 RHO=S(N)/DELT
      QR=0.
      IF (K.EQ.KO.AND.IQRE.EQ.ICHK(7)) QR=QRE(IJ)
C
C     ---SIP NORMAL ALGORITHM---
C     ---FORWARD SUBSTITUTE, COMPUTING INTERMEDIATE VECTOR V---
      IF (K.EQ.1) GO TO 131
      IF (K.EQ.KO) GO TO 133
      GO TO 130
  131 E=-B-D-F-H-SU-Z-RHO-TL(L)+TLK(L)
      GO TO 132
  133 E=-B-D-F-H-SU-Z-RHO+TLK(LKB)-TL(L)
      GO TO 132
  130 E=-B-D-F-H-SU-Z-RHO+TLK(LKB)+TLK(L)-TL(L)
  132  CONTINUE
      BL=B/(1.+W*(EL(NIB)+GL(NIB)))
      CL=D/(1.+W*(FL(NJB)+GL(NJB)))
      C=BL*EL(NIB)
      G=CL*FL(NJB)
      WU=CL*GL(NJB)
      U=BL*GL(NIB)
      IF (K.EQ.1) GO TO 140
      AL=Z/(1.+W*(EL(NKB)+FL(NKB)))
      A=AL*EL(NKB)
      TU=AL*FL(NKB)
      DL=E+W*(A+C+G+WU+TU+U)-CL*EL(NJB)-BL*FL(NIB)-AL*GL(NKB)
      EL(N)=(F-W*(A+C))/DL
      FL(N)=(H-W*(G+TU))/DL
      GL(N)=(SU-W*(WU+U))/DL
      SUPH=0.DO
      IF (K.NE.KO) SUPH=SU*PHI(NKA)
      RES=-B*PHI(NIB)-D*PHI(NJB)-E*PHI(N)-F*PHI(NJA)-H*PHI(NIA)-SUPH-Z*P
     1HI(NKB)-WELL(N)-RHO*OLD(N)-QR-SL(L)
      V(N)=(RES-AL*V(NKB)-BL*V(NIB)-CL*V(NJB))/DL
      GO TO 150
  140 DL=E+W*(C+G+WU+U)-CL*EL(NJB)-BL*FL(NIB)
      EL(N)=(F-W*C)/DL
      FL(N)=(H-W*G)/DL
      GL(N)=(SU-W*(WU+U))/DL
      SUPH=0.DO
      IF (K.NE.KO) SUPH=SU*PHI(NKA)
      RES=-B*PHI(NIB)-D*PHI(NJB)-E*PHI(N)-F*PHI(NJA)-H*PHI(NIA)-SUPH-WEL
     1L(N)-RHO*OLD(N)-QR-SL(L)
      V(N)=(RES-BL*V(NIB)-CL*V(NJB))/DL
  150   CONTINUE
        J9=J6
```

```
  152 J4=J5+1
  155 CONTINUE
C
C     ---BACK SUBSTITUTE FOR VECTOR XI---
      DO 165 K=1,KO
      K3=KO-K+1
        J4=JDIML2(IO)-JDIML1(IO)+2
        KN=(K3-1)*NIJ
      DO 162 I=1,I2
      I3=IO-I
        J5=JDIML2(I3)-JDIML1(I3)+J4
        J6=NIJ-J4+1+KN
        J7=J6+JDIML2(I3+1)-JDIML1(I3+1)+1
      DO 160 IJ=J4,J5
      N=NIJ-IJ+1+KN
      IF(S(N).LT.0.) GO TO 160
      IF(ITL.NE.ICHK(12)) GO TO 157
      L=N
      LKB=N-NIJ
      GO TO 158
  157 L=1
      LKB=1
  158 IF(K3.EQ.KO) GO TO 151
      IF(K3.EQ.1) GO TO 159
      IF(T(N).EQ.0..AND.TK(N).EQ.0..AND.TK(N-NIJ).EQ.0..AND.TLK(L).EQ.
     1 0..AND.TLK(LKB).EQ.0.) GO TO 160
      GO TO 156
  151 IF(T(N).EQ.0..AND.TK(N-NIJ).EQ.0..AND.TLK(LKB).EQ.0.) GO TO 160
      GO TO 156
  159 IF(T(N).EQ.0..AND.TK(N).EQ.0..AND.TLK(L).EQ.0.) GO TO 160
  156 GLXI=0.D0
        NJA=N+1
        NIA=N+JDIML2(I3)-JDIML1(I3+1)+1
        IF(N.EQ.J6) NJA=1
        IF(NIA.GT.J7)NIA=1
        IF(NIA.LE.J6) NIA=1
        IF(I.EQ.1) NIA=1
      IF (K3.NE.KO) GLXI=GL(N)*V (N+NIJ)
      V (N)=V(N)-EL(N)*V (NJA)-FL(N)*V (NIA)-GLXI
C
C     ---COMPARE MAGNITUDE OF CHANGE WITH CLOSURE CRITERIA---
      TCHK=ABS( V(N))
      IF (TCHK.GT.BIG) BIG=TCHK
      PHI(N)=PHI(N)+ V(N)
      XI(N)=XI(N)+ V(N)
  160   CONTINUE
  162  J4=J5+1
  165 CONTINUE
      IF (BIG.GT.ERR) TEST=1.
      TEST3(IT+1)=BIG
      IF (TEST.EQ.0.) RETURN
```

```
      GO TO 60
C     .................................................................
 170  J8=1
      DO 205 KK=1,K0
      K=K0-KK+1
        J4=JDIML2(I0)-JDIML1(I0)+2
        KN=(K-1)*NIJ
      DO 202 II=1,I2
      I=I0-II
        J5=JDIML2(I)-JDIML1(I)+J4
        J6=NIJ-J5+1+KN
        J7=NIJ-J4+1+KN
        J9=J6-JDIML2(I-1)+JDIML1(I-1)-1
      DO 200 IJ=J4,J5
      N=NIJ-J5-J4+1+IJ+KN
C
C     ---SKIP COMPUTATIONS IF NODE CONSTANT HEAD---
      IF (S(N).LT.0.) GO TO 200
C
      NIB=N-JDIML2(I-1)+JDIML1(I)-1
      NIA=N+JDIML2(I)-JDIML1(I+1)+1
      NJA=N+1
      NJB=N-1
        IF(N.EQ.J6) NJB=1
        IF(N.EQ.J7) NJA=1
        IF(NIB.GE.J6) NIB=1
        IF(NIB.LT.J9) NIB=1
        IF(NIA.GT.J8) NIA=1
        IF(NIA.LE.J7) NIA=1
        IF(I.EQ.2) NIB=1
        IF(I.EQ.I1) NIA=1
      NKA=N+NIJ
      NKB=N-NIJ
      IF (ITL.NE.ICHK(12)) GO TO 171
      L=N
      LKB=NKB
      GO TO 172
 171  L=1
      LKB=1
      TLK(LKB)=0.
      TLK(L)=0.
      TL(L)=0.
      SL(L)=0.
C     ---SKIP COMPUTATIONS IF NODE OUTSIDE FLOW SYSTEM---
 172  IF(K.EQ.1) GO TO 164
      IF(K.EQ.K0) GO TO 163
      IF(T(N).EQ.0..AND.TK(N).EQ.0..AND.TK(NKB).EQ.0..AND.TLK(L).EQ.0.
     1 .AND.TLK(LKB).EQ.0.) GO TO 200
      GO TO 161
 164  IF(T(N).EQ.0..AND.TK(N).EQ.0..AND.TLK(L).EQ.0.) GO TO 200
      GO TO 161
```

```
 163  IF(T(N).EQ.0..AND.TK(NKB).EQ.0..AND.TLK(LKB).EQ.0.) GO TO 200
C     ---COMPUTE COEFFICIENTS---
  161 J=N-J6+JDIML1(I)
      D=TR(NJB)/DELX(J)
      F=TR(N)/DELX(J)
      B=TC(NIB)/DELY(I)
      H=TC(N)/DELY(I)
      SU=0.D0
      Z=0.D0
      IF(K.EQ.1) GO TO 174
      Z=TK(NKB) + TLK(LKB)
      IF(IEQN.EQ.ICHK(11)) Z=Z/DELZ(K)
  174 IF(K.EQ.K0) GO TO 175
      SU=TK(N) + TLK(L)
      IF(IEQN.EQ.ICHK(11))SU=SU/DELZ(K)
  175 RHO=S(N)/DELT
      QR=0.
      IF (K.EQ.K0.AND.IQRE.EQ.ICHK(7)) QR=QRE(N-KN)
C
C     ---SIP REVERSE ALGORITHM---
C     ---FORWARD SUBSTITUTE, COMPUTING INTERMEDIATE VECTOR V---
      IF (K.EQ.1) GO TO 181
      IF (K.EQ.K0) GO TO 183
      GO TO 180
 181   E=-B-D-F-H-SU-Z-RHO-TL(L)+TLK(L)
      GO TO 182
 183   E=-B-D-F-H-SU-Z-RHO+TLK(LKB)-TL(L)
      GO TO 182
  180 E=-B-D-F-H-SU-Z-RHO+TLK(LKB)+TLK(L)-TL(L)
 182   CONTINUE
      BL=H/(1.+W*(EL(NIA)+GL(NIA)))
      CL=D/(1.+W*(FL(NJB)+GL(NJB)))
      C=BL*EL(NIA)
      G=CL*FL(NJB)
      WU=CL*GL(NJB)
      U=BL*GL(NIA)
      IF (K.EQ.K0) GO TO 190
      AL=SU/(1.+W*(EL(NKA)+FL(NKA)))
      A=AL*EL(NKA)
      TU=AL*FL(NKA)
      DL=E+W*(C+G+A+WU+TU+U)-AL*GL(NKA)-BL*FL(NIA)-CL*EL(NJB)
      EL(N)=(F-W*(C+A))/DL
      FL(N)=(B-W*(G+TU))/DL
      GL(N)=(Z-W*(WU+U))/DL
      ZPHI=0.D0
      IF (K.NE.1) ZPHI=Z*PHI(NKB)
      RES=-B*PHI(NIB)-D*PHI(NJB)-E*PHI(N)-F*PHI(NJA)-H*PHI(NIA)-SU*PHI(N
     1KA)-ZPHI-WELL(N)-RHO*OLD(N)-QR-SL(L)
      V(N)=(RES-AL*V(NKA)-BL*V(NIA)-CL*V(NJB))/DL
      GO TO 200
  190 DL=E+W*(C+G+WU+U)-BL*FL(NIA)-CL*EL(NJB)
```

```
      EL(N)=(F-W*C)/DL
      FL(N)=(B-W*G)/DL
      GL(N)=(Z-W*(WU+U))/DL
      ZPHI=0.D0
      IF (K.NE.1) ZPHI=Z*PHI(NKB)
      RES=-B*PHI(NIB)-D*PHI(NJB)-E*PHI(N)-F*PHI(NJA)-H*PHI(NIA)-ZPHI-WEL
     1L(N)-RHO*OLD(N)-QR-SL(L)
      V(N)=(RES-BL*V(NIA)-CL*V(NJB))/DL
  200   CONTINUE
        J8=J7
  202   J4=J5+1
  205 CONTINUE
C
C     ---BACK SUBSTITUTE FOR VECTOR XI---
        J8=1
      DO 215 K=1,K0
        J4=JDIML2(1)-JDIML1(1) + 2
        KN=(K-1)*NIJ
      DO 212 I=2,I1
        J5=JDIML2(I)-JDIML1(I)+J4
        J6=J5+KN
        J7=J4+KN
      DO 210 IJ=J4,J5
      N=J5-IJ+J4+KN
      IF (S(N).LT.0.) GO TO 210
      IF(ITL.NE.ICHK(12)) GO TO 204
      L=N
      LKB=N-NIJ
      GO TO 206
 204  L=1
      LKB=1
 206  IF(K.EQ.1) GO TO 201
      IF(K.EQ.K0) GO TO 207
      IF(T(N).EQ.0..AND.TK(N).EQ.0..AND.TK(N-NIJ).EQ.0..AND.TLK(L).EQ.0.
     1 .AND.TLK(LKB).EQ.0.) GO TO 210
      GO TO 203
 201  IF(T(N).EQ.0..AND.TK(N).EQ.0..AND.TLK(L).EQ.0.) GO TO 210
      GO TO 203
 207  IF(T(N).EQ.0..AND.TK(N-NIJ).EQ.0..AND.TLK(LKB).EQ.0.) GO TO 210
  203 GLXI=0.D0
        NJA=N+1
        NIB=N-JDIML2(I-1)+JDIML1(I)-1
        IF(NIB.GE.J7) NIB=1
        IF(NIB.LT.J8) NIB=1
        IF(I.EQ.2) NIB=1
        IF(N.EQ.J6) NJA=1
      IF (K.NE.1) GLXI=GL(N)*V (N-NIJ)
      V (N)=V(N)-EL(N)*V (NJA)-FL(N)*V (NIB)-GLXI
C
C     ---COMPARE MAGNITUDE OF CHANGE WITH CLOSURE CRITERIA---
      TCHK=ABS( V(N))
```

```
      IF (TCHK.GT.BIG) BIG=TCHK
      PHI(N)=PHI(N)+ V(N)
      XI(N)= XI(N)+ V(N)
  210  CONTINUE
        J8=J7
  212 J4=J5+1
  215 CONTINUE
      IF (BIG.GT.ERR) TEST=1.
      TEST3(IT+1)=BIG
      IF (TEST.EQ.0.) RETURN
      GO TO 60
C     .................................................................
C
C     ---FORMATS---
C
C
C
  220 FORMAT ('0EXCEEDED PERMITTED NUMBER OF ITERATIONS'/' ',39('*'))
  230 FORMAT (///1H0,I5,22H ITERATION PARAMETERS:,1P6E15.7/(/28X,
     .1P6E15.7/))
  240 FORMAT ('-',44X,'SOLUTION BY THE STRONGLY IMPLICIT PROCEDURE'/45X,
     143('_'))
      END
      SUBROUTINE CHECKI(PHI,STRT,OLD,T,S,TR,TC,TK,WELL,DELX,DELY,DELZ,FA
     1CT,JFLO,FLOW,QRE,XI,RATE,ZCB,SS,TL,TLK,SL,RM,JDIML1,JDIML2)
C     -----------------------------------------------------------------
C     COMPUTE A VOLUMETRIC BALANCE
C     -----------------------------------------------------------------
C
C     SPECIFICATIONS:
      REAL *8PHI
C
      DIMENSION PHI(IOJO,KO), STRT(IOJO,KO), OLD(IOJO,KO), T(IOJO,KO
     1), S(IOJO,KO), TR(IOJO,KO), TC(IOJO,KO), TK(IKJK,K5), WELL(IO
     2JO,KO), DELX(JO), DELY(IO), DELZ(KO), FACT(KO,3), JFLO(NCH,3), FLO
     3W(NCH), QRE(IQJQ)
     4,XI(IOJO,KO),RATE(1),ZCB(1),SS(1),TL(1),TLK(1),SL(1),RM(1)
     5,JDIML1(IO),JDIML2(IO)
C
      COMMON /INTEGR/ IO,JO,KO,I1,J1,K1,NPER,KTH,ITMAX,LENGTH,KP,NWEL,
     1NUMT,IFINAL,IT,KT,IHEAD,IDRAW,IFLO,IERR,I2,J2,K2,IMAX,ITMX1,NCH,
     2IDK1,IDK2,IWATER,IQRE,IPJP,IQJQ,IKJK,K5,IPU1,IPU2,ITK,IEQN,MODE
     .,ITL,IOJO,K6,K7,ILJL
      COMMON /SPARAM/ TMAX,CDLT,DELT,ERR,TEST,SUM,SUMP,QR,DELTM1
      COMMON /SARRAY/ ICHK(13)
      COMMON /CK/ ETFLXT,STORT,QRET,CHST,CHDT,FLUXT,PUMPT,CFLUXT,FLXNT
      RETURN
C     .................................................................
C     ********************
      ENTRY CHECK
C     ********************
```

```
C     ---INITIALIZE VARIABLES---
      NIJ = IOJO
      PUMP=0.
      STOR=0.
      FLUXS=0.0
      CHD1=0.0
      CHD2=0.0
      QREFLX=0.
      CFLUX=0.
      FLUX=0.
      ETFLUX=0.
      FLXN=0.0
      II=0
      ACHD1=0.
      ACHD2=0.
C     ................................................................
C
C     ---COMPUTE RATES,STORAGE AND PUMPAGE FOR THIS STEP---
      DO 225 K=1,KO
       J7=1
      NK = IOJO*(K-1)
        J4=JDIML2(1)-JDIML1(1) + 2
      DO 222 I=2,I1
        J5=JDIML2(I)-JDIML1(I)+J4
        J6=J5+JDIML2(I+1)-JDIML1(I+1) + 1
        DO 220 IJ=J4,J5
      NI = IJ + NK
      NIJB=NI-NIJ
      IF(ITL.EQ.ICHK(12)) GO TO 4
      NI=1
      NIJB=1
    4 IF(K.NE.1) GO TO 5
      IF (T(IJ,K).EQ.0..AND.TK(IJ,K).EQ.0..AND.TLK(NI).EQ.0.) GO TO 220
      GO TO 7
    5 IF(T(IJ,K).EQ.0..AND.TK(IJ,K).EQ.0..AND.TK(IJ,K-1).EQ.0..AND.
     1 TLK(NI).EQ.0..AND.TLK(NIJB).EQ.0.) GO TO 220
    7 J=IJ-J4+JDIML1(I)
      AREA=DELX(J)*DELY(I)
      VOLUME=AREA*DELZ(K)
      IF (S(IJ,K).GE.0.) GO TO 180
C
C     ---COMPUTE FLOW RATES TO AND FROM CONSTANT HEAD BOUNDARIES---
      II=II+1
      FLOW(II)=0.
      JFLO(II,1)=K
      JFLO(II,2)=I
      JFLO(II,3)=J
        IF(IJ.EQ.J4) GO TO 30
      IF (S(IJ-1,K).LT.0..OR.T(IJ-1,K).EQ.0.) GO TO 30
      X=(PHI(IJ,K)-PHI(IJ-1,K))*TR(IJ-1,K)*DELY(I)
      IF(IEQN.EQ.ICHK(11)) X=X*DELZ(K)
```

```
      FLOW(II)=FLOW(II)+X
      IF (X) 10,30,20
   10 CHD1=CHD1+X
      GO TO 30
   20 CHD2=CHD2+X
   30   IF(IJ.EQ.J5) GO TO 60
      IF (S(IJ+1,K).LT.0..OR.T(IJ+1,K).EQ.0.) GO TO 60
      X=(PHI(IJ,K)-PHI(IJ+1,K))*DELY(I)*TR(IJ,K)
      IF(IEQN.EQ.ICHK(11)) X=X*DELZ(K)
      FLOW(II)=FLOW(II)+X
      IF (X) 40,60,50
   40 CHD1=CHD1+X
      GO TO 60
   50 CHD2=CHD2+X
   60 IF (K.EQ.1) GO TO 90
      IF (S(IJ,K-1).LT.0..OR.TK(IJ,K-1).EQ.0.) GO TO 90
      X=(PHI(IJ,K)-PHI(IJ,K-1))*TK(IJ,K-1)*AREA
      FLOW(II)=FLOW(II)+X
      IF (X) 70,90,80
   70 CHD1=CHD1+X
      GO TO 90
   80 CHD2=CHD2+X
   90 IF (K.EQ.K0) GO TO 120
      IF (S(IJ,K+1).LT.0..OR.TK(IJ,K).EQ.0.) GO TO 120
      X=(PHI(IJ,K)-PHI(IJ,K+1))*TK(IJ,K)*AREA
      FLOW(II)=FLOW(II)+X
      IF (X) 100,120,110
  100 CHD1=CHD1+X
      GO TO 120
  110 CHD2=CHD2+X
  120   NIB=IJ-JDIML2(I-1)+JDIML1(I)-1
        IF(NIB.GE.J4) NIB=1
        IF(NIB.LT.J7) NIB=1
        IF(I.EQ.2) NIB=1
      IF (S(NIB,K).LT.0..OR.T(NIB,K).EQ.0.) GO TO 150
      X=(PHI(IJ,K)-PHI(NIB,K))*TC(NIB,K)*DELX(J)
      IF(IEQN.EQ.ICHK(11)) X=X*DELZ(K)
      FLOW(II)=FLOW(II)+X
      IF (X) 130,150,140
  130 CHD1=CHD1+X
      GO TO 150
  140 CHD2=CHD2+X
  150   NIA=IJ+JDIML2(I)-JDIML1(I+1)+1
        IF(NIA.GT.J6) NIA=1
        IF(NIA.LE.J5) NIA=1
        IF(I.EQ.I1) NIA=1
      IF (S(NIA,K).LT.0..OR.T(NIA,K).EQ.0.) GO TO 171
      X=(PHI(IJ,K)-PHI(NIA,K))*TC(IJ,K)*DELX(J)
      IF(IEQN.EQ.ICHK(11)) X=X*DELZ(K)
      FLOW(II)=FLOW(II)+X
      IF (X) 160,171,170
```

```
160 CHD1=CHD1+X
    GO TO 171
170 CHD2=CHD2+X
171 IF(FLOW(II)) 172,220,174
172 ACHD1=ACHD1 + AREA
    GO TO 220
174 ACHD2=ACHD2 + AREA
    GO TO 220

     ---CHECK FOR EQUATION BEING SOLVED---
180 IF(IEQN.EQ.ICHK(11)) GO TO 211

    ---EQUATION 4---
    ---RECHARGE AND WELLS---
    IF (K.EQ.KO.AND.IQRE.EQ.ICHK(7)) QREFLX=QREFLX+QRE(IJ)*AREA
    IF (WELL(IJ,K)) 190,210,200
190 PUMP=PUMP+WELL(IJ,K)*AREA
    GO TO 210
200 CFLUX=CFLUX+WELL(IJ,K)*AREA

    ---COMPUTE VOLUME FROM STORAGE---
210 STOR=STOR-S(IJ,K)*XI(IJ,K)*AREA
    GO TO 215

    ---EQUATION 3---
    ---RECHARGE AND WELLS---
211 IF (K.EQ.KO.AND.IQRE.EQ.ICHK(7)) QREFLX=QREFLX+QRE(IJ)*VOLUME
    IF (WELL(IJ,K)) 212,214,213
212 PUMP=PUMP+WELL(IJ,K)*VOLUME
    GO TO 214
213 CFLUX=CFLUX+WELL(IJ,K)*VOLUME

    ---COMPUTE VOLUME FROM STORAGE---
214 STOR=STOR-S(IJ,K)*XI(IJ,K)*VOLUME
215 IF (ITL.NE.ICHK(12))   GO TO 220
    Z = 0.0
    SU = 0.0
    IF (K.NE.1)   Z = TLK(NI-NIJ)*PHI(IJ,K-1)
    IF (K.NE.KO)   SU = TLK(NI)*PHI(IJ,K+1)
    QLEAKN=-(TL(NI)*PHI(IJ,K)-SU-Z-SL(NI))*AREA
    FLUXS = FLUXS + QLEAKN
    IF (QLEAKN.LT.0)   FLXN=FLXN-QLEAKN
220   CONTINUE
      J7=J4
222   J4=J5+1
225 CONTINUE
    ..................................................................

    ---COMPUTE CUMULATIVE VOLUMES, TOTALS, AND DIFFERENCES---
    FLUXT = FLUXT + FLUXS*DELT
    FLXNT=FLXN*DELT+FLXNT
```

```
      FLXPT = FLUXT + FLXNT
      STORT=STORT+STOR
      STOR=STOR/DELT
      QRET=QRET+QREFLX*DELT
      CHDT=CHDT-CHD1*DELT
      CHST=CHST+CHD2*DELT
      PUMPT=PUMPT-PUMP*DELT
      CFLUXT=CFLUXT+CFLUX*DELT
      TOTL1=STORT+QRET+CFLUXT+CHST+FLXPT
      TOTL2=CHDT+PUMPT+ETFLXT+FLXNT
      SUMR=QREFLX+CFLUX+CHD2+CHD1+PUMP+ETFLUX+FLUXS+STOR
      DIFF=TOTL2-TOTL1
      PERCNT=0.0
      IF (TOTL2.EQ.0.) GO TO 230
      PERCNT=DIFF/TOTL2*100.
  230 RETURN
C     ..................................................................
C
C     ---PRINT RESULTS---
C     ************************
      ENTRY CWRITE
C     ************************
C
      WRITE (6,260) STOR,QREFLX,STORT,CFLUX,QRET,PUMP,CFLUXT,ETFLUX,CHST
     1,FLXPT,CHD2,TOTL1,CHD1,FLUX,FLUXS,ETFLXT,CHDT,SUMR,PUMPT,FLXNT,TOT
     2L2,DIFF,PERCNT
C
C     ---COMPUTE VERTICAL FLOW---
  240 X=0.
      Y=0.
      IF (K0.EQ.1) RETURN
        J4=JDIML2(1)-JDIML1(1) + 2
      DO 252 I=2,I1
        J5=JDIML2(I)-JDIML1(I)+J4
      DO 250 IJ=J4,J5
        J=IJ-J4+JDIML1(I)
      X=X+(PHI(IJ,1)-PHI(IJ,2))*TK(IJ,1)*DELX(J)*DELY(I)
      Y=Y+(PHI(IJ,K1)-PHI(IJ,K0))*TK(IJ,K1)*DELX(J)*DELY(I)
  250   CONTINUE
  252   J4=J5+1
      WRITE (6,290) Y,X
      WRITE (6,300) ACHD1,ACHD2
      RETURN
C
C     ---FORMATS---
C
C     ------------------------------------------------------------------
C
C
C
  260 FORMAT ('0',10X,'CUMULATIVE MASS BALANCE:',16X,'L**3',23X,'RATES F
```

```
   1OR THIS TIME STEP:',16X,'L**3/T'/11X,24('-'),43X,25('-')//20X,'SOU
   2RCES:',69X,'STORAGE =',F20.4/20X,8('-'),68X,'RECHARGE =',F20.4/27X
   3,'STORAGE =',F20.2,35X,'CONSTANT FLUX =',F20.4/26X,'RECHARGE =',F2
   40.2,41X,'PUMPING =',F20.4/21X,'CONSTANT FLUX =',F20.2,30X,'EVAPOTR
   5ANSPIRATION =',F20.4/21X,'CONSTANT HEAD =',F20.2,34X,'CONSTANT HEA
   6D:'/27X,'LEAKAGE =',F20.2,46X,'IN =',F20.4/21X,'TOTAL SOURCES =',F
   720.2,45X,'OUT =',F20.4/96X,'LEAKAGE:'/20X,'DISCHARGES:',45X,'FROM
   8PREVIOUS PUMPING PERIOD =',F20.4/20X,11('-'),68X,'TOTAL =',F20.4/1
   96X,'EVAPOTRANSPIRATION =',F20.2/21X,'CONSTANT HEAD =',F20.2,36X,'S
   nUM OF RATES =',F20.4/19X'QUANTITY PUMPED =',F20.2/27X,'LEAKAGE =',
   nF20.2/19X,'TOTAL DISCHARGE =',F20.2//17X,'DISCHARGE-SOURCES =',F20
   n.2/15X,'PER CENT DIFFERENCE =',F20.2//)
290 FORMAT ('OFLOW TO TOP LAYER =',G15.7,'   FLOW TO BOTTOM LAYER =',G
   115.7,'        POSITIVE UPWARD')
300 FORMAT ('0',5X,'AREA OF CONSTANT HEAD DISCHARGE = ',G15.7,'L**2',
   13X,'AREA OF CONSTANT HEAD SOURCE = ',G15.7,'L**2')
310 FORMAT('0',5X,'BOUNDARY FLUX IN =',G15.7,'L**3/S',3X,'BOUNDARY FLU
   1X OUT =',G15.7,'L**3/S'/5X,'NOTE: THESE FLUXES ARE INCLUDED IN THE
   2 BUDGET AS CONSTANT FLUX AND PUMPING')
    END
    SUBROUTINE COEF(PHI,STRT,OLD,T,S,TR,TC,TK,WELL,DELX,DELY,DELZ,FACT
   1,PERM,BOTTOM,QRE,XI,RATE,ZCB,SS,TL,TLK,SL,RM,JDIML1,JDIML2)
    -------------------------------------------------------------------
    COMPUTE COEFFICIENTS
    -------------------------------------------------------------------

    SPECIFICATIONS:
    REAL *8PHI

    DIMENSION PHI(IOJO,KO), STRT(IOJO,KO), OLD(IOJO,KO), T(IOJO,KO
   1), S(IOJO,KO), TR(IOJO,KO), TC(IOJO,KO), TK(IKJK,K5), WELL(IO
   2JO,KO), DELX(JO), DELY(IO), DELZ(KO), FACT(KO,3), PERM(IPJP), BOT
   3TOM(IPJP), QRE(IQJQ)
   .,XI(IOJO,KO),RATE(ILJL,K7),ZCB(ILJL,K7),TL(ILJL,K6),SS(K7),
   .TLK(ILJL,K6),SL(ILJL,K6),RM(2,MODE,ILJL,K7),JDIML1(IO),JDIML2(IO)
    DIMENSION A(10,10),B(10),B1(10),BO(10)

    COMMON /INTEGR/ IO,JO,KO,I1,J1,K1,NPER,KTH,ITMAX,LENGTH,KP,NWEL,
   1NUMT,IFINAL,IT,KT,IHEAD,IDRAW,IFLO,IERR,I2,J2,K2,IMAX,ITMX1,NCH,
   2IDK1,IDK2,IWATER,IQRE,IPJP,IQJQ,IKJK,K5,IPU1,IPU2,ITK,IEQN,MODE
   .,ITL,IOJO,K6,K7,ILJL
    COMMON /SPARAM/ TMAX,CDLT,DELT,ERR,TEST,SUM,SUMP,QR,DELTM1
    COMMON /SARRAY/ ICHK(13)
    RETURN
    ..................................................................
    ---COMPUTE TRANSMISSIVITY FOR UPPER HYDROLOGIC UNIT WHEN
    IT IS UNCONFINED---
    ********************
    ENTRY TRANS(N3)
    ********************
      J6=1
```

```
        J4=JDIML2(1)-JDIML1(1)+2
      DO 12 I=2,I1
        J5=JDIML2(I)-JDIML1(I)+J4
      DO 10 IJ=J4,J5
      IF (PERM(IJ).EQ.0.) GO TO 10
      T(IJ,KO)=PERM(IJ)*(PHI(IJ,KO)-BOTTOM(IJ))
      IF (T(IJ,KO).GT.0.) GO TO 10
        J=IJ-J4+JDIML1(I)
      IF (WELL(IJ,KO).LT.0.) WRITE (6,600) I,J,KO
      IF (WELL(IJ,KO).GE.0.) WRITE (6,610) I,J,KO
      PERM(IJ)=0.
      T(IJ,KO)=0.
        NJB=IJ-1
        IF(IJ.EQ.J4) NJB=1
      TR(NJB,KO)=0.
      TR(IJ,KO)=0.
      TC(IJ,KO)=0.
        NIB=IJ-JDIML2(I-1)+JDIML1(I)-1
        IF(I.EQ.2) NIB=1
        IF(NIB.GE.J4) NIB=1
        IF(NIB.LT.J6) NIB=1
      TC(NIB,KO)=0.
      IF (KO.NE.1) TK(IJ,K1)=0.
      PHI(IJ,KO)=1.D30
   10 CONTINUE
        J6=J4
   12   J4=J5+1
      IF (N3.EQ.1) RETURN
      N1=KO
      N2=KO
      N4=K1
      GO TO 20
C     ..................................................................
C     ---COMPUTE T COEFFICIENTS---
C     ..................................................................
C     *********************
      ENTRY TCOF
C     *********************
      N1=1
      N2=KO
      N4=1
   20 DO 45 K=N1,N2
        J4=1
      DO 42 I=1,I1
        J5=JDIML2(I)-JDIML1(I)+J4
        J6=J5+JDIML2(I+1)-JDIML1(I+1) + 1
      DO 39 IJ=J4,J5
      IF (T(IJ,K).EQ.0.) GO TO 39
        NJA=IJ+1
        IF(NJA.EQ.J5+1) NJA=1
        J=IJ-J4+JDIML1(I)
```

```
      IF (T(NJA,K).EQ.0.) GO TO 30
      TR(IJ,K)=(2.*T(NJA,K)*T(IJ,K))/(T(IJ,K)*DELX(J+1)+T(NJA,K)*
     1DELX(J))*FACT(K,1)
30      NIA=IJ+JDIML2(I)-JDIML1(I+1)+1
        IF(NIA.GT.J6) NIA=1
        IF(NIA.LE.J5) NIA=1
        IF(I.EQ.I1) NIA=1
      IF (T(NIA,K).EQ.0.) GO TO 39
      TC(IJ,K)=(2.*T(NIA,K)*T(IJ,K))/(T(IJ,K)*DELY(I+1)+T(NIA,K)*
     1DELY(I))*FACT(K,2)
39    CONTINUE
42      J4=J5+1
45      CONTINUE
      IF (K0.EQ.1.OR.ITK.EQ.ICHK(10).OR.N3.EQ.0) RETURN
      DO 53 K=N4,K1
        J4=1
      DO 52 I=2,I1
        J5=JDIML2(I)-JDIML1(I)+J4
      DO 50 IJ=J4,J5
      IF (T(IJ,K+1).EQ.0.) GO TO 50
      T1=T(IJ,K)*FACT(K,3)
      T2=T(IJ,K+1)*FACT(K+1,3)
      TK(IJ,K)=(2.*T2*T1)/(T1*DELZ(K+1)+T2*DELZ(K))
50    CONTINUE
52      J4=J5+1
53      CONTINUE
      RETURN
      ..................................................................

      ---COMPUTE COEFFICIENTS FOR TRANSIENT PART OF LEAKAGE TERM---
      *********************
      ENTRY CLAY
      *********************
      R24 = 1.0/24.0
      P1 = 3.1415927
      P2 = 9.8696044
      P4 = 97.409091
      F0 = P2/6.0
      G0 =-P2/12.0
      G1 =-7.0*P4/720.0
      G2 =-0.5
      DO 60 K=1,K0
      DO 60 IJ=1,I0J0
      TL(IJ,K) = 0.0
      TLK(IJ,K) = 0.0
60    SL(IJ,K) = 0.0
      IF (SS(1).GT.0.) GO TO 65
      DO 55 K=1,K1
      KP1 = K + 1
      DO 55 IJ=1,I0J0
      IF (ZCB(IJ,K).LE.0.) GO TO 55
```

```
      AFACT=RATE(IJ,K)/ZCB(IJ,K)
      TLK(IJ,K) = AFACT
      TL(IJ,KP1) = AFACT
      TL(IJ,K) = TL(IJ,K) + AFACT
   55 CONTINUE
      RETURN
   65 IF(KP.NE.1.OR.KT.NE.1) GO TO 160
      IF (MODE.GT.0)   GO TO 80
      B(1) = G0
      B1(1) = F0
      GO TO 160
   80 IF (MODE.GT.1)   GO TO 90
      B(1) = G0
      GO TO  135
   90 DO 100 J=1,MODE
      B(J) = 0.0
      RJ2 = J*J
      DO 100 I=1,MODE
      I3 = I - 3
  100 A(I,J) = RJ2**I3
      B(1) = G1
      B(2) = G0
      B(3) = G2
      DO 110 I=2,MODE
      RAIJ = 1.0/A(I-1,I-1)
      DO 110 K=I,MODE
      AA = A(K,I-1)*RAIJ
      B(K) = B(K)-B(I-1)*AA
      DO 110 J=I,MODE
  110 A(K,J) = A(K,J) - AA*A(I-1,J)
      B(MODE) =B(MODE)/A(MODE,MODE)
      DO 130 K=2,MODE
      J = MODE + 2 - K
      JJ = J - 1
      BJJ = B(JJ)
      DO 120 I=J,MODE
  120 BJJ = BJJ -A(JJ,I)*B(I)
  130 B(JJ) = BJJ/A(JJ,JJ)
  135 SUMN2 = 0.
      SUMN4 = 0.
      DO 140 K=1,MODE
      B1(K) = 1.0
      L = MODE + 1 - K
      B(L+1) = B(L)
      SUMN4 = SUMN4 + 1.0/(K*K*K*K*1.0)
  140 SUMN2 = SUMN2 + 1./(K*K*1.0)
      CN = (P4/90.0-SUMN4)*MODE**4
      B1(MODE+1) = 1.0 + CN
      B1(1) = F0 - SUMN2 - CN/(1.0*MODE*MODE)
      B(1) = 0.0
      DO 145 K=1,MODE
```

```
      RK = 1.0/(1.0*K*K)                                               00013500
      RK = RK*RK                                                       00013510
      B1(K+1) = RK*B1(K+1)                                             00013520
  145 B(K+1) = RK*B(K+1)                                               00013530
      DO 150 K=1,K1                                                    00013540
      DO 150 IJ=2,IOJO                                                 00013550
      ---SKIP COMPUTATIONS IF T, RATE OR M = 0, OR IF CONSTANT
         HEAD BOUNDARY---
      IF (RATE(IJ,K).LE.0..OR.T(IJ,K).EQ.0..OR.ZCB(IJ,K).EQ.0..OR.     00013560
     .T(IJ,K+1).EQ.0.)   GO TO 155
      RATE(IJ,K) = RATE(IJ,K)/ZCB(IJ,K)                                00013570
      ZCB(IJ,K) = RATE(IJ,K)*P2/(ZCB(IJ,K)*SS(K))                      00013580
      IF(IDK1.EQ.ICHK(4).OR.IPU1.EQ.ICHK(8)) GO TO 150                 00013590
      DO 151 M=1,MODE                                                  00013600
      RM(1,M,IJ,K) = 0.0                                               00013610
  151 RM(2,M,IJ,K) = 0.0                                               00013620
      GO TO 150                                                        00013630
  155 RATE(IJ,K) = - 1.0                                               00013640
  150 CONTINUE                                                         00013650
  160 CONTINUE                                                         00013660
      DO 180 K=1,K1                                                    00013670
      DO 180 IJ=2,IOJO                                                 00013680
      ---SKIP COMPUTATIONS IF T, RATE OR M = 0, OR IF CONSTANT
         HEAD BOUNDARY---
      IF (RATE(IJ,K).LT.0.0)   GO TO 180                               00013690
      XLM = ZCB(IJ,K)                                                  00013700
      XLMT = XLM*DELT                                                  00013710
      RXLMT = 1.0/XLMT                                                 00013720
      XLMT1 = XLM*DELTM1                                               00013730
      RXLMT1 = 1.0/XLMT1                                               00013740
      TLN = RATE(IJ,K)                                                 00013750
      HIM1 = PHI(IJ,K)                                                 00013760
      HIM2 = PHI(IJ,K+1)                                               00013770
      SLN = TLN*(HIM2-HIM1)                                            00013780
      SLM = TLN*(HIM1-HIM2)                                            00013790
      C1 = 2.*TLN*RXLMT                                                00013800
      C2 = 2.*TLN*RXLMT1                                               00013810
      TLM = 0.5*( TLN - C1*P2/6.0)                                     00013820
      TLN = 0.5*( TLN + C1*P2/3.0 )                                    00013830
      IF (MODE.LT.1)   GO TO 175                                       00013840
      C1 = C1*RXLMT                                                    00013850
      C2 = C2*RXLMT1*DELTM1                                            00013860
      RDELT = 1.0/DELT                                                 00013870
      OLDM1 = XI(IJ,K)                                                 00013880
      OLDM2 = XI(IJ,K+1)                                               00013890
      DO 170 M=1,MODE                                                  00013900
      BM = B(M+1)                                                      00013910
      B1M = B1(M+1)                                                    00013920
      XN = M*M                                                         00013930
      XPP = XN*XLMT1                                                   00013940
      TEX = XPP*(24.+XPP*(-12.+XPP*(4.-XPP)))*R24                      00013950
```

```
      IF (XPP.GT.1.0E-01)   TEX = 1.0-EXP(-XPP)
      XPN = XN*XLMT
      XXN = XPN*(24.+XPN*(-12.+XPN*(4.-XPN)))*R24
      IF (XPN.GT.1.0E-01)   XXN = 1.0-EXP(-XPN)
      DTEX = 1.0 - XXN
      XXE = C1*XXN
      TLN = TLN - XXE*B1M
      TLM = TLM - XXE*BM
      RM(1,M,IJ,K) = RM(1,M,IJ,K)-C2*(B1M*OLDM1-BM*OLDM2)*TEX
      RM(2,M,IJ,K) = RM(2,M,IJ,K)-C2*(B1M*OLDM2-BM*OLDM1)*TEX
      SLN = SLN + RM(1,M,IJ,K)*XXN*RDELT
      SLM = SLM + RM(2,M,IJ,K)*XXN*RDELT
      RM(1,M,IJ,K) = RM(1,M,IJ,K)*DTEX
  170 RM(2,M,IJ,K) = RM(2,M,IJ,K)*DTEX
  175 SLN = SLN + TLN*HIM1 - TLM*HIM2
      SLM = SLM + TLN*HIM2 - TLM*HIM1
      TL(IJ,K) = TL(IJ,K) + TLN
      TL(IJ,K+1) = TLN
      TLK(IJ,K) = TLM
      SL(IJ,K+1) = SLM
      SL(IJ,K) = SL(IJ,K) + SLN
  180 CONTINUE
      RETURN
  600 FORMAT ('-',20('*'),'WELL',2I3,' IN LAYER',I3,' GOES DRY',20('*'))
  610 FORMAT ('-',20('*'),'NODE',2I3,' IN LAYER',I3,' GOES DRY',20('*'))
      END
      BLOCK DATA
C     ----------
C
C     SPECIFICATIONS:
C
      COMMON /SARRAY/ ICHK(13)
      COMMON /PR/ DIGIT(129),VF4(12),VF5(12),
     1VF6(12),VF7(12),VF8(12),VF9(12),VF10(12)
C     ***************************************************************
C
      DATA ICHK/'DRAW','HEAD','MASS','DK1','DK2','WATE','RECH','PUN1','P
     1UN2','ITKR','EQN3','ITLR','MPTY'/
      DATA DIGIT/'1','2','3','4','5','6','7','8','9','10','11','12','13'
     1,'14','15','16','17','18','19','20','21','22','23','24','25','26',
     2'27','28','29','30','31','32','33','34','35','36','37','38','39','
     340','41','42','43','44','45','46','47','48','49','50','51','52','5
     43','54','55','56','57','58','59','60','61','62','63','64','65','66
     5','67','68','69','70','71','72','73','74','75','76','77','78',' 79
     6','80','81','82','83','84','85','86','87','88','89','90','91','92'
     7,'93','94','95','96','97','98','99','100','101','102','103',' 104'
     8,'105','106','107','108','109','110','111','112','113','114','115'
     9,'116','117','118','119','120','121','122',',','/','//','///','///
     ./',' ','X,'/
      DATA VF4/'(','    ','   ','  ','    ','F10.','4/(8','F10.','4))',3
     1*' '/
```

```
      DATA VF5/'(/I3','    ','    ','X,','    ','F6.1','/(5X',
     1',20F','6.1)',')',2*' '/
      DATA VF6/'(','    ','    ','    ','    ','F4.0','/(20','F4.0','))',3
     1*' '/
      DATA VF7/'(/I6','    ','    ','X,','    ','F9.5','/(1H',' ,5X',
     1',14F','9.5)',')',' '/
      DATA VF8/'(/I6','    ','    ','X,1P','    ','E12.','5/(1','H ,5'
     1,'X,1P','10E1','2.5)',')'/
      DATA VF9/'(/I6','    ','    ','X,1P','    ','E11.','3/(1','H ,5'
     1,'X,1P','10E1','1.3)',')'/
      DATA VF10/'(/I5','    ','    ','X,','    ','F7.2','/(5X',',18F'
     1,'7.2','))',2*' '/
*********************************************************************
      END
```

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